TOOLS FOR RESULTS-BASED TRANSPORTATION ENGINEERING AND PLANNING FOR REMOTE COMMUNITIES IN NORTHERN CANADA

BY

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A Thesis
Submitted to the Faculty of Graduate Studies
In Partial Fulfillment of the Requirements
For the Degree

MASTER OF SCIENCE

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FACULTY OF GRADUATE STUDIES

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ABSTRACT

The purpose of this research is to develop a set of tools to facilitate results-based transportation engineering and planning for remote communities in northern Canada. The geographic scope of the research encompasses northern Manitoba and the Kivalliq region of Nunavut. The tools are designed to address national issues specific to the roles and responsibilities of Transport Canada. They offer a pragmatic approach to northern transport engineering, planning and decision-making because they can be implemented individually or collectively.

The thesis: (1) selects, defines and adapts a theoretical framework for transport systems analysis; (2) develops a comprehensive, interoperable, synthesized and user-friendly GIS-T analytical platform; (3) identifies results-based indicators to measure the performance of the northern transportation system with respect to national transportation goals and objectives; and (4) defines an associated evaluation methodology.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1. THE RESEARCH

The thesis researches and develops pragmatic tools to facilitate results-based transportation engineering and planning for remote communities in northern Canada. The tools involve: (1) a theoretical systems analysis framework; (2) a comprehensive, synthesized, user-friendly, interoperable and relevant GIS-T analytical platform; (3) a set of transportation objectives and related results-based measurement criteria reflecting national concerns; and (4) an associated matrix-based evaluation methodology.

The tools are designed to address national issues specific to the roles and responsibilities of Transport Canada. The GIS-T analytical platform is developed and applied to the geographic area encompassing northern Manitoba and the Kivalliq region of Nunavut; however, the theoretical analysis framework and planning toolset are relevant and applicable in all northern, remote regions of Canada.

1.2. BACKGROUND AND NEED

The value of the thesis stems from: (1) the need for an integrated transportation planning process that is specific to Canada's northern regions; (2) public concern relating to equity and the elimination of regional disparities and the judiciousness of incorporating these concepts into the transportation planning process; (3) the federal government's commitment to providing fiscally responsible access to remote communities; and (4) the requirement for tools to better inform decision-making in an environment of continuous change and adaptation.

The nature of the northern Canadian transportation system, its operational characteristics and quality of service differ from the transport system serving southern Canada. Transportation plays a vital role in sustaining northern communities, but environmental and fiscal constraints impede the provision of an adequate, economic and efficient system. Large geographic distances between communities, rugged terrain, permafrost and concerns about environmental degradation limit the feasibility of permanent, land-based transportation infrastructure. From an economic perspective, the region does not have a sufficient population base to financially support large-scale infrastructure projects (Prentice & Thompson 2004). Competition within and between modes is also limited by the lack of demand (Government of Nunavut 2001). As a result, the northern transport system is sustained through direct and indirect government subsidization. The thesis proposes a planning process that considers these unique characteristics of the northern transport system and employs pragmatic tools that are relevant and applicable within the northern context for the early part of the 21^{st} century.

Spatial separation from major urban centers and the quality of external transport links affect the standard of living in northern, remote communities. Communities without year-round, land-based transportation infrastructure experience "high cost of living, limited mobility, lack of economic growth opportunities and lower quality of life" (MTGS n.d.: 18). Lack of transportation options also limits access to educational and employment opportunities, health care, emergency services and external communication. These conditions present a barrier to equity in northern communities.

Equalization and the elimination of regional disparities are values upheld by the *Constitution Act* of 1982, in which the federal and provincial governments committed to: (a) promoting equal opportunities for the well-being of Canadians; (b) furthering economic development to reduce disparity in opportunities; and (c) providing essential public services of reasonable quality to all Canadians (*Constitution Act* 1982, Part III). The *Canada Transportation Act* of 1996 recognizes transportation as a key to regional development and a tool to meet national policy objectives. Further, the historic meeting between First Ministers and National Aboriginal Leaders held in November 2005 stressed the imperativeness of "closing the gap" in the quality of life that exists between Aboriginal and other Canadians in areas of health, education, housing, relationships and economic opportunity. At this meeting Prime Minister Paul Martin stated that Aboriginal people "must have an equal opportunity to work for and enjoy the benefits of our collective prosperity" and that the gaps between Aboriginal Canadians and other Canadians "are not acceptable in the 21st century. They never were acceptable" (Martin 2005). Improvements to the transport system have the potential to enhance the quality of life in northern communities and address public concerns relating to equity and regional disparity. The thesis provides a foundation for evaluating transport projects in terms of these qualitative goals in addition to traditional quantitative measures.

Providing access to Canada's remote regions is a principle of the federal government's vision for a sustainable transportation system for Canada (Transport Canada 2003d). Where transport services are essential for the survival of a remote community, the federal government is committed to seeking the best means of access in the most cost-effective manner. The thesis provides tools that assist government officials in fulfilling this mandate. Results-based methodologies encourage fiscal responsibility and government accountability and transparency. Specifically, implementing a results-based system for northern transportation planning allows decision-makers to:

- better understand the performance of the current system;
- identify and assess alternative projects, programs and policies with the aim to improve resource allocation;
- implement the most beneficial projects, programs and policies with the limited resources available;
- guide and support decision-making and policy initiatives through long-term monitoring of progress; and
- demonstrate to the public the value of investments from safety, operational and economic perspectives.

The US Bureau of Transportation Statistics suggests that "because transportation and the world it serves are constantly changing, informed decisions require continual updating of our understanding of the transportation system, how it is used, what it contributes, and what it affects" (US DOT 1997: 4). The tools developed in this research are designed to support informed decision-making. Figure 1.1 shows schematically how each of the research tools enhances the planning process by: (1) facilitating informed analysis and interpretation of transportation data; (2) improving understanding of the implications and outcomes of projects, programs and policies; (3) providing a mechanism for evaluation of alternatives to clarify the issues and support decision-making; and (4) providing continuous feed-back through long-term monitoring of results. The tools offer a pragmatic approach to transport engineering and planning because they can be implemented individually or collectively.

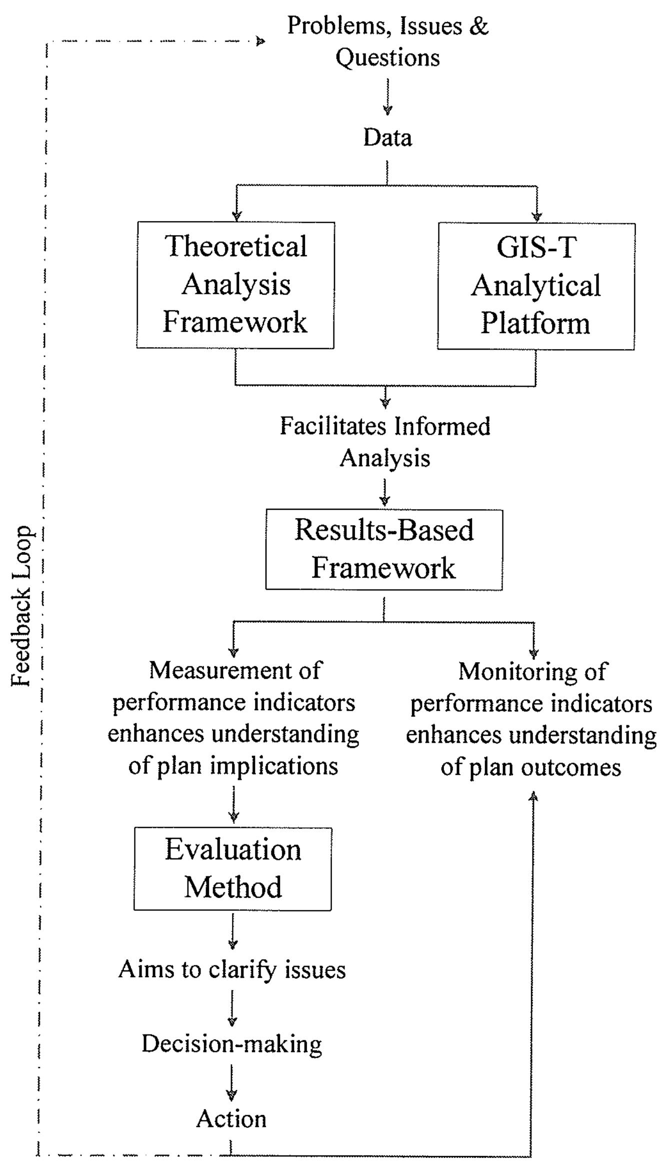

Figure 1.1: Components of the Research Toolset

1.3. OBJECTIVES

The objectives of the research are:

1. To conduct an environmental scan of the subject matter, involving synthesis of government and industry intelligence and a literature review of relevant journals, research reports and other published materials.

2. To select, define and adapt a theoretical framework and related procedures for systematic analysis of the issues and opportunities relevant to national transportation planning considerations in the defined region.

3. To build on existing datasets to create a current, interoperable and user-friendly GIS-T platform for the research. This involves the spatial structure of the transport system (T) and demand system (D). An auxiliary component of this objective is to design and render interoperable and user-friendly the attribute databases and information systems which are used to populate the T, D and flow (F) systems of the platform.

4. To understand essential aspects of the laws, regulations, policies and practices governing national transportation considerations within the region and to identify related goals and objectives applicable to the defined region.

5. To define results-based measurement criteria to be used by decision-makers in evaluating system issues and opportunities.

1.4. SCOPE AND OTHER RESEARCH CONSIDERATIONS

The following requirements are essential to the conduct of this research:

- Readily available data sources are used to define the spatial structure of the northern transport system and to populate the associated attribute databases. The research enhances existing GIS platforms and datasets, including Transport Canada's Small and Remote Community Information System (SARCIS), by linking data from multiple sources. Understanding the structure of the spatial and attribute data and knowledge of GIS and database software packages (GeoMedia, Access, MapInfo) are essential for synthesis and analysis of this information.

- Understanding essential aspects of the laws, regulations, policies and practices that impact transportation engineering and planning within the defined region is necessary for identification of the primary operational goals and objectives of providing transportation services to northern, remote communities. Input and guidance from government officials is critical to ensure that the research is relevant, practical and useful.

- The research considers the current state of the northern transportation system. It develops knowledge bases to describe and understand the transportation system and methodologies to apply this knowledge to transportation engineering, planning and decision-making.

- It is recognized that the northern transportation system is continuously evolving and that a dynamic relationship exists between planning initiatives and related system impacts. The goal of the research is not to resolve transport problems at a fixed point in time, but to develop continuous management tools that can be enhanced and adapted to reflect future system characteristics.

- Active participation at national and international conferences and symposia provides technical training and practical insight into the research. Conferences specifically addressing issues and opportunities in northern transportation, including Airships to the Arctic Symposium III (Winnipeg, June 2005) and the Northern Transportation Conference (Yellowknife, November 2005), are fundamental information sources for current developments in the field of research.

1.5. THESIS ORGANIZATION

The thesis is comprised of seven chapters. *Chapter 2* defines the geographic scope of the research and clarifies the meaning of the terms northern and remote as they are used in the context of this research.

Chapter 3 defines the theoretical model for transport systems analysis and the GIS-T analytical framework used to synthesize, store and analyze the related spatial and attribute data.

Chapter 4 applies these models to the defined geographic region. The transportation (T), demand (D) and flow (F) systems of the region are described.

Chapter 5 outlines the evolution of national transportation policy as it applies to northern Canada and describes the current vision for national transportation policy. Key goals are selected from this analysis as inputs to the results-based measurement program.

Chapter 6 discusses the applicability of results-based planning methodologies in northern, remote regions and outlines the basic requirements of a results-based planning program. An evaluation methodology is defined to compare alternatives, to assess the impacts of each alternative on related performance indicators and to identify differential effects and trade-offs.

Chapter 7 provides conclusions and outlines considerations for future research.

CHAPTER 2

GEOGRAPHIC SCOPE

The concept of what describes the north is difficult to define. Even more complex are the concepts of remoteness and the characterization of remote regions or communities. This chapter presents alternative definitions for these terms that are available from the literature, selects the most suitable definitions of northern and remote within the context of this research and uses these interpretations to establish the geographic scope of the research.

2.1. DELINEATION OF CANADA'S NORTHERN REGION

A general definition of the Canadian north is the region north of the 60th parallel, including the Yukon, Northwest Territories and Nunavut. While this geographic delineation presents a convenient political boundary, it disregards the similarities in climatic and physical attributes, economic structure and population settlement patterns between the territories and the northern portions of the provinces (McNiven & Puderer 2000).

The ill-defined northern region south of the 60th parallel is what Coates and Morrison (1992) refer to as "the forgotten north." All of the provinces, with the exception of the Maritimes, have sizeable northern regions, although the definition of the north-south divide is imprecise and varies from province to province. Scholars define the southern limit of the north in different ways:

- The circumpolar north is defined as the region north of the 55th parallel of latitude.
- A basic approximation proposed by Morton (1970) distinguishes between southern lands where commercial agriculture is viable and the north, where prospects for extensive agriculture are limited.
- Hamelin (1988) defined a complex nordicity index based on a set of environmental, demographic, accessibility and economic indicators. Lines on a map connecting locations with the same degree of nordicity represent major geographic fronts delineating between the middle north, the far north and the extreme north.
- A two-tiered approach is used by Indian and Northern Affairs Canada (INAC) to designate the Canadian north. The far north consists of Yukon, Nunavut, Northwest Territories, northern Quebec and Labrador. The mid-north is approximately the northern half of the western provinces, northern Ontario and the portion of Quebec between southern urban Quebec and what has been defined as the far north (INAC 1996).
- According to Coates and Morrison (1992), the best approach to categorizing northern regions is on a case-specific basis, recognizing that nordicity varies spatially and temporally due to shifts in political and economic circumstances.

Delineation of the north-south boundary based on environmental or climactic zones is problematic since most statistical data is based on pre-defined administrative units that do not necessarily follow natural or geographic divisions. Bone (1992) operationalized the Hamelin nordicity index by applying the index to Canadian census divisions, thus making it more applicable for spatial analysis.

More recently, the geography division of Statistics Canada developed a standard delineation of the north for statistical purposes (McNiven & Puderer 2000). The north-south line represents the average of 16 variables that delineate regions of the country according to environmental, political, biotic and socioeconomic indicators. The definition attempts to incorporate as many of the current north concepts and variations as possible. This aggregation of indicators forms a "functional definition of Canada's north" (McNiven & Puderer 2000: 3). Transition areas reflecting the gradual change from north to south are also defined, such that any geographic unit can be assigned to one of the north, south or transition zones based on the location of its population-weighted representative point. Figure 2.1 shows the location of the Canadian north-south line and the associated transition zones.

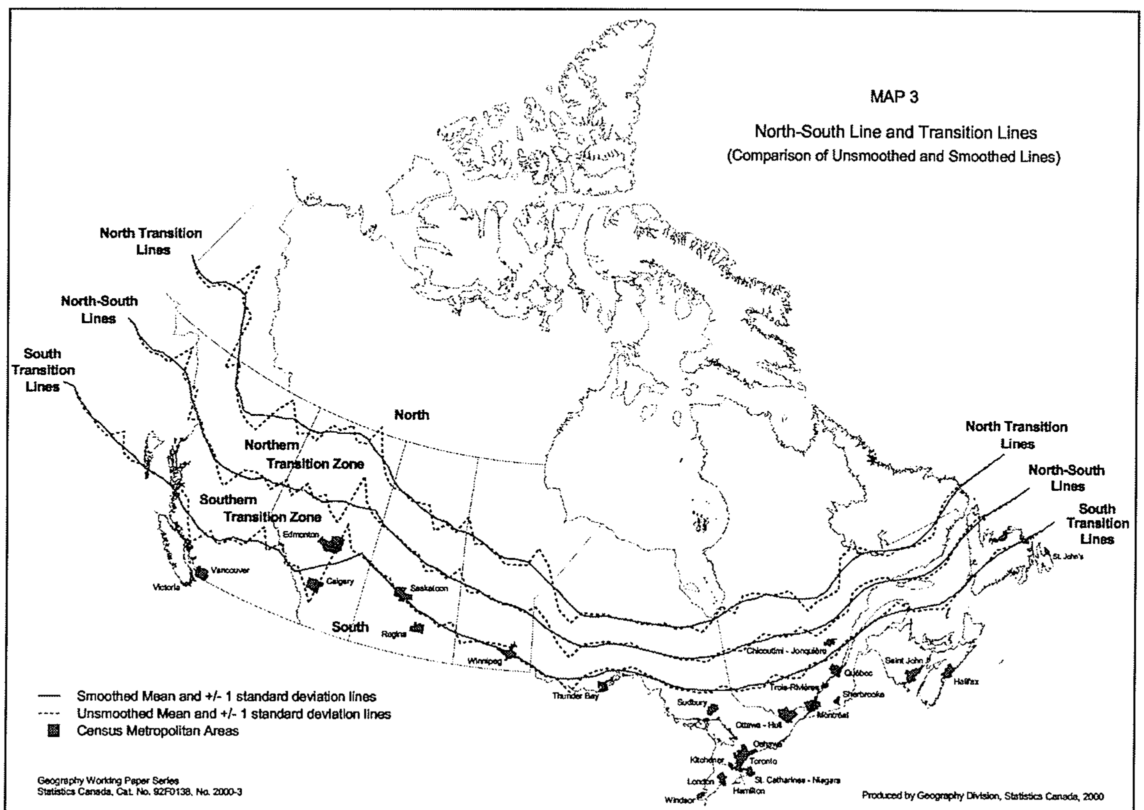

Figure 2.1: Statistics Canada North-South Delineation
Source: McNiven & Puderer 2000

2.2. DEFINITION OF REMOTE

The provincial, territorial and federal governments of Canada do not have a common set of criteria that are used to designate remote areas. National and international remoteness definitions generally include concepts of distance to service centers, accessibility to goods and services and the availability and quality of transportation infrastructure. More complex classification schemes integrate socio-demographic indicators and geographical criteria. The aim of most definitions is to quantify the remoteness concept, thus facilitating its use as an analytical and policy tool.

2.2.1. Criteria for Remoteness Designation

There are two primary approaches to conceptualizing remoteness. The *geographical approach* defines remoteness in terms of environmental parameters that influence access to services or physical distances between spatial units. This approach focuses on how distance impacts opportunity for interaction. The *sociological approach* focuses on perceptual, behavioral and socioeconomic characteristics and how these factors influence accessibility to services. This methodology recognizes that sociological disadvantage exacerbates locational disadvantage (Commonwealth of Australia 2001).

There are many definitions of remoteness, each based on different criteria and quantification methodologies. In some cases different phraseology (e.g. underdeveloped, isolated) is used to refer to communities that can be generally categorized as remote. Definitions from the literature include:

- The SCONE Report (1987) classifies northern communities as "developed" and "underdeveloped." Criteria utilized in classifying the communities are primarily socioeconomic, including population, market potential, viability of the private sector, unemployment levels, wages, education levels and ethnic origin. The quality of transport links is also considered (Legislative Assembly of the Northwest Territories 1987).

- The Accessibility/Remoteness Index of Australia (ARIA) is a purely geographical approach to measuring remoteness in which road distances to service centers are used as a proxy for accessibility. The ARIA classification scheme makes special provision for communities that do not have road access by assigning a weighted distance measure to reflect the additional costs associated with air travel (Commonwealth of Australia 2001).

- Petrov (2004) associates remoteness with measures of transportation accessibility, including physical distance, road density and rail accessibility.

- Indian and Northern Affairs Canada (INAC) maintains the *Band Classification Manual*, which categorizes First Nation Bands according to their degree of remoteness. Bands are assigned to one of four geographic zone classifications based on the nearest city center, the distance to the nearest service center and the type of road access to the community (INAC 2005).

- The Isolated Posts and Government Housing Directive (IPGHD) designates northern communities as "isolated" if they meet specified criteria relating to population, climate, topography and transportation infrastructure (National Joint Council 2005).

Tables 2.1 and 2.2 summarize the socioeconomic and geographical criteria used in each of the remoteness definitions discussed above.

Table 2.1: Socioeconomic Criteria for Designating Remote Communities

	SCONE Report	ARIA	Petrov	INAC	IPGHD
Population	✓				✓
Economic Conditions					
Market potential	✓				
Viability of private sector	✓				
Unemployment rate	✓				
Wages	✓				
Demographic Characteristics					
Education levels	✓				
Ethnic origin	✓				

Table 2.2: Geographical Criteria for Designating Remote Communities

	SCONE Report	ARIA	Petrov	INAC	IPGHD
Climate					
Degree of wind-chill					✓
Length of period of darkness					✓
Annual precipitation					✓
Temperature variation					✓
Topography					
Barren or taiga lands					✓
Transportation Accessibility	✓				
All-weather road access				✓	✓
Rail service			✓		✓
Air service					✓
Road density			✓		
Distance to Service Centers					
Road distance		✓		✓	✓
Straight line distance			✓		
Degree of Latitude					✓

2.2.2. Recommendations from the Literature

In Australia it is "preferable to adopt an unambiguously geographical approach to defining remoteness" (Commonwealth of Australia 2001: 7). Specific advantages of utilizing a purely geographical approach include reduced ambiguity as to whether an area is locationally disadvantaged or socio-economically disadvantaged and increased applicability in multiple types of analyses.

There are obvious distinctions between different types of communities which are based not only on spatial distribution, but on other socioeconomic indicators as well. There are, however, some major drawbacks to incorporating too many indicators into the remote definition. Methodologies that utilize multiple forms of geographic and socioeconomic data require substantial human and computing resources to ensure currency and accuracy. According to the Government of the Northwest Territories, this type of approach is not recommended for long-term planning and funding (Government of the Northwest Territories 2004).

All of the definitions associate remoteness with the availability of transportation infrastructure and services or the distance that must be traveled to reach service centers. These types of geographical data are unambiguous and readily available for most northern Canadian communities. A further advantage of utilizing a geographic approach is the increased temporal stability provided by geographic criteria. Travel distances and transport options are less likely to change over time compared to socioeconomic indicators and are therefore more appropriate for mid to long-range planning initiatives.

2.2.3. Proposed Community Classification System

This research utilizes criteria established in the *Band Classification Manual* (2005) for designating remote communities. The following definitions are adapted from the Manual:

> *Remote Community:* A community that is located over 350 kilometers from the nearest service center with year-round road access.
>
> *Special Access Community:* A community that does not have year-round road access to a service center and, as a result, experiences a higher cost of transportation.
>
> *Service Center:* The nearest community in which the following services are available:
>
> a) suppliers, material and equipment
> b) a pool of skilled and semi-skilled labor
> c) at least one financial institution
> d) provincial services (health, community, social and environmental services)
> e) federal services (Canada Post, employment center)

> *Road Access:* Includes surface transportation on year-round paved or gravel roads. Ferry service forming part of the provincial road network and capable of transporting adequate quantities of material, equipment and supplies constitutes road access.

Also included in the *Band Classification Manual* (2005) are definitions for urban communities (located within 50 kilometers of a service center) and rural communities (located between 50 and 350 kilometers of a service center). These categorizations are not explicitly considered in this research.

2.3. GEOGRAPHIC SCOPE AND ANALYSIS UNITS

2.3.1. Geographic Analysis Units

A census subdivision (CSD) is an area that is a municipality or an area that is equivalent to a municipality for statistical reporting purposes such as an Indian reserve or an unorganized territory (Statistics Canada 2001b). Census subdivisions serve as the base enumeration unit for this research because they represent areas for which data is readily available from the 2001 census.

Many northern communities have small and dispersed populations. To ensure confidentiality, these communities are subject to data suppression techniques employed by Statistics Canada and other data providers. CSDs with fewer than 150 residents do not have a sufficient population base to allow for meaningful data collection and are therefore excluded from this research. Local government districts, unorganized divisions and rural municipalities that are sparsely populated and cover a large geographic area are also excluded from the scope of this research.

2.3.2. Geographic Scope

The geographic scope of the research includes the region defined as northern Manitoba and the Kivalliq region of Nunavut. Using the Statistics Canada north and north transition zone definitions, a total of 65 CSDs are included in this region (hereafter referred to as the study area). The study area covers approximately 1,279,752 km^2 (Table 2.3).

Table 2.3: Total North and North Transition Zone Coverage in the Study Area

	Area of North Zone (km^2)	**Area of North Transition Zone (km^2)**
Kivalliq Region	856,278	0
Northern Manitoba	263,778	159,696
Total	1,120,056	159,696

The research only considers CSDs that are classified as remote or special access according to the criterion outlined in the *Band Classification Manual* (2005) and summarized in Section 2.2.3. None of the communities in the study area are classified as remote, while 27 meet the special access criterion (Table 2.4).

Table 2.4: Community Remoteness Classifications

	Urban	**Rural**	**Remote**	**Special Access[1]**	**Not Applicable[2]**
Kivalliq Region	0	0	0	7	1
Northern Manitoba	7	25	0	20	5
Total	7	25	0	27	6

[1]Three northern Manitoba special access communities are too small (population < 150) to be included in the analysis. Therefore, the total number of special access communities considered is 24.
[2]The *Band Classification Manual* criteria do not apply to unorganized districts, local government districts and rural municipalities that span a large geographic area.

Figure 2.2 shows the North and North Transition zones within the study area and the location of the 24 special access communities considered in this research. Refer to Appendix A for a complete a list of the northern CSDs in the study area and their remoteness classification.

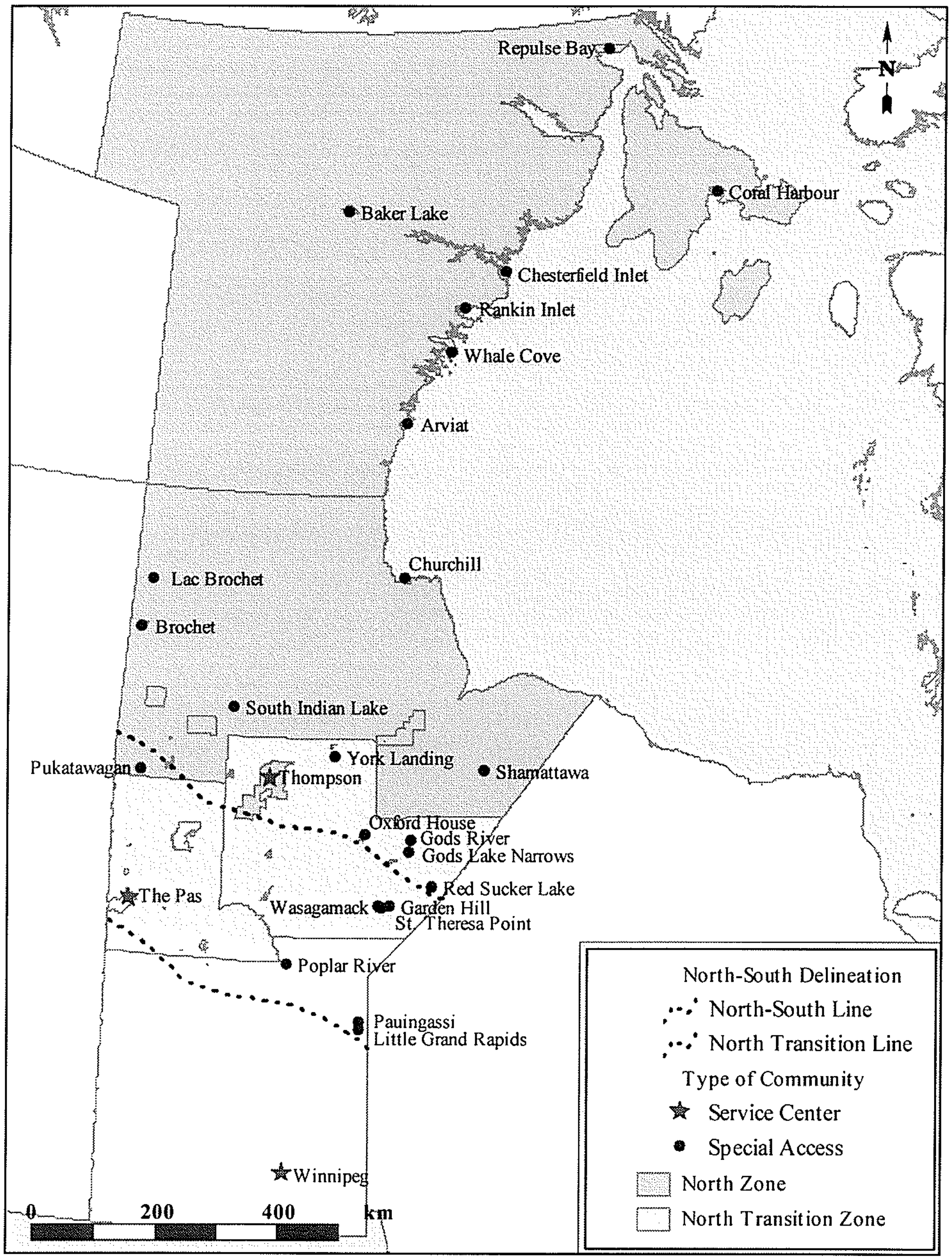

Figure 2.2: Research Study Area
C. Isaacs 2005
TIS Laptop\C:\Users\Crystal\GIS Data\Thesis Data\Chapter 2 Maps\Research Study Area.gws

The criteria used to define the geographic scope of the research impacts which communities and regions are included in the analysis. Some communities are located north of the north-south line defined by Statistics Canada, but are excluded from this analysis because they have access to the all-weather road network and are closer than 350 kilometers from a service center (these communities are classified as rural by INAC). Other communities, located on the east side of Lake Winnipeg, do not have all-weather road access (and would therefore be classified as special access) but are located in the south transition zone. The criteria used in this research to define the terms northern and remote determined the geographic scope. It is recognized that in using this approach, some communities have been excluded from the analysis.

CHAPTER 3

FRAMEWORK FOR TRANSPORTATION SYSTEMS ANALYSIS

This chapter defines the two interrelated components of the framework for transportation systems analysis used in the research. The theoretical component outlines a systematic methodology for analysis of the transportation system after Manheim (1979). The analytical component utilizes a customized GIS-T framework to synthesize, store and analyze the related spatial and attribute data.

3.1. THEORETICAL FRAMEWORK

The two foundational premises of the theoretical approach to transport systems analysis used in this research are:

- The total transportation system of a region must be viewed as a single, multimodal system; and
- Consideration of the transportation system cannot be separated from consideration of the social, economic and political systems of the region (Manheim 1979: 11).

The transportation system of a region is highly interrelated with the socioeconomic activity that takes place within and adjacent to the region. Changes made to the transport system affect change in the socioeconomic system and likewise, changes in the socioeconomic activity within a region will bring about changes to the existing transport system.

The overall system, as defined by Manheim (1979), includes three basic variables: (1) the transportation system (T); (2) the demand system (D); and (3) the flow system (F). These three components interact with one another in three types of relationships:

1. The flow pattern is determined by both the transportation system and the demand system.
2. The current flow pattern will cause changes over time in the demand system.
3. The current flow pattern will also cause changes over time in the transportation system (Manheim 1979: 13).

These relationships are shown schematically in Figure 3.1. The research focuses on the first type of relationship and adapts the theoretical framework for defining this particular relationship.

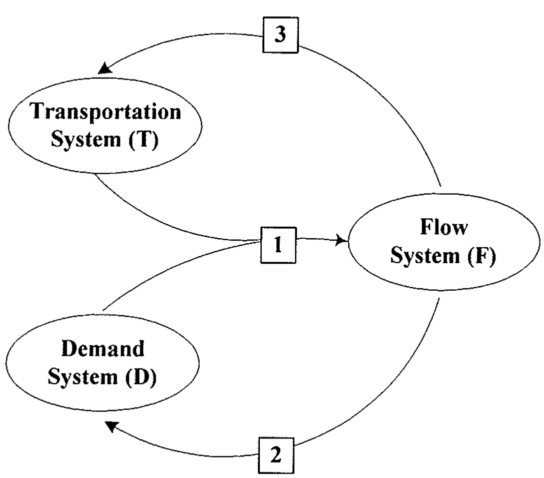

Figure 3.1: Basic Relationships between T, D and F
Source: Manheim 1979

3.1.1. The Transportation System (T)

The transportation system is defined by the physical multimodal transportation infrastructure as well as the regulatory and policy framework governing the provision and use of transportation facilities. Within the transportation system the following factors, outlined by Manheim (1979), define the space of possible transportation plans and policies:

- Technological advancements in the means of propulsion, the medium through which vehicles travel, vehicle characteristics, network characteristics and modal operations have the potential to enhance the transport options and increase the modal choices available to the consumer.

- Network options include the general configuration of the network and the geographical location of transport facilities.

- Links within the transportation network include highways, rail lines, streets, airports, intermodal terminals and ports. Nodes represent the connectivity between links in the network and serve to express the topology of the network. The physical characteristics of links and nodes, the spatial distribution of facilities and the capacity of the infrastructure are all components of the transport system that can be modified to enhance system performance.

- The vehicles used to transport passengers and freight are also important components of the transport system. Changing the number of vehicles and the characteristics of the vehicles employed will impact the transportation system, the demand system and the overall flow pattern.

- System operating policies reflect decisions about how the transportation system is operated. Options within this category include changes relating to weight limits, route restrictions, scheduling, consumer pricing, financing, subsidies and regulatory decisions.

- Organizational policies include the types and number of institutions, domains of responsibility and channels of communication, coordination and control.

3.1.2. The Demand System (D)

Transportation is a derived demand, meaning that "travel is desirable not in itself but as a means of being at certain locations at certain times, and this goal is itself derived from the desire to undertake certain patterns of activities" (Manheim 1979: 62). The demand system is defined as the social, economic, political and other transactions that take place in a particular region over space and time. These transactions constitute the demand for transportation and include land use, commercial and industrial activity, health care, educational and employment opportunities and demographic characteristics (Manheim 1979).

A consumer has a number of options available to them from a transportation perspective, including whether or not to make a trip, where to make the trip, at what time to make the trip and what mode and route to take. How they make these decisions will depend on attributes of the transportation system including travel time, distance and convenience. In theory, the decisions made by users will depend on both the perceived characteristics of the transportation system and the actual and potential transactions in the demand system (Manheim 1979). In the north, these decisions are superficial and travel choices are based primarily on the availability of services (Government of Nunavut 2001).

3.1.3. The Flow System (F)

Flows are measured in terms of people, freight and vehicular movement within the system, including the amount of movement, quality of service and resources consumed.

The flow pattern is determined from the interplay between the transportation system and the demand system.

At the core of any transportation systems analysis is prediction of changes in flows. Any change that is imposed on the transportation system will have related impacts on the pattern of flows within the system. The challenge for transport analysts is to predict the impacts that will result from implementation of different transport alternatives.

3.2. ANALYTICAL FRAMEWORK

The analytical framework developed in this research synthesizes, stores and analyzes spatial and attribute data relating to the three components of the transport system defined by Manheim (1979). Geographic information systems (GIS), database software and spreadsheet applications are used collectively to create a customized, multi-faceted, interoperable and user-friendly GIS-T platform.

3.2.1. Definitions

A *geographic information system* (GIS) is an interconnected system of "hardware, software, data, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth" (Dueker & Kjerne 1989, quoted in Stokes & Marucci 1995: 28). GIS-T is the specific application of a GIS to transportation related problems.

Spatial data are geographic features composed of points, lines or polygons that, when coupled with coordinate information, are used to represent real-world entities. Spatial data contains information about the locations and shapes of geographic features and the relationships between them. This information is presented in the form of coordinates and topology (ESRI 2005).

Each spatial dataset has an associated attribute dataset which provides additional information related to the real-world features. *Attribute data* are "[t]abular and/or textual data describing the geographic characteristics of map features" (ESRI 2005). Attribute information is either embedded into the spatial data or manually joined using GIS analytical tools. Integration of spatial data with associated attribute information within a GIS allows multiple forms of data to managed, manipulated, analyzed and displayed simultaneously.

3.2.2. Software

The GIS-T platform for the research was developed using GeoMedia Professional Version 5.2. Other GIS software packages, including MapInfo and TransCAD were utilized for data conversion purposes. Microsoft products (Excel and Access) were used for data storage, analysis and preparation for integration into the GIS-T platform. All maps presented in this report were generated using the GeoMedia platform. To enhance the usefulness of the research for Transport Canada personnel all spatial and attribute data were also converted to formats compatible with MapInfo.

3.2.3. GIS-T Platform

Transportation systems are complex and continuously changing. Implementation of a GIS-T allows transportation planners and engineers to model the complexity of the transportation system and to readily update the data as system characteristics evolve over time. GIS-T supports decision-making by facilitating informed analysis and interpretation of transportation data and providing decision-makers with a better understanding of the overall transport system.

Geographic information systems are ideally suited to transportation applications because of their ability to conduct spatial analyses. GIS-T allows users to collect and integrate multiple types of transportation information and to relate these data to geographically referenced entities such as links or nodes in the transportation network (Stokes & Marucci 1995). Since most transportation data can be geographically referenced, GIS provides the means of integrating location information and transportation data (NCHRP 1993).

This strength of GIS is also problematic in some respects. Collecting data, converting it for use in a GIS-T and data integration across different applications are identified by Stokes and Marucci (1995) as "obstacles" to GIS-T implementation. It has also been observed that constructing GIS-T platforms for multi-jurisdictional analyses is challenging because of "the complexity and difficulty associated with conducting data sharing and ensuring spatial data interoperability" (Han, Minty & Clayton 2003: 1).

3.3. DEVELOPMENT OF THE GIS-T PLATFORM

3.3.1. Interoperability Issues

Interoperability in a GIS environment refers to "the ability of software components to communicate with applications built by different software vendors, operate on different platforms and use data in different formats and from disparate databases" (Forsman 2005). Han, Minty and Clayton (2003) recommend utilizing techniques to resolve interoperability issues by focusing on spatial data processing. This involves:

1. gathering GIS-T data from various sources;
2. transforming the spatial data structure of each data set to accommodate the final application; and
3. merging these manipulated data sets.

Spatial and attribute data are handled separately in this process and joined once the required spatial modifications are complete. Since spatial data have common location information that can be used as a linking agent, GIS users can "use the interoperable spatial data as bridges to allow the free flow of attribute information" (Han, Minty & Clayton 2003: 811).

For this research, GIS-T data from multiple sources are integrated in the analytical platform. Technical considerations that were addressed in the compilation of GIS data for this research include:

- GIS data is typically developed and analyzed in a software-specific environment. Each type of software utilizes different file formats that are not compatible with one another and require some form of data conversion. The GIS-T platform for this research is based in GeoMedia Professional (version 5.2). GeoMedia utilities were used to construct warehouse configuration files and coordinate system definitions so that the data from each source could be imported into a common data warehouse.

- The structure and level of detail associated with attribute databases from different sources varies. Some database re-organization was required to ensure consistent and accurate attribute data and to allow for linkages between databases. Updates to the attribute data were also made as required to reflect recent changes in the transportation system.

- Jurisdictions may use a specific projection to display their data that is unique to that particular region of the world. A common projection must be selected to present data from multiple sources within the same platform. For this research, maps were produced using the Lambert Conformal Conic projection, which is considered appropriate to cover the entire study area.

3.3.2. Data Processing and Spatial Analysis

Many of the spatial datasets utilized in this research cover all of Canada or North America. To facilitate spatial analysis and thematic mapping it was necessary to reduce the size and coverage of most spatial layers to include only the study area and the immediate vicinity. This was accomplished using data processing features in GeoMedia including attribute queries (selecting spatial features based on a specific set of attribute values) and spatial overlays (selecting spatial features based on their proximity to other spatial features). All edits were executed on data replicas, leaving the original datasets intact.

3.3.3. Creation of Spatial Datasets

In some cases, spatial datasets were created by defining a new feature class and then using GeoMedia's insert feature command to populate the new database. New features were added to point layers, line layers and text layers.

1. Point feature classes were created by entering the geographic coordinates (longitude and latitude) of the entity and allowing GeoMedia to place the object in the correct, georeferenced position on the map.

2. Line feature classes were generated by drawing straight lines, arcs and compound features to approximate the location of linear features. This method was used to display the north-south line and northern air and shipping routes.

3. Text feature classes were defined to store and display spatial feature labels.

3.4. INTEGRATION OF THEORETICAL AND ANALYTICAL CONCEPTS

Manheim (1979) provides a convenient framework for organization of the spatial and attribute information required to populate the GIS-T analytical platform. The data included in this research is categorized according to the three components of Manheim's model for transport systems analysis, namely the transportation system (T), the demand system (D) and the flow system (F). A customized GeoMedia warehouse and/or supplementary attribute datasets were developed as part of this research to store the data relating to each of these components. An additional warehouse containing physical and geographic features provides the required base map components for visual display of the research analysis.

3.4.1. Base Map Spatial Features and Attribute Information

Table 3.1 lists the core spatial datasets that form the base map for the research and their corresponding attribute information. These datasets reside in the *Base Map Geography* warehouse in the GeoMedia platform. Information pertaining to warehouse configuration parameters and specific metadata for the spatial datasets used in this research is provided in Appendix B.

Additional attribute information that is stored in spreadsheet format includes:

- SGC code
- Location in north, south or transition zones
- INAC classification and geographic zone
- Remote classification
- Nearest service center
- Distance to nearest service center

Table 3.1: Base Map Spatial and Attribute Information

Spatial Dataset (raw data source)	Description	Associated Attribute Information
Canada_Boundaries (GeoGratis)	• Provincial and territorial outlines for Canada	• Region name • Area
Remote_Communities (GeoGratis)	• Selection set of communities from the populated places spatial dataset provided by GeoGratis • Community type information derived from INAC remoteness designation criteria	• Region name • Generic classification • Concise classification • Name • Type • Population (2001)
Canada_Lakes (Transport Canada)	• Selection set of lakes in Canada • Area features	• ID • Area
Canada_Rivers (Transport Canada)	• Selection set of rivers in Canada • Line features	• Length • Name
North_South_Line (C Isaacs)	• Approximate location of the north-south line proposed by McNiven and Puderer (2000)	
MB_NU_CSD (GeoGratis)	• Selection set of census subdivisions (CSD) in northern Manitoba and the Kivalliq region of Nunavut • Area features	• Area and perimeter • Province • Census division ID, name and type • Census subdivision ID, name and type • Census Metropolitan Area ID and Name
Kivalliq_Region_Communities (GeoGratis)	• Selection set of census subdivisions (CSD) in the Kivalliq region • Area features	• Area and perimeter • Province • Census division ID, name and type • Census subdivision ID, name and type
Kivalliq_Region_Unorganized (GeoGratis)	• Kivalliq region unorganized district • Area feature	• Area and perimeter • Province • Census division ID, name and type • Census subdivision ID, name and type
MB_Northern_CSD (GeoGratis)	• Selection set of census subdivisions (CSD) in northern Manitoba • Area features • Attribute data relating to "North Classification" was joined from Statistics Canada Census Geography Classification information	• Area and perimeter • Province • Census division ID, name and type • Census subdivision ID, name and type • Census Metropolitan Area ID and name • SGC Code • MIZ Category • Location in north, south or transition zones • North classification

3.4.2. Transportation System Spatial Features and Attribute Information

Table 3.2 shows the spatial and attribute data relating to the transportation system that were synthesized and developed for this research. These datasets reside in the *Transportation System* warehouse in the GeoMedia platform.

Additional attribute information that is stored in spreadsheet format includes:

Transportation System – General Attributes

- Community transportation infrastructure
- Level of accessibility (LOA) designation

Transportation System – Rail Attributes

- Estimated travel times and distances on selected northern rail routes
- Estimated fares on selected northern rail routes
- Rail schedules for the Pukatawagan-The Pas and Thompson-Churchill routes

Transportation System – Air Attributes

- Published commercial flight schedules
- Aircraft characteristics
- Airport infrastructure characteristics

Transportation System – Marine Attributes

- Northern Manitoba ferry schedules, facility descriptions and vessel descriptions
- Kivalliq region marine facilities
- Kivalliq region sealift cargo delivery schedule and rates (NSSI 2005)

Table 3.2: Transportation System Spatial and Attribute Information

Spatial Dataset (raw data source)	Description	Associated Attribute Information
MLI_Highways (Manitoba Land Initiative)	• Selection set of the National Road Network, Canada, Level 1 (NRNC1) • Provides a quality geometric description and set of basic attributes for Manitoba all-weather roads	• Spatial data accuracy • Data acquisition technique • Data provider • Acquisition/revision date • National road classification • Number of lanes • Pavement status
MLI_Winter_Roads (Manitoba Land Initiative)	• Selection set of the National Road Network, Canada, Level 1 (NRNC1) • Provides a quality geometric description and set of basic attributes for Manitoba winter roads	• Spatial data accuracy • Data acquisition technique • Data provider • Acquisition/revision date • National road classification • Number of lanes • Pavement status
Rail_Network (GeoGratis)	• Provides location information and a set of basic attributes for the Canadian rail network	• Length • Rail ID • Owner • Province
Rail_Stations (C Isaacs)	• Location of selected rail stations on the Hudson Bay Railway route	• Name
Airports (C Isaacs)	• Location of Airports • Selection set of communities from the Remote_Communities spatial file that have an airport identified in the *Canada Flight Supplement* • Attribute table populated from the *Canada Flight Supplement*	• Region name • Community • Certification status • Critical aircraft (service characteristics)
Air_Routes (C Isaacs)	• Approximate air route connections for study area communities • From published air schedules for carriers operating in northern Manitoba and the Kivalliq region	• Origin • Destination • Operator • Route name • Number of flights per week
Ferry_Segments (Manitoba Land Initiative)	• Selection set of the National Road Network, Canada, Level 1 (NRNC1) • Provides location information for provincially operated ferries in northern Manitoba	• Spatial data accuracy • Data acquisition technique • Data provider • Acquisition/revision date • National road classification • Route number
Shipping_Routes (C Isaacs)	• Shows the approximate location of shipping routes to Kivalliq region communities • Derived from information presented at the Shortsea Shipping Workshop (2003)	

3.4.3. Demand System Spatial Features and Attribute Information

The following spatial and attribute data relating to the demand system were synthesized and developed for this research (Table 3.3). These datasets reside in the *Demand System* warehouse in the GeoMedia platform.

Table 3.3: Demand System Spatial and Attribute Information

Spatial Dataset (raw data source)	Description	Associated Attribute Information
Mineral_Exploration_Licenses (Manitoba Industry, Economic Development and Mines)	• Location of active mineral exploration licenses in northern Manitoba	• Area • Holder • Zone • Number • Recording Date • Anniversary Date
Mineral_Occurrence (Manitoba Industry, Economic Development and Mines)	• Location and type of mineral occurrences in northern Manitoba	• NTS • MDS Number • Commodity 1 • Commodity 2 • Name • Area • Link • Report Number
Mining_Claims (Manitoba Industry, Economic Development and Mines)	• Location of active mining claims in northern Manitoba	• Name • Number • Holder • Stake Date • Record Date • Expiry Date • Hectares • Grouping

Demand system attribute data is stored in spreadsheet format, with the capability of joining the data to the Remote_Communities spatial layer (*Base Map Geography* warehouse) using the community name as the linking attribute. Demand system attributes are categorized into ten domains as shown in Table 3.4.

Table 3.4: Demand System Attributes

Domain	Attributes
Population	1996 Population
	2001 Population
Ethnic Origin	Total Aboriginal identity population
	Total non-Aboriginal population
Total Labour Force Activity	Total population 15 years and over by labour force activity
	In the labour force
	Employed
	Unemployed
	Not in the labour force
	Participation rate
	Employment rate
	Unemployment rate
Male Labour Force Activity	Males 15 years and over - Labour force activity
	In the labour force
	Employed
	Unemployed
	Not in the labour force
	Participation rate
	Employment rate
	Unemployment rate
Female Labour Force Activity	Females 15 years and over - Labour force activity
	In the labour force
	Employed
	Unemployed
	Not in the labour force
	Participation rate
	Employment rate
	Unemployment rate
Average Income	Individual Average Income
	Couple Families Average Income
	Lone Parent Families Average Income
Education Levels	Total population 20 years and over by highest level of schooling
	Less than grade 9
	Grades 9 to 13
	Without high school graduation certificate
	With high school graduation certificate
	Trades certificate or diploma
	College
	Without certificate or diploma
	With certificate or diploma
	University
	Without degree
	With bachelor's degree or higher
Employment Status	Total population 15 years and over with employment income
	Worked full year, full time
	Worked part year or part time
Income Sources	Composition of total income in 2000
	Employment income %
	Government transfer payments %
	Other %

3.4.4. Flow System Attribute Information

Flow system attribute data is stored in spreadsheet format, with the capability of joining the data to related spatial features in the *Transportation System* warehouse in the GeoMedia platform. The following attribute data relating to the flow system are included in this research:

Flow System – Air Traffic Attributes

- Northern Manitoba airport traffic history (enplaned/deplaned passengers, aircraft movements, freight volumes)
- Kivalliq region airport traffic history (enplaned/deplaned passengers)

Flow System – Marine Traffic Attributes

- Northern Manitoba ferry traffic history (passenger and vehicular traffic)

Flow System – Freight Traffic Attributes

- Freight shipments by mode (air, rail, winter road, ferry/barge) for northern Manitoba special access communities
- Estimated annual freight per capita in northern Manitoba special access communities

CHAPTER 4

THE NORTHERN TRANSPORTATION SYSTEM

The purpose of this chapter is to synthesize data describing the transportation, demand and flow systems in the study area. The theoretical concepts of transport systems analysis presented by Manheim (1979) are applied to the defined study area and the GIS-T analytical platform is used to store and analyze the raw data. The chapter presents a baseline of information developed by this research that provides a better understanding of the overall transportation system in the study area and, in conjunction with the tools developed in subsequent chapters, is useful in guiding decision-making.

4.1. TRANSPORTATION SYSTEM

The transportation infrastructure available to northern communities includes all-weather roads, winter roads, rail lines, airports and marine ports. The type and quality of transportation facilities vary by community. Special access communities have fewer transport modes compared to northern service centers and are not accessible from the all-weather road network. Regional variations are also evident. The transportation system serving special access communities in northern Manitoba relies on winter roads for seasonal resupply and air transport for year-round access. Special access communities in Nunavut also depend on air transport for year-round access, but do not have any form of intra-community surface transportation. Seasonal resupply is accomplished through marine networks and basic docking facilities in each of the communities.

As part of this research, and in conjunction with research conducted for Transport Canada (Coordination and Policy Advice, Prairie and Northern Region), a level of accessibility (LOA) was defined for northern communities. The level of transport accessibility is based on the community's ability to connect to the all-weather, land-based transportation network. Criteria used to designate each of the communities are:

> *Level A*
> In addition to air transport services, the community is serviced by year-round, land-based transportation infrastructure (either all-weather roads or rail lines). Level A is the highest level of transport accessibility.
>
> *Level B*
> The community is able to connect to the all-weather road network through a combination of seasonal ferry services and ice bridges. During the winter freeze-up and spring thaw the community relies on air transportation.
>
> *Level C*
> The community does not have access to the all-weather road network and relies on seasonal, land-based infrastructure (winter roads), marine and/or air service. Level C is the lowest level of transport accessibility (Isaacs 2005a).

Using these criteria and data relating to transportation infrastructure obtained from Transport Canada, a LOA was assigned to each of the communities in the study area. Table 4.1 lists the communities according to their transportation infrastructure and the corresponding LOA.

Table 4.1: Transportation Modes and LOA in Special Access Communities

Community	Region	Airport	All-weather Road	Rail	Winter Road	Marine	LOA
Brochet	MB	✓			✓		C
Churchill	MB	✓		✓		✓	A
Garden Hill	MB				✓		C
God's Lake Narrows	MB	✓			✓		C
God's River	MB	✓			✓		C
Lac Brochet	MB	✓			✓		C
Little Grand Rapids	MB	✓			✓		C
Oxford House	MB	✓			✓		C
Pauingassi	MB				✓		C
Poplar River	MB	✓			✓	✓	C
Pukatawagan	MB	✓		✓	✓		A
Red Sucker Lake	MB	✓			✓		C
Shamattawa	MB	✓			✓		C
South Indian Lake	MB	✓			✓	✓	B
St. Theresa Point	MB	✓			✓		C
Wasagamack	MB				✓		C
York Landing	MB	✓			✓	✓	B
Arviat	NU	✓				✓	C
Baker Lake	NU	✓				✓	C
Chesterfield Inlet	NU	✓				✓	C
Coral Harbour	NU	✓				✓	C
Rankin Inlet	NU	✓				✓	C
Repulse Bay	NU	✓				✓	C
Whale Cove	NU	✓				✓	C

Source: Raw data provided by Transport Canada 2003a

4.1.1. Surface Transportation

The Kivalliq region of Nunavut does not have a surface transportation network of highways and rail lines connecting special access communities to service centers. Overland travel takes place on "inter-community trails" which are not formally marked or defined (Government of Nunavut 2001). The use of all-terrain vehicles (ATVs) and snowmobiles for inter-community travel forms a part of the informal transport network, but is not included in this analysis due to the lack of adequate information relating to these modes.

The surface transportation network in northern Manitoba consists of all-weather road access to service centers, winter road access to outlying special access communities and rail access to communities along the Hudson Bay Railway route. Figure 4.1 shows the components of the surface transportation network in northern Manitoba.

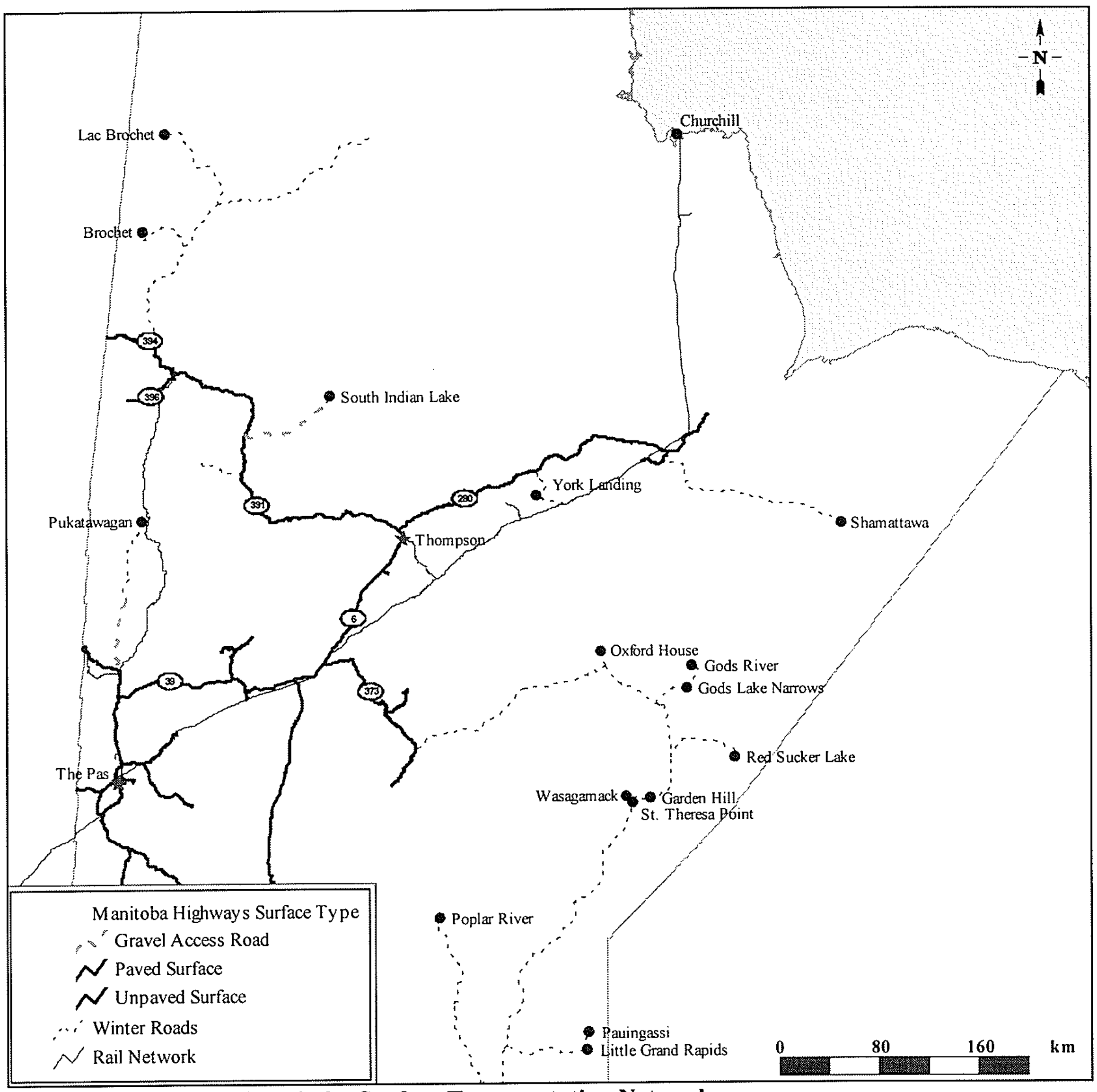

Figure 4.1: Northern Manitoba Surface Transportation Network
C. Isaacs 2005
TIS Laptop\C:\Users\Crystal\GIS Data\Thesis Data\Chapter 4 Maps\Surface Transportation Network.gws

4.1.2. All-Weather Roads

Although the all-weather road network does not extend to the remote regions of Manitoba, it is a critical element in the overall system of passenger and goods movement in the north. Service centers support a wide range of goods and services that are not available in smaller communities. The all-weather road network is used to transport raw and finished products to and from southern supply centers and distribution depots. Provincial Trunk Highway (PTH) 6 is the primary north-south corridor in Manitoba. PTH 6 is a paved, 2-lane highway that links Thompson to Winnipeg. The travel distance between Winnipeg and Thompson is 738 kilometers.

4.1.3. Winter Road Network

During the winter season, the winter road network becomes an extension of the all-weather road network, connecting special access communities to northern service centers and southern supply centers. Most winter roads connect to unpaved sections of the secondary highway network, which then link to paved portions of the primary highway network.

The Province of Manitoba maintains an extensive network of winter roads connecting all of the special access communities (except Churchill) to the all-weather road network. Winter roads facilitate the hauling of freight to isolated communities and provide temporary inter-community travel and road access to the southern parts of the province. The provincial government "recognizes the important role the winter road system plays in overcoming social and economic challenges facing the northern and remote communities in Manitoba" (MTGS 2004a: 1).

Characteristics of the northern Manitoba winter road system are:

- Winter roads are capable of supporting loads up to 36,500 kg (80,000 lbs) at a maximum speed of 15 km/hour (MTGS 2004a). A standard tractor semi-trailer (3S-2) operating on RTAC highways is restricted to a maximum gross vehicle weight (GVW) of 39,500 kg (88,000 lbs). The same type of vehicle operating on winter roads has an 8,000 pound payload disadvantage.

- Typically, winter roads are operational for approximately eight weeks from mid-January to early March. Periodically no service is available due to unfavorable weather conditions (Flood 2005).

- Winter roads are expected to become impassable on a more frequent basis due to the reoccurrence of unusually warm winters (Dillon 2000).

- Travel on the winter road network poses unique safety concerns for commercial and personal vehicles. Safety concerns include road blockages, sudden storms, ground drifting, whiteout conditions, swirling snow, reduced visibility and slippery driving surfaces resulting in increased stopping distances. Travel during mild conditions is considered to be "hazardous" and can further deteriorate road conditions (MTGS 2004b).

- Winter roads support major freight shipments into remote regions of the province. During the short winter road season, a year's supply of non-perishable goods, construction materials and fuel are hauled to the communities.

- MTGS has an annual budget of $5.8 million for the construction and maintenance of approximately 2,200 kilometers of winter roads. This amounts to an average annual cost of $2,600/km of winter roads (MTGS 2005a).

- The construction and maintenance of winter roads is contracted out to communities involved, creating local employment opportunities (MTGS 2005a).

- The system provides "marginally acceptable service" to the communities in most years, but the total costs are rising with the growing population (Dillon 2000: 2).

4.1.4. Climate Change Impacts

The impact of climate change on the northern transportation system is identified by Purdy (Special Advisor to the Deputy Minister, Transport Canada) as one of the five main challenges for northern transportation (Purdy 2005). Kuryk, (manager, MTGS) also cites climate change as a specific challenge for provision of transport services to Manitoba communities that rely on the winter road system for annual resupply (Kuryk 2005).

Climate change is a concern for northern Manitoba transport systems and adaptation strategies are required to mitigate the potential impacts. Manitoba experienced an unusually warm winter in 1997/98, which resulted in failure of the winter road network. Twelve northern Manitoba communities were left without winter road access. Freight was air lifted to these communities at an estimated cost of 15 million dollars (Kuryk 2005). Winter roads are expected to become impassable on a more frequent basis due to the reoccurrence of unusually warm winters, which may be linked with climate change.

In *Definition of Climate Change Scenarios: Task Three Report* (Isaacs 2005b), two general temperature change scenarios are developed for the prairie region from North American climate change projections. One represents the warmest temperatures projected by select climate models and the other represents the coldest projected temperatures. These scenarios were created by selecting the maximum and minimum temperature change values from a set of 15 combinations of global climate models (GCMs) and emissions scenarios. The values correspond to the predicted temperature change for the 2010-2039 timeframe (Isaacs 2005b). The temperature change scenarios were developed and analyzed in a GIS platform, which also serves as a supplementary dataset for this research. Figures 4.2 and 4.3 show the projected minimum and maximum temperature change scenarios for the prairie region. Temperature changes are shown for the winter season (December, January and February).

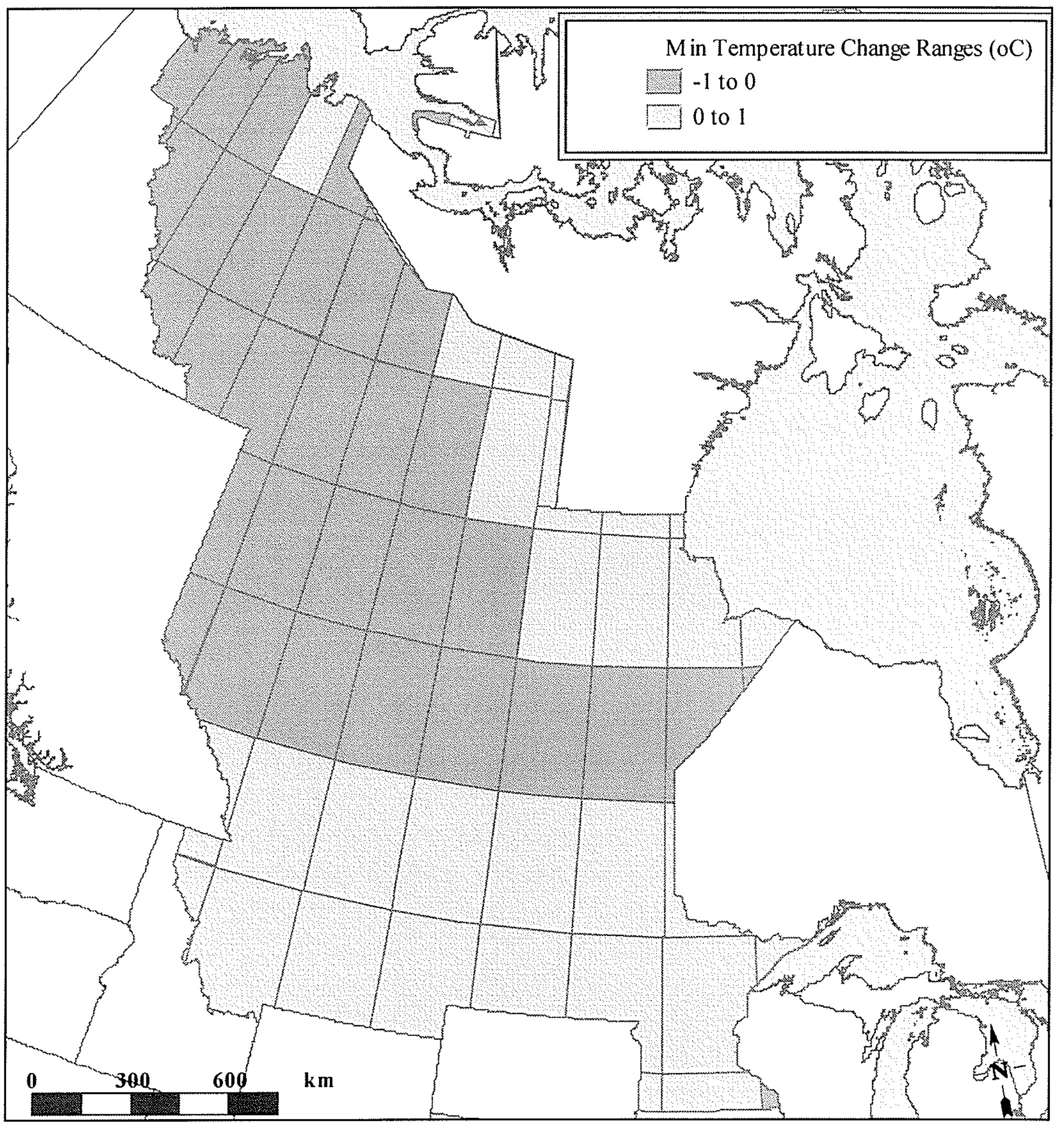

Figure 4.2: Minimum Projected Winter Temperature Change 2010-2039
C. Isaacs 2005
TIS Laptop\C:\Users\Crystal\GIS Data\Thesis Data\Chapter 4 Maps\Climate Change Scenarios.gws

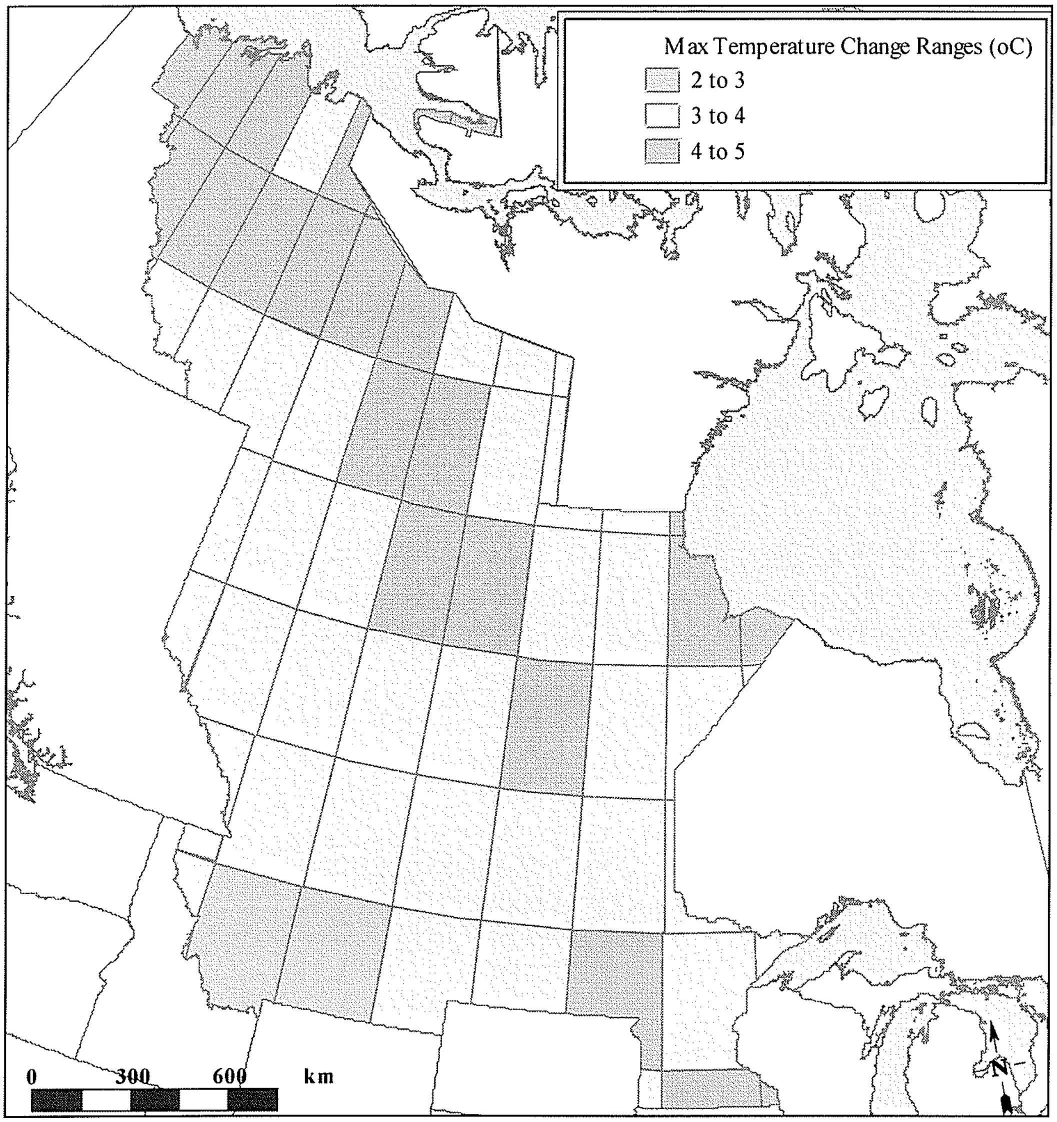

Figure 4.3: Maximum Projected Winter Temperature Change 2010-2039
C. Isaacs 2005
TIS Laptop\C:\Users\Crystal\GIS Data\Thesis Data\Chapter 4 Maps\Climate Change Scenarios.gws

These figures show that within the 2010-2039 timeframe, winter temperatures in northern Manitoba may decrease by one degree (minimum temperature change scenario). The maximum temperature change scenario predicts a three to four degree increase in average winter temperatures for Northern Manitoba. When the two scenarios are averaged, the temperature is projected to increase by two to three degrees.

4.1.5. Rail Network

Pukatawagan and Churchill are the only special access communities in northern Manitoba that have rail transport operations. The Hudson Bay Railway (HBRY), a subsidiary of OmniTRAX, provides freight transport to the communities and passenger services are provided under contract by Via Rail. Figure 4.4 shows the rail network in northern Manitoba and Table 4.2 shows the estimated travel distances between selected communities.

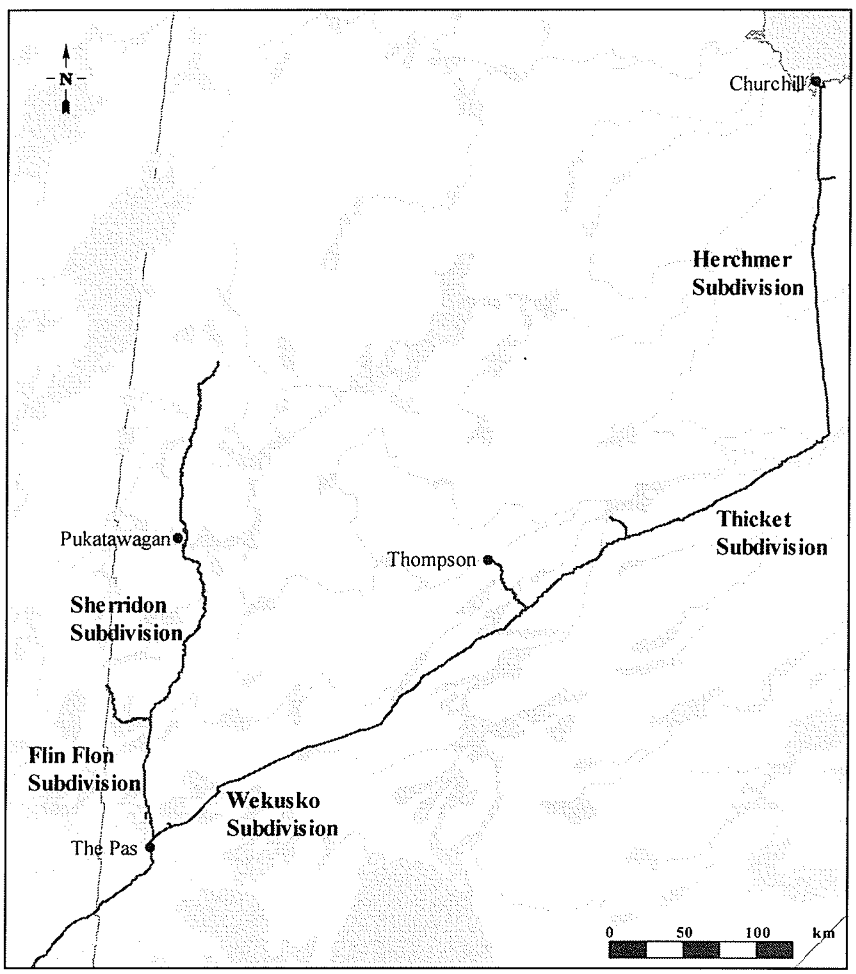

Figure 4.4: Northern Manitoba Rail Network
C. Isaacs 2005
TIS Laptop\C:\Users\Crystal\GIS Data\Thesis Data\Chapter 4 Maps\Rail Network.gws

Table 4.2: Travel Distances by Rail (km)

Origin	Destination	Travel Distance (km)
Winnipeg	The Pas	777
The Pas	Pukatawagan	251
Winnipeg	Pukatawagan	1028
The Pas	Churchill	920
Winnipeg	Churchill	1697
Thompson	Churchill	548

Passenger Services

Scheduled passenger services are available three times per week between Churchill and Thompson. There are two scheduling options for these services. Option 1 allows passengers to arrive in Thompson, conduct business and return to Churchill on the same day. Option 2 gives travelers more time to conduct business, but requires an overnight stay. The travel, business and round trip times are compared for these two options in Table 4.3.

Table 4.3: Rail Passenger Transport Options between Thompson and Churchill

	Option 1	Option 2
Travel time (one direction)	14 hours, 35 minutes	14 hours, 35 minutes
Time available in Thompson to conduct business (including time required for embarking and debarking the train)	6 hours, 50 minutes	30 hours, 50 minutes
Total round trip time	36 hours	60 hours

Source: VIA Rail 2005 published schedules

Although Thompson is the closest service center to Pukatawagan by air, The Pas is the closest service center by rail. Passenger services between Pukatawagan and The Pas are scheduled twice weekly. The travel, business and round trip times are compared for the two scheduling options in Table 4.4.

Table 4.4: Rail Passenger Transport Options between The Pas and Pukatawagan

	Option 1	Option 2
Travel time (one direction)	14 hours, 54 minutes	14 hours, 54 minutes
Time available in The Pas to conduct business (including time required for embarking and debarking the train)	41 hours, 45 minutes	65 hours, 45 minutes
Total round trip time	56 hours, 39 minutes	80 hours, 39 minutes

Source: VIA Rail 2005 published schedules

Passenger services are also available between Winnipeg and Churchill (approximate round trip travel time is 71 hours, 10 minutes) and Winnipeg and Pukatawagan (approximate round trip travel time is 43 hours, 48 minutes). Travel from Winnipeg to Pukatawagan may require an overnight stay in The Pas, depending on the scheduling option selected. Table 4.5 compares the cost for an adult to travel between select communities on the HBRY route.

Table 4.5: Adult Passenger Rail Fares

Fare Plan	Winnipeg to Churchill (round trip)[1]	Thompson to Churchill (round trip)[1]	Winnipeg to Pukatawagan (round trip)[1,2]	The Pas to Pukatawagan (round trip)[1]
Comfort Liberty	$539.28	$186.18	$346.68	$104.86
Single Bedroom	$945.88	$667.68	-	-
Double Bedroom	$1,284.00	$1,001.52	-	-

Source: VIA Rail online ticket purchases
[1]Fares accurate as of September 1, 2005
[2]Higher class fares only available on The Pas - Winnipeg leg of the trip

Freight Services

The HBRY provides freight service to northern Manitoba's resource-based industries and acts as a gateway to the communities in the Kivalliq region of Nunavut. Major customers include the Canadian Wheat Board, Hudson Bay Mining and Smelting, Tolko Manitoba, Gardewine North and Manitoba Hydro. Commodities transported on the HBRY include grain, metal concentrates, copper and zinc metal, logs, kraft paper, lumber, petroleum products, construction material and general merchandise (OmniTRAX 2005). For this research, rail freight rate schedules are not readily available.

A transload service is offered in Thompson, which includes transloading between truck and railcars, automobile transportation and piggyback service, largely between Churchill and Thompson. This service is offered in partnership with Gardwine North (OmniTRAX 2005).

4.1.6. Air Transportation

Airports are a critical component in the northern transportation system as they are the only means of year round transportation to special access communities (except for the two communities that have rail services). The Government of Nunavut describes air travel as "an essential lifeline to the outside world" for communities in the territory (Government of Nunavut 2003: 1).

The air transport system in the north is described as a long, thin market because carriers must transport small numbers of people and low volumes of cargo over large distances. High airfares and low flight frequencies are typical strategies used by air carriers to improve the financial viability of northern air routes. From an industry perspective, the system operates at over capacity, but from the perspective of passengers there is a shortage of scheduled flights between communities (Government of Nunavut 2003).

Airport Infrastructure

Twenty-one of the 24 special access communities in the study area have airport facilities. Of these, 13 airports are owned and operated by the Government of Manitoba, seven by the Government of Nunavut and the federal government operates the airport at Churchill.

Churchill airport functions as a gateway hub for passengers and cargo traveling from Manitoba to the Kivalliq region of Nunavut. Currently, there are four scheduled flights per week between Rankin Inlet and Winnipeg (operated by First Air). All other flights between Manitoba and the Kivalliq region pass through Churchill. The airport in Churchill is equipped with a 9,200 foot paved runway that is capable of accommodating jet aircraft. Rankin Inlet is considered the gateway to the central region of Nunavut (Government of Nunavut 2001). The airport in Rankin Inlet has a 6,000 foot asphalt runway and is served by regularly scheduled Boeing 727 and 737 jet service. The remaining community airports have runways composed of either gravel or crushed rock. Runway lengths range from 2,500 feet in Poplar River to 5,000 feet in Coral Harbour.

Runway surface type and runway length impact the operation and level of service provided by an airport (MTGS 1998, Government of Nunavut 2003). These two factors restrict the type of aircraft that can operate in the community:

- Airports with runways less than 4,000 feet cannot accommodate air transport category aircraft and must be served by commuter aircraft (Government of Nunavut 2003).
- Airports with runways less than 3,000 feet cannot accommodate the aircraft commonly used in air ambulance operations (MTGS 1998).

- The Boeing 727 and 737 families of aircraft are capable of landing on gravel runways, but are expected to be phased out of service within the short to medium term planning horizon. No new large jet aircraft are expected to be certified for gravel operations since the world market for this specialty adaptation is too small (Government of Nunavut 2001).

Airport certification status also impacts the type of service offered to a community. A certified airport is an aerodrome for which an airport certificate is issued, requiring the operator to maintain and operate the site in accordance with applicable Transport Canada standards. Regular inspections are conducted to ensure compliance with national safety and design standards. A registered aerodrome is not certified as an airport and is therefore not subject to an ongoing inspection program (Canada 2001a). An airport must be certified to support scheduled services. Scheduled service to registered airports is only permitted if the air operator is authorized to do so in its air operator certificate (Canadian Aviation Regulations 2005-1, 704.14). Figure 4.5 shows the location of each airport in the study area, the certification status and the type of service that the airport is capable of handling based on its runway characteristics.

Aircraft Characteristics

Combi (split passenger / freight) aircraft configurations predominate in the northern market. The operational flexibility provided by combi configurations allows aircraft operators to maximize payloads and better match passenger and cargo demand with capacity (Government of Nunavut 2003). Most communities only require a small aircraft, operated at low frequency, to meet passenger and cargo demand. Combining passenger and cargo on single plane allows carriers to use larger aircraft on a more frequent basis in a cost-effective manner.

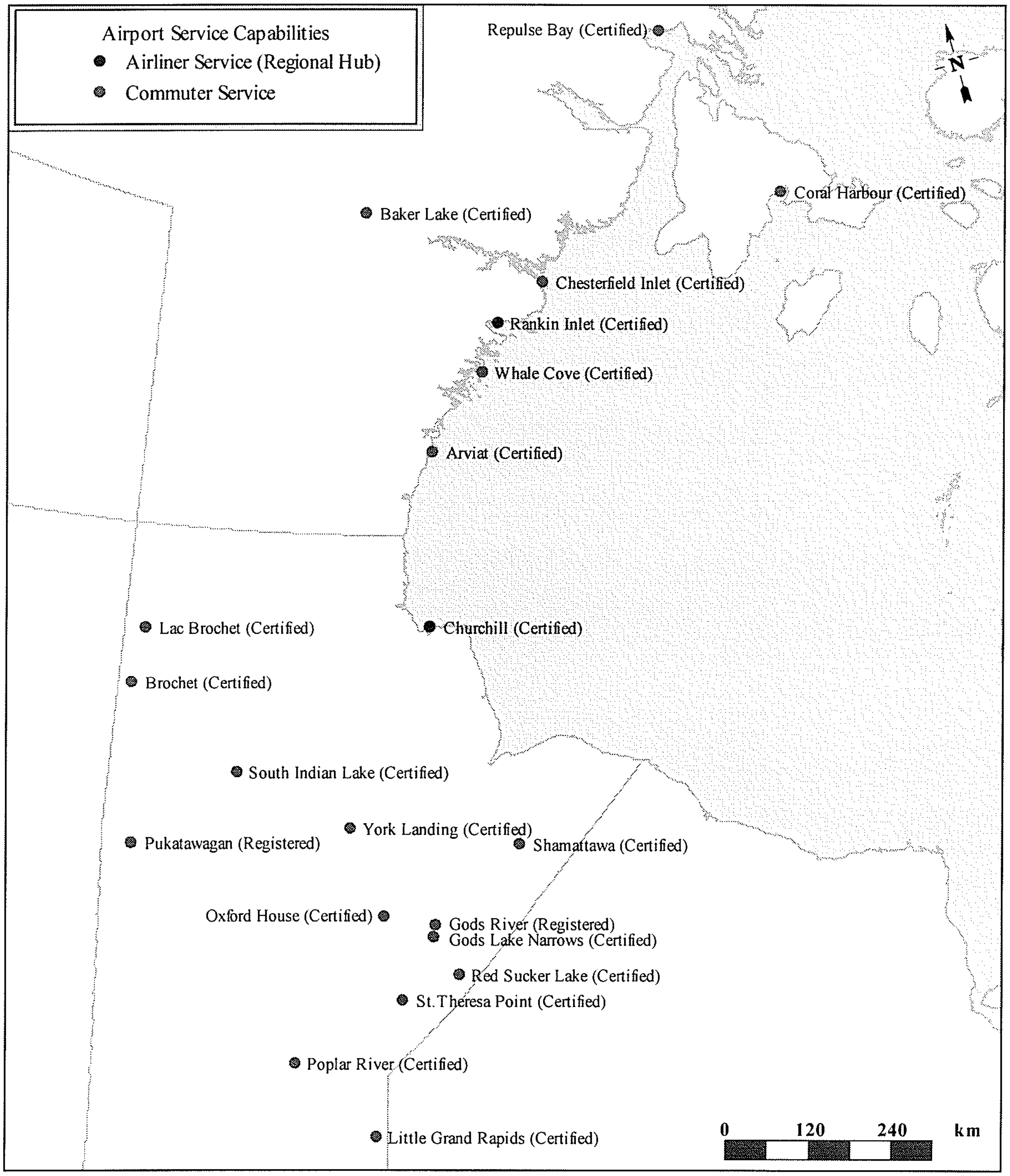

Figure 4.5: Airport Infrastructure
C. Isaacs 2005
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Typical aircraft serving northern airports include the SAAB 340B and the Hawker HS 748. These aircraft are termed the "critical aircraft" and are often used for design purposes (Government of Nunavut 2001). Both aircraft are twin engine turbo prop aircraft capable of carrying 33 to 40 passengers or a combination of cargo and passengers. The Cessna Grand Caravan and Cessna 207 are able to land on runways less than 2000 feet and are used to serve smaller markets. These aircraft carry between seven and nine passengers.

Routes and Scheduling

As of September 2005 there are seven air carriers operating scheduled air services to special access communities in the study area. Most routes in the study area operate as multi-stop itineraries. This operating arrangement is another strategy used by air carriers to match capacity with market demand. Since an aircraft cannot be filled to capacity at a single stop, additional communities are added to the route to justify the operation. Multi-stop flights are more cost-effective for the operator but increase route travel time and limit connection opportunities for passengers (Government of Nunavut 2003).

Figure 4.6 shows the current flight routes serving the special access communities in northern Manitoba and the Kivalliq region of Nunavut.

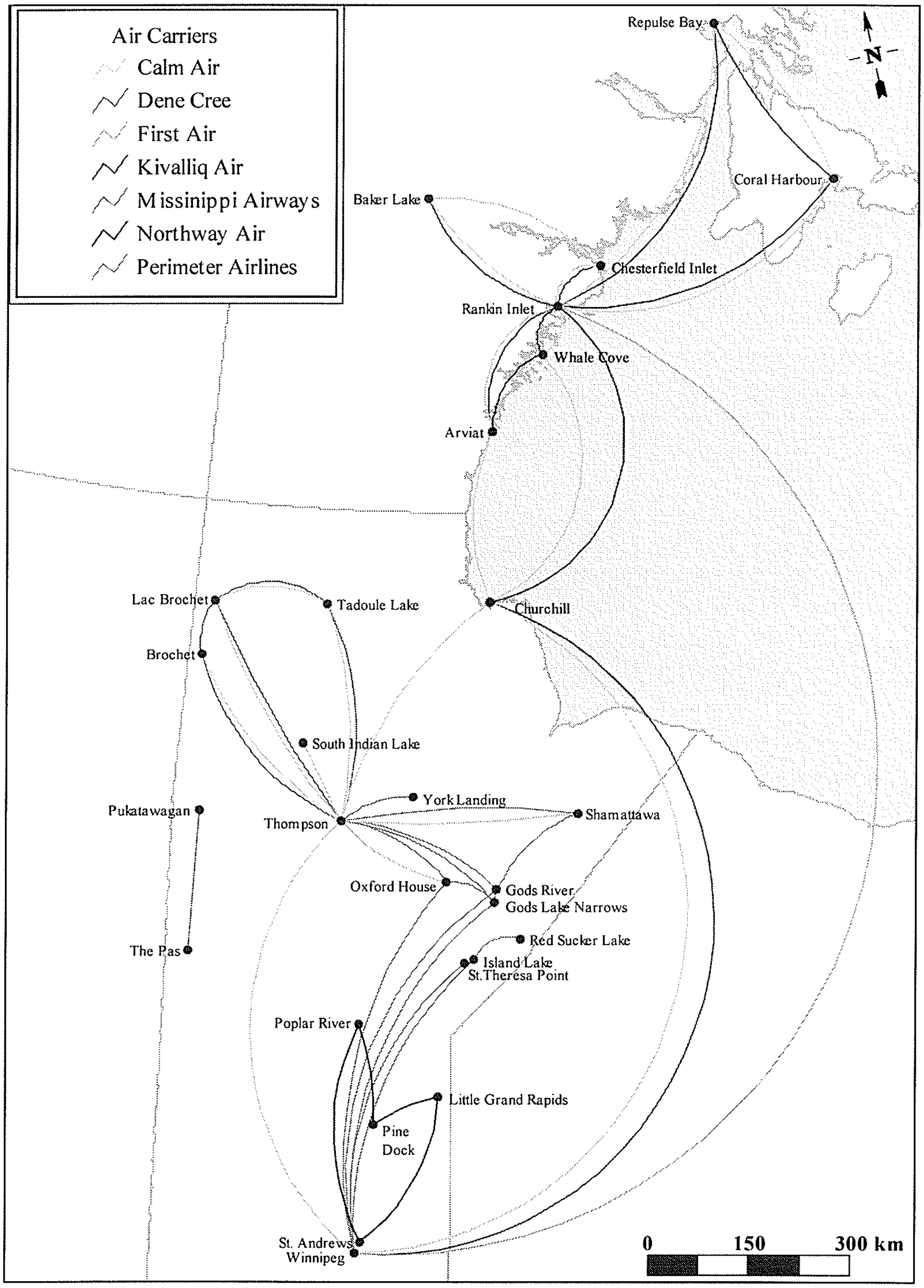

Figure 4.6: Air Routes in Northern Manitoba

Source: Published commercial airline schedules

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Characteristics of the current scheduled air routes with service implications for northern special access communities include:

- Communities in the Kivalliq region of Nunavut are serviced by scheduled flights from Kivalliq Air and Calm Air. Both carriers enter and exit Manitoba through Churchill, but Calm Air is the only carrier with a direct link between Churchill and Thompson.
- Flights for Poplar River and Little Grand Rapids originate and terminate in St. Andrews rather than Winnipeg. Additional travel costs and time are required for passenger and freight movements between St. Andrews and Winnipeg.
- Flight routes are often circuitous. Consequently, there may be a direct flight between a community and its service center in one direction, but in the return direction multiple stopovers are required.
- Although the Island Lake communities (Red Sucker Lake, St. Theresa Point and Wasagamack) are geographically closer to Thompson, the structure of the air routes to these communities makes Winnipeg the most accessible and practical service center.
- Currently, all scheduled flights servicing Pukatawagan are based out of The Pas. Missinippi Airways is planning to offer a scheduled flight between Pukatawagan and Thompson in the near future.

In southern markets, travelers are offered choice as to where, when and how they travel, which mode to use and how much they are willing to pay for services. In the north, travelers are not offered these options. Most air routes between special access communities and their nearest service center are serviced by one or two air carriers. While the system has "the appearance of competition, customers have very little actual choice" (Government of Nunavut 2001: 4-6). This is because different carriers usually provide different types of service using different types of aircraft. When options are offered to travelers, the choices are between non-stop jet service and multi-stop itineraries on smaller, turbo-prop aircraft.

4.1.7. Marine Transportation

The marine transport system in Nunavut differs from marine operations in northern Manitoba. All of the communities in the Kivalliq region are located on coastal waters and rely on marine operations for community resupply. There is limited marine activity in northern Manitoba, since most communities are land locked.

Northern Manitoba Port Infrastructure

There is one deep-sea port in northern Manitoba, located in Churchill. The port at Churchill is equipped with a 140,000 tonne grain elevator, concrete docks, six miles of storage track, a petroleum tank farm and a resupply warehouse and berth previously operated by the Northern Transportation Company Limited (NTCL). NTCL closed its Churchill terminal after losing the contracts to ship and supply fuel to communities in the Kivalliq region of Nunavut. The port has a total of four berths for the loading and unloading of grain, general cargo and tanker vessels. Coordination with the Hudson Bay Railway allows freight from points across North America to be shipped through the Churchill port (OmniTRAX 2005).

Poplar River is the only other special access community in Manitoba with marine freight transport services. Freight is shipped on Lake Winnipeg to the community via Selkirk.

Northern Manitoba Ferry Operations

Manitoba Transportation and Government Services (MTGS) operates ferry services in South Indian Lake and York Landing. A privately owned barge operates between the airport and the community at St. Theresa Point. Characteristics of the marine facilities at these locations are listed in Table 4.6. The vessels used in the Provincial ferry operations are described in Table 4.7.

Table 4.6: Northern Manitoba Ferry Infrastructure

Community	Purpose	Facility Description
South Indian Lake	• Operates on Southern Indian Lake, connecting the community of South Indian Lake to the access road at South Bay • The 74 km access road connects to PR 391 at Leaf Rapids	• The docking facilities consist of a timber dock and two rock filled tie up cribs • Site was constructed of blasted rock, capped with gravel and sloped to suit the ferry traffic ramps
York Landing	• Operates between York Landing and Split Lake • Provides access to the all-weather road network (PR 280) at Split Lake	• The docking facilities consist of a timber dock and two rock filled tie up cribs • Site was constructed of blasted rock, capped with gravel and sloped to suit the ferry traffic ramps
St. Theresa Point	• Links the community to the airport	• Privately owned barge service

Source: Transport Canada 2003a

Table 4.7: Vessels used in Northern Manitoba Ferry Operations

Community	Vessel Name	Vessel Type	Year Built	Vehicle Capacity	Passenger Capacity	Number of Crew
South Indian Lake	C.F. Johnny Paul	Passenger Vehicle Cable Ferry	2004	16	50	2
York Landing	M.V. Joe Keeper	Self Propelled Passenger Vehicle Ferry	1977	16	40	4

Source: MTGS 2005b

The ferries at South Indian Lake and York Landing function as part of the provincial highway system, providing seasonal access to the all-weather road network. In winter, ferry operations are replaced by winter road connections. During spring thaw and winter freeze-up, the communities are left without access and rely on air services. Table 4.8 shows the service schedules for the ferries and the approximate duration of ferry and winter road service interruptions.

Table 4.8: South Indian Lake and York Landing Ferry Schedules

Community	Service Schedule	Average Start-up Date	Average Shut Down Date	Duration of Ferry Service	Duration of Winter Road Service	Approximate Duration of Service Interruptions
South Indian Lake	Daily 24 hour service	May 24	November 4	6 months	1.5 months	4.5 months
York Landing	Twice daily (ferry closed every Tuesday)	June 3	October 28	5 months	1.5 months	5.5 months

Source: MTGS 2005b

Kivalliq Region Marine Facilities

Despite the fact that Kivalliq region communities rely on marine operations for seasonal re-supply, Nunavut has "no recognizable marine facilities" (Government of Nunavut 2001: 7-12). Communities are equipped with push outs but no places where ships or barges can be moored for cargo handling operations. Facilities range from "meeting basic needs to being poor and well below basic needs" (Government of Nunavut 2001: 3-23). Short shipping seasons, extreme tidal ranges, ice action and low cargo volumes make construction of upgraded facilities difficult and expensive. Table 4.9 provides a summary of the marine facilities in the Kivalliq region.

Table 4.9: Kivalliq Region Marine Facilities

Community	Duration of Open Season	Landing Beach	Public Dock	Facilities Owner
Arviat	Mid July – Mid October	no data	no	Government of Nunavut
Baker Lake	Mid July – Mid October	no data	push out	Government of Nunavut
Chesterfield Inlet	Mid July – Mid October	no data	push out	Government of Nunavut
Coral Harbour	Mid July – End October	no data	push out	Government of Nunavut
Rankin Inlet	Mid July – Mid October	no data	push out	Government of Nunavut
Repulse Bay	End August – End September	no data	no	Government of Nunavut
Whale Cove	Mid July – Mid October	no data	no data	Government of Nunavut

Source: Government of Nunavut 2001

Kivalliq Region Marine Operations

Prior to the 2003 season, cargo shipments to the eastern Arctic (including the Kivalliq region) were administered by the Canadian Coast Guard. Responsibility for the Arctic Sealift, for dry cargo and bulk fuel, currently rests with the Government of Nunavut. Nunavut Sealink and Supply Inc. (NSSI), a partnership between Transport Desgagnes and Arctic Cooperatives Ltd, was awarded the dry cargo sealift contract for 2005. The Woodward Group was awarded the contract to deliver bulk fuel to Nunavut communities. Communities in the Kivalliq region will be supplied with fuel from a marine tank farm at Churchill (Transport Canada 2003b).

The marine resupply system in Nunavut is characterized by "long lead times to consolidate cargoes and long voyages stopping at several communities over weeks" (Government of Nunavut 2001: 4-37). The sea routes to the Kivalliq region communities are shown on Figure 4.7.

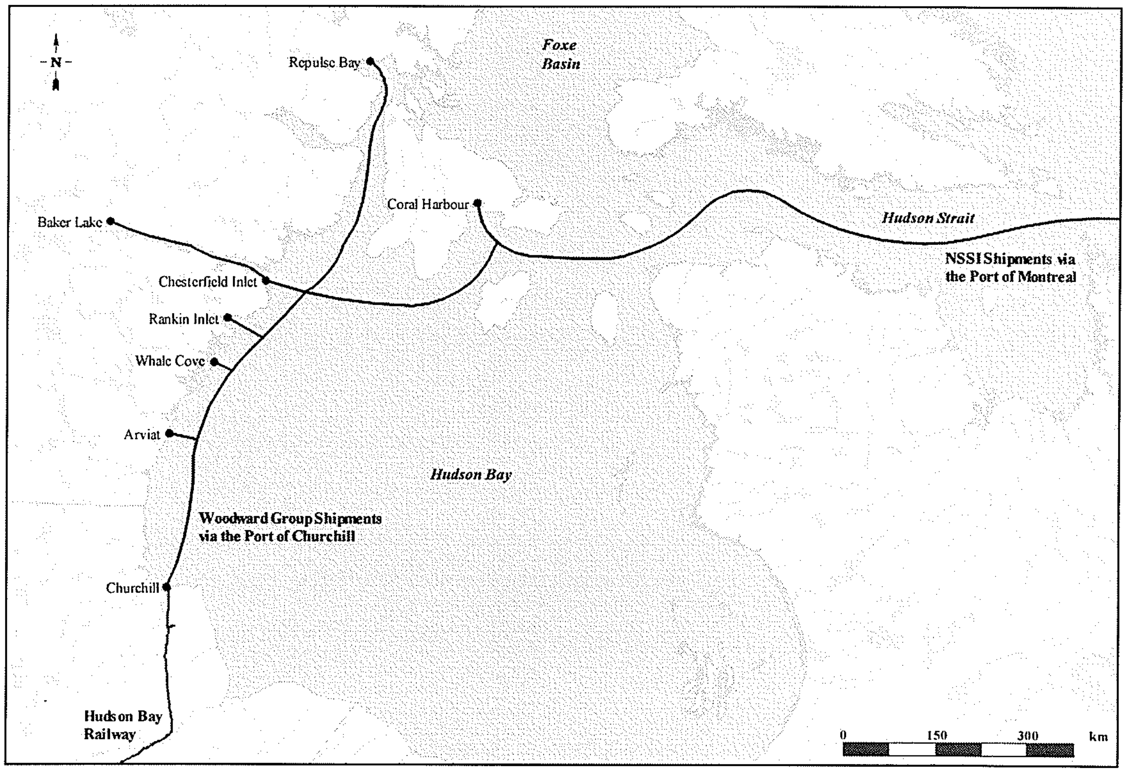

Figure 4.7: Kivalliq Region Shipping Routes
Source: Shipping routes approximated from Shortsea Shipping Workshop Maps (Transport Canada 2003c)
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Nunavut Sealink and Supply Inc. has two scheduled shipments to the Kivalliq region for 2005, one in early September and the other in October. Vessels depart from the NSSI terminal in Montreal, travel through the Hudson Strait and call at port in communities along the east coast of the Hudson Bay. Rankin Inlet and Arviat are the only communities to receive two NSSI scheduled calls at port in 2005. The proposed sealift cargo delivery schedule for the Kivalliq communities is shown in Table 4.10.

Table 4.10: NSSI 2005 Sealift Cargo Delivery Schedule

	Community	Estimated Arrival Date	Estimated Departure Date
Camilla Desgagnes Voyage 1	Repulse Bay	September 2	September 2
	Rankin Inlet	September 4	September 4
	Baker Lake	September 5	September 6
	Arviat	September 5	September 6
Camilla Desgagnes Voyage 2	Arviat	October 17	October 18
	Whale Cove	October 19	October 20
	Rankin Inlet	October 21	October 22
	Chesterfield Inlet	October 23	October 23
	Coral Harbour	October 24	October 25

Source: NSSI 2005

The use of containers for cargo shipments to the arctic is limited by logistical problems with transferring cargo from a ship at anchor, across a beach and into the community. Currently, cargo is placed on a small barge, a tug pushes the barge to the beach and the cargo is transferred above high water with a fork lift truck. Opportunities exist for improving the efficiency of cargo handling and reducing damage during off-loading operations (Government of Nunavut 2001).

4.2. DEMAND SYSTEM

4.2.1. Ethnic Origin

The population in special access communities in the study area is predominantly Aboriginal identity (Table 4.11). Aboriginal identity "refers to those persons who reported identifying with at least one Aboriginal group (North American Indian, Métis or Inuit/Eskimo) and/or those who reported being a Treaty Indian or a Registered Indian as defined by the *Indian Act* of Canada and/or who were members of an Indian Band or First Nation" (Statistics Canada 2001b: 3).

Table 4.11: Ethnicity

	Aboriginal Identity Population (%)	Non-Aboriginal population (%)
Northern Manitoba Special Access Communities	95.6	4.4
Kivalliq Region Communities	90.6	9.4
Canada	3.3	96.7

Source: Raw data provided by Statistics Canada 2001a

A wide gap exists in the quality of life for Aboriginal Canadians compared to other Canadians, specifically in the areas of health, education, housing and economic opportunity (Canada 2005). Recently, Prime Minister Paul Martin outlined a plan of action (in collaboration with First Ministers and National Aboriginal Leaders) aimed at closing this gap (Canada 2005). This will have significant implications for northern special access communities, where the population is predominantly Aboriginal.

4.2.2. Population

Northern special access communities have small population bases. In Manitoba, special access communities represent approximately 1.5 percent of the total provincial population. The total population of Nunavut, where all communities are classified as special access, represents 0.09 percent of the total population in Canada. Approximately 28 percent of the population in Nunavut lives in the Kivalliq region. Special access communities in the study area experienced a 10 percent increase in population between 1996 and 2001. During the same time period, the total population in the Province of Manitoba grew by 0.5 percent. Table 4.12 shows the total population in Kivalliq and Manitoba special access communities.

Table 4.12: Population in Special Access Communities in the Study Area (2001)

	1996 Population	Percent of Provincial / Territorial Population	2001 Population	Percent of Provincial / Territorial Population	Population Growth (%)
Northern Manitoba Special Access Communities	15,375	1.4	16,952	1.5	10.3
Kivalliq Region Communities	6,868	27.8	7,557	28.3	10.0
Nunavut	24,730	-	26,745	-	8.1
Manitoba	1,113,898	-	1,119,583	-	0.5

Source: Raw data provided by Statistics Canada 2001a

The population in the special access communities in the study area ranges from 287 (Brochet) to 2184 (St. Theresa Point). The population in each of the special access communities is shown in Figure 4.8.

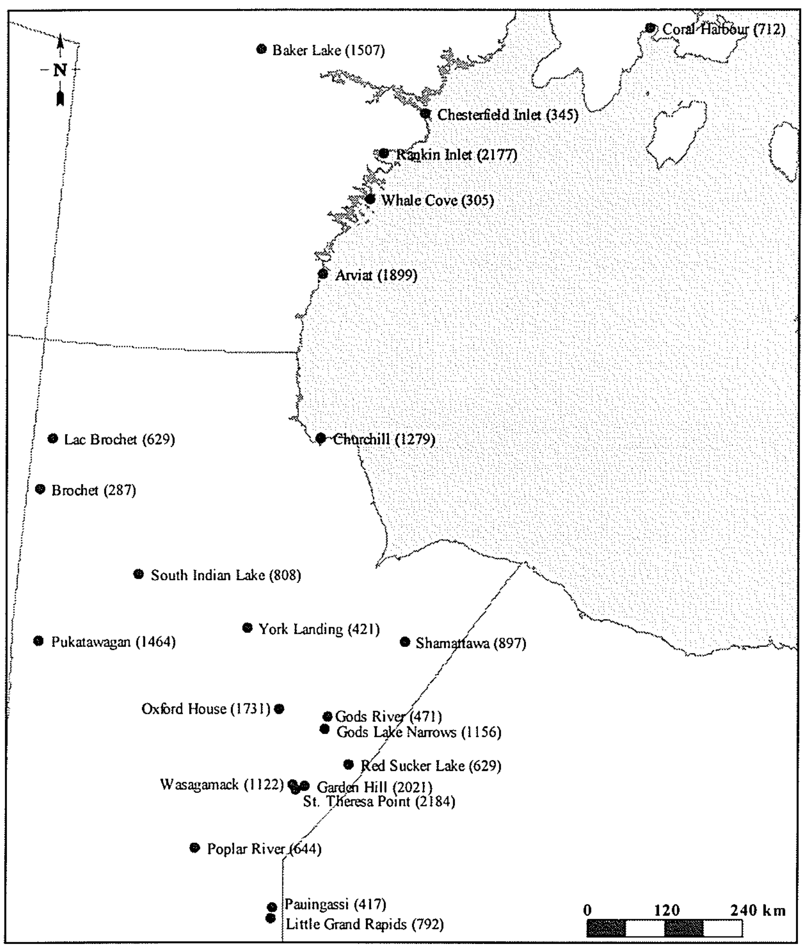

Figure 4.8: 2001 Population in Special Access Communities
Source: Raw data provided by Statistics Canada 2001a
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4.2.3. Levels of Education

Education levels are defined by the highest level of schooling obtained by the population 20 years of age and over. For this research, levels of education are categorized as greater than grade nine and high school diploma or higher (including high school graduation, college or trade education and university education). The proportion of the population with higher than grade nine education can be used as a proxy for adult literacy (Beavon & Cooke 2003). Education levels directly impact quality of life and high educational attainments are "closely linked to the ability to take advantage of employment opportunities and for social mobility" (NRC 2004: 5). Higher levels of education are also correlated with high income and active political participation (FCM 1999). Figure 4.9 compares the levels of education for special access communities in northern Manitoba and the Kivalliq region of Nunavut with Canada as a whole.

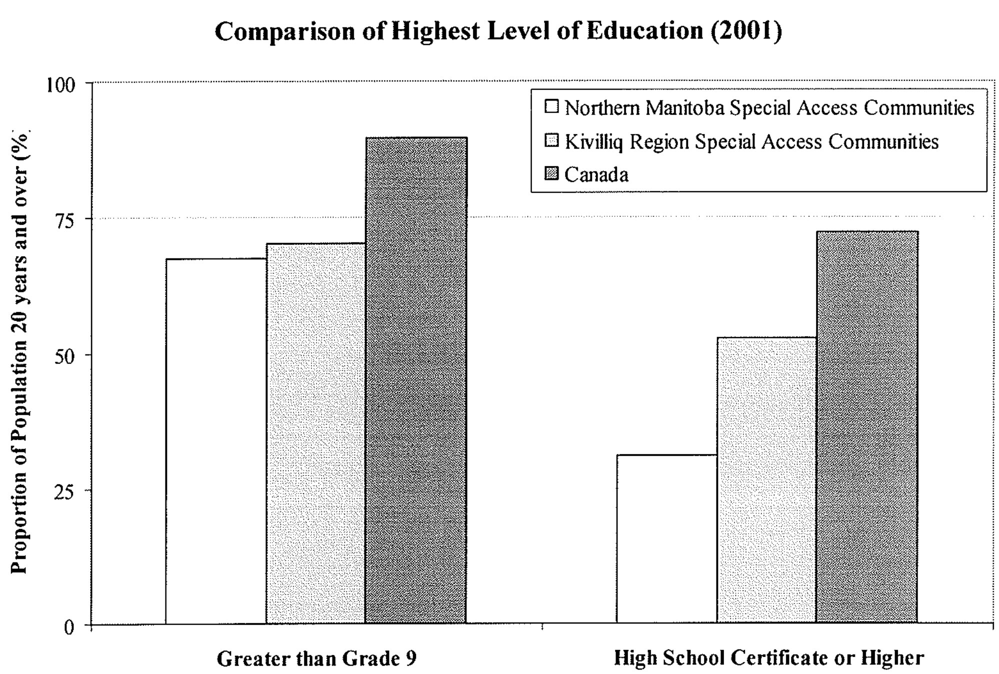

Figure 4.9: Comparison of Education Levels (2001)
Source: Raw data provided by Statistics Canada 2001a

Education levels are lowest in northern Manitoba special access communities. Approximately 67 percent of the population has minimum grade nine education compared to 70 percent in the Kivalliq region and 90 percent in Canada as a whole. Likewise, the proportion of the population with a minimum high school education is low (31 percent) in northern Manitoba special access communities compared to the Kivalliq region (53 percent) and Canada (72 percent).

4.2.4. Employment Characteristics

The characteristics and quality of employment in a community provide an indication of the current and future economic health of the region. Factors such as unemployment rate, employment income and participation rate all contribute to the overall quality of employment. Indicators relating to total income reflect the economic status of various demographic groups within each region.

The labour force refers to persons who were either employed or unemployed during the week prior to Census Day. It does not include students, homemakers, retired workers, seasonal workers in an off season who were not looking for work or persons who could not work because of a long-term illness or disability (Statistics Canada 2001b). Members of the labour force who fished, hunted, or trapped (whether for profit or for maintenance of their community) are included in the "employed" category as unpaid family workers.

The participation rate is the labour force in the week prior to Census Day, expressed as a percentage of the population 15 years of age and over (Statistics Canada 2001b). In communities with limited employment options, residents may choose not to participate in the labour force because they perceive a lack of opportunity. Since homemakers are not included in the labour force definition, communities that have a large proportion of unpaid household labour and childcare may also exhibit low participation rates.

Figure 4.10 compares the labour force participation rate for special access communities, service centers and Canada. It also shows the proportion of employed and unemployed members of the labour force.

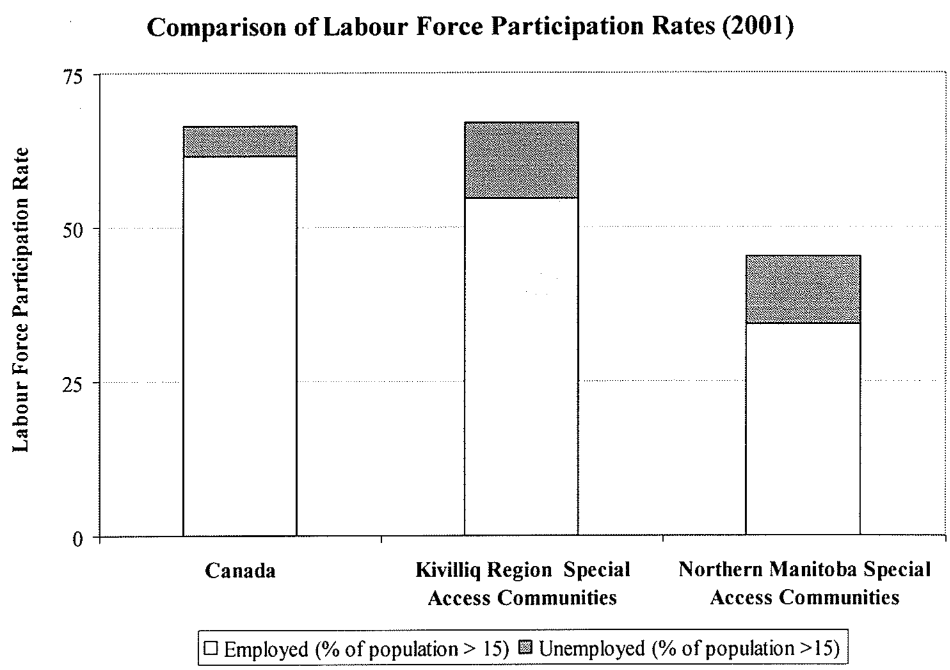

Figure 4.10: Comparison of Labour Force Participation (2001)
Source: Raw data provided by Statistics Canada 2001a

The participation rate for Kivalliq region communities is comparable to the Canadian average, while northern Manitoba special access communities have lower participation rates. Unemployment rates are 2.5 and three times higher than the Canadian average in Manitoba and Kivalliq special access communities respectively.

Indicators relating to total income account for all income sources including employment income, investment income and government transfer income. It is useful to compare the average income of individuals as well as the variation in total family income for different family structures (Figure 4.11).

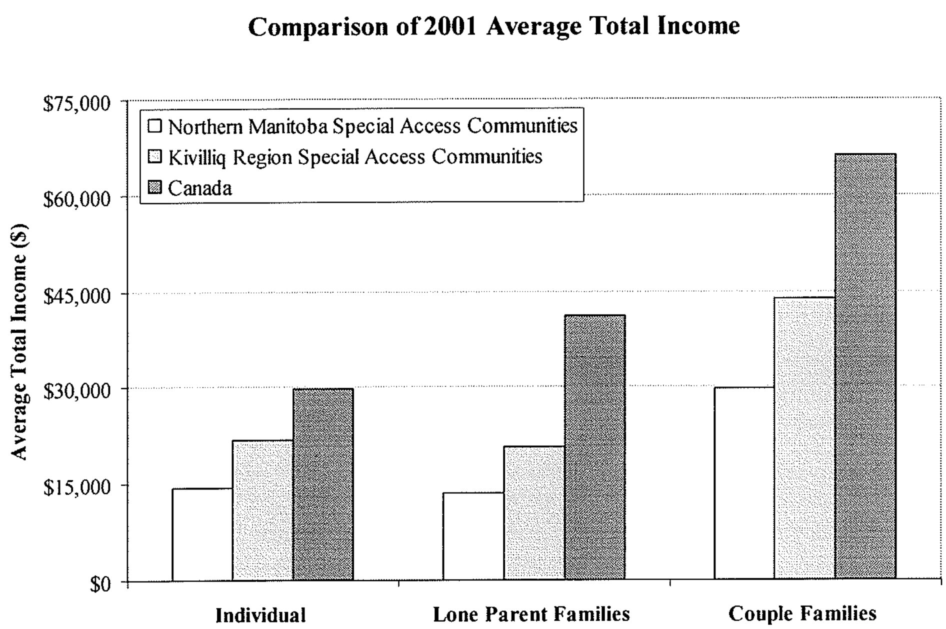

Figure 4.11: Comparison of 2001 Average Total Income
Source: Raw data provided by Statistics Canada 2001a

Special access communities in northern Manitoba have the lowest average income in all three categories, followed by Kivalliq region communities. The largest discrepancy in income is in lone-parent families, where the total average family income is two times lower than the Canadian average in Kivalliq communities and three times lower in northern Manitoba special access communities. Approximately 26 and 28 percent of families in Kivalliq and northern Manitoba special access communities are headed by a single parent, compared to 16 percent in Canada as a whole.

The ratio of individuals working part year, part time to individuals working full year, full time is another indicator of employment opportunity. A higher proportion of people working part time relative to those working full time may indicate a shortage of employment opportunities in the community.

The proportion of the population aged 15 years and over that were employed full time is lower in special access communities compared to the rest of Canada. The proportion of part-time and full-time employees is summarized in Table 4.13. Values may not sum to 100 percent due to rounding in the census tabulations.

Table 4.13: Comparison of Full-time to Part-time Employment Opportunities (2001)

	Worked full year, full time (%)	**Worked part year or part time (%)**
Northern Manitoba Special Access Communities	38.7	58.2
Kivalliq Region Special Access Communities	41.3	54.9
Canada	52.9	44.5

Source: Raw data provided by Statistics Canada 2001a

Government transfer payments refer to the total income from all transfer payments received from federal, provincial or municipal governments during calendar year 2000.

Since most government transfer payments are targeted towards low-income groups, this is an important indicator of community affordability. Government transfers include:

- the Old Age Security pension and Guaranteed Income Supplement;
- benefits from Canada or Quebec Pension Plan;
- benefits from Employment Insurance;
- Canada Child Tax benefits; and
- other income from government sources (Statistics Canada 2001b: 35).

Table 4.14 shows the proportion of total income derived from government transfer payments in special access communities and Canada.

Table 4.14: Income Sources (2001)

	Employment Income	Government Transfer Payments	Other
Northern Manitoba Special Access Communities	64.2	33.7	2.0
Kivalliq Region Special Access Communities	78.9	18.3	2.9
Canada	77.1	11.6	11.3

Source: Raw data provided by Statistics Canada 2001a

The proportion of total income derived from government transfers in northern Manitoba special access communities is three times higher than the Canadian average. Government transfer payments are lower in the Kivalliq region, but are still approximately 1.5 times higher than the Canadian average.

4.2.5. Demand System Implications for Northern Transportation

Transportation engineers and planners are concerned with modeling the transportation system and predicting the resulting flows. Understanding the characteristics of the demand system is essential for transport systems analysis because the transportation, demand and flow systems of a region are interrelated (see Figure 3.1).

The social, economic and political transactions that take place in a region determine the demand for transportation (Manheim 1979). The social and economic indicators discussed in the preceding sections impact the northern transportation system in the following ways:

- Low population density impacts the amount of travel that occurs within the region. The amount of movement measured in terms of the number of passengers and volume of freight is lower than regions with larger population bases. However, the amount of travel measured in terms of travel distance per capita may be higher due to the large geographic distances between special access communities and service centers.
- Due to limited employment and educational opportunities in special access communities, residents must travel to locations away from their home community to pursue these activities.
- Northern residents may not have the financial resources to pay for transport services (due to lower income levels) and thus the amount of travel may be reduced.

Additionally, the levels and spatial patterns of social and economic activity are affected by the transport services that are provided (Manheim 1979). Enhancing the quality of the transport system improves accessibility and has the potential to stimulate economic growth and regional development (EMCT 2001a). This would impact some of the indicators used to describe the demand system, including employment characteristics and income levels.

4.3. FLOW SYSTEM

4.3.1. Airport Activity

Air traffic records are maintained by the Province of Manitoba Northern Airports and Marine Operations Department. These records include flights that occur during regular office hours (7:00 am to 4:00 pm). Aircraft movements (departures and arrivals) that are excluded from the traffic records include scheduled, charter and medevac flights that take-off or land after hours.

As a result, the air traffic statistics obtained from Northern Airports and Marine Operations are underestimated. Based on the published airline schedules obtained for this research, it is estimated that approximately 26 percent of the scheduled flights in northern Manitoba special access communities are overlooked. Charter and medevac flights that occur after hours are also missed in the traffic data.

With these considerations in mind, historical air traffic statistics for northern Manitoba special access communities are presented in Figure 4.12. The chart shows the aggregate enplaned and deplaned passengers and total aircraft movements at the 13 airports located in special access communities in northern Manitoba. Air traffic data for Island Lake airport, which services the community of Garden Hill, is also included in this analysis. Charts for air traffic statistics at individual airports are provided in Appendix C.

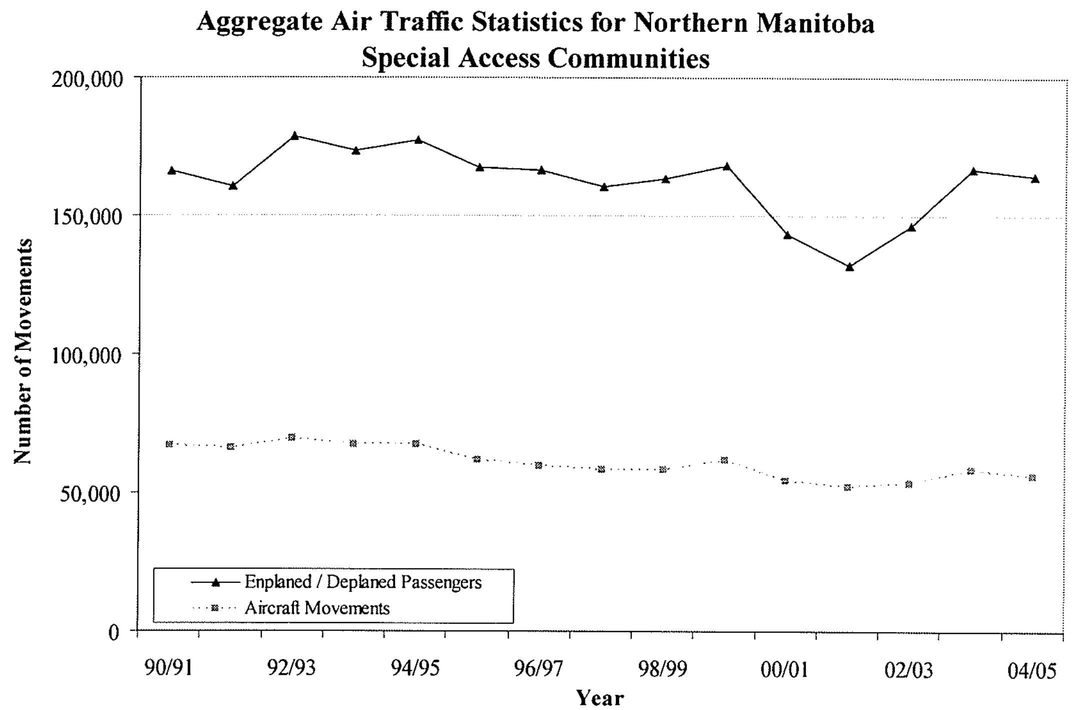

Figure 4.12: Airport Activity Manitoba Special Access Communities (1990-2005)
Source: Raw data provided by MTGS 2005c

Figure 4.13 shows the total enplaned and deplaned passengers at airports in the Kivalliq region for the period between 1994 and 1999. Current data for these communities is not publicly available. The Government of Nunavut (2001) estimates that the "propensity to travel" in the Kivalliq region is 2.5 trips/person/year (equivalent to 5 enplanements /deplanements). Rankin Inlet is assumed to have 8.6 trips/person/year (17.2 enplanements/deplanements). Using these estimates for the propensity to travel and population projections released by the Nunavut Bureau of Statistics (Government of Nunavut 2000), air traffic estimates are shown as a dashed line for the years 2000 through 2005. Air passenger traffic statistics at individual airports in the Kivalliq region are provided in Appendix C.

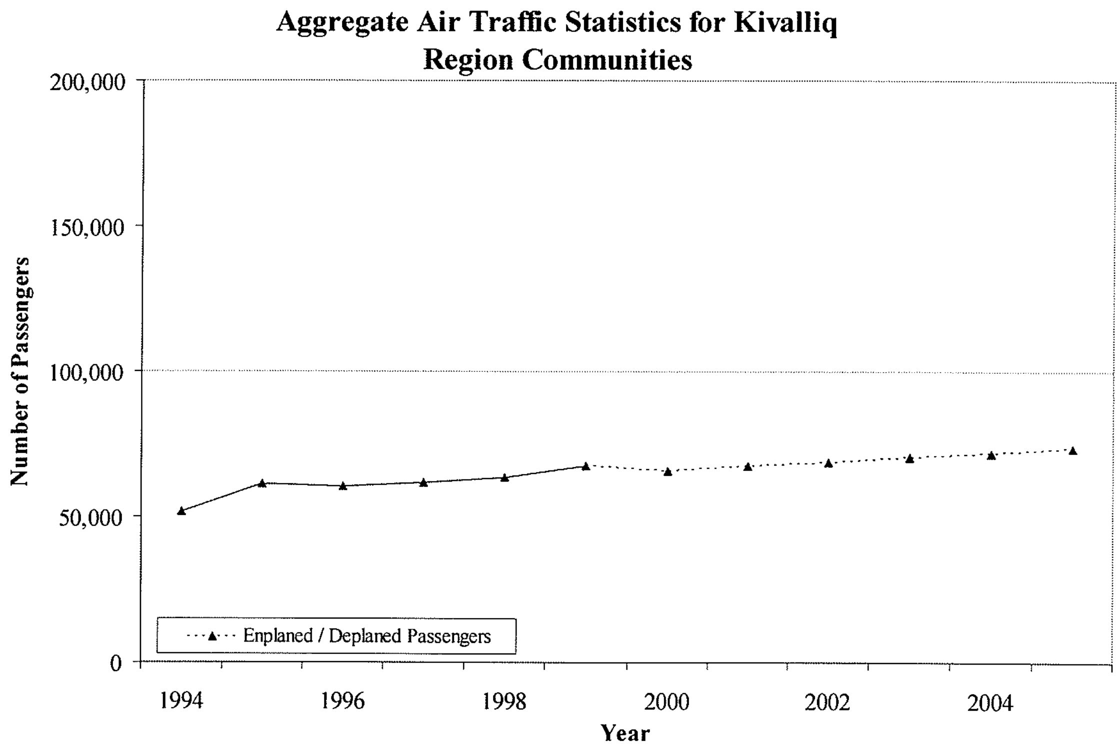

Figure 4.13: Airport Activity Kivalliq Region Communities (1994-2005)
Source: Raw data provided by Government of Nunavut 2000 and Government of Nunavut 2001

4.3.2. Northern Manitoba Ferry Traffic

Traffic records for ferry operations in northern Manitoba are maintained by the Province of Manitoba Northern Airports and Marine Operations Department. Passenger and vehicular traffic statistics for the South Indian Lake and York Landing ferry operations are shown in Figure 4.14 and Figure 4.15 respectively. Between 1990 and 2005, the annual ferry traffic (both passenger and vehicular) on South Indian Lake was approximately six times higher than at York Landing.

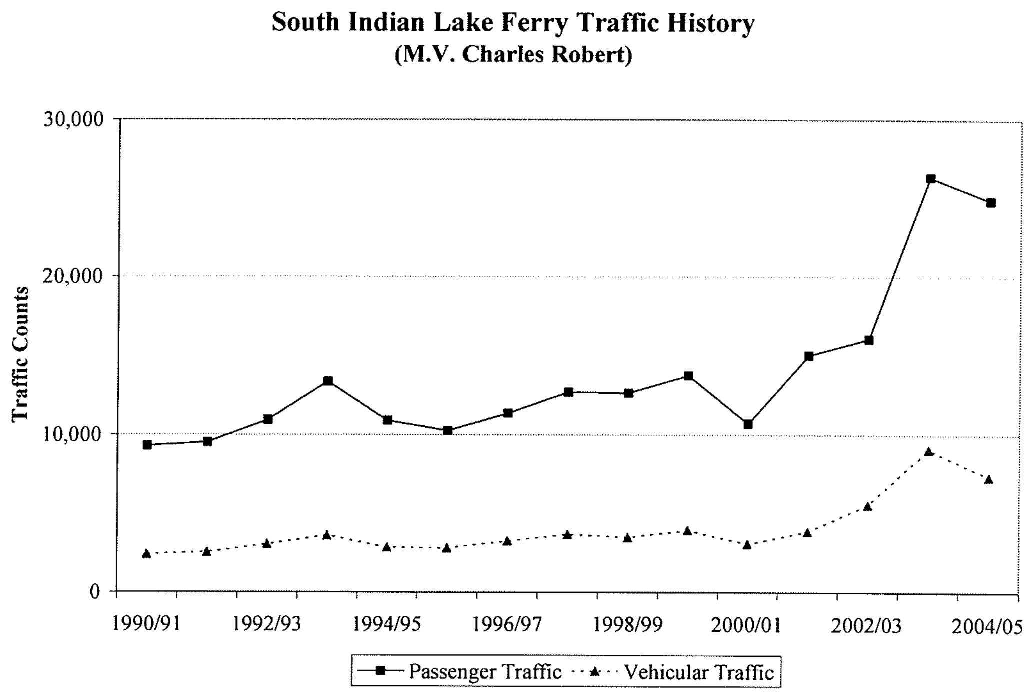

Figure 4.14: South Indian Lake Ferry Traffic History (1990-2005)
Source: Raw data provided by MTGS 2005d

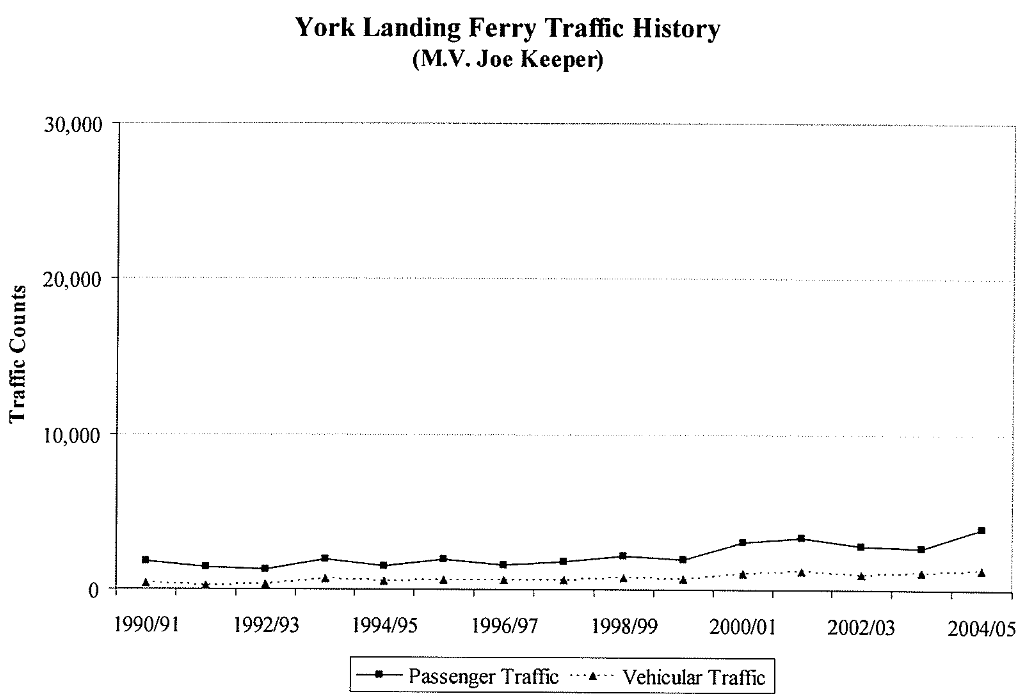

Figure 4.15: York Landing Lake Ferry Traffic History (1990-2005)
Source: Raw data provided by MTGS 2005d

4.3.3. Kivalliq Region Marine Traffic

Marine transportation in the Kivalliq region is geared towards freight, with minimal passenger services. No scheduled carriers transport passengers in Nunavut, however in 1999 one cruise ship traveled to the Kivalliq region (Government of Nunavut 2001).

Determining the amount of freight transported by ship in Nunavut is problematic, because "[r]eliable statistical data for actual cargo movements into Nunavut communities are not available" (Government of Nunavut 2001: 5-11). According to the Government of Nunavut (2001) the following estimates provide a reasonable order of magnitude for cargo requirements in Kivalliq communities:

- Dry goods 2.0 tonnes/person/annum
- Produce 0.4 tonnes/person/annum

It is assumed that produce will typically move by air since delivery of perishable items is time sensitive. Shipment of dry goods by marine will vary with the availability of air capacity (Government of Nunavut 2001).

One further characteristic of the Kivalliq region marine transport system is that cargo movements are primarily unidirectional. This means that vessels usually travel back to their bases empty of freight (Government of Nunavut 2001).

4.3.4. Northern Manitoba Freight Traffic

Figure 4.16 shows the breakdown of freight movements in 13 special access communities in northern Manitoba for the year 2000. Data are unavailable for Churchill, Brochet, Lac Brochet and South Indian Lake.

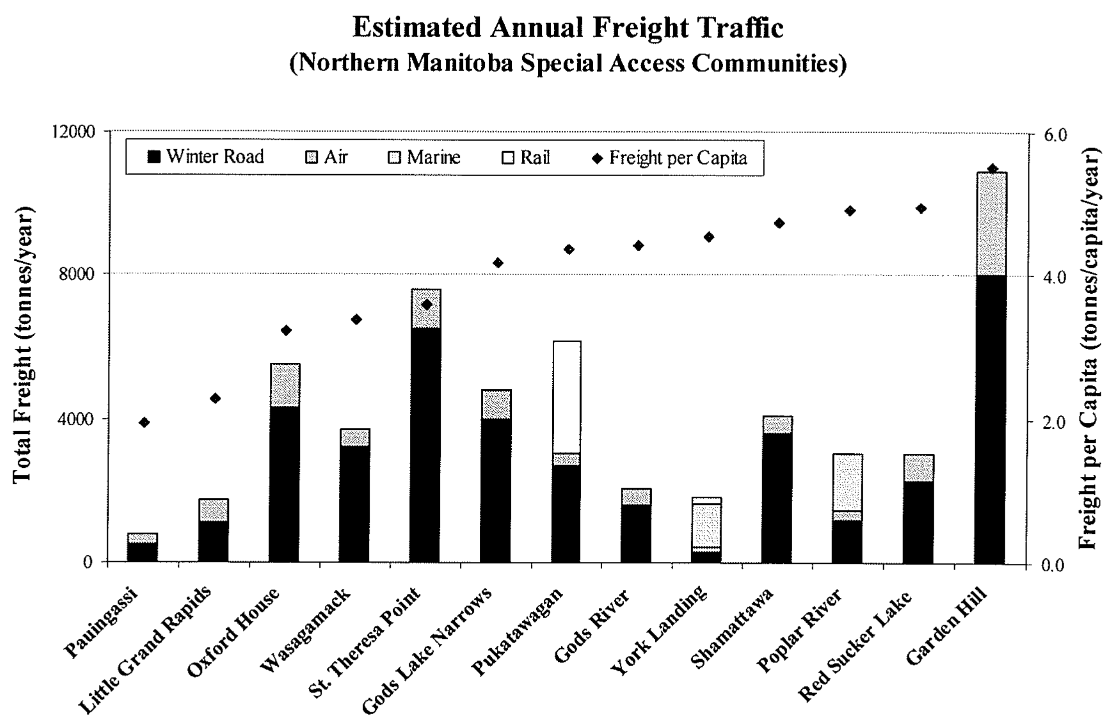

Figure 4.16: Northern Manitoba Freight Traffic (2000)
Source: Raw data provided by Dillon 2000 and Dillon 2001a,b,c

As can be seen in the figure, most of the cargo shipments to these communities utilize the winter road system. Winter road freight (transported by truck or by personal vehicle) accounts for approximately 71 percent of the total freight shipped to the special access communities in 2000. Air transport supplements winter road transport and represents approximately 18 percent of the total freight shipments.

Pukatawagan receives approximately 51 percent of its total freight by rail. York Landing does not have rail service, but residents can access the Hudson Bay Railway via a winter road to Ilford. Rail shipments to York Landing by rail and winter road account for approximately nine percent of the total freight to the community. York Landing and Poplar River also receive marine cargo shipments.

The diamonds in Figure 4.16 show the total per capita freight shipped annually to each community. Per capita freight estimates are based on the total cargo tonnage shipped to each community in 2000 (based on data from Dillon 2000, 2001a, 2001b, 2001c) and the total population in 2000. The population in 2000 was estimated by straight line interpolation between the 1996 and 2001 census population counts. Per capita freight shipments range from 1.9 tonnes/person/annum (Pauingassi) to 5.5 tonnes/person/annum (Garden Hill). The amount of cargo shipped to northern Manitoba special access communities is higher than the 2.4 tonnes/person/annum estimated by the Government of Nunavut (2001) for Kivalliq region communities.

4.3.5. Manitoba Highway Traffic Information System

The Manitoba Highway Traffic Information System (MHTIS) is a partnership between the Traffic Engineering Branch of Manitoba Transportation and Government Services (MTGS) and the University of Manitoba Transportation Information Group (UMTIG). The purpose of MHTIS is to analyze and disseminate traffic information for provincial highways in Manitoba and to conduct research involving traffic information systems.

MTGS has recently added winter roads to their GIS highway basemap and are examining ways to incorporate winter road traffic data into the MHTIS. Traffic information relating to northern Manitoba ferries and airports could also be rendered interoperable and integrated into the MHTIS database.

CHAPTER 5

POLICY FRAMEWORK FOR NORTHERN CANADIAN TRANSPORTATION

This chapter briefly outlines the evolution of national transportation policy as it applies to northern Canada and describes the current vision for national transportation policy in Canada. Key goals identified in this analysis are used as inputs to the results-based measurement program discussed in chapter six.

Transportation engineers and planners work within a complex legislative and policy environment. Policies and regulations govern all aspects of the transportation system, from planning and design of transport facilities, to construction and maintenance of infrastructure, operation of the transport system and provision of transport services. Transportation engineers and planners must be knowledgeable of the applicable policies and aware of the political realities which govern their work.

5.1. EVOLUTION OF NATIONAL TRANSPORTATION POLICY IN CANADA

Throughout the early years of railway development in Canada, the federal government used transportation regulation as a policy tool for nation building. The recommendations submitted by the MacPherson Commission in 1961 altered this approach and changed the direction of national transport policy in Canada. Four issues that emerged from the Commission are identified as having significance for the current discussion:

1. The recommendation that transportation policy should be achieved through competition rather than regulation.

2. Recognition of the inherent interplay between the economic and efficiency goals of commercial enterprise and the public policy objectives of national unity and regional development.

3. The recognition that while transportation could be useful in assisting regional development it should not be treated as the prime national instrument for this purpose.

4. The requirement for government to compensate transport providers when it interfered with normal economic processes to implement national policy objectives (Royal Commission on Transportation 1961).

The National Transportation Act (NTA) of 1967 was based on the findings of the MacPherson Commission. A series of policy developments, shown in Figure 5.1, led to the current statement of National Transportation Policy.

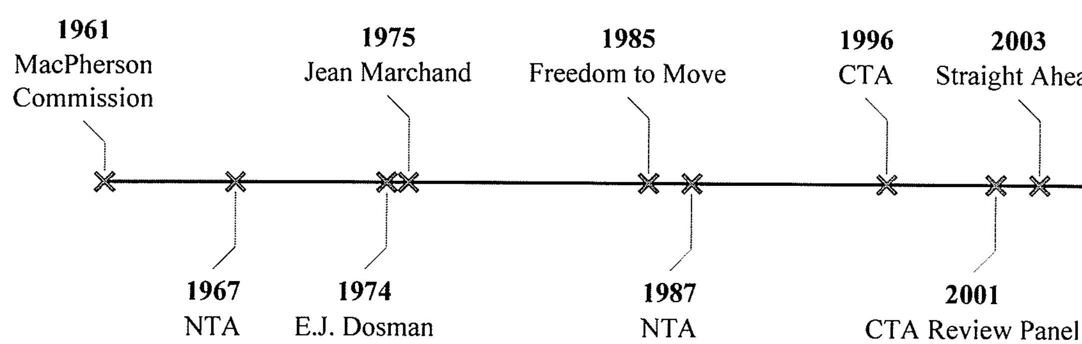

Figure 5.1: Timeline of Relevant National Transportation Policy Initiatives

5.2. HISTORICAL APPROACH TO NORTHERN TRANSPORTATION POLICY

The historical context of transport policy is important for contemporary transportation engineering and planning. Canadian transport policy initiatives built on one another. The fundamental principles defined by the MacPherson Commission in 1961 have been discussed from different angles throughout the past four decades, and are still embedded in the transportation policy of today. Transportation engineers and planners are governed and influenced by policies that were established in the past and have opportunity to learn from the past to better understand the present and anticipate the future. Three reports, Dosman (1974), Marchand (1975) and Mazankowski (1985), provide historical insight into northern transportation policy that is relevant to the current discussion.

Dosman (1974) identified four reasons to justify federal assistance for northern regions. These issues are also current federal priorities:

1. the federal government has endeavored to strengthen its claim to sovereignty by establishing a permanent "presence" in the North;
2. the Indian Affairs Branch (currently Indian and Northern Affairs Canada) has a special obligation to assist the scattered indigenous population in the north;
3. the federal government has always encouraged the belief that the area contained rich mineral deposits; and
4. protection of the environment (Dosman 1974: 446).

Dosman (1974) also emphasized the need to "establish the principle that separate standards and criteria for national transportation investment and regulation be accepted for the North" (Dosman 1974: 460). The tendency in the past was to evaluate northern proposals using the same criteria that were applicable in southern regions. Using the same policies in the north as the south resulted in "inequalities which were no longer tolerable in the light of government priorities and public expectations" (Dosman 1974: 460).

Another difference between the southern and northern regions of Canada relates to the concept of competition enunciated by the NTA of 1967. Dosman (1974) raised concerns regarding the use of competition as a premise for transport policy. He argued that "unlike the South, with a fully developed – perhaps overdeveloped – transport grid, deregulation in favour of intermodal competition was (and is) not feasible in the North" (Dosman 1974: 451).

Transport Minister Jean Marchand also acknowledged the need for policy reform to address the unique characteristics of northern transportation. In the policy paper on transportation entitled *Transportation Policy: A Framework for Transportation in Canada*, Marchand highlighted the importance of the "underdeveloped riches of the North." He also proposed that the *National Transportation Act*, which focused on transportation services and pricing in a mature and relatively developed economy, did not "take into account sufficiently the diversity of transportation markets and conditions in Canada and, in particular, the developmental nature of significant parts of the country and its transportation services" (Transport Canada 1975: 24). A revised framework for transport policy was required that recognized the need for extended, expanded and improved services in the developing regions of Canada, that accounted for the different states of transportation facilities and services and permitted each to be treated accordingly.

The framework developed by Marchand defined transportation problems in terms of: (a) what had to be moved; (b) its origin, destination, and the intermediate points through which it traveled; (c) the maturity of the transport service; and (d) the degree of inter-modal competition (many modes and several carriers per mode) and intra-modal competition (one mode and several carriers). These conditions were represented in the form of a matrix representing the state of maturity of the transport system (Figure 5.2).

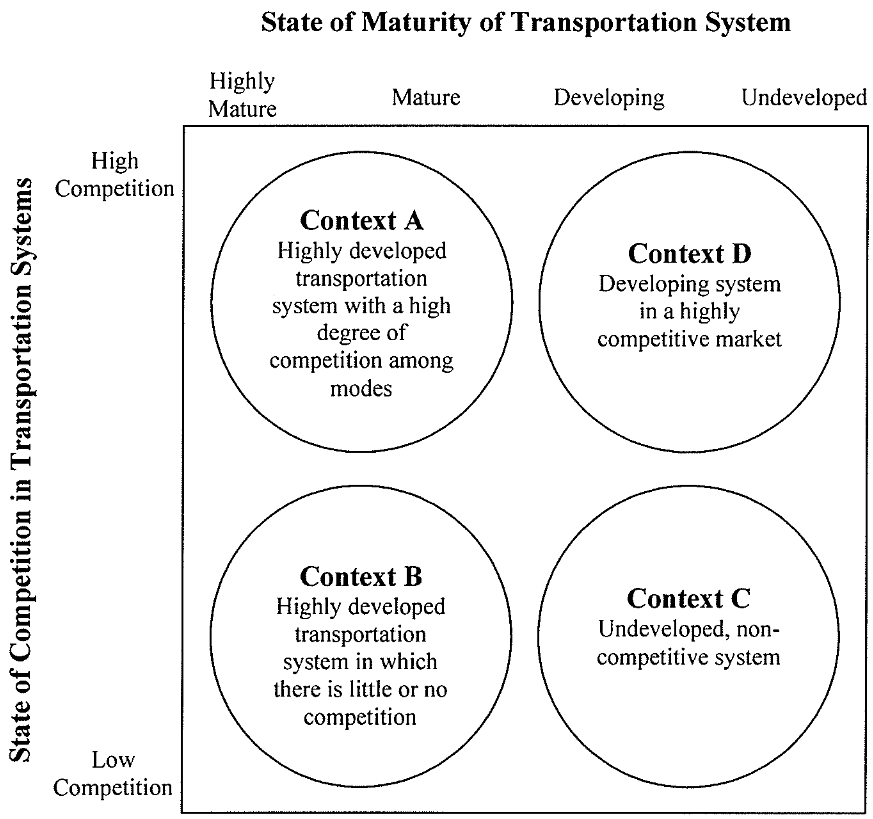

Figure 5.2: Transportation Contexts
Source: Transport Canada 1975

Marchand argued that the NTA applied best to context A, which corresponded to the most highly developed transportation system. Context C corresponded to an undeveloped, non-competitive market, which is generally the case in northern and remote areas where the transportation infrastructure is relatively undeveloped, the volumes are low and suited to only one mode and transport services are subject to little or no competition (Transport Canada 1975).

The proposed degree of government intervention in terms of public policy differed for each context. In particular, for context C it was recommended that government action be:

- Developmental - designed to encourage the development of transportation, where necessary, through direct investments, subsidies or grants;
- Regulatory - designed to ensure that the system operates in an economic and equitable manner; and
- Operational - through direct provision of transportation services where private services are not available (Marchand 1975: 12).

The conceptual framework developed by Marchand (Figure 5.2) formed the basis for the following policy principles:

1. A total transportation system for Canada, providing accessibility and equity of treatment for users, is an essential instrument of support for the achievement of national economic and social objectives.
2. It is the responsibility of government to attend to the provision of an efficient total system for this purpose.
3. Achievement of this purpose requires the integration of services provided through the most appropriate modes for each specific service (Transport Canada 1975: 28).

Marchand recommended that the NTA be revised to state that the transportation system should be accessible, equitable and efficient, rather than economic, efficient and adequate. He argued that this provided a better definition to the concept of adequacy (in terms of equity and accessibility), while retaining the criterion of efficiency. The proposed policy framework also provided for the fact that there was a wide range of transportation services in Canada, with varying degrees of maturity and competition and stressed the importance of maintaining essential services in underdeveloped regions. Marchand's policy principles envisaged "the use of transportation as an instrument of national policy rather than as a passive support service" (Transport Canada 1975: 30).

In July 1985 Transport Minister Don Mazankowski introduced a position paper on transportation in the House of Commons entitled *Freedom to Move – A Framework for Transportation Reform.* The paper opposed Marchand's analysis and "outlined sweeping revisions to the transportation policy that involved reduced economic regulation and greater reliance on market forces" (CTA 2004: 68). The goal of the reform was to increase flexibility in the transport system and encourage greater freedom of movement.

Although Mazankowski's reform in the transportation sector was based on less regulation and greater reliance on competition, the statement of principles and directions outlined in *Freedom to Move* made specific concessions for remote regions in Canada. Specifically, Mazankowski proposed that transportation policy objectives should "recognize the needs of those in small or remote communities, where low traffic volumes or long distances make it difficult to have a competitive environment" (Canada 1985: 18).

5.3. VISION FOR NATIONAL TRANSPORTATION POLICY IN CANADA

The modern approach to national transportation policy follows Mazankowski's rationale. Concessions are made for northern and remote regions without explicit reference to a separate northern transportation policy.

The vision for transportation in Canada, while maintaining the key economic principles enunciated in previous versions of the national transportation policy, is moving toward inclusion of more public policy objectives. Safety and security, accessibility, sustainability and environmental preservation have recently emerged as priorities in transport engineering, planning and decision-making. Two documents, *Vision and Balance* (2001) and *Straight Ahead – A Vision for Transportation in Canada* (2003) highlight the importance of these issues.

5.3.1. Recommendations of the CTA Review Panel

The *Canada Transportation Act* review panel (Brian Flemming, Chair) was established in 2000. In *Vision and Balance*, the Panel states that "Canadians' economic well-being is best served by an efficient, competitive transportation system" (Canada 2001b: 2). While the economic performance of the transportation network is a central objective of national transportation policy, the Panel advises that "balance" should be a second major theme. "A balance is required between maximizing economic performance and ensuring that desirable social outcomes are also achieved" (Canada 2001b: 2).

The Panel outlines the features of "a desirable national transportation policy" based on 11 policy guidelines:

1. Economic well-being and growth are best served by an economic and efficient transportation system, making the best use of all modes at the lowest total cost;
2. Competition and market forces are to guide the transportation system;
3. Where competition is lacking, regulation may be needed to limit the exercise of market power. Such regulations should be neutral, not favouring one carrier or mode over another;
4. Transportation users and providers pay for the real costs of resources, facilities and services provided to them at public expense and, as far as practicable, shared public infrastructure facilities include direct user input in decisions on funding and spending;
5. The transportation system conforms to the highest practicable safety standards;
6. All Canadians require reasonable access to the transportation system. Where such access cannot be provided on a commercially viable basis, governments should only provide it in such a way as to minimize interference or modifications of the commercial system;
7. Government interventions to provide non-commercial services occur in the most cost-effective way and, as far as possible, do not favour one mode over another;
8. Providers of transportation services and infrastructure are compensated for any imposed public duties that cause them to incur additional costs in carrying out the imposed public duties;
9. Fares, rates and conditions do not impose undue obstacles to the mobility of persons with disabilities;
10. As far as practicable, the real costs of environmental effects are incorporated into taxes and user fees, and/or taken into account by regulations where that is more efficient and effective than direct charging; and
11. The transportation system and government policy should facilitate the ability of Canadian firms to compete internationally (Canada 2001b: 312).

The purpose of these guidelines is to promote a new focal point for discussion of Canadian transportation policy and to form a basis for defining a new statement of national transportation policy to replace section five of the *Canada Transportation Act* (1996).

5.3.2. Straight Ahead

Straight Ahead – A Vision for Transportation in Canada is a policy statement tabled by Transport Minister David Collenette in February 2003. This document describes the government's vision for transportation in Canada and proposes strategic directions to address key issues in the years ahead.

While continuing the legacy of an economic and efficient transportation system, *Straight Ahead* also highlights the importance of safety, security and environmental responsibility. Canada relies on a sustainable transportation system that is advanced through the integration of economic, social and environmental considerations. From an economic perspective it is important to have a transportation system that is efficient and competitive, that makes use of all available resources in an effective manner and contributes to domestic growth and Canada's competitive position in world markets. From a social perspective, safety and security are key considerations. Additionally, a system that respects the natural environment is essential for long-term sustainability. The "fundamental policy challenge" for transportation is to balance these three criteria in transportation decision-making to develop a transportation system that meets the needs of both present and future generations (Transport Canada 2003d: 17).

Straight Ahead "serves to point transportation policy in the right direction in support of a better quality of life for our communities" (Transport Canada 2003d: 17). The vision for a sustainable transportation system presented in *Straight Ahead* is guided by eight principles:

1. highest practicable safety and security of life and property – guided by performance-based standards and regulations when necessary;
2. efficient movement of people and goods to support economic prosperity and a sustainable quality of life;
3. respect for the environmental legacy of future generations of Canadians;
4. user pricing that better reflects the full costs of transportation activity, and transportation infrastructure decisions that meet user needs;
5. reasonable access to the national transportation system by Canada's remote regions;
6. accessibility in the national network without undue obstacle for persons with disabilities;
7. coordinated and harmonized actions across all modes of transport in support of intermodality and to achieve modal neutrality; and
8. partnerships and collaboration among governments and with the private sector for an integrated, coherent transportation policy framework, taking into account the respective jurisdiction, role and responsibilities of all participants (Transport Canada 2003d: 17).

With specific reference to access for Canada's remote communities, the federal government committed to "continue to seek the best means to provide reasonable access to the national transportation system for remote communities where such access is not financially self-sufficient but is essential to their survival" (Transport Canada 2003d: 56). This objective will be met by maintaining federally supported infrastructure in the most cost-effective manner, encouraging local control of transportation infrastructure and examining alternative arrangements with other partners (provinces, territories and the private sector) to support transportation (Transport Canada 2003d).

5.4. KEY GOALS OF NATIONAL TRANSPORTATION POLICY

Table 5.1 lists five goals of national transportation policy in Canada and identifies their inclusion in each of the legislated statements of national transportation policy (NTA 1967, NTA 1987, CTA 1996) and the two most recent documents on the vision for Canadian transport policy (Canada 2001b, Transport Canada 2003d). This list highlights key policy goals that have implications on the provision of transportation services in the north.

Table 5.1: Key National Transportation Policy Goals

	1967 NTA	1987 NTA	1996 CTA	2001 CTA Review	2003 Straight Ahead
Transportation services are economic and efficient	✓	✓	✓	✓	✓
Transportation is used as a tool to advance regional economic development objectives	✗	✓	✓	✗	✗
The transportation system meets specified safety standards	✗	✓	✓	✓	✓
All Canadians have reasonable access to the transportation system	✗	✗	✗	✓	✓
Transport decision-making incorporates environmental costs and sustainability criteria	✗	✗	✗	✓	✓

CHAPTER 6

THEORETICAL CONSIDERATIONS FOR RESULTS-BASED TRANSPORTATION PLANNING

This chapter defines and discusses terminology, concepts and principles relevant to the creation of a results-based approach to transportation engineering and planning in northern and remote regions; develops a set of performance indicators to measure progress towards five national goals for transportation; and defines a methodology for evaluating the performance of the northern transportation system.

6.1. TERMINOLOGY

Different terminology and nomenclature are used in reference to results-based planning methodologies and frameworks. For example, The World Bank uses the phrase "results-based monitoring and evaluation" while the National Cooperative Highway Research Program (NCHRP) and the Transportation Research Board (TRB) use "performance-based planning." This research assumes that the general concepts of performance-based planning and results-based methodologies are similar and that the associated terminology may be used interchangeably.

- Kusek and Rist (2004) define a results-based monitoring and evaluation system as a "public management tool governments can use to measure and evaluate outcomes, and then feed this information back into the ongoing process of governing and decisionmaking" (Kusek & Rist 2004: 12).

- Pickrell and Neumann (2001) define performance-based planning as the systematic and ongoing process of using performance measures to influence agency decisions, particularly policy and resource allocation decisions.

- NCHRP (2000) proposes that "performance-based planning provides a process and tools to identify and assess alternative programs, projects, and services with respect to overall transportation plan goals and objectives" (NCHRP 2000: 3). The goals of a performance-based approach are to improve decision-making and strengthen the link between planning goals and investment decisions.

- The government of Canada (2005) identifies elements that are critical for robust reporting. These include "use of data and statistics; results-based approach; building the reporting framework on common principles and understanding; making reporting useful and reciprocal for all parties; and the need for joint processes to establish performance measures that will lead to transformative change" (Canada 2005b: 1).

Commonalities in these definitions include: (1) results-based approaches are designed to aid in decision-making; (2) the process involves measurement of performance indicators and evaluation of these indicators with respect to specified goals and objectives; and (3) results-based approaches are ongoing processes which involve information feed-back at different stages in the process. The value in performance measurement lies in its ability to tie the components of the transportation planning process into a "consistent framework of planning, monitoring, evaluation and feedback" (Pickrell & Neumann 2001: 22).

Prime Minister Paul Martin, in his address at the First Ministers meeting (November 2005), stated that the "challenges we face require goals that are concrete, and achieving them requires that we measure our progress along the way." Performance measurement and the use of broad indicators to assess progress are integral components in the strategy outlined by the Prime Minister to close the gap in the quality of life for Aboriginal

Canadians. The strategy also requires "openness, transparency and good governance" within federal, provincial, territorial and Aboriginal leadership (Canada 2005).

6.2. THEORETICAL CONSIDERATIONS FOR A RESULTS-BASED FRAMEWORK FOR NORTHERN CANADIAN TRANSPORTATION

Pickrell and Neumann (2001) identify seven features and elements that are common in performance-based approaches. These basic components are further developed and clarified by NCHRP (2000).

1. *Broad Goals*
   Policy goals describe what the agency needs to accomplish in order to fulfill its stated mandate or mission. Goals are high-order objectives to which a project, program or policy is expected to contribute (Kusek & Rist 2004). It is essential to create "operational" goals that can be linked to specific measures of progress and be used to improve tracking between plans and decisions (NCHRP 2000: 14).

2. *Objectives*
   As distinct from goals, "an objective is a concrete step toward achieving a goal, stated in measurable terms" (NCHRP 2000: 14). This is similar to what Kusek and Rist (2004) refer to as an outcome, or the desired effects of a project, program or policy. Objectives provide specificity to goals and allow for the measurement of progress. Objectives can be either explicit and quantifiable or more general and strategic. Comparison of performance data with objectives allows agencies to determine how well the system is performing, suggest future implications of policies and identify opportunities for improvement. Setting goals and objectives that are "clear, concise, and achievable" is a foundational component to successful planning efforts (NCHRP 2000: 8).

3. *Performance Indicators*
   Performance indicators are qualitative or quantitative variables that provide a means to measure achievement, to reflect changes in a project, program or policy or to assess the performance of the system against a stated objective (Kusek & Rist 2004). Defining performance indicators that are clearly related to the stated goals and objectives is central to the results-based approach. Indicators "should be identified in response to goals and objectives, rather than the other way around" (Pickrell & Neumann 2001: 19).

4. *Analytical Methods and Data Needs*
   The need for data collection and synthesis is inherent in results-based approaches. It is recommended that agency goals and objectives determine what information will be collected and provided to decision-makers. Ideally, an agency will develop a set of predictive tools and data collection programs that will support a robust and descriptive set of performance indicators (Pickrell & Neumann 2001).

5. *Decision Support*
   Information from performance indicators is used to support decision-making and to influence policy choices and resource allocation. Performance indicators do not make choices "easier" or automatic, but they can be used to "inform a decision-making process and more effectively communicate the consequences of various choices" (Pickrell & Neumann 2001: 19).

6. *Monitoring and Feedback*
   This component involves the continuous monitoring of system performance and suitable feedback to the planning and decision-making processes (Pickrell & Neumann 2001).

7. *Communicating and Reporting Results*
   The value of performance measurement is diminished if the results are not presented to appropriate audiences in a manner that is informative and readily understandable. The audience will vary depending on the specific plan and contiguous circumstances, but may include agency staff responsible for implementation of the plan, management, elected officials, decision-makers and customer and stakeholder groups. Provision of summary reports to stakeholders is a "key element in establishing accountability" (Pickrell & Neumann 2001: 19).

6.2.1. Implementation of a Results-Based System

Guidance from the literature suggests that attention be paid to the following practical matters in developing and implementing a results-based program:

- Development of a results-based system is an incremental process (NCHRP 2000).
- Start with a structured, simplified system by focusing on primary goals and practical performance indicators (NCHRP 2000).
- Involve those accountable for the program in its development (NCHRP 2000).

- Buy-in from customers, stakeholders, decision-makers, top management, and front-line employees is critical for initial acceptance and continued success of the program (TRB 2000).
- Performance indicators must be integrated into the decision-making process (TRB 2000).
- The presentation of performance data must be carefully designed so that the information is easily understood and the analysis provides the necessary information to improve decision-making (TRB 2000).

6.2.2. Selection Criteria for Performance Indicators

Selection of performance indicators to measure progress towards the stated objectives and provide feedback to decision-makers is an essential component in a results-based system. Performance indicators should address the specific needs, capabilities and intended use of the measures in the agency's program. The "more precise and coherent the indicators, the better focused the measurement strategies will be" (Kusek & Rist 2004: 67). Guidance from the literature outlines five criteria for the selection of performance indicators (Kusek & Rist 2004):

- Clear – Precise and unambiguous
- Relevant – Appropriate to the subject at hand
- Economic – Available at a reasonable cost
- Adequate – Provide a sufficient basis to assess performance
- Monitorable – Amenable to independent validation

6.2.3. Additional Considerations

The literature recommends the use of outcome-based performance indicators in addition to traditional output-based indicators. Output indicators "reflect the quantity of resources used, the scale or scope of activities performed by an organization, and the efficiency in converting those resources into some type of product" (NCHRP 2000: 19). Outputs are useful measures for tracking, comparing and managing resources. Outcome indicators have been traditionally neglected from planning processes because they are more difficult to measure and link with the actions of an agency. Outcome indicators "reflect an agency's success in meeting stated goals and objectives and focus on the beneficiaries of the agency's service" (NCHRP 2000: 20).

Results-based planning should not be viewed as a purely rational or quantitative methodology. The role of performance indicators is to augment rather than replace other qualitative processes. Performance measurement is most valuable when integrated into a comprehensive planning process that "includes public outreach and participation, strategic visioning, competent analysis, and periodic incorporation of results into the process" (NCHRP 2000: 3).

"Hard" performance indicators are quantitative in nature and are easy to evaluate in numerical terms. "Hard systems" methodology, is characterized by "bounded rationality and unbounded uncertainty" (Khisty 1996: 5). Pure technical rationality has been criticized for its inability to predict the outcomes of possible actions, to comprehend the present and future preferences of society and to address the spatial and temporal variability of tastes, desires and values (NCHRP 2000). Further critiques of rationalism presented by Skelton (2004) include: (1) it is usually impossible to state the problem fully (i.e. the required data cannot be collected, all alternatives and criteria cannot be specified and impacts cannot be anticipated or quantified with certainty); (2) rationalism assumes a commonality of interest which depends on the existence of an identifiable "public good"; and (3) people rarely change their opinion based on rational argument and require personal experience or narrative relating to their personal experience.

Therefore, quantitative measures should be balanced by "soft systems" methodology, which is "a learning and managing process, with the distinctive feature of its ability to deal with ill-structured, messy, complex situations" (Khisty 1996: 6). While "hard" measures are easier to interpret, "soft" measures are also necessary and appropriate in certain cases and must be considered in the analysis (NCHRP 2000: 10).

Kusek and Rist (2004) express caution about selecting indicators based on the ease with which the data can be collected. It is important to consider not only how readily available the data is, but also how important the performance indicator is in measuring the extent to which objectives are being met.

6.3. PRACTICAL APPLICATIONS OF RESULTS-BASED FRAMEWORKS

Results-based systems are effective in: (1) monitoring the long-term performance of projects, programs and policies; (2) evaluating the effectiveness of existing projects, programs and policies; and (3) evaluating alternative courses of action (see Figure 6.1).

The basic components of a results-based system, monitoring and evaluation, work together to provide information and feedback to transportation engineers, planners, decision-makers and the public.

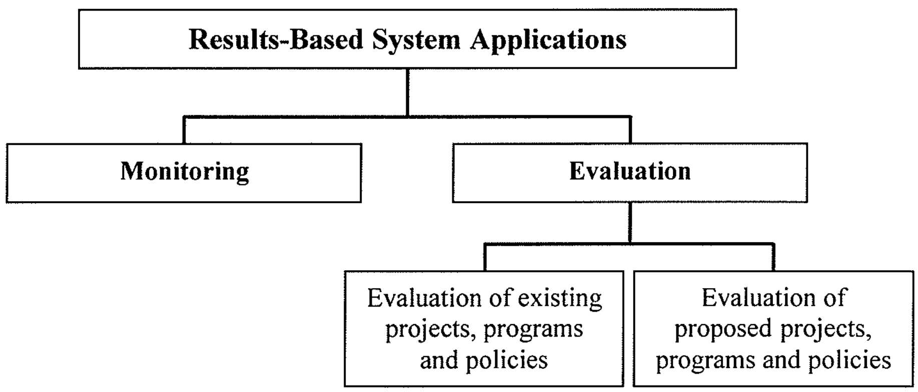

Figure 6.1: Monitoring and Evaluation in the Results-Based Framework

6.3.1. Monitoring

The Organization for Economic Cooperation and Development (OECD 2002) defines monitoring as "a continuous function that uses the systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated resources" (OECD 2002: 27). Monitoring within the results-based framework is a means to track progress towards the stated goals and objectives. Examples of current initiatives in monitoring transportation system performance, nationally and internationally, include:

- Transportation in Canada – Annual report on the state of transportation in Canada (Transport Canada)

- Annual reports and business plans prepared by provincial and territorial transportation authorities
- Transport data collected and disseminated by Statistics Canada
- The National Highway Planning Network (NHPN) – A network database containing line features representing current and planned highways in the United States (US Department of Transportation, FHWA)
- Data collected and disseminated by the Bureau of Transportation Statistics (BTS) in the United States (including the Journal of Transportation Statistics, Commodity Flow Survey, Transportation Statistics Annual Report, National Transportation Atlas Database, National Transportation Statistics, Pocket Guide to Transportation)

6.3.2. Evaluation

Evaluation can occur at two levels. The OECD defines evaluation as " the systematic and objective assessment of an ongoing or completed project, program, or policy, including its design, implementation and results. The aim is to determine the relevance and fulfillment of objectives, development efficiency, effectiveness, impact and sustainability" (OECD 2002: 21). This type of evaluation considers the effectiveness of an existing project, program or policy in light of the goals and objectives set out at the beginning of the project. It is a complement to monitoring that helps to "clarify the realities and trends noted with the monitoring system" (Kusek & Rist 2004: 13).

The second type of evaluation occurs before a project, program or policy is implemented. It involves examining the available alternatives in light of the goals and objectives, assessing the relative desirability of each alternative, and summarizing the key issues to be considered by decision-makers (Manheim 1979).

Results-based planning is a method that can be used to inform decision-making. The role of evaluation in this context is to support decision-making by providing relevant information and outlining the consequences of alternative plans. According to Manheim (1979), the objective of analysis is "to clarify the issues that should be considered by decision makers, to assist them in reaching a decision on a course of action" (Manheim 1979: 330). Evaluation is a key component in the process of analysis in which the analyst synthesizes the information provided through analytical techniques, examines it to enhance understanding of the issues and summarizes the results in the form of an evaluation report. The primary product of evaluation is a summary of the key issues to be considered by decision-makers (Manheim 1979).

Implementation of a results-based monitoring and evaluation program for northern transportation provides the capability for transportation engineers, planners, government officials and members of the general public to answer the following types of questions:

- What are the safety characteristics of the northern transportation system with regards to the number of transportation related injuries and fatalities in the north?
- How effective are climate change adaptation strategies in extending the duration and reliability of the winter road network in northern Manitoba?
- What are the incremental costs to shippers and consumers for air transport compared to winter road transport in the event of a winter road failure?
- How have consumer perceptions about system performance changed over the past x years, since implementation of a specific project, program or policy?
- What are the differential impacts of an engineering design on each of the communities in the project region?

6.4. PERFORMANCE INDICATORS FOR NORTHERN CANADIAN TRANSPORTATION

After explicit consideration of the above guidelines and criteria, and the analysis and findings of the foregoing chapters, five broad goal categories for northern transportation were selected. These are:

- Accessibility
- Economic Viability and System Efficiency
- Regional Economic Development
- Safety
- Equity

Each of these goal categories are further subdivided into objectives (specific steps taken to achieve the broad goals) and performance indicators (qualitative or quantitative variables that provide a means to measure achievement). The structure of the results-based framework is shown in Figure 6.2.

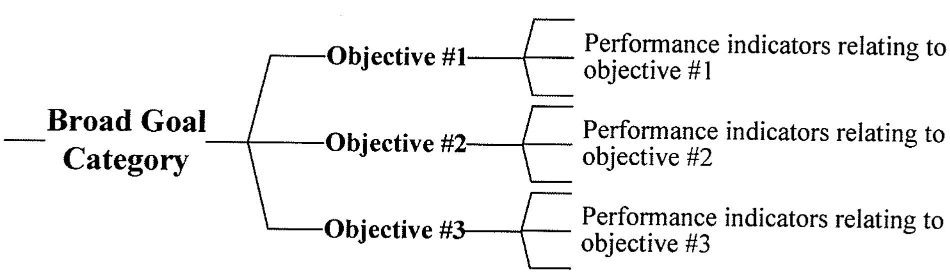

Figure 6.2: Structure of the Results-Based Framework

Broad goal categories for this research were developed from statements of national transportation policy in Canada and emerging issues in the transport industry. Recommendations from the literature and examination of how results-based methodologies are implemented by other jurisdictions and countries guided the development of specific objectives and performance indicators relating to each of the broad goals. Adaptation of these recommendations was necessary to address the unique transportation needs and constraints that are prevalent in the context of northern Canada.

6.4.1. Accessibility

In *Straight Ahead* (2003), the Government of Canada commits to "seek the best means to provide reasonable access to the national transportation system for remote communities" (Transport Canada 2003d: 56). According to NCHRP (2000) and Litman (2005), measures of accessibility reflect the ability of people and goods to access services and to reach desired activities and destinations. Basic access is defined by Litman (2005) as the ability of people to "reach activities considered important to society" such as essential services, education and employment opportunities and freight transport (Litman 2005: 6).

Three objectives are defined by this research within the accessibility goal category:

- *Objective 1:* To improve access to the national transportation network by increasing the number of modal options available in remote communities.
- *Objective 2:* To maintain essential transportation services in remote communities where there is no alternative year-round service.

- *Objective 3:* To encourage local control of transportation infrastructure and services by including direct user input in decision-making on funding and spending for transport infrastructure.

Figure 6.3 shows the performance indicators related to each of these objectives.

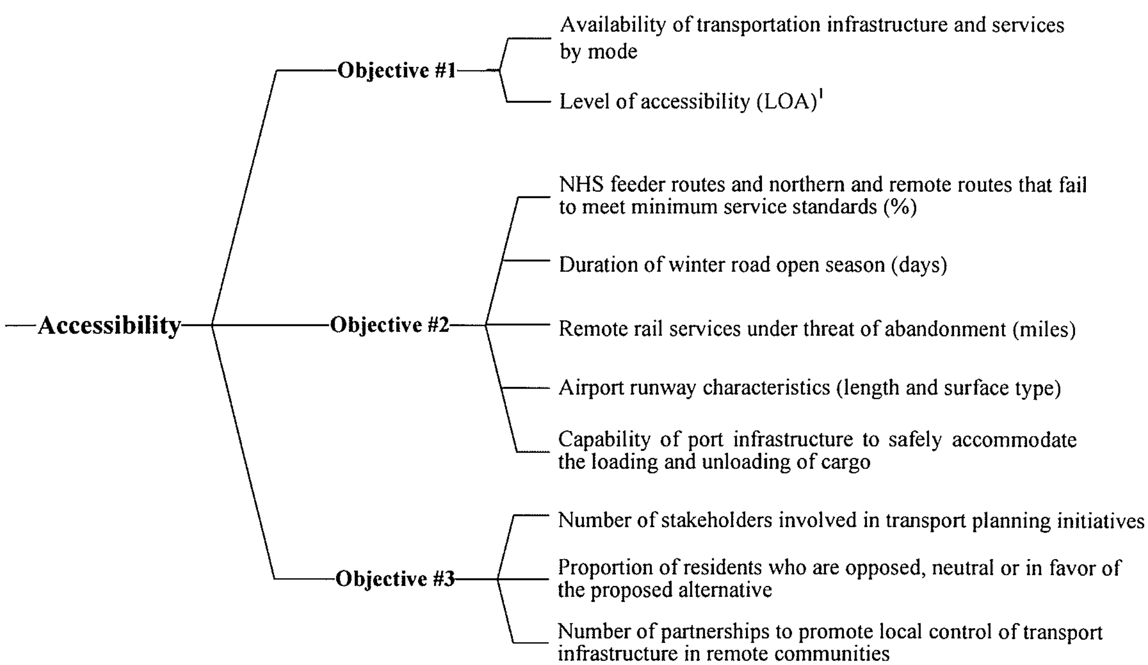

Figure 6.3: Accessibility Performance Indicators[1]

Feeder routes are key linkages to the core NHS routes from population and economic centers (including links to intermodal facilities and significant border crossings). Northern and remote routes are key linkages to core and feeder routes that provide the primary means of access to northern and remote areas, economic activities and resources. To comply with minimum performance characteristics, as outlined in the *National Highway System Review Task Force Report* (2005), NHS routes should:

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[1] See chapter four for the definition of LOA

- provide a minimum operating speed of 90 km/hour;
- be capable of providing all-weather service, with no seasonal load restrictions and be capable of carrying the national standards for weights and dimensions; and
- provide a riding comfort index (RCI) of 6.0 or greater, or the equivalent rating using other measurement systems (Council of Ministers Responsible for Transportation and Highway Safety 2005: 10).

6.4.2. Economic Viability and System Efficiency

The concept of an economically viable and efficient transport system is foundational to Canada's transport policy. A transportation system that is economic and efficient "supports trade, economic prosperity and an enhanced quality of life through low costs, high productivity, best use of all modes, and innovation and skills" (Transport Canada 2003d: 19). As discussed in chapter five, competition and market forces are the desired agents in providing an effective transport system for Canadians (*Canada Transportation Act* 1996). However, competition is limited in the north and transport services are not always economically viable. Where government intervention is required to provide non-commercial services, financial support should be provided in the most cost-effective manner (Canada 2001b).

Three objectives are defined by this research within the economic viability and system efficiency goal category:

- *Objective 1*: To provide direct financial support to northern transportation services that, though not economically viable, are deemed to be in the public interest.

- *Objective 2:* To utilize the most efficient mode and carrier for northern, remote passenger and freight transport services.
- *Objective 3:* To provide northern, remote passenger and freight transport services at the lowest total cost.

Figure 6.4 shows the performance indicators related to each of these objectives.

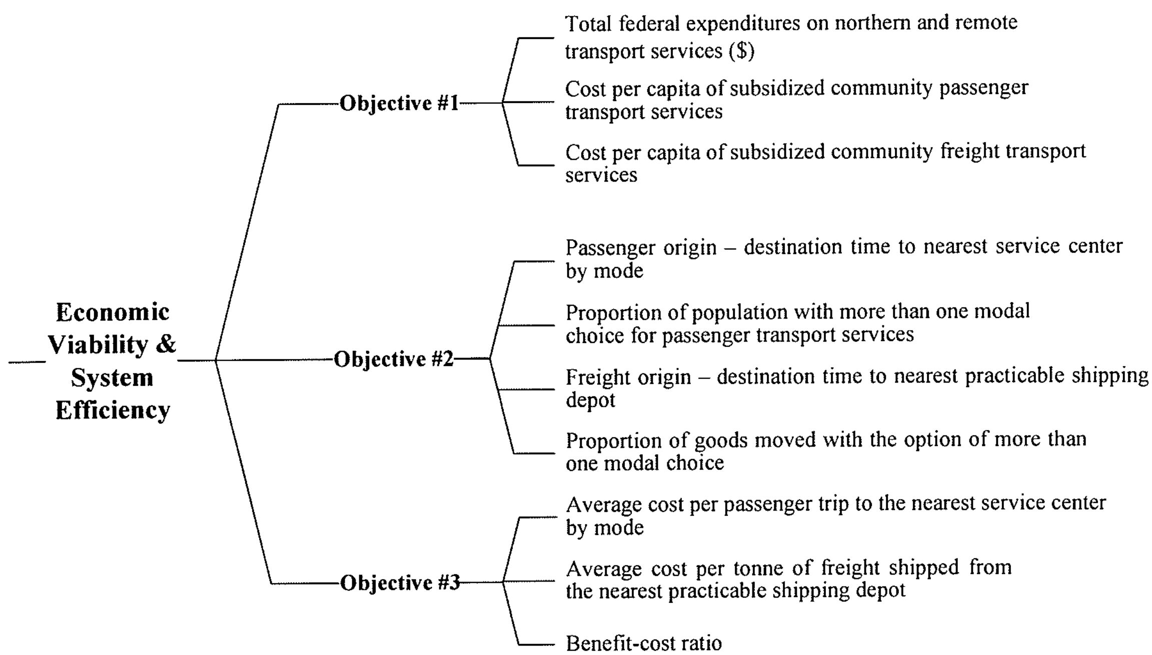

Figure 6.4: Economic Viability and System Efficiency Performance Indicators

6.4.3. Regional Economic Development

The *Canada Transportation Act* states: "transportation is recognized as a key to regional economic development and that commercial viability of transport links is balanced with regional economic development objectives so that the potential economic strengths of each region may be realized" (Canada Transportation Act 1996: Section 5d). The relationship between economic development and transportation infrastructure and services is complex, however transport systems are "an unquestionable prerequisite for economic activity" (NCHRP 2000: B-17).

Historically, the objective of constructing transport links was to open up new geographic areas for development and to provide access to resources. The European Conference of Ministers of Transport (ECMT) argues that "there is no doubt that these initial investments in transport links, which improved accessibility considerably, contributed significantly to economic growth and regional development" (EMCT 2001a: 11).

The 1994 World Development Report, *Infrastructure and Development,* (The World Bank 1994) supports this view. The report defines a linear relationship between whole infrastructure stock (including, but not limited to, transportation infrastructure) and gross domestic product (GDP). As the infrastructure stock increases incrementally, the GDP also increases. The report also notes that as the income structure of a region shifts, the composition of the infrastructure stock changes. In low-income countries, basic infrastructure such as potable water and irrigation systems are more important than transport infrastructure. Transport infrastructure becomes increasingly valuable in the economic development of middle-income regions, while the richest countries rely more heavily on energy and telecommunications. The World Bank research supports economic theories which equate development with growth in macroeconomic indicators (such as GDP).

Berechman (2001) points out that "there is a strong belief among decisionmakers, transportation planners and economists that transportation plays a vital role in enhancing economic growth by stimulating private investment and output and by improving productivity of labour and capital" (ECMT 2001b: 107). This assumption is derived from the historical premise that the high-level spatial accessibility provided by transportation is a major source of economic growth and productivity.

According to the Rivard Committee (1993), regional development has two essential components, "first, to ensure that isolated areas have access to modern transportation, and second to ensure that regions realize their economic potential within the federation" (National Transportation Act Review Commission 1993: 145). The first component is measured using accessibility indicators (Section 6.4.1) and the second relates to the potential and actual economic activity that takes place in a community or region.

Two objectives are defined by this research within the regional economic development goal category:

- *Objective 1*: To provide transport links that enable economic development and create employment opportunities in remote communities.
- *Objective 2:* To construct transport facilities in proven resource locations.

Figure 6.5 shows the performance indicators related to each of these objectives.

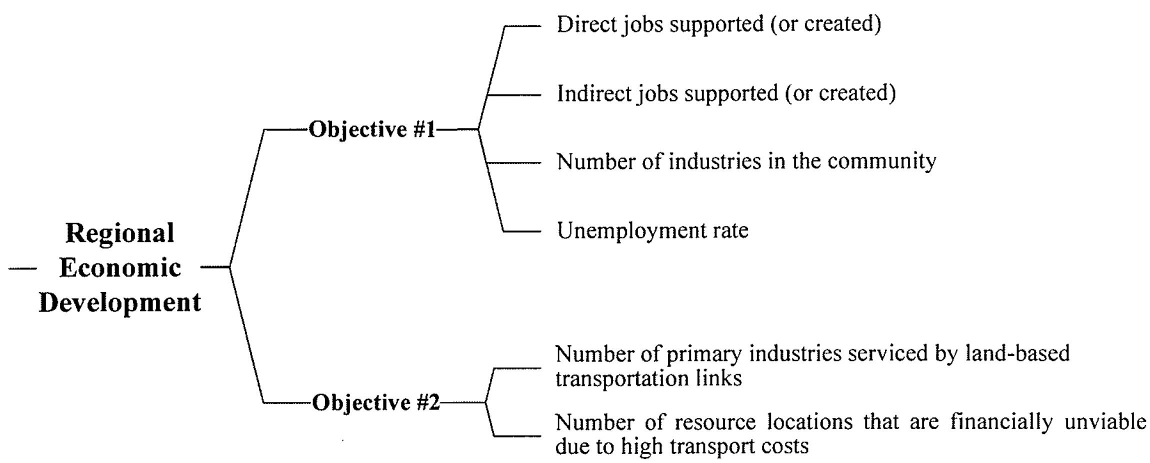

Figure 6.5: Regional Economic Development Performance Indicators

6.4.4. Safety

Safety is another goal set out in the *Canada Transportation Act*. In the statement of national transportation policy, this goal is phrased: "the national transportation system meets the highest practicable safety standards" (Canada Transportation Act 1996: Section 5a). Safety initiatives are the "top priority" in Transport Canada's national transportation strategy, with the intended outcomes being: (1) the protection of life, health, the environment and property; and (2) public confidence in the safety and security of our transportation system (Transport Canada 2005: 2).

Safety in northern and remote communities has two components. The first relates to the functioning of the components in the transportation system. The second involves community safety issues that are related to the availability of transport services, specifically services related to medical travel.

Two objectives are defined by this research within the safety goal category:

- *Objective 1:* To reduce transportation-related risk to the lowest practicable level.
- *Objective 2:* To ensure that all northern and remote communities have adequate critical medical transport services.

Figure 6.6 shows the performance indicators related to each of these objectives.

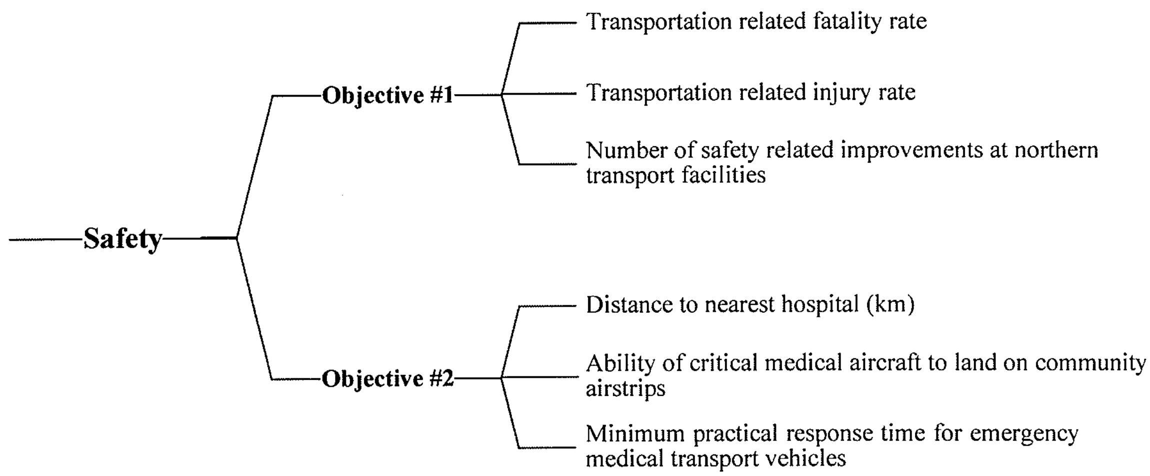

Figure 6.6: Safety Performance Indicators

6.4.5. Equity

Transportation equity is another issue at the forefront of transportation engineering, planning and decision-making. Equity "refers to the distribution of impacts (benefits and costs), and the degree to which that distribution is considered fair and appropriate" (Litman 2005: 2).

Litman (2005) defines three types of transportation equity: (1) horizontal equity (concerned with the distribution of impacts between groups and individuals with equal abilities and needs); (2) vertical equity with regard to income and social class (concerned with the distribution of impacts between groups and individuals with differing abilities and needs); and (3) vertical equity with regard to mobility and need (concerned with the distribution of impacts between groups and individuals that differ in transportation need and ability). Sustainability requires that equity objectives be met not only across different societal and geographic strata, but also between generations (The Centre for Sustainable Transportation 2002).

Equity has not been formally introduced into Canada's national transportation policy. Although the term is not used explicitly, equity objectives are reflected in statements such as:

- All Canadians require reasonable access to the transportation system. Where such access cannot be provided on a commercially viable basis, governments should only provide it in such a way as to minimize interference or modifications of the commercial system. (Canada 2001b: 312);
- Continue to seek the best means to provide reasonable access to the national transportation system for remote communities where such access is not financially self-sufficient but is essential to their survival (Transport Canada 2003d: 56);
- User pricing that better reflects the full costs of transportation activity (Transport Canada 2003d: 17); and
- Transportation users and providers pay for the real costs of resources, facilities and services provided to them at public expense (Canada 2001b: 312).

Equity objectives "often overlap and contradict" because vertical equity requires subsidization for disadvantaged people and horizontal equity requires users to bear the costs of transport facilities and services (Litman 2005: 3).

Two objectives are defined by this research within the equity goal category:

- *Objective 1:* To ensure that transportation users and providers pay for the real costs of resources, facilities and services provided to them at public expense (horizontal equity).
- *Objective 2:* To provide "basic access" for all northern residents by improving transport services between remote / special access communities and northern service centers (vertical equity).

Figure 6.7 shows the performance indicators related to each of these objectives.

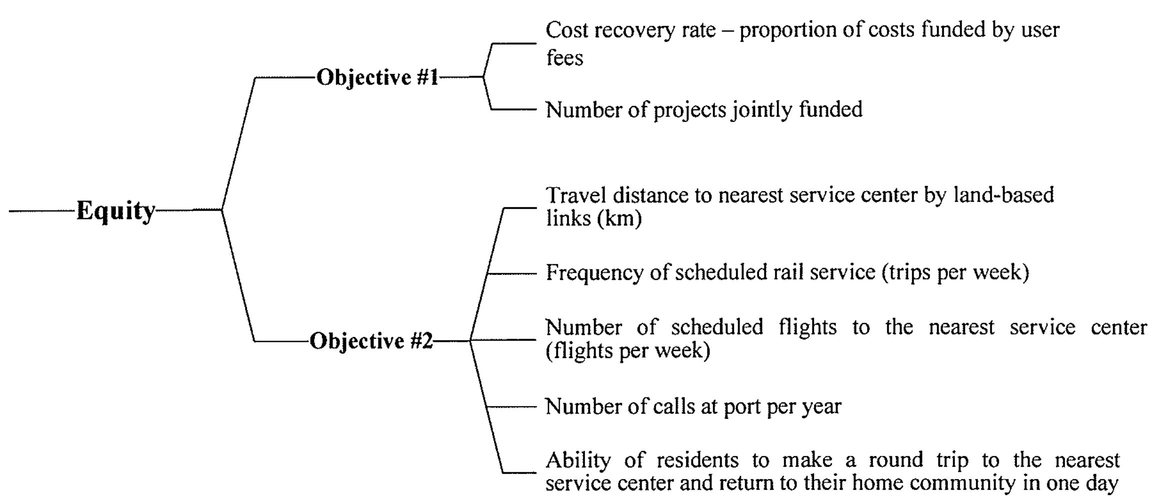

Figure 6.7: Equity Performance Indicators

6.4.6. Sustainability

A further goal category, while not included in the framework at this time, requires discussion. Environmental preservation and sustainability are priorities in developing a transportation system that meets the needs of both present and future generations. Sustainability is a key issue across multiple government departments and jurisdictions (federal, provincial / territorial and local governments are creating sustainable development strategies and action plans). Transportation plays a crucial role in achieving national sustainability goals. Sustainability is not included in the results-based framework developed for this research because Transport Canada has a set of performance indicators to reflect the transport sector's progress on sustainable transportation on a national level (The Centre for Sustainable Transportation 2002). Other organizations, including the Transportation Association of Canada (TAC) and the Organization for Economic Co-operation and Development (OECD) are also working towards this goal.

6.5. PROPOSED EVALUATION METHODOLOGY

Manheim (1979) defines evaluation as "the activity of examining the available alternative actions in light of the possible goals, assessing the relative desirability of each action, and summarizing the key issues to be considered by interested parties in reaching a decision" (Manheim 1979:331). Evaluation has a systematic nature, but it cannot be separated from its inherently political context (Seasons 2003). Further, to approach evaluation from a purely scientific perspective would be "to miss completely its fundamentally social, political, and value-oriented character" (Guba and Lincoln 1989: 7).

Evaluation, then, must operate on two sets of information:

- Information about the actual or anticipated impacts of each of the proposed projects, programs or policies. This information is evaluated in light of the goals and objectives and should consider the varying impacts on different communities and stakeholders.

- Due to the political and value-oriented character of evaluation, information relating to the values and preferences of different stakeholders is also critical. Extensive community and stakeholder consultation is necessary to understand the various perspectives and incorporate this information into the decision-making process.

To apply the performance indicators in the results-based framework to the evaluation methodology, the following steps are required:

- Problem definition is a critical component in evaluation and requires a clear and distinct definition of the base-case alternative. The base-case represents the current state and operation of the transportation system without any significant changes to the existing infrastructure or operating policies. Scheduled maintenance activities and infrastructure deterioration are components of the base-case alternative.
- Identify and define the different alternatives that are being considered.
- Identify the communities and stakeholders that will be impacted by implementation of any of the proposed alternatives.
- Select the relevant performance indicators from Figures 6.3 through 6.7. Performance indicators are a means to measure the anticipated or actual impacts of each alternative on communities and stakeholders.
- Some of the performance indicators pertain to the project as a whole (impacts may vary with different alternatives, but are expected to be consistent for different communities), others relate to the differential impacts on individual communities and stakeholders. Two types of evaluation matrices are derived to categorize the performance indicators based on their applicability in each of these areas. The first compares the project specific impacts of the various alternatives (Table 6.1) and the second compares the impacts on different communities for each alternative (Table 6.2). Manheim (1979) refers to these types of tables as impact tableaus.
- In some cases, GIS analytical tools are best suited to comparing the impacts of different alternatives. Since the goal of evaluation is to clarify the issues for decision-makers, GIS tools should be used to supplement the evaluation matrices if the data can be presented visually in a manner that enhances understanding of the issues.
- Gather data to populate the GIS databases and evaluation matrices. In cases where quantitative data is unavailable or insufficient, consider qualitatively how the

indicator is likely to change based on implementation of each alternative (i.e. will the indicator improve progress towards the stated goals or negatively impact a certain community or stakeholder group).

- Compare each proposed alternative to the base case alternative. This analysis should highlight the distributional effects (impacts to individual communities and stakeholders) and system effects (cumulative impacts to the transport system as a whole) of each alternative compared the base-case.

- Identify any significant impacts and trade-offs among the proposed alternatives. Different communities and stakeholder groups may have opposing views on the relative attractiveness of each alternative because some groups will benefit while others will be adversely affected. Particular attention must be paid to these "differential effects" (Manheim 1979: 334). Evaluation must seek to balance the gains and loses of different groups.

Table 6.1: Evaluation Matrix – Project Impacts

	Alternatives		
Performance Indicators	**Base-Case**	**Alternative #1**	**Alternative #2**
Performance Indicator #1			
Performance Indicator #2			
Performance Indicator #3			
…			

Table 6.2: Evaluation Matrix – Community and Stakeholder Impacts

		Alternatives		
Performance Indicators	**Communities or Stakeholders**	**Base-Case**	**Alternative #1**	**Alternative #2**
Performance Indicator #1	1			
	2			
	…			
Performance Indicator #2	1			
	2			
	…			
Performance Indicator #3	1			
	2			
	…			
…	1			
	2			
	…			

The combined use of GIS-T analytical tools, performance indicators from the results-based framework and the evaluation matrices summarizes the key issues to be considered by decision-makers and highlights the trade-offs between different alternatives.

CHAPTER 7

CONCLUSIONS

The purpose of this research is to develop and apply pragmatic tools to facilitate results-based transportation engineering and planning for remote communities in northern Canada. The thesis defines a theoretical analysis framework for modeling the northern transport system, applies the framework to the defined study area through development of a GIS-T analytical platform and identifies results-based indicators to measure the performance of the northern transportation system with respect to national transportation goals and objectives.

This chapter summarizes the findings of the research. Specifically, the chapter discusses: (1) development of the GIS-T analytical platform; (2) characteristics of the transportation system in northern Manitoba and the Kivalliq region of Nunavut; (3) the development and application of a results-based framework for northern transportation; (4) the challenges and implications of adopting a results-based methodology; and (5) potential future research considerations.

7.1. DEVELOPMENT OF THE GIS-T PLATFORM

Central to this research was the development of a GIS-T analytical platform to model the northern transportation system. The function of the platform is to support decision-making by facilitating informed analysis and interpretation of transportation data and providing decision-makers with a better understanding of the overall transport system. The GIS-T platform is designed to represent the transportation system at a given point in time, with the capability of readily updating the data as system characteristics evolve. It is not intended to forecast future changes in the transportation system or predict the impact of specific policies or projects on the overall performance of the transportation system.

Technical considerations addressed in the compilation of GIS data for this research include:

- Resolution of interoperability issues for integration of data from multiple sources and conduct of multi-jurisdictional analyses;
- Database re-organization to ensure consistent and accurate attribute data and allow for linkages between databases;
- Updating of attribute data to reflect recent changes in the transportation system;
- Data processing to reduce the size and coverage of spatial layers and facilitate spatial analysis and thematic mapping;
- Creation of spatial datasets (point, line, area and text features) to represent entities for which data is not readily available; and
- Synthesis of data in an integrated platform that is current, interoperable, user-friendly and centralized.

7.2. CHARACTERISTICS OF THE NORTHERN TRANSPORTATION SYSTEM

The transport system in the study area has the following characteristics:

- The type and quality of transportation facilities varies by type of community. Special access communities have fewer transport options compared to northern service centers and are not accessible from the all-weather road network.

- Due to the reoccurrence of unusually warm winters, which is potentially linked to climate change, the duration of the winter road season is decreasing and winter roads are becoming increasingly unreliable (Kuryk 2005). These factors reduce the window of opportunity for freight transport operations in northern Manitoba, increase overall costs (more freight must be transported by air) and pose safety concerns for travelers.

- Rail service forms a small part of the northern transport network in the study area. The financial viability of remote rail services relies on the combined revenue of passenger and freight transport. As northern resource industries are decommissioned, rail services are minimized, eliminated or require additional subsidization to remain viable.

- Airports are a critical component in the northern transportation system as they are the only means of year round transportation to special access communities. Airports also support emergency medical evacuations from communities that lack adequate medical facilities.

- The air transport system in the north is described as a long, thin market because carriers must transport small numbers of people and low volumes of cargo over large distances. High airfares, low flight frequencies, multi-stop itineraries and utilizing passenger and freight "combi" aircraft configurations are typical strategies used by air carriers to improve the financial viability of northern air routes.

- Competition is limited in the northern air industry. Most routes between special access communities and their nearest service center are serviced by one or two air carriers. Consumer dissatisfaction with the number of scheduled flights and the quality of service to special access communities is common.

- Opportunities exist for improving the efficiency of marine transport operations to Nunavut communities through infrastructure development, vehicle upgrades and better cargo handling capabilities.

- Socioeconomic characteristics pertain to the demand system component of Manheim's model. When compared to the rest of Canada, special access communities collectively have low population densities, lower levels of education, higher unemployment rates, lower income, fewer full time employment opportunities and a larger proportion of total income derived from government transfer payments.

7.3. APPLICATION OF THE RESULTS-BASED PERFORMANCE FRAMEWORK

Performance indicators were developed as part of this research in five broad goal categories: (1) accessibility; (2) economic viability and system efficiency; (3) regional economic development; (4) safety; and (5) equity. These goal categories are derived from emerging issues in the transport industry and statements of national transportation policy in the *Canada Transportation Act* (1996), the *CTA Review Panel* (2001) and *Straight Ahead* (2003).

The tools developed in this research complement one another. The combined use of the tools supports and informs the decision-making process in the following ways:

- The theoretical analysis framework provides a systematic structure for organization of transport-related data. Approaching transport analysis in a methodical way provides clarity, which is particularly important in the problem definition stage of engineering projects.
- The GIS-T platform stores, analyzes and displays spatial and attribute data. GIS-T analytical tools facilitate informed analysis and interpretation of transportation data.
- Performance indicators from the results-based framework, in conjunction with the proposed evaluation methodology, summarize the key issues to be considered by decision-makers and highlight the trade-offs between different alternatives.

7.4. CHALLENGES AND IMPLICATIONS OF ADOPTING A RESULTS-BASED APPROACH

Results-based planning is not a panacea. Five specific challenges to implementation of a results-based program for northern Canada are identified by this research.

First, delineating the north and defining criteria for designating remote communities and regions is problematic. Multiple definitions and remoteness criteria are used by researchers from different fields of expertise, but none are unanimously accepted by different jurisdictions, government departments, northern communities and the private sector. The lack of a concise definition presents a challenge to transportation engineers, planners, researchers and analysts when deciding which communities and regions should be included in the geographic scope of analysis. Categorizing communities and regions is also a challenge faced by government officials in allocating funding or implementing a results-based program aimed at addressing the specific needs and issues of a region or type of community. For this research, definitions from the *Band Classification Manual* (2005) were used because they present a pragmatic and concise approach to categorizing remote communities.

A second challenge relates to data availability and confidentiality issues. Many communities in the north have small population bases and therefore require the use of data suppression techniques to ensure confidentiality. This presents two obstacles for implementation of a results-based program. First, the lack of relevant, high quality and nationally and temporally consistent data limits the number of indictors that can pragmatically be employed, reduces the quality of baseline information and, if data sources are discontinued or modified, prevents long-term monitoring of indicators. Second, since results-based programs are designed to enhance openness and transparency and to improve government accountability, results-based data is often made available to the public. Issues related to confidentiality need to be addressed before performance results can be publicized. In some cases, where confidentiality issues cannot be resolved, it may be necessary to present results in an aggregated form.

Most national and international research on results-based planning deals with land-based, motorized and urban transport issues. This presents a third challenge for implementation of such a program for northern transportation engineering and planning. The performance indicators recommended in the literature are seldom applicable in the northern context and do not address the unique transportation needs and constraints that are prevalent in the north. Further, data requirements for these systems are not sensitive to the issues discussed in the previous paragraph. While the literature provides useful guidance, development of a results-based framework for northern transportation requires that adaptations be made to recommended performance indicators so that they are applicable and relevant.

The fourth challenge relates to Canada's statement of national transportation policy. The course of transportation policy development in Canada has a decidedly southern focus. This is problematic when objectives and related performance indicators are derived from national transportation goals and these goals are not congruent with actual operating conditions. For example, the *Canada Transportation Act* envisions a transportation system driven by competition and reliant on market forces to achieve economic efficiency. These goals are generally not achievable in the north, where low traffic volumes and long distances make it difficult to have a competitive environment. The differences in transport infrastructure, services and operations in northern Canada compared to the south suggest a need for a separate northern transportation policy or, as a minimum, specific recognition of northern regions within the statement of national transport policy.

Finally, results-based planning requires government to be accountable to the public for their actions. The methodology proposed in this research presents the government with additional challenges in dealing with the ostensibly conflicting responsibilities of widely differing demographic groups and geographic regions. On one hand, the residents of northern communities deserve a transportation system that is accessible, efficient, safe and provides a basis for economic development initiatives within the community. Despite the small proportion of the Canadian population that will benefit from further investment, additional funding for northern transportation is required to improve performance towards these goals. On the other hand, southern Canadians may not appreciate or understand the inequitable conditions in northern communities and will oppose further funding because they view it as a disproportionate per capita allotment of funds. The government is accountable to both parties to meet what appear to be opposing objectives.

7.5. CONSIDERATIONS FOR FUTURE RESEARCH

The following considerations for future research emerge from this thesis:

- Extensive community and stakeholder consultations are essential for further development of the objectives and performance indicators developed in this research. Results-based planning is an ongoing process that must continually evolve and adapt to meet changing societal values and goals.

- Opportunities exist for new and expanded use of advanced technologies. Intelligent transportation systems (ITS) present innovative opportunities for improvements in the safety, efficiency and control of the northern transportation system. Research into what technologies are available and applicable in low volume markets and in isolated regions is constructive in determining how these technologies can be used most effectively in the northern context. The use of global positioning systems (GPS) to provide real-time positioning and two-way communication for truckers and personal vehicles traveling in the north is a particularly useful application of ITS technology.

- Application of advanced technologies also permits implementation of condition-based or "smart" regulation of the northern transportation system. Advanced technologies have been developed and introduced that are able to monitor/sense frozen ground conditions, advise decision-makers in real-time about operating conditions, evaluate appropriate regulation changes and communicate this information to the transport industry and general public (through web-based information systems). These types of applications are ideally suited to monitor and control the winter road system to optimize the safe operating window for winter road trucking and personal travel.

- One of the critical challenges for northern transportation engineering and planning is to bring forward useful information to the public while protecting the privacy and interests of northern communities, residents and providers of transport services. Manitoba Transportation and Government Services (MTGS) has recently added winter roads to their GIS highway basemap and are examining ways to incorporate winter road traffic data into the publicly available, provincial traffic information system (MHTIS). This requires knowledge of what types of data users want (total vehicle movements, truck traffic, commodity flows), what data should be made available to the public and how the data can be collected and disseminated in a manner that protects the interests of northerners and northern transport providers.

- Web-based mapping applications bring forward opportunities for improvement and innovation by: (1) disseminating transportation data in an open and accessible environment; (2) providing easily-accessible, integrated, transparent, centralized and interoperable data and information to transportation engineers, planners, government officials and members of the general public; (3) servicing decision-making through provision of more accurate, comprehensive, relevant and timely information; and (4) providing opportunity for data linking and integration with other geospatial data through web map and web feature services.

- The recent meeting between First Ministers and National Aboriginal Leaders (November 2005) has implications for transport policy and investment. Potential research considerations include the role that transport will play in attaining the goals outlined at the First Ministers meeting and the impacts that the planned development initiatives will have on the existing transport system.

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APPENDIX A

DETAILED COMMUNITY CLASSIFICATION INFORMATION

Remote Classification for Census Subdivisions in the North and North Transition Zones

Province	SGC Code	Census Subdivision Name	Location in North or Transition Zones	INAC Classification	INAC Geographic Zone	Remote Classification	Nearest Service Center	Distance to Nearest Service Center (km)
Manitoba	4621078	Division No. 21, Unorganized	North transition	-	-	N/A	N/A	N/A
Manitoba	4622046	Division No. 22, Unorganized	North transition	-	-	N/A	N/A	N/A
Manitoba	4623062	Division No. 23, Unorganized	North	-	-	N/A	N/A	N/A
Manitoba	4621041	Kelsey (Carrot Valley)	North transition	-	-	N/A	N/A	N/A
Manitoba	4622017	Mystery Lake	North	-	-	N/A	N/A	N/A
Manitoba	4621029	Chemawawin 2	North transition	C	2	Rural	The Pas	204
Manitoba	4619082	Chemawawin 3	North transition	C	2	Rural	The Pas	183
Manitoba	4622051	Cross Lake 19	North transition	C	2	Rural	Thompson	256
Manitoba	4622052	Cross Lake 19A	North transition	C	2	Rural	Thompson	256
Manitoba	4622053	Cross Lake 19B	North transition	C	2	Rural	Thompson	256
Manitoba	4622054	Cross Lake 19C	North transition	C	2	Rural	Thompson	256
Manitoba	4622067	Cross Lake 19E	North transition	C	2	Rural	Thompson	256
Manitoba	4621064	Flin Flon (Part)	North transition	-	-	Rural	The Pas	141
Manitoba	4623027	Fox Lake 2	North	D	2	Rural	Thompson	287
Manitoba	4623022	Gillam	North	-	-	Rural	Thompson	296
Manitoba	4623025	Gillam	North	-	-	Rural	Thompson	296
Manitoba	4621025	Grand Rapids	North transition	C	2	Rural	The Pas	262
Manitoba	4621027	Grand Rapids 33	North transition	C	2	Rural	The Pas	262
Manitoba	4621057	Kelsey (Cranberry Portage)	North transition	-	-	Rural	The Pas	87
Manitoba	4623034	Leaf Rapids	North	-	-	Rural	Thompson	213
Manitoba	4623047	Lynn Lake	North	-	-	Rural	Thompson	320
Manitoba	4621058	Moose Lake 31A	North transition	C	2	Rural	The Pas	101
Manitoba	4622059	Nelson House 170	North	D	2	Rural	Thompson	79
Manitoba	4622060	Nelson House 170A	North	D	2	Rural	Thompson	79
Manitoba	4622061	Nelson House 170B	North	D	2	Rural	Thompson	79
Manitoba	4622062	Nelson House 170C	North	D	2	Rural	Thompson	79
Manitoba	4622058	Norway House 17	North transition	C	2	Rural	Thompson	289
Manitoba	4621071	Snow Lake	North transition	-	-	Rural	The Pas	209
Manitoba	4622063	Split Lake 171	North	D	2	Rural	Thompson	131
Manitoba	4621053	Kelsey (Wanless)	North transition	-	-	Rural	The Pas	49
Manitoba	4621045	The Pas	North transition	Service Center		Service Center	N/A	N/A
Manitoba	4622026	Thompson	North	Service Center		Service Center	N/A	N/A
Manitoba	4623065	Brochet 197	North	D4	4	Special Access	Thompson	326
Manitoba	4623056	Churchill	North	-	-	Special Access	Thompson	394
Manitoba	4623058	Churchill 1	North	-	-	Special Access	Thompson	394
Manitoba	4622048	Garden Hill First Nation	North transition	C5	4	Special Access	Winnipeg	470
Manitoba	4622049	God's Lake 23	North	C6	4	Special Access	Winnipeg	563

Province	SGC Code	Census Subdivision Name	Location in North or Transition Zones	INAC Classification	INAC Geographic Zone	Remote Classification	Nearest Service Center	Distance to Nearest Service Center (km)
Manitoba	4622055	God's River 86A	North	C6	4	Special Access	Winnipeg	582
Manitoba	4623063	Highrock 199	North	-	-	Special Access	Thompson	157
Manitoba	4622064	Ilford	North	-	-	Special Access	Thompson	143
Manitoba	4623067	Lac Brochet 197A	North	D4	4	Special Access	Thompson	379
Manitoba	4619051	Little Grand Rapids 14	North transition	C4	4	Special Access	Winnipeg	265
Manitoba	4622050	Oxford House 24	North	C6	4	Special Access	Winnipeg	570
Manitoba	4619079	Pauingassi First Nation	North transition	C4	4	Special Access	Winnipeg	279
Manitoba	4619075	Poplar River 16	North transition	C4	4	Special Access	Winnipeg	340
Manitoba	4623064	Pukatawagan 198	North transition	D2	4	Special Access	Thompson	212
Manitoba	4622056	Red Sucker Lake 1976	North	C6	4	Special Access	Winnipeg	529
Manitoba	4623071	Shamattawa 1	North	D4	4	Special Access	Thompson	354
Manitoba	4623037	South Indian Lake	North	-	-	Special Access	Thompson	131
Manitoba	4622801	St. Theresa Point	North transition	C5	4	Special Access	Winnipeg	461
Manitoba	4622800	Wasagamack	North transition	C6	4	Special Access	Winnipeg	465
Manitoba	4622065	York Landing	North	D1	4	Special Access	Thompson	114
Manitoba	4623039	Granville Lake	North	-	-	Special Access	Thompson	173
Manitoba	4621033	Opaskwayak Cree Nation 21A	North transition	C	1	Urban	The Pas	N/A
Manitoba	4621043	Opaskwayak Cree Nation 21AE	North transition	C	1	Urban	The Pas	N/A
Manitoba	4621040	Opaskwayak Cree Nation 21AI	North transition	C	1	Urban	The Pas	N/A
Manitoba	4621034	Opaskwayak Cree Nation 21B	North transition	C	1	Urban	The Pas	N/A
Manitoba	4621035	Opaskwayak Cree Nation 21C	North transition	C	1	Urban	The Pas	N/A
Nunavut	6105033	Keewatin, Unorganized	North	-	-	N/A	N/A	N/A
Nunavut	6105015	Arviat	North	-	-	Special Access	Thompson	621
Nunavut	6105023	Baker Lake	North	-	-	Special Access	Thompson	935
Nunavut	6105019	Chesterfield Inlet	North	-	-	Special Access	Thompson	911
Nunavut	6105014	Coral Harbour	North	-	-	Special Access	Thompson	1205
Nunavut	6105017	Rankin Inlet	North	-	-	Special Access	Thompson	830
Nunavut	6105027	Repulse Bay	North	-	-	Special Access	Thompson	1312
Nunavut	6105016	Whale Cove	North	-	-	Special Access	Thompson	756

Notes:
- Road distances for rural communities calculated using provincial road map (Rand McNally 2004)
- Distances to service centers for special access communities are approximated as the straight line distance (calculated using the "measure distance" tool in GeoMedia)
- INAC classifications are used where available. Classifications determined for non-reserve communities using INAC criteria
- Classifications are not applicable to unorganized districts, local government districts and rural municipalities that span a large geographic area
- Churchill and Churchill 1 are considered to be a single unit for the purposes of this research. All statistics are the aggregate of the combined census subdivisions
- Sources - McNiven & Purderer (2000) and INAC (2005)

APPENDIX B

METADATA

Spatial Datasets and the Availability of Detailed Metadata

Spatial Dataset	Original Data Source	Original Dataset Name	Detailed Metadata Available	Metadata Source
MLI_Highways	Manitoba Land Initiative	roadseg.shp	In progress	n/a
MLI_Winter_Roads	Manitoba Land Initiative	roadseg.shp	In progress	n/a
Ferry_Segments	Manitoba Land Initiative	roadseg.shp	In progress	n/a
Rail_Network	GeoGratis	rail_l	yes	http://geogratis.cgdi.gc.ca/clf/en?action=fullMetadata&entryId=27752
Canada_Boundaries	GeoGratis	bnd2005_p	yes	http://geogratis.cgdi.gc.ca/clf/en?action=fullMetadata&entryId=27728
Remote_Communities	GeoGratis	popplace_pt	yes	http://geogratis.cgdi.gc.ca/clf/en?action=fullMetadata&entryId=27751
MB_NU_CSD	GeoGratis	sgc_lambert	yes	http://geogratis.cgdi.gc.ca/clf/en?action=fullMetadata&entryId=1010
Kivalliq_Region_Communities	GeoGratis	sgc_lambert	yes	http://geogratis.cgdi.gc.ca/clf/en?action=fullMetadata&entryId=1010
Kivalliq_Region_Unorganized	GeoGratis	sgc_lambert	yes	http://geogratis.cgdi.gc.ca/clf/en?action=fullMetadata&entryId=1010
MB_Northern_CSD	GeoGratis	sgc_lambert	yes	http://geogratis.cgdi.gc.ca/clf/en?action=fullMetadata&entryId=1010
Rail_Stations	C Isaacs	Rail_Stations	no	n/a
Airports	C Isaacs	Airports	no	n/a
Air_Routes	C Isaacs	Air_Routes	no	n/a
Shipping_Routes	C Isaacs	Shipping_Routes	no	n/a
North_South_Line	C Isaacs	North_South_Line	no	n/a
Canada_Lakes	Transport Canada	Canada_Lakes	no	n/a
Canada_Rivers	Transport Canada	Canada_Rivers	no	n/a
Mineral_Exploration_Licenses	Manitoba Industry, Economic Development and Mines	mineral_exploration_licenses	no	n/a
Mineral_Occurrence	Manitoba Industry, Economic Development and Mines	mineral_occurrence	no	n/a
Mining_Claims	Manitoba Industry, Economic Development and Mines	mining_claims	no	n/a

GeoMedia Custom Warehouses

Base Map Geography Warehouse:

Map Projection:

Map Projection Name: Lambert Conformal Conic
Lambert Conformal Conic:
Standard Parallel: 49.000000
Standard Parallel: 77.000000
Longitude of Central Meridian: -95.000000
Latitude of Projection Origin: 49.000000
False Easting: 0.000000
False Northing: 0.000000
Planar Distance Units: metres

Geodetic Model:

Horizontal Datum Name: North American Datum of 1983
Ellipsoid Name: Geodetic Reference System 80
Semi-major Axis: 6378137.000000
Denominator of Flattening Ratio: 298.257222

Feature Classes:

1. Kivalliq_Region_Communities
   - Selection set of the 7 census subdivisions in the Kivalliq region of Nunavut
   - Original data source GeoGratis: sgc_lambert

2. Kivalliq_Region_Unorganized
   - Spatial intersection of bnd2005_p and sgc_lambert
   - Selected features from bnd2005 that touched census subdivision Kivalliq, Unorganized (SGC Code 6205033)
   - Original data sources GeoGratis: sgc_lambert and GeoGratis: bnd2005_p

3. MB_NU_CSD
   - Selection set of all the census subdivisions in Manitoba and Nunavut
   - Original data source GeoGratis: sgc_lambert

4. North_CSD
   - Import table from CSD Classification – Statistics Canada.xls (TIS Laptop/ C:\Users\Crystal\Thesis\Stats Can Data)
   - Data derived from Statistics Canada
     a. *Table 35: Census Subdivisions showing Population, MIZ Category and North/South Location, 1996 Census* (Available at http://www.statcan.ca/english/ research/92F0138MIE/00001/2000_1.htm)

   b. *Concordance: Standard Geographical Classification (SGC) 1996 - Standard Geographical Classification (SGC) 2001* (Available at http://stds.statcan.ca/english/sgc/2001/2001-sgc96-to-sgc01.asp)

5. MB_Northern_CSD
   - Joined table from North_CSD and MB_NU_CSD
   - Selection set of the census subdivisions in Manitoba classified as "north" or "north transition" according to the MIZ and North Classification
   - Raw data source: *Table 35: Census Subdivisions showing Population, MIZ Category and North/South Location, 1996 Census* (Available at http://www.statcan.ca/english/research/92F0138MIE/00001/2000_1.htm)
   - Spatial data source GeoGratis: sgc_lambert

6. Canada_Boundaries
   - Selection set of the provinces and territories in Canada (not including the "exclusive economic zone")
   - Original data source GeoGratis: bnd2005_p

7. Remote_Communities
   - Selection set of the remote communities in northern Manitoba and the Keewatin Region of Nunavut
   - Original data source GeoGratis: popplace_pt
   - Coordinates for Wasagamack obtained from INAC (community appended to GeoGratis table using GeoMedia spatial editing features)

8. Canada_Lakes
   - Selection set of the major lakes in Canada
   - Original data source Transport Canada: Canada_Lakes

9. Canada_Rivers
   - Selection set of the major rivers in Canada
   - Original data source Transport Canada: Canada_Rivers

10. North_South_Line
   - Approximation of the north-south line developed by NcNiven and Purderer (2000)
   - Lines drawn by C. Isaacs using GeoMedia spatial editing tools

GeoMedia Custom Warehouses

Transportation System Warehouse:

Map Projection:

Map Projection Name: Lambert Conformal Conic
Lambert Conformal Conic:
Standard Parallel: 49.000000
Standard Parallel: 77.000000
Longitude of Central Meridian: -95.000000
Latitude of Projection Origin: 49.000000
False Easting: 0.000000
False Northing: 0.000000
Planar Distance Units: metres

Geodetic Model:

Horizontal Datum Name: North American Datum of 1983
Ellipsoid Name: Geodetic Reference System 80
Semi-major Axis: 6378137.000000
Denominator of Flattening Ratio: 298.257222

Feature Classes:

1. Rail_Network
   - Canadian rail network
   - Original data source: GeoGratis rail_1

2. Rail_Stations
   - Selected rail stations on the Hudson Bay Railway (HBR) route
   - Point features created by C. Isaacs using GeoMedia spatial editing tools

3. MLI_Winter_Roads
   - Selection set of NATRDCLASS = "winter"
   - Original data source: MLI Core Maps – Data Warehouse (roadseg.shp)
     Manitoba - National Road Network
     UTM Zone 14 NAD 83
     http://web2.gov.mb.ca/mli/roads_hwys/index.html

4. Ferry_Segments
   - Ferry segments that are components in the Manitoba highway network
   - Original data source: MLI Core Maps – Data Warehouse (ferryseg.shp)
     Manitoba - National Road Network
     UTM Zone 14 NAD 83
     http://web2.gov.mb.ca/mli/roads_hwys/index.html

5. MLI_Highways
   - Selection set of NATRDCLASS = "Expressway / Highway"
   - Original data source: MLI Core Maps – Data Warehouse (roadseg.shp)
     Manitoba - National Road Network
     UTM Zone 14 NAD 83
     http://web2.gov.mb.ca/mli/roads_hwys/index.html

6. Airports
   - Selection set of special access communities with airports
   - Point features created by C. Isaacs using GeoMedia spatial editing tools
   - Attribute table populated from the Canada Flight Supplement (2001) and Transport Canada SARCIS

7. Air_Routes
   - Linear features depicting the air routes between special access communities
   - Air routes determined from published commercial air schedules
   - Lines drawn by C. Isaacs using GeoMedia spatial editing tools

8. Shipping_Routes
   - Linear features depicting the approximate shipping routes to Kivalliq region communities
   - Routes derived from Shortsea Shipping Workshop (2003) presentations
   - Lines drawn by C. Isaacs using GeoMedia spatial editing tools

GeoMedia Custom Warehouses

Demand System Warehouse:

Map Projection:

Map Projection Name: Lambert Conformal Conic
Lambert Conformal Conic:
Standard Parallel: 49.000000
Standard Parallel: 77.000000
Longitude of Central Meridian: -95.000000
Latitude of Projection Origin: 49.000000
False Easting: 0.000000
False Northing: 0.000000
Planar Distance Units: metres

Geodetic Model:

Horizontal Datum Name: North American Datum of 1983
Ellipsoid Name: Geodetic Reference System 80
Semi-major Axis: 6378137.000000
Denominator of Flattening Ratio: 298.257222

Feature Classes:

1. Mineral_Exploration_Licenses
   - Area features representing active mineral exploration licenses in northern Manitoba
   - Original data source Manitoba Industry, Economic Development and Mines: mineral_exploration_licenses

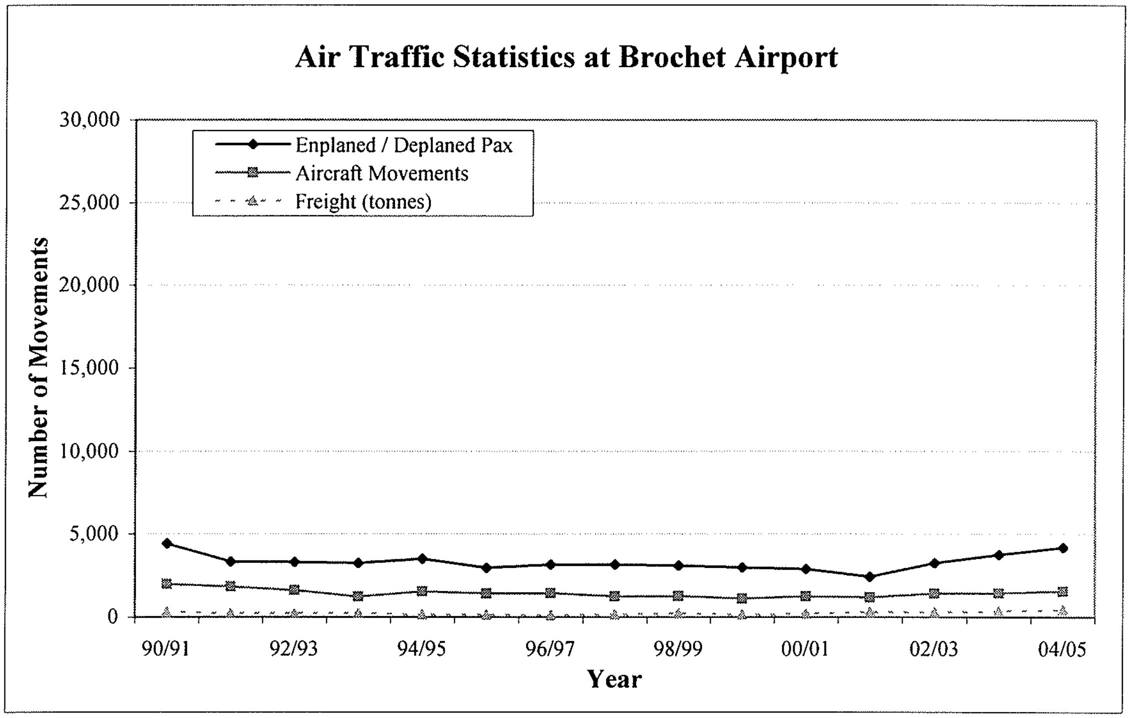
2. Mining_Claims
   - Area features representing active mining claims in northern Manitoba
   - Original data source Manitoba Industry, Economic Development and Mines: mining_claims

3. Mineral_Occurrences
   - Point features representing location and type of mineral occurrences in northern Manitoba
   - Original data source Manitoba Industry, Economic Development and Mines: mineral_occurrences

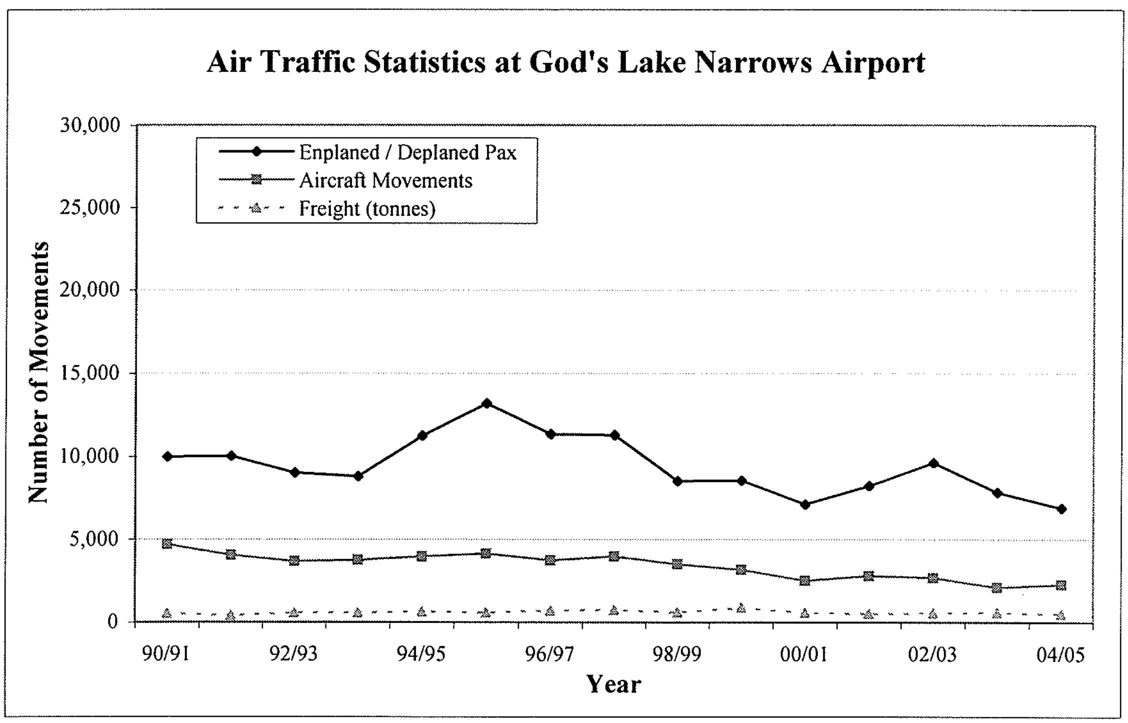
APPENDIX C

AIR TRAFFIC STATISTICS

Air Traffic Statistics - Northern Manitoba Airports

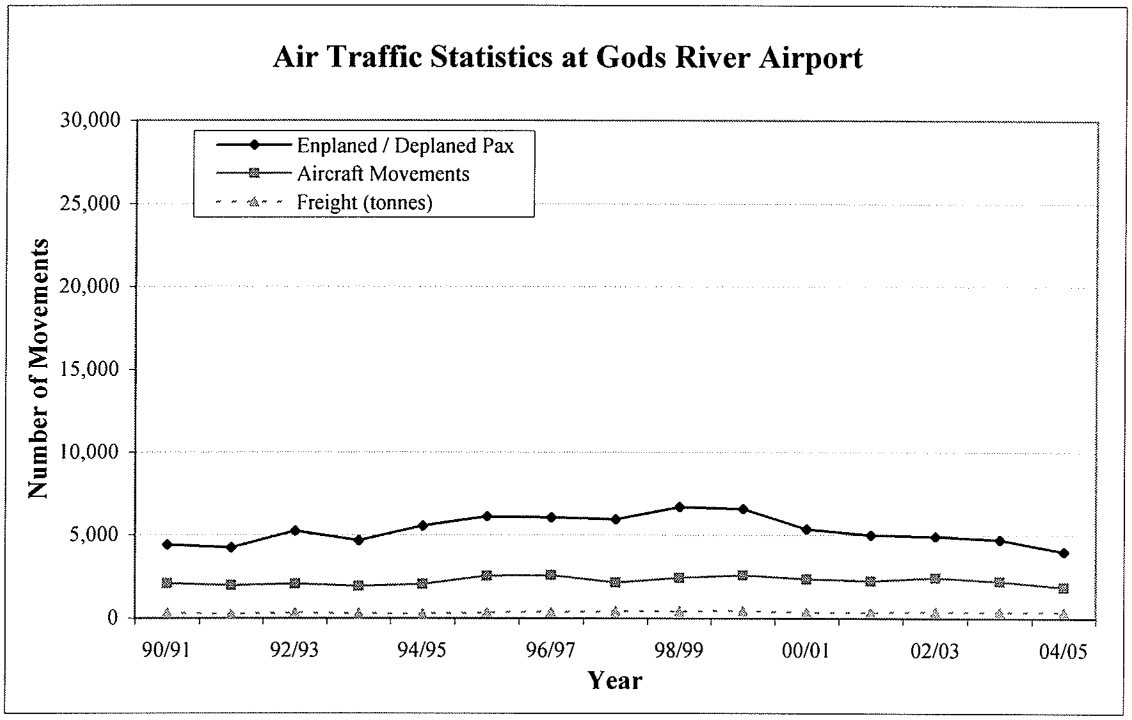


Source: Raw data provided by MTGS (2005c)

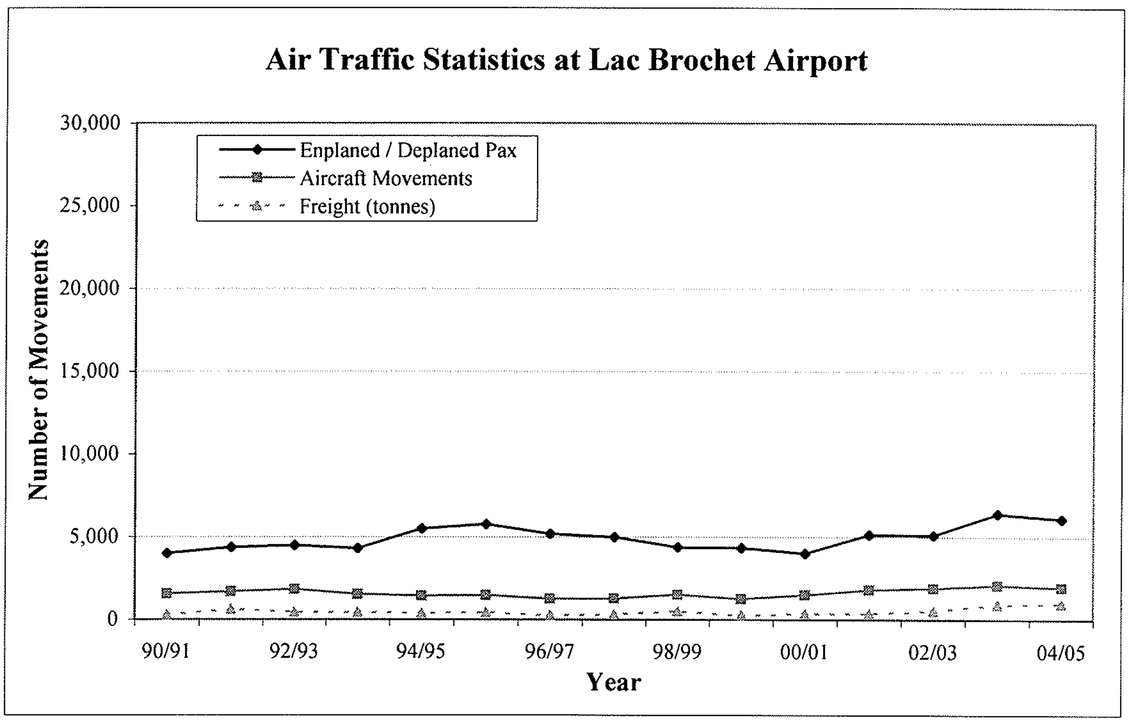


Source: Raw data provided by MTGS (2005c)

Air Traffic Statistics - Northern Manitoba Airports

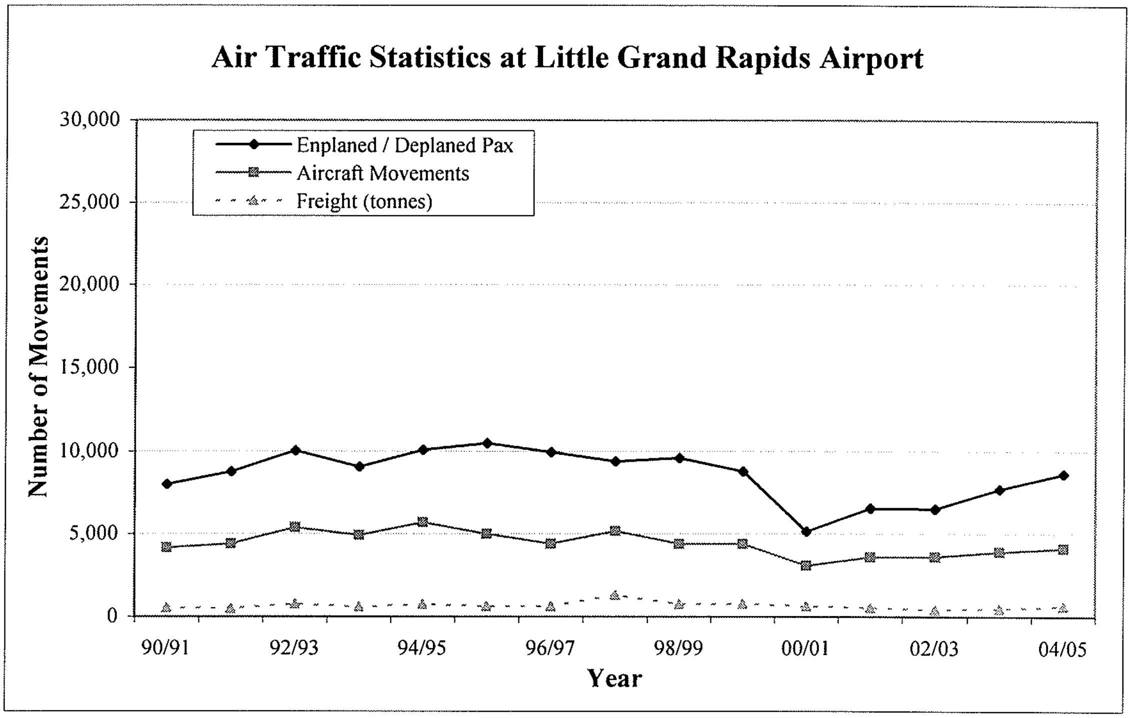


Source: Raw data provided by MTGS (2005c)

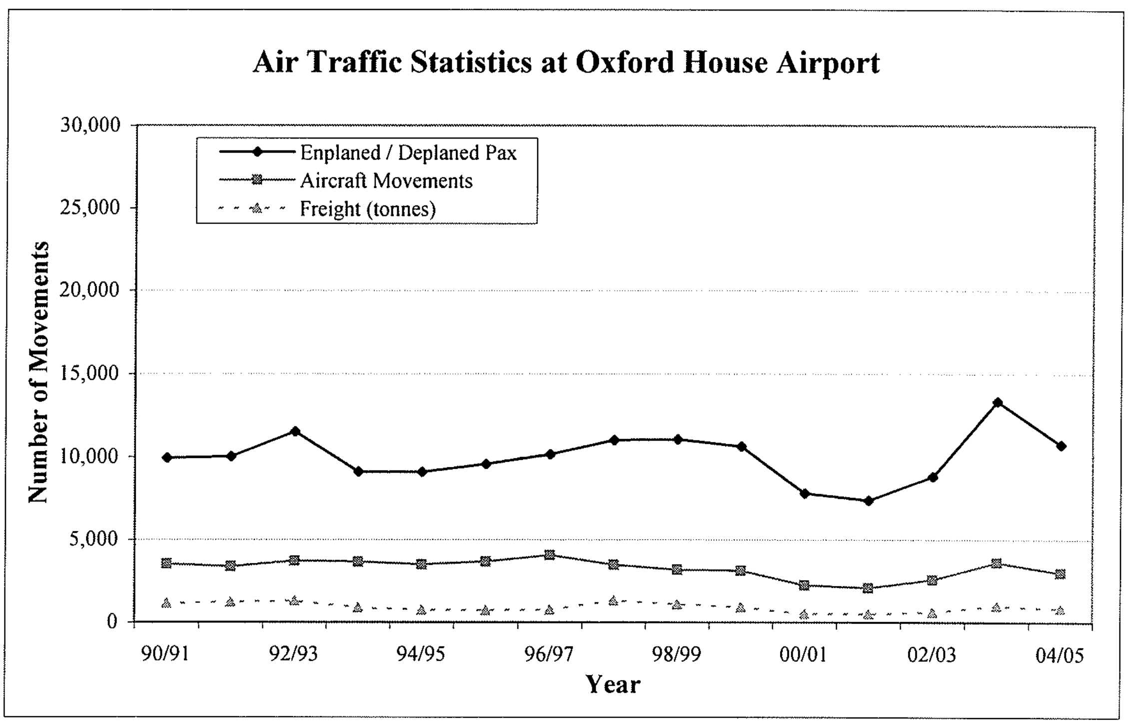


Source: Raw data provided by MTGS (2005c)

Air Traffic Statistics - Northern Manitoba Airports



Source: Raw data provided by MTGS (2005c)



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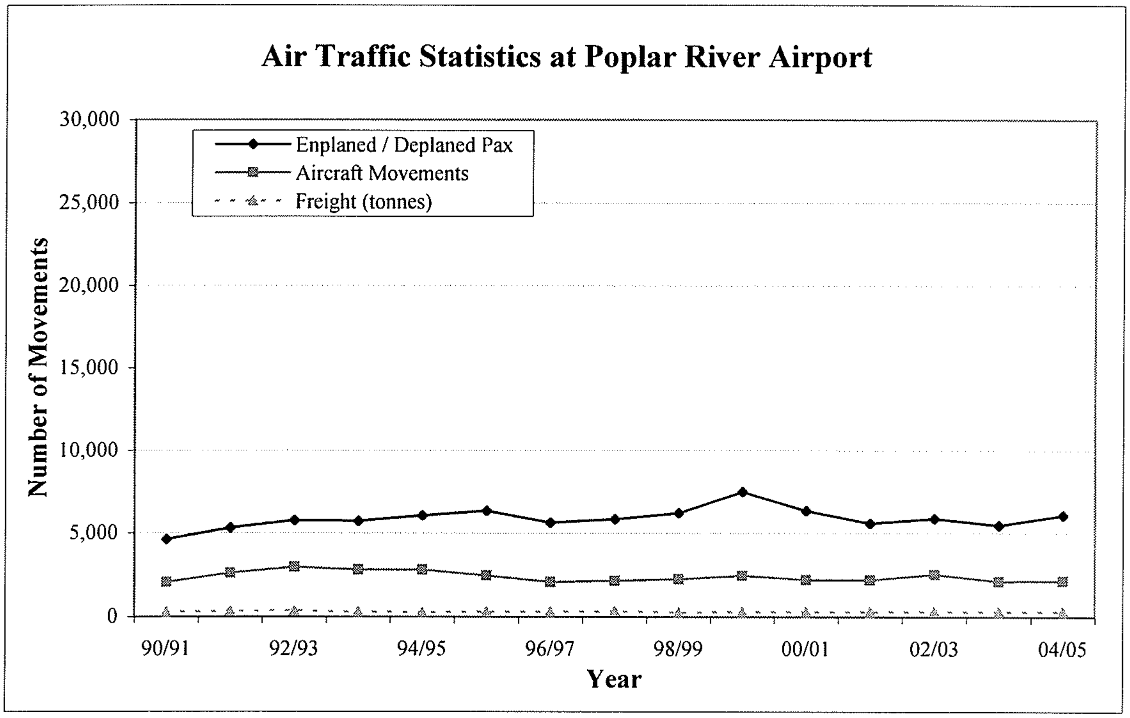
Air Traffic Statistics - Northern Manitoba Airports



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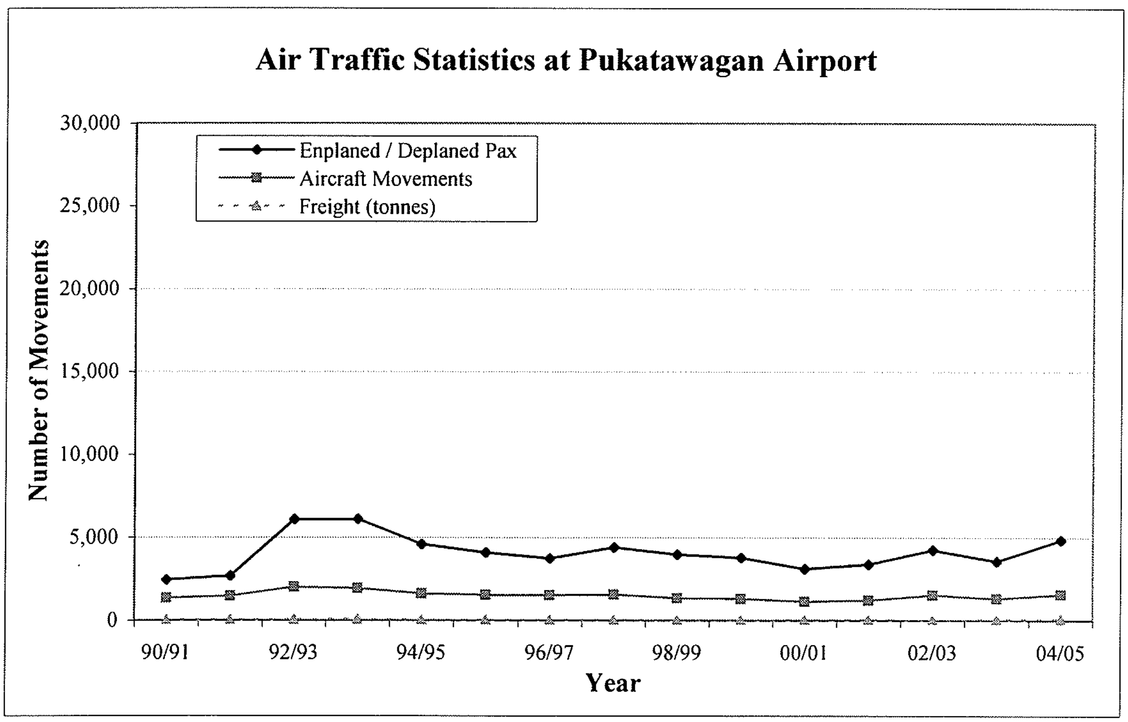

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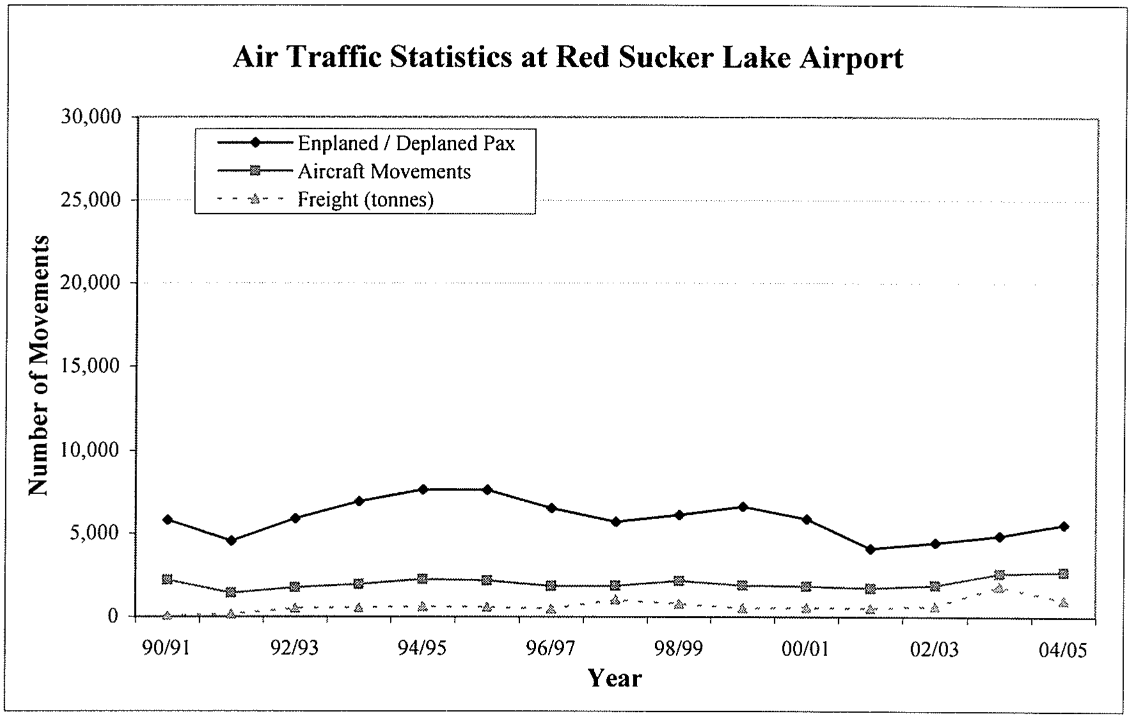
Air Traffic Statistics - Northern Manitoba Airports



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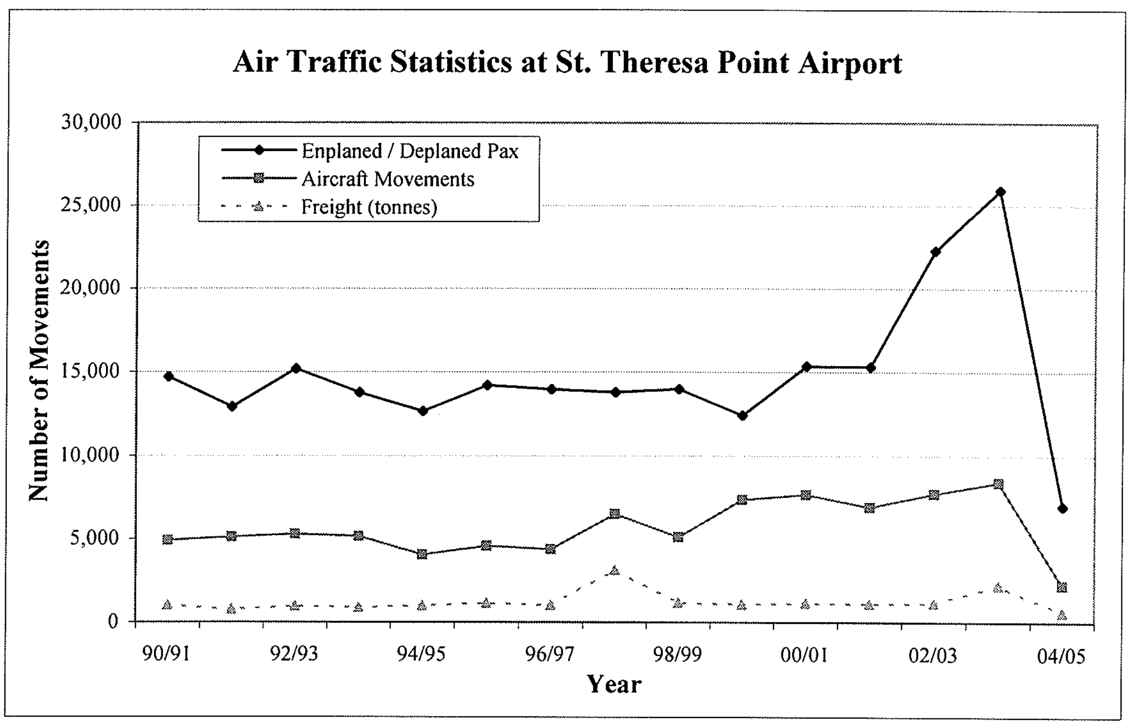

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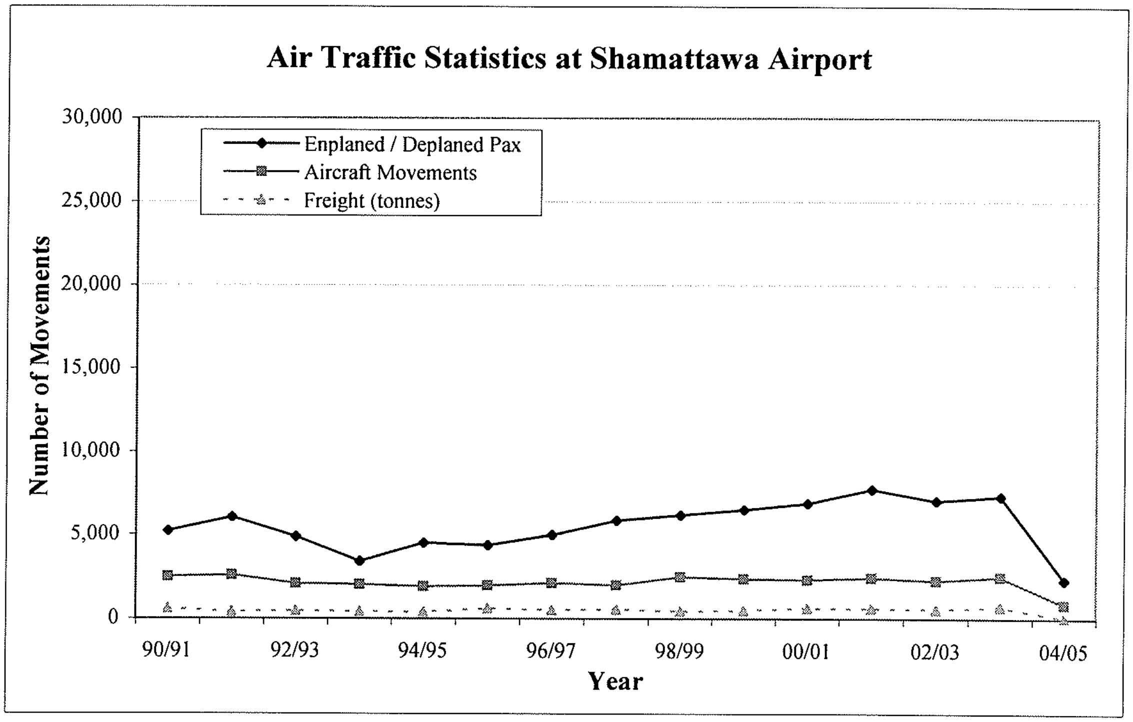
Air Traffic Statistics - Northern Manitoba Airports



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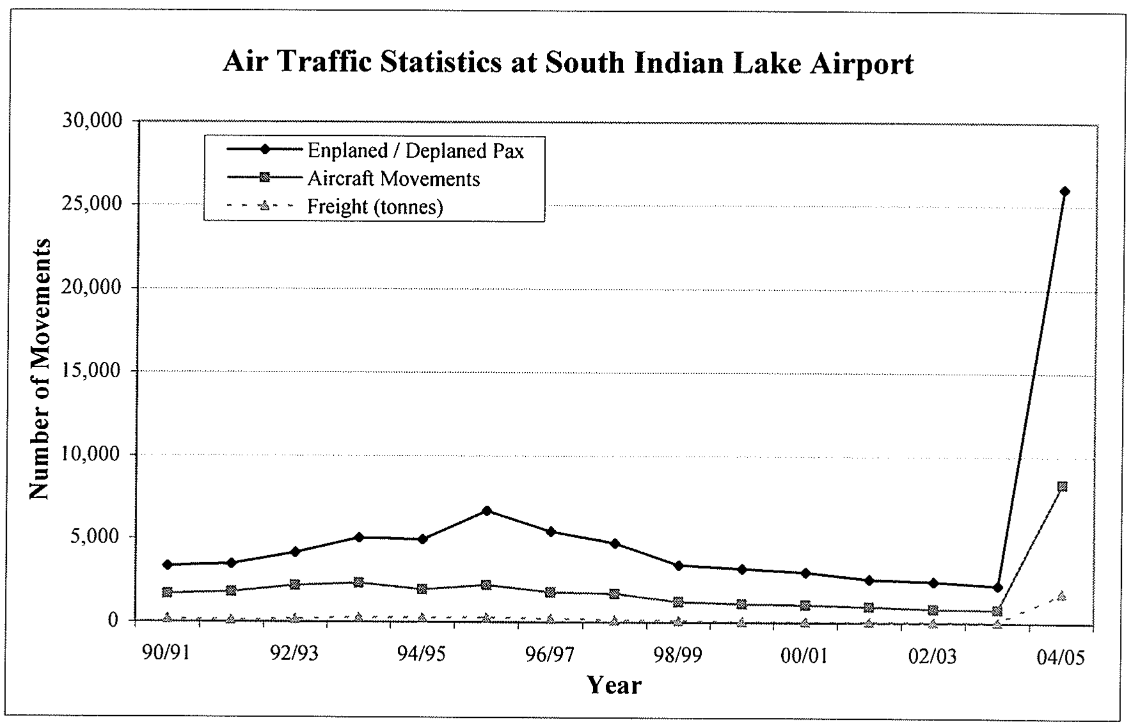

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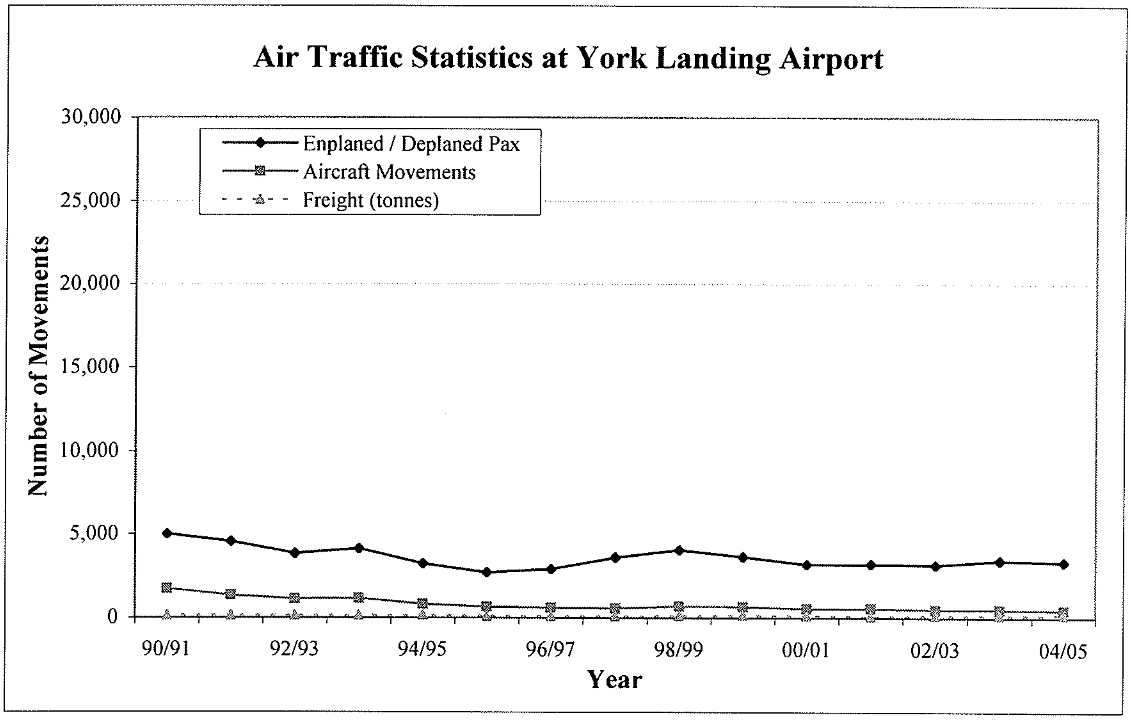
Air Traffic Statistics - Northern Manitoba Airports



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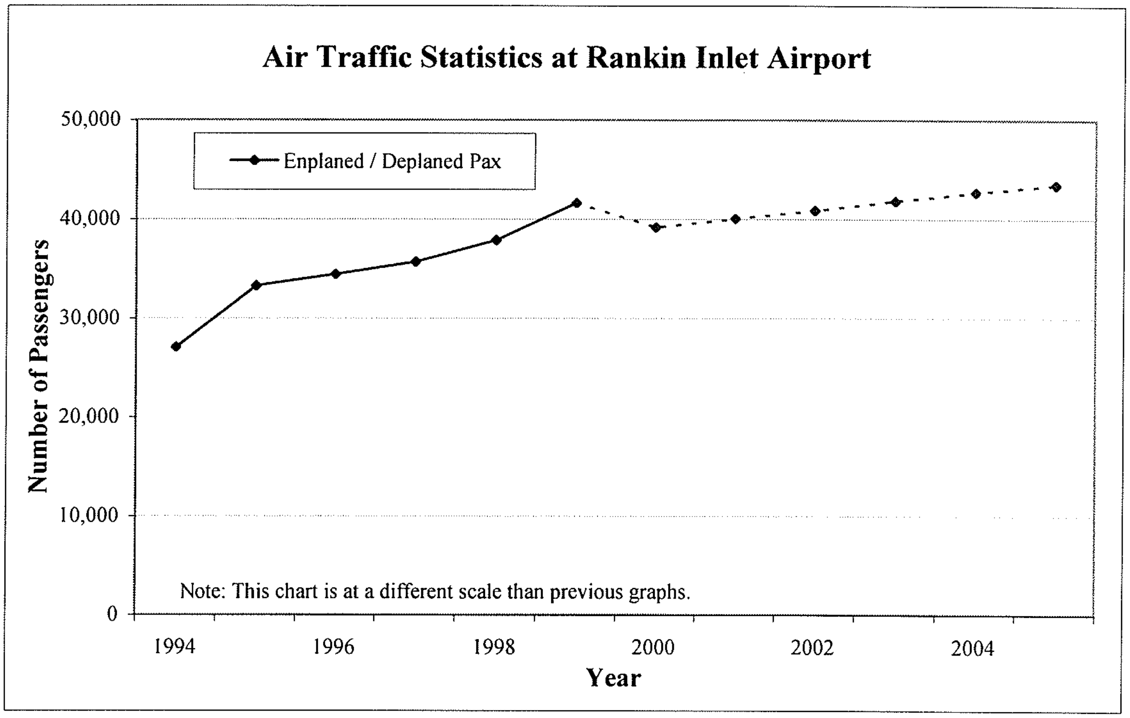
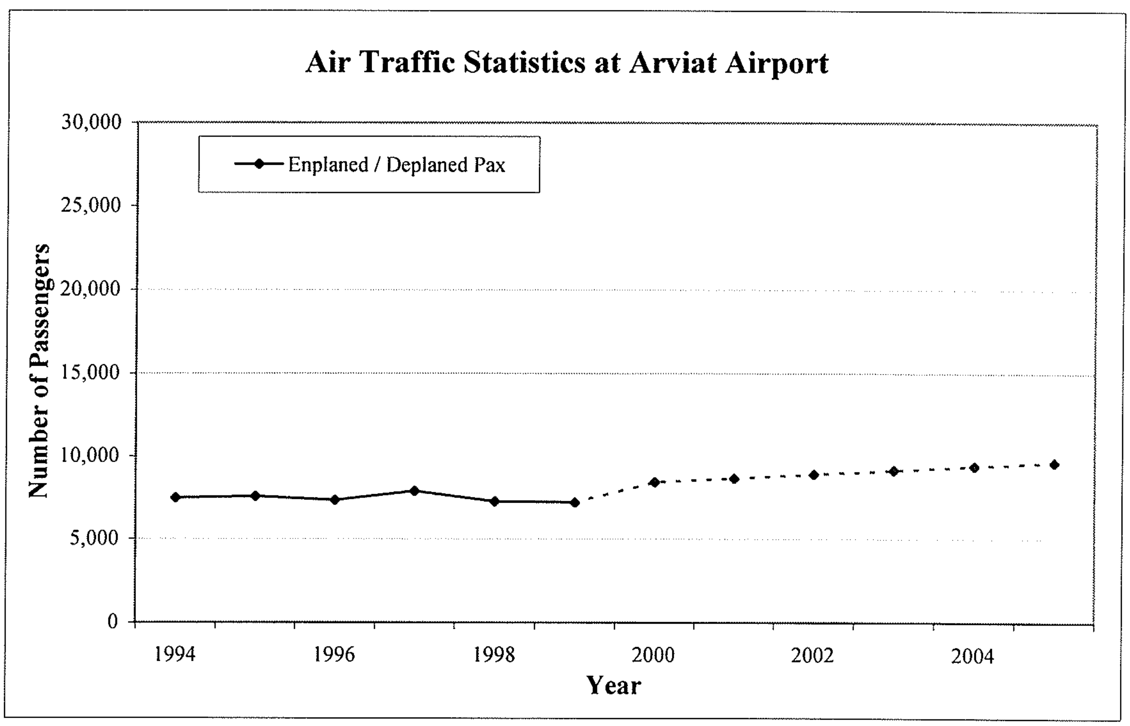
Air Traffic Statistics - Kivalliq Region Airports



Source: Raw data provided by Government of Nunavut (2001)
2000-2005 Statistics estimated using population projections and "propensity to travel"



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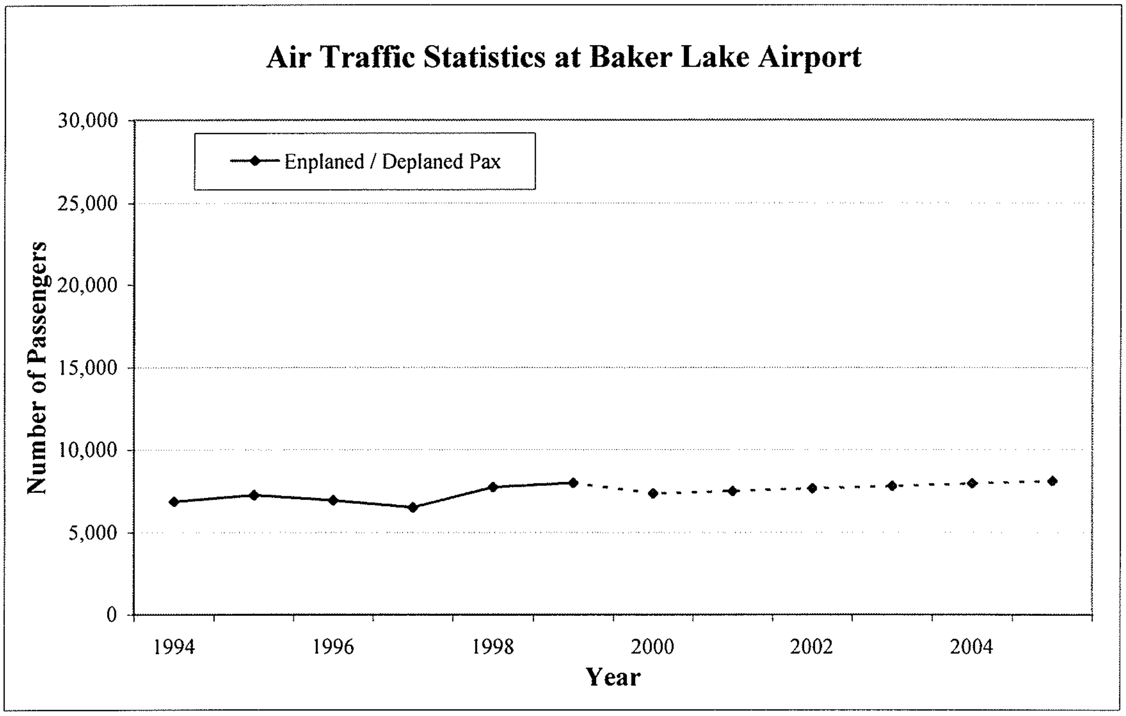
2000-2005 Statistics estimated using population projections and "propensity to travel"

Air Traffic Statistics - Kivalliq Region Airports



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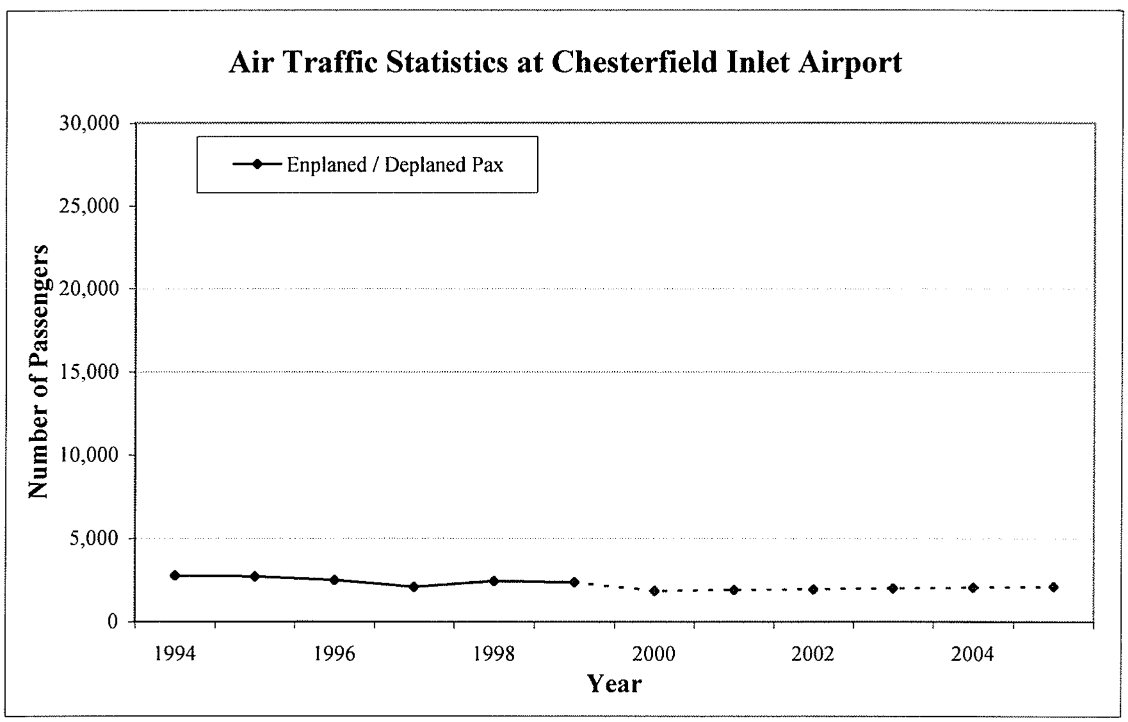

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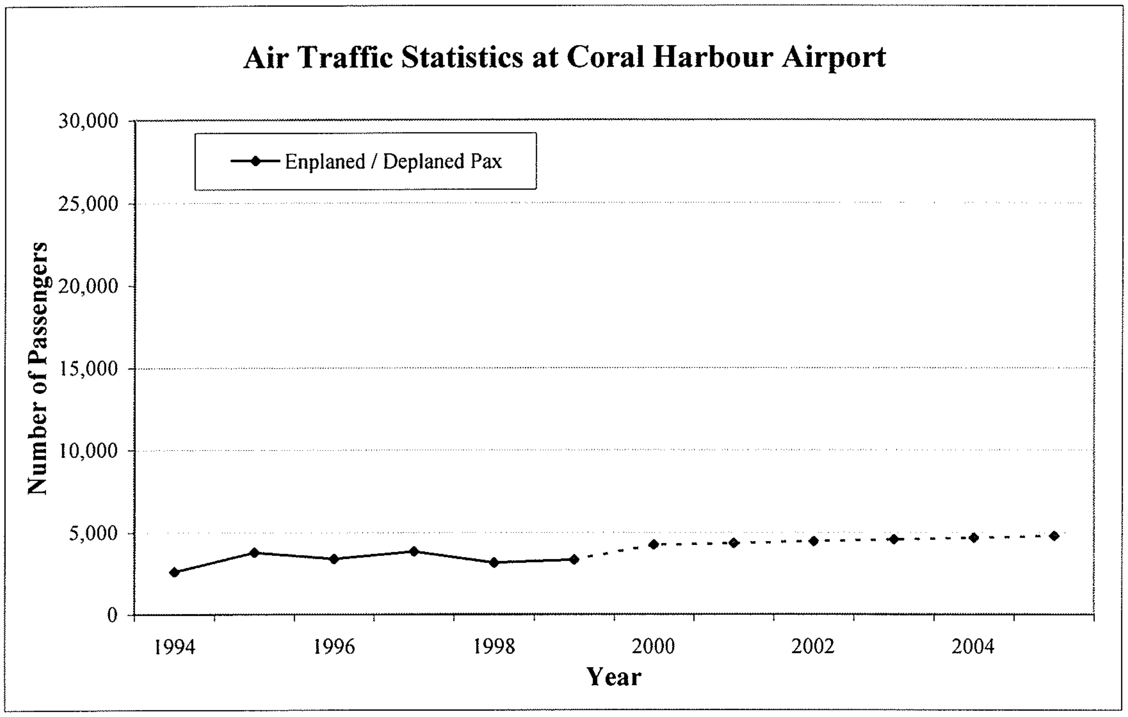
Air Traffic Statistics - Kivalliq Region Airports



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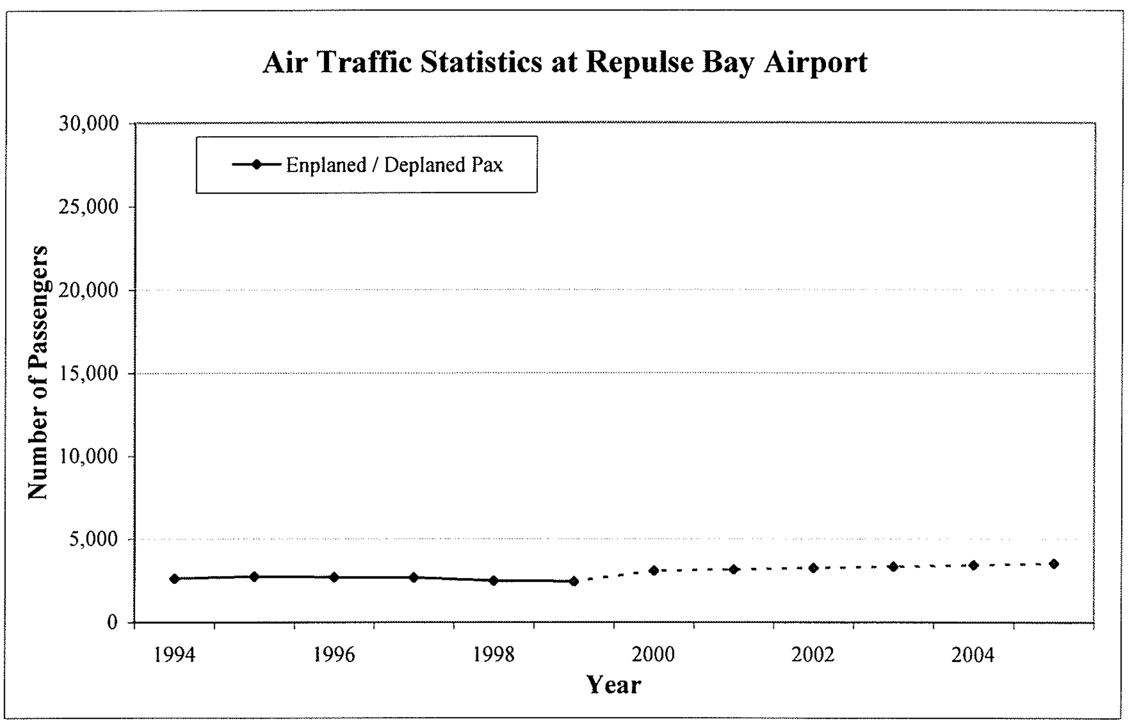

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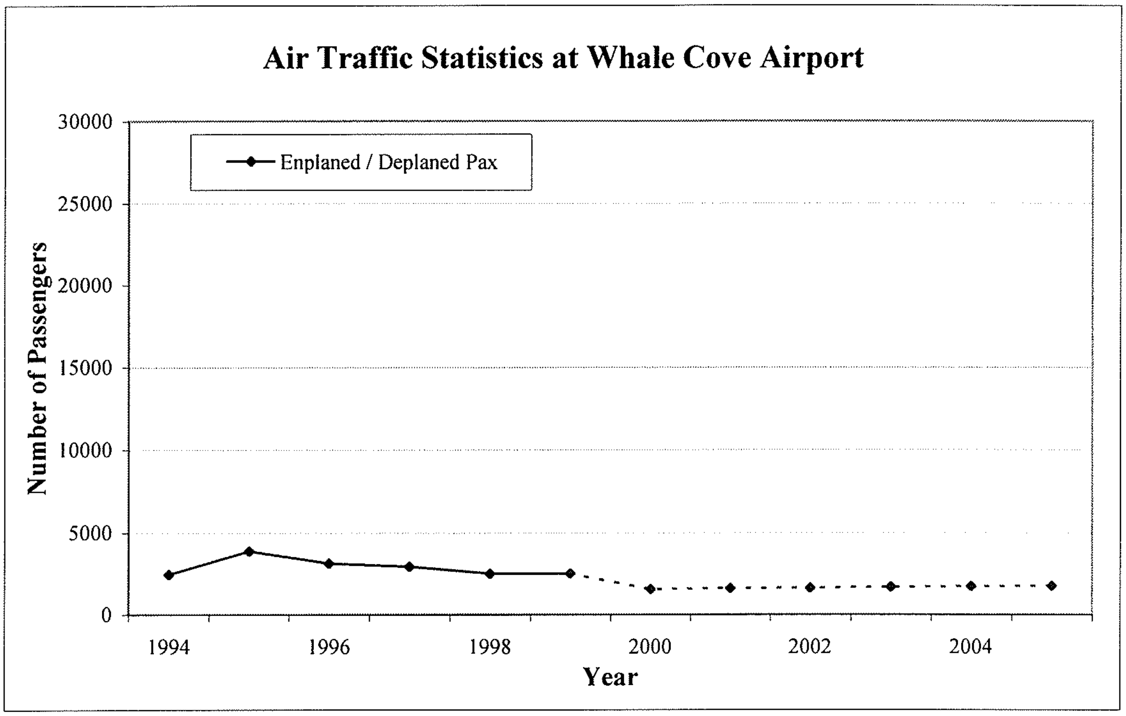
Air Traffic Statistics - Kivalliq Region Airports



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2000-2005 Statistics estimated using population projections and "propensity to travel"