No Roads to Riches:
Meeting Future Travel Demand in Alberta

by

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Abstract

Within Canada, Alberta is projected to be one fastest growing provinces, both in demographics and size of its economy. If current trends continue, its transportation network will need to grow significantly to facilitate the future movement of goods and people. This study looks specifically at the transportation corridor between Alberta's two largest cities of Edmonton and Calgary. This study's projections and highway capacity analysis predict that the main highway between the two cities will not be able to meet future demand; as a result, commercial traffic movements will halt and will severely hinder the Albertan Economy.

This study looks at three different infrastructure investments to accommodate future traffic growth, including addition lane upgrades, bypass routes, and a high speed rail line. The results of multi criteria analysis finds that construction of additional lanes upgrades will maintain traffic flow within the Edmonton Calgary transportation corridor.

Keywords: Alberta, Transportation Planning, Travel Demand, Capacity Analysis, Level of Service

Dedication

This thesis is dedicated to my parents, my brothers, and the countless teachers who supported my dream of higher education. If not for them, I would be still driving delivery. I have never been the best student; I have never felt brilliant nor talented by any standard; however, I have had the ability to surround myself with amazing people, and that made me best man I could ever be.

My parents' love and support cultivated the work ethic necessary for me to finish this study and excel at whatever I do after it. My brothers Scott and Derek provided me examples of character that I always strive to live up to. Without their friendship, I would not have been tough enough to complete my education. Finally, along my long journey as a student, there were many teachers who had patience to deal with me as an average student. Their guidance has given me the competence to rise above that, which I will take forward in all my endeavors.

There are no words I can write to show the appreciation I have for the people in my life. Thank you everyone.

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Finally this thesis would not have been possible if not for the expertise and cooperation of the staff at Alberta Transportation. Their generosity with their time made much of my analysis possible.

Table of Contents

List of Tables

List of Figures

List of Acronyms

AADT	Average Annualized Daily Traffic
CS	Control Section
ECTC	Edmonton Calgary Transportation Corridor
GOA	Government of Alberta
LOS	Level of Service
QE2	Queen Elizabeth Number 2 Highway
SFU	Simon Fraser University
TCS	Traffic Control Section
WAADT	Weighted Average Annualized Daily Traffic

Glossary

Control Section	A unit of analysis of road length. It is also an aggregation of traffic control sections. Usually represents a regional characteristic of a long section of road. For example, if the road is a rural or urban route.
Level of service	Refers to methodology to analyze congestion. Also is a rank assigned to road segments by the level of service methodology.
Right of way	Land purchased by government for infrastructure investment.
Road segment	A specific point on the highway. Smallest unit of analysis for traffic length. It is the unit of analysis that traffic data is gathered from.
Traffic Control Section	A unit of analysis of road length. It is an aggregation of road segments grouped by similar characteristics such as growth rate and traffic composition.

Executive Summary

Alberta is the fastest growing province in the last decade, both in terms of economy and population. If this growth continues into the future, there will be increased demands placed upon the provincial transportation network. This study aims to analyze future growth in travel demand between the two major cities of Edmonton and Calgary. This region, known as the Edmonton-Calgary transportation corridor, is reliant on efficient travel along the Queen Elizabeth number 2 Highway. This study's analysis is based off projections made in order to understand what daily traffic on the Queen Elizabeth number 2 Highway could look like in the future. Using these projections with the Transportation Research Board's level of service methodology, this study found that even the province's immediate plans to expand the highway's capacity will be insufficient.

As a result, this study then tests estimated impacts of three potential infrastructure projects as policy options to deal with future congestion. These options include addition lane additions to the Queen Elizabeth number 2 Highway; bypasses of the cities of Airdrie, Red Deer, and Nisku; and a high speed rail line between the cities of Edmonton and Calgary.

These policy options are evaluated on the basis of four criteria. An effectiveness criterion is based off each option's ability to reduce congestion on the Queen Elizabeth number 2 Highway. This is measured using the level of service methodology. A cost criterion is applied to each option, measured by comparing the capital cost of each project. An implementation criterion is also considered that focuses on the complex land purchase and municipal negotiations required to implement each policy option. Finally, a government acceptability criterion is used evaluate the amount of government action required to implement each option.

The results of the multi-criterion analysis recommends continued lane expansion on the Queen Elizabeth number 2 Highway. However, the highway bypass option also ranks high and initial planning for its future implementation is recommended for

consideration. Overall, high speed rail performed poorly in the analysis. As a result, its implementation should not be prioritized.

Chapter 1.

Introduction

The province of Alberta has experienced high rates of population and economic growth since the early 2000's. One aspect of this growth is the increased demand for interconnectedness of both people and their productive activities, a major manifestation of which is the development of an expansive transportation network. This study projects that the current transportation network between Alberta's two largest cities is inadequate to meet future travel demand. If no action is taken, then commercial traffic flow that acts as the major arteries of the Albertan economy will be severed, halting productive economic activity and slowing future growth in the province.

Using highway capacity analysis, this paper explores three potential options for meeting the future travel demand in the Edmonton Calgary Transportation Corridor (ECTC). Policy options are large infrastructure investments including, 30 kilometers of lane addition to the Queen Elizabeth number 2 Highway: three major bypass routes around the cities of Airdrie, Red Deer and Nisku: and a high speed rail line between Edmonton and Calgary. Options are analyzed based on criteria of effectiveness, cost, implementation complexity and government acceptability. The results of this analysis show that the current strategy of adding additional capacity to the Queen Elizabeth number 2 highway is the best option.

Chapter 2.

The Province of Alberta

This chapter provides background information on the province of Alberta where the Edmonton Calgary Transportation Corridor (ECTC) is located. Section 2.1 discusses the basic geography of the province: section 2.2 describes the growing population in Alberta and the projections of growth along the ECTC.

2.1. The Geography

The province of Alberta is located in western Canada. Most of the geography of Alberta is relatively flat prairie land, except to the west, where the Rocky Mountains form the border of the province. The ECTC is located in the southern half of the province in the middle of the flat prairie land. This is fortunate because there is minimal rough terrain for linear infrastructure like roads or railways to navigate, unlike many other transportation corridors.

The province of Alberta has a significant amount of surface water, characterized by meandering streams: the most significant water way that the Edmonton-Calgary Transportation corridor crosses is the Red Deer River. These waterways provide one of the few engineering challenges along the ECTC.

2.2. The Population

Since 2009, Alberta's population has grown faster than any other province (Statistics Canada, 2014a). Alberta's population is increasing both naturally, by sharing the highest birth rate and having the lowest mortality of all the provinces, and, significantly, from immigration. Alberta has the highest interprovincial migration growth rate and was third among the province in international migration growth rates (Statistics Canada, 2014a).

When looking at the geographical distribution of the population, 65.64% of Alberta's population resides along the ECTC. Most of the population resides in the cities of Edmonton and Calgary and their respective surrounding areas. Table 1 shows the 10 largest census subdivisions along the ECTC. Except for Red Deer and Red Deer County, the rest of the CSD's are located in either Calgary or Edmonton's CMA. Please refer to figure 1 for a map of the area.

Table 1: Ten Largest CSD along ECTC

Municipality	2013 Population	% of Alta Populaton
CALGARY	1,149,552	30.03%
EDMONTON	817,498	21.35%
RED DEER	97,109	2.54%
STRATHCONA COUNTY	92,490	2.42%
ST. ALBERT	61,466	1.61%
AIRDRIE	49,560	1.29%
SPRUCE GROVE	27,875	0.73%
LEDUC	27,241	0.71%
FORT SASKATCHEWAN	21,795	0.57%
RED DEER COUNTY	18,351	0.48%
ECTC POPULATION TOTAL	**2,474,556**	**64.64%**
ALBERTA POPULATION TOTAL	**3,828,484**	**100.00%**

Source: Municipal Affairs (2013)

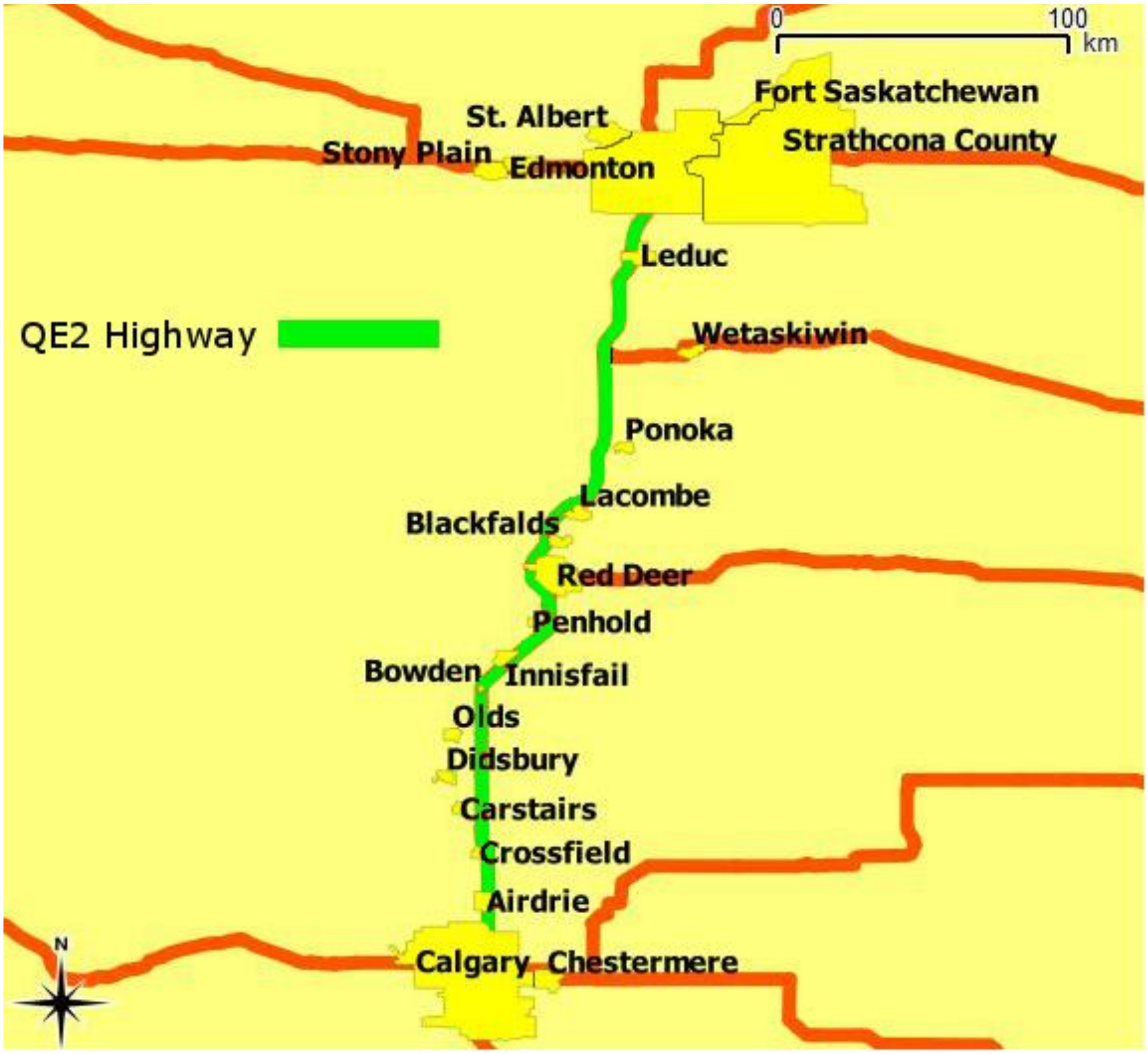
The Edmonton and Calgary metropolitan areas are two of the fasted growing metropolitan areas in the country. Calgary and Edmonton have grown more than 25% since the 2001 census. Table 2 shows Edmonton and Calgary are growing faster than the rest of the CMAs in Canada. Furthermore, when smaller CMA's with populations under one million are excluded, the Alberta CMA's are growing 8% percent faster than other large population CMA's such as Toronto and Vancouver.

Table 2: 11 fastest Growing Census Metropolitan Areas in Canada

Census Metropolitan Area	2001	2011	%Change from 2001 to 2011
Calgary, Alberta	977,834	1,264,460	29.3%
Edmonton, Alberta	962,323	1,206,040	25.3%
Barrie, Ontario	155,337	192,777	24.1%
Kelowna, British Columbia	154,188	183,524	19.0%
Oshawa, Ontario	308,599	367,266	19.0%
Toronto, Ontario	4,882,782	5,769,759	18.2%
Saskatoon, Saskatchewan	231,077	270,226	16.9%
St. John's, Newfoundland and Labrador	176,443	202,533	14.8%
Moncton, New Brunswick	122,270	140,228	14.7%
Ottawa-Gatineau, Ontario/Quebec	1,110,344	1,270,232	14.4%
Vancouver, British Columbia	2,074,543	2,373,045	14.4%

Source: Statistics Canada (2011a)

Figure 1: Map of the Edmonton Calgary Transportation Corridor



Source: QGIS

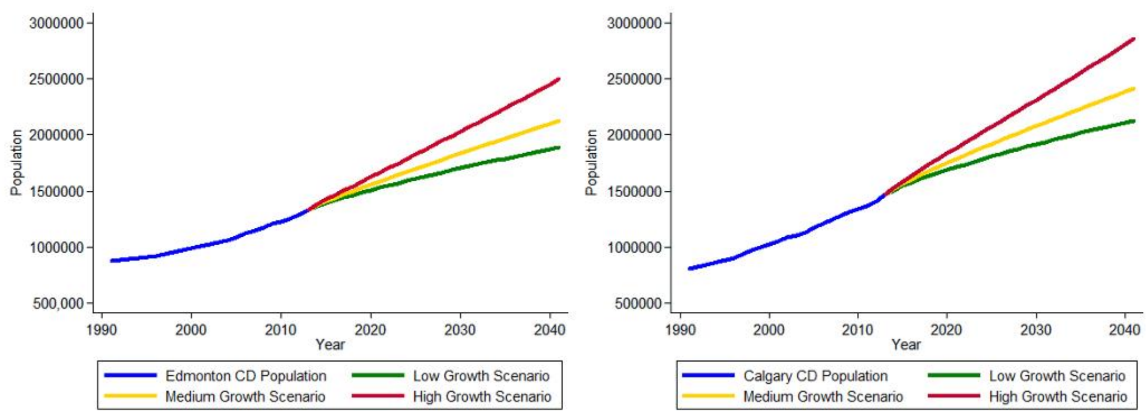
. All of Statistics Canada's population projections predict that Alberta will have the highest population growth rate in the country until 2038 (Statistics Canada, 2014b). Similarly, the Government of Alberta's Department of Finance and Treasury Board estimates project high growth in the province[1]. While such projections are based on

1 The Department of Finance use a component method to project the future population. Fertility, mortality and migration assumptions are applied to the base population to project the number of births, deaths, and migrants occurring within a given year.

numerous assumptions, they provide a glimpse of what the province's population will potentially look like in the future.

According to Government of Alberta (GOA)'s projections the largest growth of population will occur in the major cities of Edmonton and Calgary and the surrounding areas (Hansen, 2014). Figure 2 shows the historic population growth, with blue lines for both major cities. It also shows GOA's low, medium, and high growth scenarios for each city and surrounding area.

Figure 2: Population and Growth Scenarios of Edmonton and Calgary Census Divisions



Note. Census divisions overlap Census Metropolitan Areas, meaning both include surrounding areas and municipalities.
Source: Hansen (2014)

Past trends show that the major Albertan cities and their surrounding areas are some of the fastest growing in the country. The current projections by both Statistics Canada and the Government of Alberta foresee continued growth in the corridor. Some of these future residents will themselves travel along the corridor. More importantly, they will consume, produce and exchange various goods and services that require movement of freight and people along the ECTC.

Chapter 3. The Economy and Transportation

This chapter provides a picture of the Albertan Economy and why it is dependent on the ECTC transportation network. It discusses the makeup of the economy in the major cities of Calgary and Edmonton and provides summary statistics on the production and consumption activities.

In section 3.1, I detail the significant spin off industries that have emerged around the ECTC. Next, in section 3.2, I discuss the high standard of living and accompanying levels of consumption. Finally, in section 3.3, I show the role the transportation industry in the movement of goods in Alberta to accommodate both the production and consumption that occurs within the province.

3.1. The Albertan Economy: A Tale of Two Cities driven by one industry

While Alberta has a diversified economy, much of its economic growth is due to the fast development of its oil resources, which are located in the northern region of the province. While numerous jobs exist in extraction and processing in northern Alberta, the oil industry has had wider economic impacts such as creating supporting industries and increasing economic growth in the rest of the province.

Oil and gas extraction accounts for 29% of GDP, based on a 2007 break down of Alberta's GDP by industry (Statistics Canada, 2011b). However, by examining employment around major Albertan cities, it is evident that the oil and gas industry has generated other economic activities. Edmonton and Calgary have benefitted differently from economic growth from the oil sector.

Looking at the labour force is in the Edmonton CMA, 6.6% found employment in the manufacturing sector (Statistics Canada, 2013b). This accounted for 13% of the Edmonton CMA's GDP in 2012. Many of the products the Edmonton region specializes in fabrication and the manufacturing of machinery that is directly related to oil and gas extraction. These products include drilling rigs, modular fabrications, pipes and valves (City of Edmonton, 2014).

Alberta has scarcity of metals within the province; so much of the raw materials for the manufacturing industry must be imported. In 2012, Alberta imported $2.2 billion of articles of steel and iron (Tremblay, 2013). These materials serve as the primary inputs of the metal manufacturing industry, of which 40% are based in the Edmonton CMA (City of Edmonton, 2014). This means much of the resources need by industry must travel north via the ECTC.

Another major spin off industry in the Edmonton CMA is the value-added petrochemical industry. In Alberta, this industry sector produced $31 billion in value added products in 2012 and employed 14,000 people. Much of this production is located within the Edmonton CMA, in an area called Alberta's Industrial Heartland. This area is home to the largest concentration of petroleum refineries and chemical processing plants in Canada (Government of Alberta, 2014)

In Alberta, the value-added petrochemical industry has the opposite industry profile of the metal manufacturing and fabrication industry. It has close contact with the majority of raw inputs into its manufacturing process. However, most of its products are destined for markets outside of the province in North America and Asia. This places demand on transportation network to get the products of industry out of Alberta. While CN Rail ships these products east of the city, bypassing the ECTC, CP Rail transports all its petrochemical stock south via the ECTC.

Calgary, in contrast to Edmonton, has a much more human capital dependent industrial profile. While Edmonton specializes in handling the physical inputs and outputs of the oil and gas industry, Calgary specializes in financial, technical, and management aspects of the oil and gas industry.

Calgary is a management hub for western Canada. As of 2013, Calgary is the home of 132 company head offices; this is the second most concentration of head offices in the country. Among these head offices are major firms in the oil gas industry such as, Suncor Energy, Enbridge, and Imperial Oil (Calgary Economic Development, 2014).

The human capital dependence of Calgary is most obvious in its breakdown by of employment by industry. The largest industry by employment is professional, scientific and technical services. 11.7% of the Calgary CMA's labour force falls into this category (Statistics Canada, 2013b). Nearly 40% of these workers are in engineering related occupations. This category of industry classification also includes people in management and administrative services (Statistics Canada, 2013b).

The different ways economic activity is constituted in Alberta and along the ECTC generates different types of transportation demand. As a result, there are different transportation needs that have to be accommodated along the corridor, which are discussed at length in sections 4.1 and 4.4.

3.2. The Alberta Economy: Consumption and the Retail Industry

In 2012, Alberta had the highest median Income for both individuals and total census family types, when compared to all other provinces (Statistics Canada, 2014e). [2] Similarly, Alberta has the highest average wage among the provinces (Statistics Canada, 2014d). These trends continue at the CMA level: out of all Canadian CMAs, Edmonton and Calgary are among top three for highest total and median income (Statistics Canada, 2014e).

People in Alberta clearly have some of the highest incomes in Canada; this is especially true for the people who live in the major cities at either end of the ECTC. As a result, they have more money for consumption relative to other Canadians. Between

[2] Census family types include couple families, with or without children, and lone-parent families

2010 and 2012, Albertan households have the highest expenditures out of all provinces (Statistics Canada, 2014c). This has had significant effect on retail trade industry in Alberta and the ECTC.

During the period between 2009 and 2013, the retail trade industry accounted for 4.2 to 4.4% of Alberta's GDP. The retail trade's importance is magnified within the major cities when you look at employment by industrial sector. In Edmonton, retail trade is the largest sector of employment[3], accounting for 11.1% of the CMA's labour force. Similarly, in Calgary, it is second largest sector by employment, with 10.6% of the Calgary CMA's labour (Statistics Canada, 2013b).

Retail trade is thus a significant part of the Albertan economy, and one of the largest areas of economic activity in the province. In 2014, this sector sold $78.5 billion worth of goods (Statistics Canada, 2015). Much of these goods are imported and shipped from other parts of the country and the world. Within the ECTC, goods need to be transported at least one direction between the cities.

3.3. The Alberta Economy: Prevalence of the Transportation Industry

The Transportation Industry also plays a pivotal role in the Albertan economy. Alberta needs to get factor inputs to its domestic producers and retailers as well as export their outputs to the rest of the country and the world. A significant local transportation industry has flourished as a result.

During the period of 2009 to 2013, the transportation and warehousing industry annually contributed 3.9-4% to Alberta's GDP. Province wide, the sector employs 5% of the Albertan labour force, of which approximately one third are truck drivers (Statistics Canada, 2013b). In the Edmonton and Calgary CMAs, the transportation and warehousing industry employs 4.8 and 5.7% of the labour force respectively. This only

[3] The retail trade sector comprises establishments primarily engaged in retailing merchandise, generally without transformation, and rendering services incidental to the sale of merchandise

measures employment of individuals in the transportation and warehousing industry in Alberta. There are many more individuals who are legally defined as working outside of the province, but who also operate as truck drivers regularly on Alberta’s roads

Chapter 4.

Transportation Demand

This chapter describes the current transportation network in Alberta, and how it facilitates goods and people movements along the ECTC. Specifically, it discusses the pivotal role the Queen Elizabeth number 2 highway plays in the area. This section also introduces transportation planning terminology that is necessary to understand the problem. Transportation demand is discussed by showing the current composition of users and traffic. Finally future demand is estimated with simple projections of daily traffic counts.

4.1. The Transportation Network: Composition and Usage

The Alberta transportation network is based on road and rail travel[4]. The provincial highway network is publicly owned and is one of the largest capital assets of the provincial government, having a replacement value of $58.4 billion (Alberta Transportation, 2014d). Railways in Alberta are privately owned. For the most part railways are regulated by the Federal government. However, railways that operate only within Alberta and do not cross provincial borders are under provincial jurisdiction.

The majority of automobile travel is accommodated by the paved provincial highway network that covers 28,578 km (Alberta Transportation, 2014d). The highway network facilities private travel of individuals as well as commercial traffic as well. The majority of Alberta goods that are traded outside of the province are either traveling to or

[4] This paper will not look at pipelines which are significant source of transportation within in the province. While air travel plays a significant role in transportation it is not within the scope of this paper. These modes transport very specific goods and people, unlike road and rail transportation.

from the United States, specifically 91% of exports and 73% of imports.[5] Of these exports the three largest groups of commodities are mechanical and electrical machinery, mineral products, and live animals and animal products.[6] The top imports from the United States are mechanical and electrical machinery, vehicles, aircrafts, vessels and associated equipment, and articles of base metal (Alberta Transportation, 2013).

The rail network covers much less of the province, only spanning a distance of 7068km, of which two companies, Canadian Pacific Rail and Canadian National Rail, own 6813km. There are only two rail lines between the cities of Edmonton and Calgary. Rail tends to carry bulk goods, such as grain, wood products and bulk petroleum products. Looking at the broad commodity categories of exports and imports highlights the role rail transportation plays in in the overall transportation network and the economy. Looking only at goods transported by rail, Alberta's three largest export commodities by value are mineral products, vegetable products, and petroleum products. Specifically, rail primarily exports raw and processed bitumen products, agricultural products and value added petrochemicals to global markets. The top three largest commodity groups of imports by value that are transported by rail into Alberta are articles of base metals, mechanical and electrical machinery, and mineral products. Of these imports 63% are unloaded at intermodal facilities in the Edmonton area and 35% are unloaded in the Calgary region (Alberta Transportation, 2013). These import categories suggest that rail imports crucial inputs for Alberta's manufacturing industry and oil extraction that are destined for value added industries in the Edmonton region or to be shipped farther north to primary resource extraction sites.

There appears to be overlap of the most valuable exported and imported commodities by truck and rail transportation. Table 3 highlights the overlap. However, truck transportation is used to transport more value added goods within the Alberta economy than rail (Alberta Transportation, 2013). Trucks do not generally compete with

[5] Due to the high amount of goods exchanged by truck with the United States, export and import figures by truck will only to refer commodities exchanged with the united states. Intermodal rail transport will look at total global exports.

[6] Mineral products includes fuels, and bitumen substances.

rail over longer hauls for lower value bulk goods. Modal choice of commercial transportation is determined in the network by distance traveled and related costs. For example, on shorter distance hauls like those between Edmonton and Calgary, trucks on the highway network have a cost advantage and so tend to dominate. In contrast, rail has a cost advantage on long hauls, like those across the country, and dominates transportation for such distances. On medium hauls around 1000 km, like from Calgary to Vancouver, there can be some competition. Rail and road networks have been found to be complementary within the economy. Furthermore, it is hard to substitute one mode's specialty for another. For example, truck transportation on the highway is better suited for higher value, lower volume loads that are transported as smaller shipments in vehicles that are loaded under their full capacity. Besides cost advantage, mode choice of transportation is highly dependent on quality of service that can be provided, not just cost (Alberta Transportation, 2006). For example, a truck can be scheduled to deliver to any point connected to the highway network at any time, while a train runs on a much more restricted schedule and on a rail network that is not nearly as expansive. Trucks have greater ability to fulfil time sensitive transportation in modern "just in time" production.

Table 3: Top Three imports and exports in Alberta by mode of Transport

Mode of Tranport	Truck	Rail		Truck	Rail
Rank by Value	**Export commodity category**			**Import commodity category**	
1st	mechanical and electrical machinery	mineral products		mechanical and electrical machinery	articles of base metal
2nd	live animals and animal products	vegetable products		vehicles, aircrafts, vessels and associated	mechanical and electrical machinery
3rd	mineral products	petroleum products		articles of base metal	mineral products

Source: Alberta Transportation (2013)

Unlike other jurisdiction in Europe and Asia that have utilized rail to move people as well as freight, Alberta primarily uses motor vehicles. The only passenger train service in Alberta is from the eastern recreation area of jasper to Edmonton, on VIA

Rail’s Vancouver to Toronto line. There is no service that runs north south along the ECTC. As a result, the flow of people between Edmonton and Calgary primarily depends on automobile traffic on the Queen Elizabeth No.2 (QE2) Highway.

The QE2 highway and the ECTC are also part of the CANAMEX continental trade corridor that connects Canada, America and Mexico by one highway network. This indicates that transportation along this corridor also provides international goods movement, not just domestic movement of goods and people.

4.2. The Queen Elizabeth Highway

Based on the Alberta highway service classification system, the QE2 highway is a primary highway class 1A. A primary highway with 1A classification serves as major arterial that is “intended to serve all major cities and accommodate interprovincial and international travel” (Alberta Infrastructure, 1999). Highways of this classification correspond with the National Highway System. Highways classifications are decided by population served, average travel distance, and average annual daily traffic (AADT).

As discussed section 2.2, the QE2 highway is linked to the majority of Alberta’s population. Traffic levels concentrate at the same points in the network as population and economic activity, resulting in different levels of traffic along the highway. The sections of the QE2 highway with the highest level of traffic are focused in three areas: the stretches of road from Leduc to Edmonton, Airdrie to Calgary, and the sections of Highway 2 that lead into and pass through Red Deer.

The QE2 highway is a divided highway, meaning that it consists of two one-direction roads that are separated by some sort of barrier. The majority of QE2 highway consist of four lanes.[7] However, the highest traffic areas are currently accommodated with 6 lane sections of highway. These sections are located at Leduc heading in Edmonton, at Airdrie heading into Calgary, and in a small section south of Red Deer. The current infrastructure provides adequate capacity for current travel demand along

[7] A four lane highway has 2 lane for each directional split.

QE2 highway; this is shown more precisely in section 4.4. However, existing infrastructure will not meet travel demand as the population and the economy grow.

4.3. Traffic terminology

This section provides a brief overview of transportation planning terminology. This terminology conveys information about traffic based on how it effects the operation of stretches of highway.

The QE2 highway services both private travel of individuals and the movement of commercial goods. To understand effects of congestion, engineers and planners must take into account different types of vehicles. For example, commercial vehicles have different spatial, acceleration, and handling characteristics that make them drive differently than regular passenger vehicles. These characteristics mean that the addition of a single commercial vehicle impacts traffic flow more than the addition of a passenger vehicle. As a result, transportation engineers and planners classify traffic counts in different categories. These categories and their abbreviations include Passenger Vehicles (PV), Recreational Vehicles (RV), Buses (BU), Single Unit Trucks (SU), and Tractor Trailer combinations (TT). Buses, single unit trucks, and tractor trailer combinations are commonly grouped together into a category of commercial traffic (CM).

In order to display traffic counts, the transportation department divide lengths of highways into traffic control sections (TCS). A traffic control section is a segment with similar traffic characteristics, such traffic growth and vehicle category composition. In Alberta, traffic control sections are determined by Alberta Transportation, the provincial ministry of transportation (Alberta Transportation, 2014c). Along the QE2 highway between Edmonton and Calgary there are 95 traffic control sections. Automatic traffic recorders count vehicles traveling on the traffic control sections. The total sum of vehicles is then divided over 365 days and produces the annualized average daily traffic

(AADT). AADT is the basic measure of highway usage and traffic at a single point on the highway[8].

These traffic control sections are aggregated into control sections. Control sections are larger sub region aggregations and tend to show section divisions between urban, sub urban and rural regions. The QE2 highway in the ECTC is divided into 8 Control Sections. Control sections display traffic data as weighted annualized average daily traffic (WAADT). WAADT is simply the sum of daily traffic counts along the traffic control sections divided by the total length. WAADT provides a general view of a highway control section; comparatively, AADT is a measure of a specific point on a highway.

4.4. Current Travel Demand

Looking at QE2 highway's control sections provides a general picture of travel demand. Table 4 displays traffic volume along the QE2 highway at the different control section. The traffic volumes jump up considerably outside the major cities at control section 18 and 32. Similarly, traffic volumes increase around Red Deer but not to the same extent as by the major cities. Figure 3 provides a Map of the Control sections for reference.

[8] WAADT and AADT will be referred to as daily traffic from this point on.

Table 4: Traffic Volumes and Vehicle Classifications by Control Section

Location		Traffic Volume	Vehicle Classifications					
CS	Description	WAADT	%PV	%RV	%BU	%SU	%TT	%CM
18	North of Calgary to South of Carstairs	47928	86.1	1.1	0.3	3.4	9.1	12.8
20	South Carstairs to South of Olds	29936	80.6	2.2	0.2	3.7	13.3	17.2
22	South of Olds to East of Innisfail	30339	81.3	2.1	0.4	3.6	12.6	16.6
24	East of Innisfail to West of Red Deer	37478	84	1.7	0.4	4.1	9.8	14.3
26	West of Red Deer to West of Ponoka	30438	82.6	1.9	0.4	3.3	11.8	15.5
28	West of Ponoka to West of Wetaskiwin	26999	79.2	1.5	0.4	3.1	15.8	19.3
30	West of Wetaskiwin to Leduc	27921	79.9	1.7	0.3	3.1	15	18.4
32	Leduc to south of Edmonton	77063	88.8	0.6	0.3	3.9	6.4	10.6

Source: Alberta Transportation (2014b)

Table 4 also shows the composition of traffic along the QE2 highway. For example, the percent of passenger vehicles (%PV) increases near the major cities, and to a lesser extent, around Red Deer. This increase can be explained by local commuting traffic interacting with QE2 highway. The basic mechanics of local commuting travel demand utilizing the road that also serves the purpose of facilitating international, interprovincial and interregional travel demand is what requires action.

Traffic composition information is also much more detailed when not averaged over the entire control section. When traffic composition is averaged over control section 32, it has the lowest percentage of commercial traffic along the QE2 highway. This can mislead individuals to think there is less commercial traffic on the QE2 highway outside of Edmonton. However, due to overall high daily traffic, segments in control section 32 have more commercial vehicles present than anywhere else in the network. Table 5 compares the distribution of commercial daily traffic counts (CM) between the control sections heading into each major city.[9] Overall, more commercial traffic appears to be heading into the Edmonton region, on control section 32, than Calgary, on controls section 18, which supports this paper's perspective that industrial activity outside of Edmonton is more dependent on the QE2 than Calgary. However, as chapter 3

9 Commercial daily traffic counts are the number of commercial vehicles that are traveling at a given segment or control section.

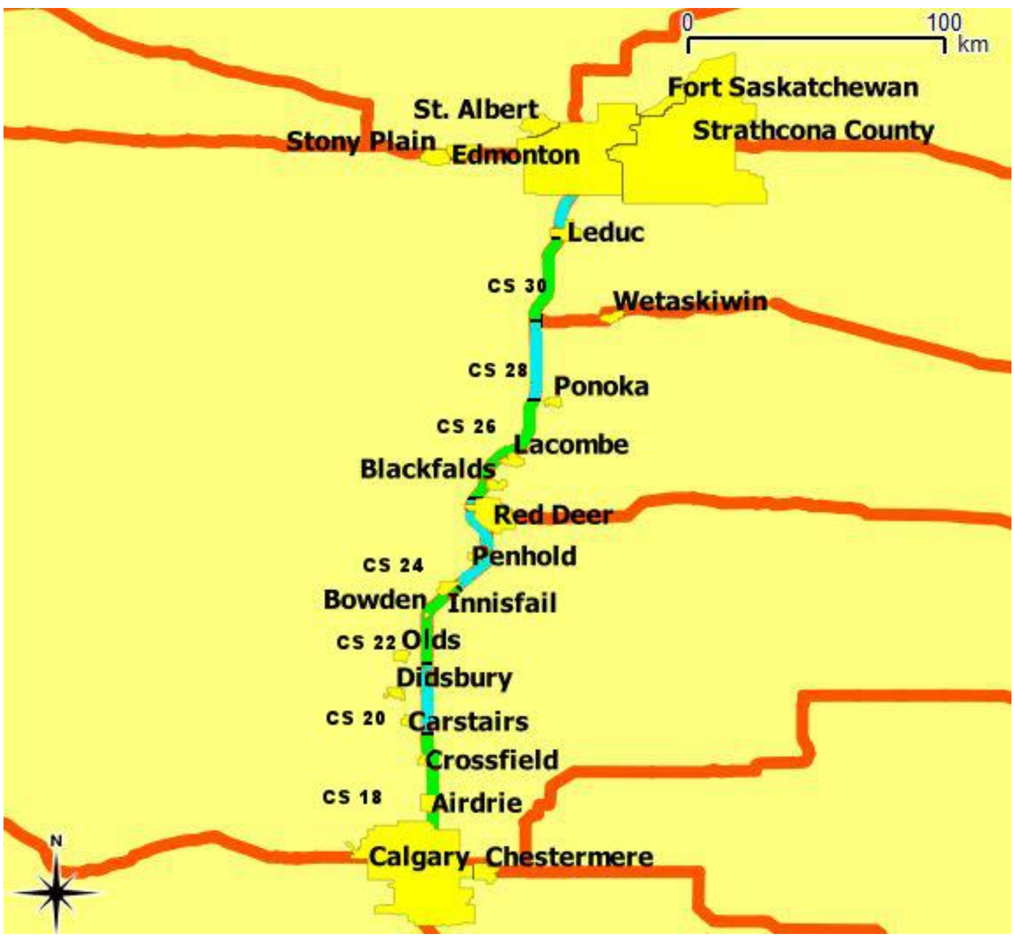
discusses, both major cities have significant need for commercial traffic, with retail trade being just one of the industries dependent on it.

Table 5: Distribution of Daily Commercial Traffic Counts (CM) at Control Sections outside Edmonton and Calgary

Control Section	Min CM traffic	Max CM Traffic	Mean CM
18	4,466	7,543	6,157
32	6,046	8,999	7,600

Source: Alberta Transportation (2014b)

Figure 3: Map of QE2 Highway Control Sections



Source: QGIS (2014)

Control section Level traffic volumes provide an overall understanding of travel. However, using WAADT to reflect general traffic levels does not show congestion that develops at specific points on highways. Table 6 shows daily traffic at specific points at the higher volume traffic control sections. There is a significant difference from the weighted numbers above. Daily traffic counts are what actual design decisions are based on. For example, The Alberta Transport Geometric Design Guide (ATGDG) suggests daily traffic under 31,000 vehicles will be adequately served by a 4 lane divided rural highway. However, the ATGDG recommends that as daily traffic increases from 31,000 to 50,000 vehicles, an additional lane in each direction is warranted. A segment with daily traffic over 50,000 vehicles requires 8 lanes or more (Alberta Infrastructure, 1999).

Table 6: Traffic Volumes at specific points on the Highway

CS	TCS	Location Description	AADT	CS	TCS	Location Description	AADT
18	04	N OF 566 E OF BALZAC	78570	24	04	N OF 590 AT INNISFAIL	32220
		4.6 KM S OF 2 & 567 AIRDRIE	78400			S OF OLD POLE RD	32430
		S OF BIG HILL SPRINGS RD	78570			N OF OLD POLE RD	32530
		N OF BIG HILL SPRINGS RD	60930			S OF 42 E OF PENHOLD	33670
		S OF TWP RD 272, AIRDRIE	46520		08	N OF 42 E OF PENHOLD	36760
32	04	N OF 50 AVE AT LEDUC	48370			2.6 KM N OF 2 & 42 PENHOLD	36670
		S OF 50 ST, LEDUC	48370		09	S OF GAETZ AVE IN RED DEER	38460
	08	N OF 50 ST, LEDUC	60330		10	N OF GAETZ AVE IN RED DEER	27450
		S OF AIRPORT RD	60330			S OF 2A & TAYLOR DR IN RED DEER	27450
	12	N OF AIRPORT RD	74160		11	N OF 2A & TAYLOR DR IN RED DEER	41380
		S OF 19 & 625 W OF NISKU	74160			5.9 KM S OF 2 & 11 RED DEER	41220
	16	N OF 19 & 625 W OF NISKU	85990			S OF 32 ST IN RED DEER	41380
		5.9 KM N OF 2 & 19 NISKU	85990		12	N OF 32 ST IN RED DEER	51300
		S OF ELLERSLIE RD	85980			S OF 11 AT RED DEER	51300
		N OF ELLERSLIE RD	89990		16	N OF 11 AT RED DEER	40240
		S OF 216 S OF EDMONTON	89990			S OF 11A AT RED DEER	40240

Source: Alberta Transportation (2014)

Traffic control section (TCS) 4 in control section (CS) 8, which is just north of Calgary, displays significantly higher AADT than its WAADT numbers would suggest. According to the recommendations made by the ATGDG, this control section, which is only a 6 lane facility, should be upgraded with an additional lane. Similarly, at traffic control section 12 in control 24 there is enough daily traffic to warrant an upgrade to a 6 lane facility. The largest AADT counts are located in in traffic control section 16 in control section 32. This traffic is already accommodated by an 8 lane facility; however, this will be insufficient as traffic continues to increase.

4.5. Traffic Projections

Advanced models for traffic growth prediction exist; however, they are expensive and take time and expertise to create that are outside of this study's capabilities. A simpler way that planners predict growth is by applying a ten year average growth rate to traffic counts. This method provides a very general picture of how daily traffic may grow. Growth rates are averaged from the percentage change from one year to next, over a ten year period. In this study, growth rates were averaged again along traffic control sections. Averaging growth rates over traffic control sections was performed to fill missing data on control section 32.[10] A major assumption built into this study's prediction is that traffic will have the same distribution of vehicle categories. The necessary resources to predict how vehicle categorizes could evolve over time to change the distribution are beyond the scope and capability of this study.

This study performs an updated prediction in 2014 using the most recent 2013 traffic counts. Table 7 displays updated prediction using the 10 year average growth method along control sections with the highest daily traffic levels. Control sections 18, 24, and 32 have both high daily traffic levels and growth rates higher than 4%. Daily traffic at these points will effectively double within the next 20 years. While an increase of this much daily traffic may seem unrealistic, it is predicted to grow at a similar rate as the GOA medium case population scenarios displayed in figure 2. This supports the idea that these sections are being influenced by the local commuting traffic growth from the faster growing urban areas. If population and traffic grows as shown, it is unlikely even the 2023 projected level of daily traffic could be met by the current capacity of the QE2 highway.

The control sections with lower daily traffic levels such as control sections 20, 22, 26, 28, and 30, do not have growth rates higher than 4%, except for a traffic control 2 in control section 26 that is close enough to Red Deer to still have a local commuter effect. These areas are historically the more rural, lower traffic areas. However, these control

[10] This had little to no effect on overall traffic growth rates, the difference from sectional growth rates only by no more than .003%.

sections will eventually need capacity expansion since their daily traffic levels will be equivalent to the current higher traffic areas outside the major cities. For example, control section 20 by 2038 will have daily traffic greater than 72,000 vehicles a day along its entire length. Since traffic control sections with daily traffic as low as 46,000 vehicles a day, like traffic control section 4 in control section 18, already have 3 lanes of capacity, these other sections could warrant capacity upgrades in the next 20-30 years.

The growth rates produced by this study were reviewed by an Engineer at Alberta Transportation[11]. The engineer compared this study's growth rates to those derived from various automatic traffic recorders spread along highway. His growth rates are thus derived from more accurate data but from significantly fewer points on the highway compared to my growth rates which cover the majority of the QE2 highway. The segment data is gathered by temporary traffic counts and turning studies that are then calibrated using the automatic traffic recording data. The results of the comparison in general finds that this study's methodology produced higher growth rates than those of the engineers. However, there were several similarities. This study's growth rate, the Alberta Transportation 10 year average, and the Alberta transportation average historic growth rate, find most rural traffic control section growth rates to be around 3%. One major difference that arose from this study's use of segment level data is that the Red Deer area's growth rates appear to be inflated when compared to automatic traffic recorders counts with in that region.[12] Similarly, traffic control section 16 at control section 32 also has a higher growth rate of 5.0%.[13] These high growth rates have explanations; however, they do highlight limitations of attempting to project growth at the individual segment level.

[11] This review and comparison happened through email conversations from December 15th to 17th ,2014.

[12] The high growth rate and traffic count growth may have resulted from recent reclassification of traffic control sections in the area. This can affect how traffic counts are estimated for the segments in the area.

[13] This high growth rate outside of Edmonton is mostly explained by an outlier segment in traffic control section 16 that experienced a 14.5% growth from the previous year. The data point was not excluded from analysis due to it being part of an important trend of increased traffic growth outside the city of Edmonton.

Table 7: 10, 20 and 25 year Projections of Daily Traffic Growth at Control Sections with the Highest Daily Traffic

CS	TCS	Location Description	2013 AADT	Growth Rate used	Estimated 2023 AADT	Estimated 2033 AADT	Estimated 2038 AADT
18	04	N OF 566 E OF BALZAC	78,570	4.2%	118,559	178,900	219,761
		4.6 KM S OF 2 & 567 AIRDRIE	78,400		118,302	178,513	219,285
		S OF BIG HILL SPRINGS RD	78,570		118,559	178,900	219,761
		N OF BIG HILL SPRINGS RD	60,930		91,941	138,735	170,421
		S OF TWP RD 272, AIRDRIE	46,520		70,197	105,924	130,117
	8	N OF TWP RD 272, AIRDRIE	40,150	4.2%	60,561	91,347	112,188
		S OF 2A & 72 SE OF CROSSFIELD	40,150		60,561	91,347	112,188
	12	N OF 2A & 72 SE OF CROSSFIELD	33,780	4.5%	52,213	80,705	100,338
	16	S OF ACME RD	33,780	4.2%	52,084	80,506	100,090
24	4	N OF 590 AT INNISFAIL	32,220	2.9%	42,791	56,830	65,492
		S OF OLD POLE RD	32,430		43,070	57,200	65,919
		N OF OLD POLE RD	32,530		43,203	57,377	66,122
		S OF 42 E OF PENHOLD	33,670		44,717	59,388	68,440
	8	N OF 42 E OF PENHOLD	36,760	2.9%	49,098	65,577	75,788
		2.6 KM N OF 2 & 42 PENHOLD	36,670		48,978	65,417	75,602
	9	S OF GAETZ AVE IN RED DEER	38,460	1.9%	46,287	55,706	61,112
	10	N OF GAETZ AVE IN RED DEER	27,450	3.7%	39,338	56,375	67,487
		S OF 2A & TAYLOR DR IN RED DEER	27,450		39,338	56,375	67,487
	11	N OF 2A & TAYLOR DR IN RED DEER	41,380	5.2%	63,040	95,125	116,851
		5.9 KM S OF 2 & 11 RED DEER	41,220		62,796	94,757	116,399
		S OF 32 ST IN RED DEER	41,380		63,040	95,125	116,851
	12	N OF 32 ST IN RED DEER	51,300	5.3%	78,204	118,007	144,960
		S OF 11 AT RED DEER	51,300		78,204	118,007	144,960
	16	N OF 11 AT RED DEER	40,240	3.7%	60,429	91,185	112,011
		S OF 11A AT RED DEER	40,240		60,429	91,185	112,011
32		N OF 50 AVE AT LEDUC	48,370		65,997	90,048	105,184
	4	S OF 50 ST, LEDUC	48,370	3.2%	65,997	90,048	105,184
		N OF 50 ST, LEDUC	60,330		81,666	110,547	128,618
	8	S OF AIRPORT RD	60,330	3.1%	81,666	110,547	128,618
	12	N OF AIRPORT RD	74,160	4.2%	111,904	168,859	207,426
		S OF 19 & 625 W OF NISKU	74,160		111,904	168,859	207,426
	16	N OF 19 & 625 W OF NISKU	85,990	5.0%	130,752	197,299	242,361
		5.9 KM N OF 2 & 19 NISKU	85,990		130,752	197,299	242,361
		S OF ELLERSLIE RD	85,980		130,736	197,276	242,333
		N OF ELLERSLIE RD	89,990		136,834	206,476	253,635
		S OF 216 S OF EDMONTON	89,990		136,834	206,476	253,635

Source: Alberta Transportation (2014a)

However, flaws with this methodology are evident. A ten year average growth rate was used by Al-Terra Engineering Ltd. in their planning study of QE2 highway 2 in 2004. Table 8 shows the difference between 2013 actual daily traffic and Al-Terra's projections along the Control Sections with the highest daily traffic in 2013. Al-Terra's use of the 10 year average growth method significantly under predicted the level of travel demand entering Calgary and Edmonton. Due to the need to plan infrastructure decades in advance, over and under estimating growth rates can compromise project prioritization.

Despite these significant limitations, it is the best method for predicting traffic growth available to this study.

Table 8: Comparison of 2013 actual ADDT with Al-Terra 2013 Projections

CS	TCS	Location Description	2013 AADT	Alterra 2013 AADT Projection
18	04	N OF 566 E OF BALZAC	78,570	68,200
		4.6 KM S OF 2 & 567 AIRDRIE	78,400	65,500
		S OF BIG HILL SPRINGS RD	78,570	51,800
		N OF BIG HILL SPRINGS RD	60,930	N/A
		S OF TWP RD 272, AIRDRIE	46,520	N/A
24	11	N OF 2A & TAYLOR DR IN RED DEER	41,380	37,000
		5.9 KM S OF 2 & 11 RED DEER	41,220	36,900
		S OF 32 ST IN RED DEER	41,380	44,300
	12	N OF 32 ST IN RED DEER	51,300	44,100
		S OF 11 AT RED DEER	51,300	44,500
	16	N OF 11 AT RED DEER	40,240	38,500
		S OF 11A AT RED DEER	40,240	38,500
32	12	N OF AIRPORT RD	74,160	63,000
		S OF 19 & 625 W OF NISKU	74,160	68,200
	16	N OF 19 & 625 W OF NISKU	85,990	68,200
		5.9 KM N OF 2 & 19 NISKU	85,990	N/A
		S OF ELLERSLIE RD	85,980	N/A
		N OF ELLERSLIE RD	89,990	N/A
		S OF 216 S OF EDMONTON	89,990	N/A

Source: Alberta Transportation (2014) and Al-Terra Engineering Ltd (2004)

4.6. Impacts on Commercial Traffic

During 2013, daily commercial traffic on the QE2 highway ranges from just under 4,000 commercial vehicles a day to over 9,000, depending on which point of the highway is analyzed. If traffic continues to grow without upgrades to existing facilities, congestion will become a pressing issue. While congestion affects the reliability and total travel times of all vehicles, its effect on commercial traffic poses a significant threat to the Albertan economy. As discussed above, the major sectors of the Albertan economy are very dependent on the flow of goods along the QE2 highway. Even if Calgary's office workers aren't waiting on raw materials to be able to work, like manufacturers in Edmonton may be, they still need many of the retail goods that flow between the two cities to live their day to day lives.

Travel time delays for commercial traffic are more costly than travel time delays of other drivers in several ways. Some of these costs are easy to capture, such as fuel and driver wages. There are other costs that are harder to estimate such tire wear, repair, and cleaning costs that add up over the length of a trip. There also miscellaneous costs that add up based on the category of freight such as dunnage, fasteners, and maintenance of refrigeration or heating equipment. For the value of commercial travel, time this paper will use a figure established by a study commissioned by Transportation Canada that takes into account these factors. The study established hourly operating cost of varying commercial vehicle types and trailer combinations for each province. In Alberta, the average of those hourly operating costs is $222.98 in 2012 Canadian dollars (Transport Canada, 2005). Within Alberta, commercial traffic also has to pay certain fixed costs that are not captured in the above number. For example, special licencing fees apply to drivers, and registration and inspection fees apply to individual commercial vehicles. The province distance based fees for truck carriers besides the gasoline tax, are only for speciality loads such as oversized, overweight, and dangerous good loads, which are charged per use or per kilometer.[14]

However, this figure does not capture the entire value associate with commercial driving time. The value of travel reliability is not addressed by my analysis but it is important to keep in mind these other important factors. Due to the *Commercial Vehicle Drivers Hours of Service Regulations*, drivers have limited hours they can drive without rest (Government of Canada, 2005). Delays caused by congestion can disrupt these schedules and increase total trip times by eight hours for drivers to get the required rest. These time costs, however, do not just affect long haul trucking companies. These costs extend to all shippers and receivers due to modern “Just in Time” inventory management protocols. Many firms base their inventorying and even production operations around trucks arriving at specific times (Small, Noland, Chu and Lewis, 1999). While directs costs such as travel time are relatively easy to capture, these other significant costs revolving around reliable truck scheduling are more difficult to capture.

[14] These speciality permits have aspects of demand management, but are more focused on capturing the costs network damage associated with their transport and to manage safety concerns. The permit system does not appear to be dynamic. Permits are applied for and defined upfront before goods are moved.

Chapter 5. Scoping Limitations

My study focuses on supply side solutions to meeting future travel demand. This is not because demand side solutions like road pricing for example, are not effective; they are extremely effective measures for dealing with congestion. For example, a study published by the Vancouver regional transportation authority, Translink, finds several road pricing schemes that have the potential to relieve congestion during peak hours, although the same study states that some schemes could just divert traffic, causing more issues (Deloitte, 2010). Examples of demand management include building new lanes and roads that have restricted use. Road pricing can be fixed or dynamic based on time to reduce peak hour use. Financial incentives can even be extended to increased parking rates or higher fuel taxes to disincentives private car use. These examples of demand management have push effects towards other modes and times of travel. Demand management policies with a pull effect include faster and more accessible public transportation systems, non-passenger vehicle dependent development, and restricting of urban sprawl (Habibian and Kermanshah, 2011). Besides gasoline taxation, most of demand management options are the jurisdiction of municipal governments and their implementation best managed at the municipal level (Robinson, 1997). This was one of the reasons for excluding them from this papers analysis, which looks at the congestion problems from the provincial government’s perspective.

There are also an issue of using a long timeframe of analysis, eventually traffic growth will exceed the effects of a demand management policy and the supply side question will arise. In other words, this study asks what the next supply side upgrade the province should implement, not what policies can be implemented to delay those upgrades. Future research should be conducted to find the best demand side solution for the Edmonton Calgary transportation corridor. A demand side policy option would allow the province to delay implementing the expensive supply side solutions and extract additional revenue for their capital costs. Furthermore, demand and supply side solutions are not mutually exclusive; both the additional lanes and bypass policy options could be tolled. The net effect of adding a pricing scheme to these options would increase their effectiveness at reducing congestion and decrease the total financial cost. While the QE2 highway is a provincial highway and under the provincial government's jurisdiction, road pricing schemes affect certain municipalities directly, and their implementation need to be integrated regional transportation strategies. This means that there could be significant issues regarding municipal negotiations, although both the Edmonton and Calgary regions' transportation plans mention the need to explore demand management principles. Furthermore, there are no previous examples of road tolling in the province and no obvious legislation discussing their implementation, which means that significant government actions may be necessary for their implementation. Overall, the viability and implementation of demand management policy in Alberta and its major cities is a different question and is worthy of its own study. As a result, they will not be part of my study.

Chapter 6. Methodology

My methodology for this study uses a level of service calculation, from the Highway Capacity Manual to measure the impact of future congestion, an issue which is explained more in depth in section 5.1. This methodology is the North American standard for understanding congestion as it relates to road capacity. There are more advanced methods to analyze congestion; however, those methods require both software and hardware that are beyond this study's scope. Furthermore, transportation agencies with the resources to acquire these expensive methods of traffic analysis still use this level of service methodology because of its proven reliability.

A level of service calculations allows daily traffic volumes to be converted into hourly flow rates and vehicle density per lane. These new measurements are used to calculate the speed at which vehicles can travel at various points along the highway. Applying this calculation to the traffic volume projections made in section 4.4 provides a timeline for when each control section becomes critically congested. The same calculation can also measure the impacts of future transportation investments.

6.1. Level of Service and Flow Rate Calculation

Level of service calculation allows for engineers or planners to take traffic counts and evaluate how well a given stretch of highway is meeting travel demand. For my analysis, a level of service calculation needs to be done for each point for which traffic data has been gathered to see the current effectiveness of the existing QE2 highway. Addition "level of service" calculations also need to be done for each segment in this study's daily traffic projections. Finally, level of service calculations need to be done on the QE2 highway projections with the estimated effect on daily traffic that would result from each potential policy option.

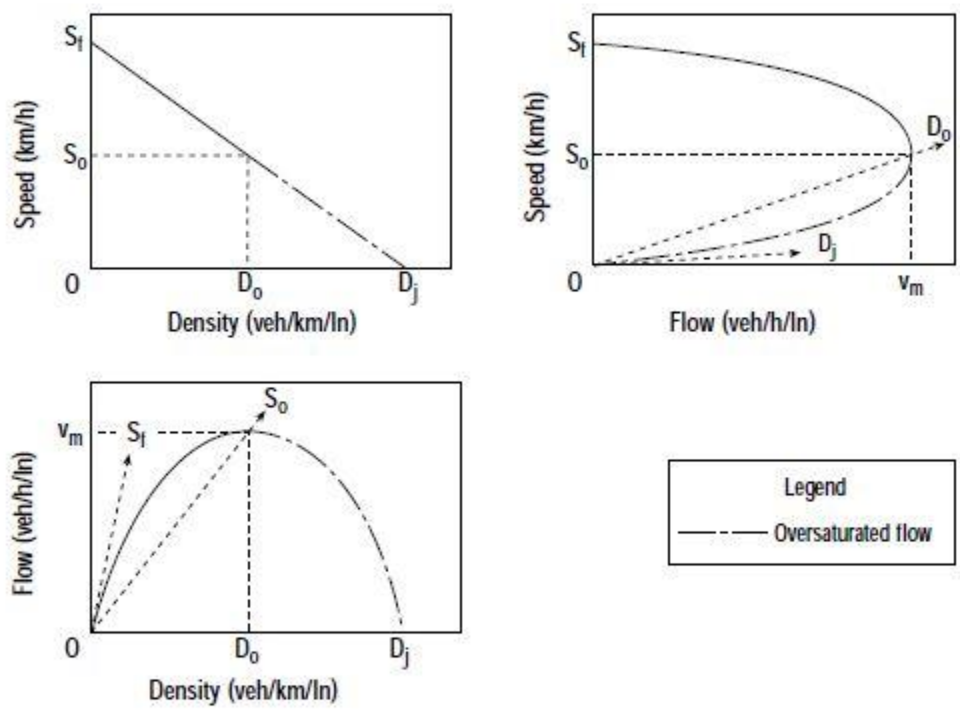
A Level of service is assigned to a segment according to set ranges of traffic flow rate, density and speed variables. This involves ranking a point on a highway based on how dense daily traffic is, how much traffic flows through the point in given hour, and the impact of both of those factors on travel speeds. Density *(D)* is measured by passenger car equivalents per kilometer per lane (pc/km/ln). Flow rate *(Vp)* is measured in passenger car equivalent per hour per lane (pc/h/ln). Speed *(S) is* by average passenger car speed (km/h). The three measures simplest relationships are given in Equation 1.

$$D = \frac{V_P}{S} \qquad (1)$$

The simple relationship depicted by equation 1 is complicated by the conditionality of regular and oversaturated flows. Figure 4 shows that the relationships of these variables change at a critical point. Generally, speed and density are negatively related. As more vehicles occupy a segment of road their speed decreases. This is the simple understanding of congestion. However, the relationship between the other two variables is not linear. Flow rates can increase with traffic density to a certain critical point. Once the segment becomes oversaturated, these variables become inversely related. After the oversaturation point is reached, as density increases both speed and flow rate decline until both reach zero. This is when a traffic jam occurs and queuing begins.

A “level of service” is like a report card for road congestion. Low congestion with no reduction in travel speeds is ranked with a level of service grade A or B. The more congestion and reduction of speed occur on a segment, the lower grade (i.e, C, D, E, F) it receives from the calculation. The Level of Service methodology is one of the primary tools for traffic analysis in North America. It provides a fairly accurate estimation of congestion on road facilities from easy to acquire data such as daily traffic counts.

Figure 4: Speed, Flow Rate and Density Relationships



Source: Transportation Research Board (2000) Exhibit 7-2, p 88

Before a level of service calculation can be performed the daily traffic counts created by Alberta Transportation (2014a) and this study's projections must first be converted in to hourly vehicle volume and then into the hourly flow rate of traffic. An hourly volume V is converted from daily traffic counts by using the Design Directional Hourly Volume (*DDHF*) equation. The equation to convert daily traffic volumes into hourly volume is represented by equation 2.

$$V = DDHV = K \times D \times AADT \tag{2}$$

The K in equation 2 accounts for the temporal aspect of peak and off peak vehicle volumes. To examine an hourly volume closer to peak I use a higher *K* value. Hourly volumes are input as one direction of traffic. Since there can be directional imbalances in traffic, especially during peak hours, this must be accounted for in hourly volume calculations, i.e. a perfect split of traffic in each direction has (D) value of 0.50[15]. As flows become more imbalanced this value gets higher. For this study an assumed value 0.55 reflects mild directional imbalance.

Once daily traffic counts have been converted into an hourly traffic volume, a flow rate can be calculated. To determine a freeway flow rate (v_p) several factors are taken into account. A flow rate consists of an hourly volume (V), that has been adjusted by a factor to account for peak hour volumes (i.e., Peak Hour Factor, PHF). The peak hour factor measures how consistent travel demand is during peak hours. There must also be an adjustment for the presence of commercial vehicles, a heavy vehicle factor (f_{HV}). The heavy vehicle adjustment factor is determined by the percentage of traffic that is made up by recreational vehicles and commercial traffic and the terrain of the road. Recreational and commercial vehicles take up more space, have less maneuverability and travel generally slower, especially in rolling and mountainous terrain. Flow rates also incorporate whether a road is utilized by local commutating drivers who are familiar with the roads being analyzed or non-local drivers who are less familiar. This is the driver population factor (f_p). In an interview, an engineer from Alberta Transportation stated the driver population factor plays a minimal role in roads like QE2 highway because it is straight and has high engineering standards such as shoulder width and interchange density[16]. Finally, freeway flow rates can be significantly affected by the number of lanes (N) available to traffic. It is clear that increasing the number of lanes can significantly reduce the number of vehicles flowing per lane. The relationships for the freeway flow rate calculation can be found in equation 3.

$$v_p = \frac{V}{PHF \times N \times f_{HV} \times f_p} \tag{3}$$

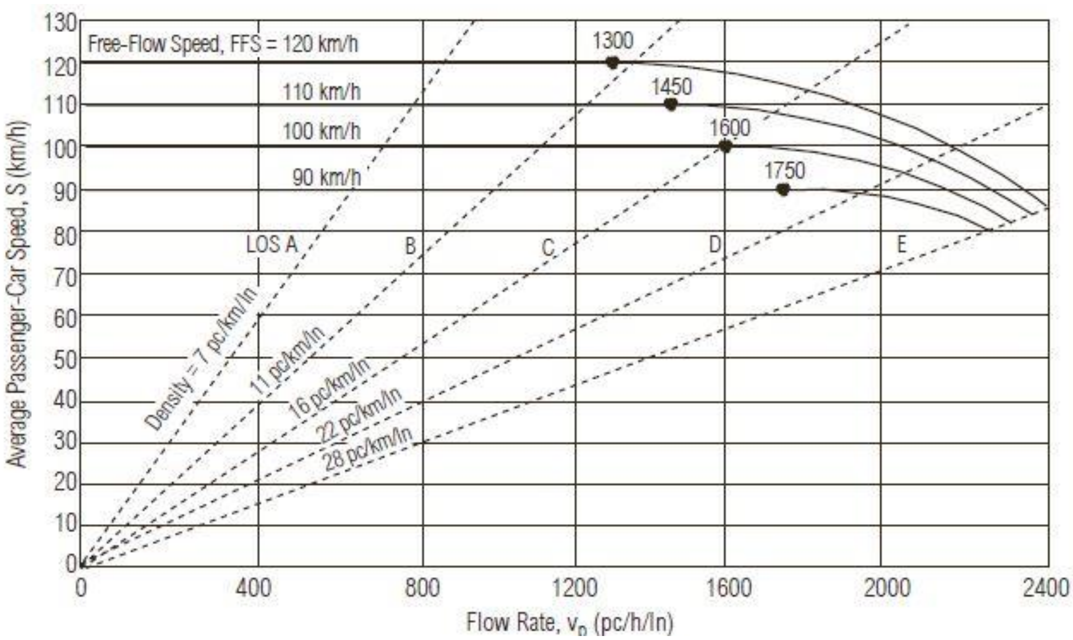
[15] Caution should be used when looking at equations 1 and 2. *(D)* is used differently to represent Density in *equation 1 and direction split in equation 2.*

[16] This is from several phone interviews with an Engineer from Alberta Transportation on January 22 and 23 of the year 2015. This Engineer helped provide assumed values for some the factors in the Level of Service Calculations. After the Final Level Service table was created, this engineer looked over the results and compared them to Alberta Transportation's own Level of Service projections and stated they were reasonably accurate.

All components of the Highway flow rate calculation are integers between 1 and 0 except for number of lanes factor which can be numbers 1 to 7.

After calculating the flow rate from equation 3, average passenger car speed is deduced by referring to the "speed-flow curves" from the Highway Capacity Manual (Transportation Research Board, 2000).[17] These curves represent the relationship between flow rate, speed and density that past research has established. Figure 5 shows the relationship established for basic freeway segments. Free Flow Speed (FFS) is established by field measurements. Based on department measurements, Alberta Transportation recommended that a FFS of 120 km/h should be used for level of service calculations for the QE2 highway.

Figure 5: Speed-Flow Curves and LOS for Basic Freeway Segments



Source: Transportation Research Board (2000) Exhibit 23-3, p 870

[17] These curves were established by previous studies, which has been approved by the Transportation Research Board that publishes the Highway Capacity Manual (Transportation Research Board, 2000).

Level of service rankings are based on acceptable ranges of speed, flow and density. The ranges are based on different speed-flow curves. There are different curves based on the free flow speed of the road, which is, “the average speed of passenger vehicles over a basic freeway or multilane highway segment under conditions of low volume” (Transportation Research Board, 2000, p. 86). Based on advice from engineering staff at Alberta Transport, 120 km/h is an appropriate value for FFS. Their recommendations are based on field measurements taken by Alberta Transport. The acceptable ranges of speed, flow and density for freeway facilities with a FFS of 120 km/h are available in table 9.

Table 9: Level of Service for Freeway Facilities with a Free Flow Speed of 120 km/h

Criteria	LOS				
	A	B	C	D	E
FFS = 120 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	120.0	120.0	114.6	99.6	85.7
Maximum v/c	0.35	0.55	0.77	0.92	1.00
Maximum service flow rate (pc/h/ln)	840	1320	1840	2200	2400

Source: Transportation Research Board (2000), Exhibit 23-3, p 869.

The different levels of service also have qualitative descriptions that refer to the amount of maneuverability and mental stress they cause drivers. Level of service A describes a freeway facility operating at free flow speed. At level of service A, vehicles can freely manoeuver within the traffic stream. Minor disruptions to traffic flow are easily absorbed. Level of service B describes a road segment operating at free flow speeds. Maneuverability is only slightly restricted and drivers in general have high levels of psychological comfort. Minor disruptions are still easily absorbed. Level of service C still maintains near free flow speeds. However, freedom to manoeuver is noticeably restricted and lane changes require drivers to be more aware. Minor incidents are still be absorbed, but queues can form behind significant blockages. At Level of service D travel speeds start to decline because density increases. Maneuvering becomes limited and even minor disruptions start to create queuing, due to lack of space to accommodate reduced capacity from lane restriction. At Level of service E freeway facilities are at capacity. There is little space to manoeuver at speeds that are reduced by nearly

35km/h and there is no space to absorb even the most minor disruptions. Any incident can produce serious queuing. Level of service F describes a breakdown of traffic flow on a freeway. Disruptions at level of service F have the potential to create queuing that extends upstream for significant distances (Transportation Research Board, 2000). The cases considered are those where level of service bench marks reach D, E, or F. Generally, these are considered unacceptable.

Chapter 7. Analysis

This section applies level of service (LOS) calculations to the QE2 highway. The LOS calculation is applied to current daily traffic levels.[18] I evaluate the current congestion levels on the QE2 highway. Then using the daily projections discussed in section 4.5, I will show how level of service will break down as congestion rises in the future.

7.1. Current Level of Service

Currently, there are no segments with an unacceptable LOS (i.e. LOS D, E, or F). Some areas already drop to LOS C at the busiest sections of the QE2 Highway. These most congested parts according to the LOS analysis are In Red Deer, and the segments heading into the major cities of Edmonton and Calgary. Appendix C and D show the results of the LOS analysis of the current infrastructure of the QE2 highway. Table 10 shows control sections with traffic control sections (TCS) that are already reaching LOS C. Outside of Calgary, control section 18 at TCS 4 has already reached LOS C despite having 3 lane capacity in each direction. In Red Deer, control section 24 at TCS 12, despite being significantly less busy when compared to segments outside of the major cities, has reached level LOS C. Segments with LOS C should be considered for capacity upgrades soon, especially if the segments have historically higher growth rates. Control section 32 reaches LOS C at both TCS 12 and 16. Segments of control section 32 at TCS 16 are congested to the point that even segments with 5 lanes of capacity in each direction have only LOS B. While LOS C leads to only a 5.4 km/h reduction from free flow speed, maneuverability is noticeably reduced and any significant traffic

[18] Current refers to 2013 because 2013 has the most recent published AADT numbers from Alberta Transportation.

incidents at these points can create flow halting traffic jams. These intersections will soon reach unacceptable level of services if there is no intervention.

At several of these segments outside of Edmonton and Calgary where level of service C has already been reach, upgrades are already planned or started construction to meet future demand. This means that already

Table 10: Level of Service at Most Congested Traffic Control Sections

CS	TCS	Segment Description	2013 LOS	Number of Lanes	2013 ADDT
18	4	N OF 566 E OF BALZAC	C	3	78570
18	4	4.6 KM S OF 2 & 567 AIRDRIE	C	3	78400
18	4	S OF BIG HILL SPRINGS RD	C	3	78570
18	4	N OF BIG HILL SPRINGS RD	B	3	60930
18	4	S OF TWP RD 272, AIRDRIE	B	3	46520
24	12	N OF 32 ST IN RED DEER	C	2	51300
24	12	S OF 11A T RED DEER	C	2	51300
32	12	N OF AIRPORT RD	C	3	74160
32	12	S OF 19 & 625 W OF NISKU	C	3	74160
32	16	N OF 19 & 625 W OF NISKU	C	3	85990
32	16	5.9 KM N OF 2 & 19 NISKU	C	3	85990
32	16	S OF ELLERSLIE RD	B	5	85980
32	16	N OF ELLERSLIE RD	B	5	89990
32	16	S OF 216 S OF EDMONTON	C	3	89990

The rural sections, between Red Deer-Airdrie and Red Deer Leduc, have more optimal LOS. Between Calgary and Red Deer (control section 18 TCS 4 and control section 24 TCS 12), there are 39 segments of which 35 are LOS B and 4 which are LOS A. Between control section Red Deer and Edmonton (24 TCS 12 and control 32 TCS 12) there are 41 Segments. Of these segments 23 are LOS A and are 18 LOS B. In other words, south of Red Deer heading toward Calgary, there is greater congestion than north of Red Deer heading towards Edmonton. LOS A and LOS B are acceptable ranges to have in current infrastructure, since there is plenty of room for vehicles to manoeuver and no reduction in average vehicle speed. LOS C is acceptable as well, but it warrant planning future upgrades.

Overall, LOS analysis shows no problems currently along the QE2 highway except for minor slow down and congestion around Edmonton, Calgary and Red Deer. Of the QE2 highway's 95 segments, I only observe 10 that have fallen to LOS C. However, this congestion is already an early warning sign the capacity upgrades will be needed soon.

7.2. Predicted Level of Service

The projected LOS analysis provides a timeline for how travel will break down along the QE2 highway. The complete breakdown of LOS by segment and by year can be found in appendices C and D. In the year 2015, LOS D will appear for the first time along QE2 highway heading into Edmonton (control section 32 and TCS 16). Traffic entering the city will slow by over 20 km/h. The number of LOS C segments will increase from 10 to 12. By 2018, the same area will already have degraded to LOS E. Speeds heading in and out of Edmonton will have dropped to 85km/h and even a minor traffic disturbance will halt to flow into the city. If nothing is done by 2020, a complete breakdown of traffic flow will occur outside the city of Edmonton. The following year, Red Deer will have its busiest segment reach LOS E. By 2023, segments between Calgary and Airdrie drop to LOS E. In 2023, two segments will reach LOS F in Red Deer and will have total traffic break down. In 10 years from the most current data, two major sections of the QE2 highway will have complete halts in their traffic flow. In 2024 congestion becomes noticeable in rural sections as most of the highway between Calgary and Red Deer is at LOS C. And 2025 is the year when control section 18 at TCS 4 finally reaches LOS F and complete traffic break down occurs outside of Calgary. By 2030, almost all rural segments of highway have reached LOS C or worse. By 2035, the length of QE2 highway between Calgary and Red Deer reached LOS D where ever it has not already completely failed. At the final projection year of 2038, 30 out of 95 segments have reached LOS F. In addition, 1 out of 95 segments have reached LOS E, mostly along rural segments between Calgary and Red Deer. And 34 Segments will have reached LOS D, these occur in both rural stretches between the Red Deer and the major cities. Finally, only 18 segments between Red Deer and Edmonton will maintain LOS C. One segment near Red Deer will maintain a LOS B. So, in short almost every segment will need upgrades to serve future demand.

Table 11: Level of Service Time Line

LOS	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
A	28	15	10	5	1	1	0	0	0	0	0	0	0
B	57	70	72	70	74	69	69	65	63	63	61	47	41
C	10	10	12	17	15	17	18	20	20	19	21	30	35
D	0	0	1	3	5	7	5	7	7	8	5	8	6
E	0	0	0	0	0	0	2	2	2	2	3	5	5
F	0	0	0	0	0	0	0	1	3	3	5	5	8

LOS	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
A	0	0	0	0	0	0	0	0	0	0	0	0	0
B	34	21	16	14	8	2	2	2	1	1	1	1	1
C	39	51	53	53	59	61	60	52	48	45	39	23	18
D	9	10	11	9	6	9	9	17	20	20	24	40	34
E	3	0	2	5	8	4	4	1	3	5	7	4	11
F	10	13	13	13	13	19	20	23	23	24	24	27	31

The analysis above looks at the function of all segments individually. In reality, once LOS F is reached at two points along the QE2 highway in 2023, its viability of as a major route for the Edmonton Calgary transportation corridor (ECTC) is compromised. The QE2 highway will be debilitated once traffic failure occurs at one of these crucial points, like Red Deer and Edmonton that have high traffic. During 2023 when LOS F is reached, control section 24 at TCS 12 in Red Deer projected flow rate is 2511 vehicles per hour per lane (pc/h/l). When a complete traffic breaks down occurs at this point, the length of queue will grow at the rate of 42 car lengths a minute. Assuming an average vehicle length of around 4.5 meters, within a minute 184 meter long queue will form. In 30 minutes a queue longer than 5.5 km will have formed. This traffic jam will back up into other traffic control sections, causing them to fail. The TCS outside the major cities with even higher flow rates will experience even longer queues after a complete traffic break down.

As a result of increasing congestion, all commercial vehicle movement in the corridor will either be delayed if not completely stopped. The effects on commercial activity traffic would be disastrous as one of the major corridors transportation corridors becomes unusable. The effects of provincial economy will be extensive if as traffic slows. As section 4.6 discusses, commercial traffic has significant time related costs. As traffic slows, these costs pass along the all supply chains based off the QE2 highway.

Wide spread transportation delay will increase costs of both production and consumption within the entire Edmonton Calgary transportation corridor (ECTC). Longer travel times increase variable costs of carriers, such as fuel and labour. These increased costs will be passed on to their customers making goods that are made in Alberta less competitive and goods consumed in Alberta more expensive. Furthermore, the effects of congestion extend beyond individual carrier's cost structure. Efficient transportation networks have allowed firms at all stages from production to final retail to lower overall costs of inventory management (Jung and Lee, 2010). As a result, travel times in key transportation corridors, such as the ECTC, serve a strategic role in the Alberta economy.

It is important to keep in mind that the scenarios above would most likely not happen. Alberta Transportation will respond to this growth adding capacity, but most likely one segment at a time. Adding capacity a kilometer at a time may appear fiscally attractive in the short term, because total costs aggregated over a longer time frame may be more expensive. However, the aim of this study is to look at the entire ECTC as whole, not just individual segments, to identify what the best option for dealing with future congestion is. By using a longer time horizon, options with bigger capital investments like by passes and high-speed rail could be more effective in the long term to address congestion on existing roads. So, the remaining of my capstone is an analysis of potential options based on the long term goals to eliminate the congestion predicted in this chapter. I suggest three policy options which are evaluated and ranked for a final recommendation.

Chapter 8.

Criteria and Measures for Policy Options

A set of criteria and measures is used to objectively evaluate the policy options to mitigate future congestion and allow free movement of goods and people along the ECTC. The criteria by which policy options are assessed include effectiveness in congestion reduction, cost of policy options, and implementation complexity of implementation. In other words, a cost-effectiveness analysis is conducted while also attending the administrative challenges of each option. Public support is not explicitly captured in this analysis, although it is somewhat taken into account in the administrative complexity criterion. The main reason for not looking at public support is that infrastructure investment leads to effective traffic flow along the ECTC, which is very popular among the public.[19] As one senior planner from Alberta Transportation stated, "as long as traffic is flowing along highway 2 every one seems to be happy."

Each policy option receives a score based on each criterion. The more favourably each policy satisfies a criterion the higher the score it receives on a scale of 1 to 3. For example, if a policy option is very effective at satisfying a criterion it is assigned a high score of 3 points. If it only somewhat satisfies a criterion then it receives a medium score of 2 points. And if the policy option barely satisfies a criterion it receives a low score of 1 point. Criteria are given identical weights because no one criterion is more important than another. The total score is added provides a final ranking and comparison of policy options. Table 12 shows a complete summary of the criteria and measures.

[19] This view was expressed in interviews from planning staff at Alberta Transport in phone interviews conducted on March 6th 2015.

8.1. Effectiveness

Each policy option is evaluated based on its ability to reduce congestion on the QE2 highway. The method of measuring effectiveness is LOS analysis. The specific measure is percentage of highway segments shifted to acceptable levels of service from unacceptable levels of service. Acceptable levels of service include level of service A, B and C. And unacceptable levels of service include levels of service D, E and F.

The highest score (3) is assigned to the option that can shift 20% or more of segments from unacceptable to acceptable levels of service. A medium score (2) is assigned to options that can shift 10-20% of segments into the acceptable category. A low score (1) is assigned to any options that shift l10% or less of segments into the acceptable level of service range.

8.2. Cost of Policy Options

The cost criterion includes measurement of capital. Costs are measured in current 2015 dollars. Other economic costs such as environmental damages and impacts to prices are not included in the cost criterion. While these costs are important and could affect the results of what policy option should be perused, they are not included in this study's analysis due to logistical limitations. Future research should be undertaken to explore the economic cost and benefits of policy options for future congestion in the ECTC.

Cost rankings are bench marked off the transportation allocation of the 2014-2017 capital plan. The allocation equates to 5 billion dollars. This allocation is used for capital projects as big as major city ring roads to as small as resurfacing a rural highway. Capital plans must consist of both major and minor capital project that either expand or maintain the provincial transportation network, so the expectation is that a policy would only use up part of this bench mark. A medium score (2) is assigned to a project that falls between $2.25 and 2.75 billion. A high score (3) is assigned to a project that costs less $2.25 billion. And a low score (1) is assigned to a project that costs more than 2.75 billion.

8.3. Implementation Complexity

This criterion address the challenges related to negotiating a major transportation project. When building linear infrastructure a right of way must be negotiated. This divides existing property ownership and prevents large tracts of land from being used for other purposes. It also establishes a property line that either blocks or complicates other possible rights of way, meaning if a major road is built running north to south it will either severe or need to provide access to any east west running linear infrastructure. This criterion is evaluated based on whether the right of way acquisition for the policy option is significantly large and if municipal negotiation is required. Difficulty to acquire right of way is established by a visual scan of how big the acquisition could be. The presence of municipal negotiation issues is acquired from municipal transportation plans that either incorporate or exclude policy options.

The scoring is based on presence of right of way and municipal negotiation issues. A policy ranks high (3) if it has none of these issues, medium (2) if it only has one of these issues present, and a low (1) ranking if it has both issues present.

8.4. Government Acceptability

The government acceptability criterion assess the extent to which each policy requires expansion of the role of government by legislation or by hiring more staff. This criterion is rank options by the extent they increase the administrative burden to Alberta Transportation. If a policy option requires new legislation, such as new regulations, requires significant research and study by the department beyond their current function. Also if a policy option, requires additional staffing for the program, it receives a lower score on this criterion.

The scoring of the policy options is based on how many government actions are necessary to enact a policy option. Government actions include expanding legislation and/or administrative staff. A high score (3) is assigned to a policy option that requires neither. A medium score (2) is assigned to a policy option that requires either legislation or administrative staff expansion. Finally, a low score (1) is assigned to a policy option that needs to expand both legislation and administrative staff.

Table 12: Criteria and Measures of Analysis

Criteria	Definition	Measure	Ranking
Effectiveness	To what extent does a policy option improve the level of service on the QE2 highway?	The percentage of segments shifted from unacceptable to acceptable levels of service (Segment=S).	S > 20% High = 3 points 20% >S> 10% Medium = 2 points S < 10%, Low = 1 point
Cost	The capital costs of a policy option.	Capital costs are compared to a reference point of $5 billion from the 2014-2017 capital plan allocation for transportation (Capital Costs=CC).	CC < $2.25 billion High = 3 points $2.25 billion <CC< $2.75 billion Medium = 2 points CC > $2.75 billion, Low = 1 point
Implementation Complexity	The complexity of negotiations required to implement a policy option.	The number of implementation issues present in each option. Implementation issues are: - extensive right of way acquisition - complicated municipal negotiation	No issues present High = 3 points One issue present Medium = 2 points Both issues present Low = 1 point
Government Acceptability	Does the policy option require significant government actions?	The number of government expansion actions a policy requires. Government actions are: - legislative change - hiring additional staff	No action required High = 3 points One action required Medium = 2 points Both actions required Low = 1 point

Chapter 9.

Policy Options and Analysis

Policy options discussed are additional capacity upgrades, bypass routes and a high speed rail line. The status quo is also discussed since it is not the existing infrastructure but the capacity upgrades that are already planned by the government. All policy options will be in addition to the upgrades described in the status quo. Additional capacity upgrades are extra lane additions that can be made to the QE2 highway after the assumed status quo upgrades. Bypass routes are alternative routes that can be built around larger cities along the QE2 highway to divert and optimize traffic flow. A high speed rail line is an additional mode of travel that would reduce traffic on the QE2 through modal shift.

9.1. Status quo

The status quo in this study is the current infrastructure with one additional lane of capacity. The process of upgrading the QE2 highway in this fashion would prioritize the more congested areas outside Calgary and Edmonton and inside Red Deer. Cost do not just relate to lane addition to the QE2 highway. Cost of these first round of upgrades are not included in the final analysis, since they are assumed to happen regardless of which option is chosen.

Capacity upgrades cannot be implemented at once. Besides the logistical constraints, it is neither reasonable nor warranted that the entire length be upgraded immediately. The implementation of this option is based off the 2004 Al-Terra planning study (Al-Terra Engineering Ltd, 2004). The Al-Terra planning study suggests that upgrades occur in 5 different phases, prioritized by speed of LOS decline. However, Al-Terra's prediction places the decline of LOS faster outside of Calgary than Edmonton, while this study's projections found the decline outside of Edmonton more pressing. The government of Alberta has already started some of the upgrades outside of Edmonton during the summer of 2014, and is already following the assumed phases of capacity upgrades

Table 13: Assumed Phases for Capacity Upgrades

Highway 2 Road Section	Upgrade Phase	Construction Start Year	Construction Finish Year
Calgary to Airdrie	Phase 3	2023*	2026
Airdrie to Red Deer	Phase 4	2026	2030
Red Deer Area	Phase 2	2020	2023
Red Deer to Leduc	Phase 5	2030	2034
Edmonton to Leduc	Phase 1	2014	2020

* Has sections that must be started earlier to prevent total traffic break down and must be finished before 2025.

Source: Al-Terra Engineering Ltd (2004)

The effect of phase's completion, compared to if no intervention had been taken, can be seen in Table 12. Phase 1 of upgrades already prevents the traffic break down that would have occurred that year between Edmonton and Leduc. Similarly, phase 2 prevents traffic breakdown that would have occurred within the Red Deer area. Phase 3 of upgrades prevents the breakdown of traffic between Airdrie and Calgary. However, by this time traffic has grown enough that traffic break down occurs just outside of Edmonton despite the added capacity from phase 1. Phase 4 of upgrades returns the majority of the QE2 highway between Airdrie and Red Deer back to LOS B. By this time 2 more segments have failed outside Edmonton. Phase 5, re-establishes most of QE2 highway between Leduc and Red Deer back to LOS B. However, capacity upgrades from phase 3 finally are out grown by traffic by the year 2033.

Table 14: Level of service changes after completion of each phase of construction

	Phase 1		Phase 2		Phase 3		Phase 4		Phase 5	
Number of Segments by LOS	2020 without intervention	2020 with Intervention	2023 without Intervention	2023 with Intervention	2026 without Intervention	2026 with Intervention	2030 without Intervention	2030 with Intervention	2034 without Intervention	2034 with Intervention
A	0	2	0	2	0	0	0	1	0	1
B	65	70	61	63	34	40	8	39	1	58
C	20	16	21	24	39	43	59	35	48	16
D	7	5	5	3	9	9	6	9	20	5
E	2	2	3	3	3	2	8	8	3	3
F	1	0	5	0	10	1	13	3	23	9

Overall, the capacity upgrades of one addition lane only prevent complete traffic breakdown on the QE2 highway till 2026, only six years longer than without any upgrades at all. Table 13 shows one additional lane will decrease the total amount of unacceptable segments by 51.6% in 2038. This solves most capacity issues in the more rural segments of the QE2 highway. However, there is still a significant short fall outside of Edmonton, Calgary and in the Red Deer area. The status quo scenario with one additional lane still leaves one third of the QE2 highway at unacceptable levels of service by the year 2038.

Table 15: Overall effects of 1 lane of capacity on LOS by 2038

Level of Service	# of segments in 2038 with current infrastructure	% of all segments	# of segments in 2038 with an additional lane	% of all segments
A	0	0.0%	0	0.0%
B	1	1.1%	43	45.3%
C	18	18.9%	25	26.3%
Acceptable	**19**	**20.0%**	**68**	**71.6%**
D	34	35.8%	7	7.4%
E	11	11.6%	4	4.2%
F	31	32.6%	16	16.8%
Unacceptable	**76**	**80.0%**	**27**	**28.4%**

Alberta Transportation has already started to implement some of these capacity upgrades and it is unlikely that their implementations will not happen within the above time frame. However, additional infrastructure after the one additional lane will be necessary.

9.2. Policy Option 1: Added Capacity to the Status Quo

9.2.1. Description

Addition capacity upgrades can be pursued after the above mentioned upgrades. This option mimics the current strategy of Alberta Transportation, adding capacity one stretch of highway at a time, prioritizing the lowest level of service segments first. Simply put, it is the improved status quo. The upgrades will occur on segments heading into the major cities and within the Red Deer area. This option involves adding capacity so that roads no longer fail in 2038. The implantation involves only improving one stretch of segments at time and adding one lane of capacity each phase of upgrades; as a result, there will be constant construction on the QE2 highway for 12 years.

There will be two phases of upgrades outside the city of Calgary. Similarly, two phases of upgrades will be constructed within the city of Red Deer. Finally, four different phases of upgrades are needed outside the city of Edmonton. In fact, the Control section 32 would have constant construction from the year 2023 till 2038. The net results of the upgrades can prevent the total traffic breakdown that is coming to the ECTC.

9.2.2. Analysis

Effectiveness. While additional capacity upgrades prevent total traffic breakdown within the time frame, they do not increase any of the sections' level of service to an acceptable level. Most of the sections increased to a level of service D from a level service F. This means that there will still be noticeable limitation to maneuverability and speed will still be reduced by over 20km/h from free flow speed. As a result, it will receive a low score (1).

Table 16: 2038 Level of Service by Segment with and without Addition Capacity Upgrades

Level of Service	# of Segments in 2038 without additional upgrades	% of all Segments	# of Segments in 2038 with additional upgrades	% of all segments
A	0	0.0%	0	0.0%
B	43	45.3%	43	45.3%
C	25	26.3%	25	26.3%
Acceptable	**68**	**71.6%**	**68**	**71.6%**
D	7	7.4%	21	22.1%
E	4	4.2%	6	6.3%
F	16	16.8%	0	0.0%
Unacceptable	**27**	**28.4%**	**27**	**28.4%**

Cost. The unit cost of a lane of addition is about $2 million per kilometer.[20] The cost of lane additions by geographical area are found in Table 15.Over two thirds of the lane capacity upgrades will need to happen outside the city of Edmonton. The Red Deer and Calgary areas require significantly less capacity upgrades. This is due to the significant difference between the number of lanes and the total distance of lane addition.

Table 17: Cost of Additional Lane Upgrades by Geographical Location

Construction area	Length of Upgrade	# of Lanes Added*	Cost
Outside Calgary	6.5 1	2 1	$26,000,000 $2,000,000
Inside Red Deer	2.2 4.9	1 2	$4,436,000 $19,396,000
Outside Edmonton	3.2 13	2 4	$12,960,000 $103,752,000
Total	30.8	-	$168,544,000
*In each direction			

Costs of additional capacity will exceed the $168.5 million required for lane addition. There are 40 bridge structures over the QE2 highway, and if any of them need to be replaced to accommodate additional lanes it could be costly. Al-terra's highway 2 planning study assumed a cost 20.2 million per interchange replaced.[21] There can also increase if additional land needs to be purchased for either the additional lanes or the interchanges. The majority of interchanges that would need to be upgraded for the additional capacity would have been replaced due to reaching the end of their lifespan and to accommodate the initial status quo upgrades that Alberta Transportation. As a result, replacing those interchanges will not be included the cost of this policy option. However, there are 3 interchanges in the Red Deer area and one entering the Calgary area that outside of the initial upgrade plan and will need to be upgraded to eventually

[20] This figure is based off recent tendering of highway expansion outside of Airdrie. This cost was shared by an investment planning expert at Alberta Transportation. He stated this is the most accurate figure available.

[21] This figure is inflated to 2015 dollars.

handle the addition lanes. These interchanges have an estimated of cost $80.8 million. There also should be a contingency for land acquisition of $1 million[22]. Actual need for land acquisition is unknown since no planning studies have been done; however, during interviews Alberta Transportation staff said it could be issue. Table 16 shows the breakdown of the $250.3 million total cost of the proposed upgrades. Upgrading the QE2 highway with additional capacity ranks high (3) in cost criterion.

Table 18: Total cost of Additional Capacity Upgrades

Upgrade Category	Description	Cost
Lane capacity upgrades	30.8 km of lane additions	$168,544,000
Interchange Replacement	1 interchange outside of Calgary 3 interchanges inside of Red Deer	$80,800,000
Land purchase contingency	200 acre land purchase contingency	$1,000,000
Total Cost		$250,344,000

Source: Al-Terra Engineering Ltd (2004)

Implementation Complexity. There is little to no implementation issues to additional capacity upgrades. While a right of way contingency is planned for, even if it is used the amount of land required to expand the right of way would be minimal. As a result, acquiring right of way is not a implementation issue. For similar reasons, there is no reason for municipal negotiation. Furthermore, expansion of the QE2 does not appear to conflict with any individual municipal planning strategies. Overall, highway expansion ranks high (3)

Government Acceptability. Additional lane capacity requires no expansive actions by the provincial government. Capacity upgrades, like the ones in this policy option, are part of the regular function of Alberta Transportation. As a result, this policy option ranks high (3) in government acceptability criterion because there is no need to increase staff and expand legislation.

[22] 200 acre contingency was selected from visual scan of maps additional land could be necessary. $1 million dollar total price was result of using a $5,000 per acre unit cost from Al-Terra's planning study.

9.3. Policy Option 2: Bypasses

According to the California's department of transportation a bypass is "[a]n arterial highway that permits users to avoid part or all of a city or town center, a suburban area, or an urban area" (Caltrans, 2014). It is designed to reroute or divert traffic around a municipality that currently travels through it. Bypasses can separate local travel demand from through traffic. By passes are usually characterized by faster travel times due to usually being a higher class of road than the existing through route, such as the case of QE2 highway that bypasses previous highway, now designated 2A, that used to intersect many of the adjacent towns. Since, the QE2 highway is already the highest class of highway; a bypass will not divert traffic for this reason. However, people will divert to a bypass to avoid congestion causing the bypass to balance capacity. The bypass will also separate commuting traffic into the major cities from through traffic of the ECTC.

9.3.1. Description

The locations of bypasses are where LOS is projected to degrade fastest. As a result, bypasses will be constructed around the City of Red Deer, as well as around the Airdrie and Nisku areas heading into the major cities. The Red Deer Bypass would be built around city connecting to the QE2 highway on the north and south of the city. The Airdrie Bypass would connect QE2 highway north of Airdrie to Calgary perimeter ring road, highway 201 Stoney Trail. Similarly, the Nisku bypass would be connect to the QE2 highway south of Nisku to the Edmonton perimeter ring road, highway 216 Anthony Henday Trail.

9.3.2. Analysis

Effectiveness. The effectiveness of bypasses to reduce congestion is completely based around how much traffic is diverted to the bypasses from the QE2 highway. This study assumed 40% Diversion rate. This rate was chosen to represent the a portion of traffic that would not relocate to the bypass based destination factors, which incentivise people to take slower flowing route instead of the less direct faster flowing bypass. One factor includes the need to continue on more directly attached routes such as the Gateway Boulevard or Deer Foot Trail in Edmonton and Calgary respectively. Another destination factor is that proportion of traffic will be headed to destinations that are directly attached to QE2 Highway. This is why bypasses have higher level of services than the older route. The net effect of the highway bypasses on level of service is shown by table 18. Bypasses improve the overall level of service on the QE2 highway increasing the number of segments with acceptable LOS by 18% and reducing the number of LOS F segments to 3. Furthermore, when using a corridor perspective, substituting the QE2 highway segments with the bypass segments increases the percentage of segments shifted to acceptable levels of service by 21%. As a result, the bypass option ranks high (3) in effectiveness.

Table 19: Level of Service on QE2 Highway with and without Bypasses.

Level of Service	# of Segments in 2038 without Bypass	% of all Segments	# of Segments in 2038 on QE2 highway with Bypasses diversion	% of all segments	# of Segments in 2038 on QE2 with Bypasses segments substituted	% of all segments
A	0	0.0%	3	3.2%	14	14.7%
B	43	45.3%	51	53.7%	53	55.8%
C	25	26.3%	31	32.6%	21	22.1%
Acceptable	**68**	**71.6%**	**85**	**89.5%**	**88**	**92.6%**
D	7	7.4%	7	7.4%	2	2.1%
E	4	4.2%	0	0.0%	5	5.3%
F	16	16.8%	3	3.2%	0	0.0%
Unacceptable	**27**	**28.4%**	**10**	**10.5%**	**7**	**7.4%**

Cost. Bypass construction has three major categories of costs. This includes the land purchase of right of way, construction of interchanges and construction of a new highway. Right of way purchase entails the purchasing of necessary land for the construction of both interchanges and the new highway route. Interchange construction includes building both systems interchanges, which function as major connectors linking the bypasses to the QE2 highway and the major city ring roads, and service interchanges that maintain access for routes that run east to west across the new bypass route. Highway construction entails building the new bypass highways. Cost estimates of the categories are shown in Table 19.[23] Interchange construction is the largest portion of costs for the three bypasses, making up 65-68% of costs for each bypass route. The large systems interchanges carry a price of $200 million each, while service interchanges cost only approximately $50 million each, but require 3 or 4 interchanges per route. Road construction costs range from 175 million to 180 million per bypass route. The Nisku bypass is the shortest bypass in length however, it is planned to be a 3 lane bypass making it cost more than the longer Airdrie and Red Deer bypasses. The cost of land for right of way purchase cost over a $100 million per bypass route. The total costs of all three bypasses will cost the province of Alberta over $2.5 billion to complete. As a result, the score the bypass option receives is medium (2).

Table 20: Cost of Bypass construction

Nisku Bypass		**Airdrie Bypass**		**Red deer Bypass**	
Right of way purchsase	**$101,536,800**	**Right of way purchsase**	**$103,421,000**	**Right of way purchsase**	**$103,421,000**
Interchange construction		**Interchange construction**		**Interchange construction**	
Systems interchanges construction costs	$400,000,000	Systems interchanges construction costs	$400,000,000	Systems interchanges construction costs	$400,000,000
Service interchanges construction costs	$200,000,000	Service interchanges construction costs	$150,000,000	Service interchanges construction costs	$150,000,000
Total Interchange construction cost	**$600,000,000**	**Total Interchange construction cost**	**$550,000,000**	**Total Interchange construction cost**	**$550,000,000**
Road Construction		**Road Construction**		**Road Construction**	
4 lane highway per Km	$7,000,000	4 lane highway per Km	$7,000,000	4 lane highway per Km	$7,000,000
*20km	$140,000,000	*25km	$175,000,000	*20km	$175,000,000
Lane Addition per km	$2,000,000	Lane Addition per km	$2,000,000	Lane Addition per km	$2,000,000
*20km	$40,000,000	*0km	$0	*0km	$0
total Highway construction cost	**$180,000,000**	**total Highway construction cost**	**$175,000,000**	**total Highway construction cost**	**$175,000,000**
Total Bypass Cost	**$881,536,800**	**Total Bypass Cost**	**$828,421,000**	**Total Bypass Cost**	**$828,421,000**
Total cost for bypasses	**$2,538,378,800**				

Implementation Complexity. Bypasses face considerable implementation complexity. They will need to acquire over 3600 acres of land so right of way negotiations will take considerable effort. Municipal negotiation will also be an issue. The Capital Region board that represents the municipalities around the city Edmonton proposes a bypass routes similar to this studies in their transportation master plan (Capital Region Board, 2011). However, the Calgary Region Partnerships has expressed

[23] Cost estimates were provided by Alberta Transportation through email correspondence and interviews. Costs are planning level estimates and, while not exact, they are precise enough for this study's purpose. More detailed unit costs are available in Appendix E.

aversion new highway projects similar to bypass routes.[24] Specifically, the report expresses the need for the Calgary region to “[r]educe the need for financial resources to be spent on maintaining existing roadways and building new major arterials, regional roads and highways” (Calgary Regional Partnership, 2009). The opposition from the Calgary region is significant enough to create an implementation issue. Since both right of way and municipal negotiation issues exist, this policy ranks low (1) for implementation capacity.

Government Acceptability. Similar to the additional capacity policy option, constructing bypasses is a fairly standard activity for Alberta Transportation. Even some the implementation complexities such as right of way acquisition are mitigated by the extensive legislation that facilitates expropriation (i.e., the expropriation act). Furthermore, Alberta Transportation already has the staff to facilitate large projects like these bypasses. Much larger projects, such as the twinning of highway 63, and the ring road projects are considered much larger projects. As a result, bypasses rank high (3) in the government acceptability criterion

9.4. Policy Option 3: High Speed Rail

High speed rail option would create dedicated passenger rail service between the two major cities. The purpose would be to shift passenger vehicle traffic to high speed train service, reducing congestion for commercial traffic and the remaining passenger vehicles that stay on QE2 highway. The major incentive for drivers to shift mode of transport is a significant reduction in travel time. This would separate corridor passenger through traffic from commercial traffic and local commuter passenger traffic. Two significant reports have been written on high speed rail viability in the ECTC. One report was published by Alberta Transportation, which contains information on possible modal shift and other economic benefits from the project. The other report was published and updated by the Van Horne Institute which contains financial costs and benefits of the

[24] The capital region expressed opposition to major highway projects like an outer ring road. A ring road operates similar to bypass and has relatively similar costs.

project. Both Reports look at several High speed rail options. This study will only look at the green field electrified rail options.

9.4.1. Description

The Basic design principles of the high speed project are a high speed rail line with 3 stops in Edmonton, Calgary, and Red Deer. Between the proposals forwarded by Alberta Transport and the Van Horne Institute, an electrified rail option was selected for the general capital design along with rolling stock capable of traveling 300km/h. This combination was chosen because it offered the highest modal shift from passenger vehicle and bus travel to the high speed rail.

9.4.2. Analysis

Effectiveness. According to the Alberta Transportation report, 88-90% of the demand for high speed rail travel will be redirected from other modes. While 66-67% of diverted ridership will come from passenger vehicle users, modeling from report estimates that model shift to High speed rail equate to 3% of total volume of passenger vehicle travel demand each year (Transportation Economics & Management Systems, Inc. and Oliver Wyman, 2008).[25]

The Net effect of a high speed rail line on the QE2 high speed rail level of service can be found in table 21. A high speed rail at the end of the period of analysis will only shift 4.2% of segments from unacceptable levels of service into acceptable levels. More importantly, it only reduces the number of level of service F segments by 1.This suggests, although high speed many beneficial impacts not addressed in this study, significant reduction in congestion is not one of them. As a result, the high speed rail options score under the effectiveness criterion is low (1).

[25] The study by TEMS Inc. is nearly a decade old, but is the best study available to reflect what demand could be for high-speed rail in the ECTC. A new study should be conducted to see if demand has changed. Demand could be significantly affected by changing factors such as evolving intercity transportation systems like both major cities growing light rail lines.

Table 21: Final Level of Service by Segment with and without High speed Rail

Level of Service	# of Segments in 2038 without High Speed Rail	% of all Segments	# of Segments in 2038 with High Speed Rail	% of all segments
A	0	0.0%	0	0.0%
B	43	45.3%	45	47.4%
C	25	26.3%	27	28.4%
Acceptable	**68**	**71.6%**	**72**	**75.8%**
D	7	7.4%	7	7.4%
E	4	4.2%	1	1.1%
F	16	16.8%	15	15.8%
Unacceptable	**27**	**28.4%**	**23**	**24.2%**

Cost. The capital costs of high speed rail are significant. $5.3 billion accounts for the land, fixed capital such as rails and stations, construction, engineering and planning services. This does not include the purchase of high speed rail train cars which will cost another $453.7 million according to supplier estimates. These estimated costs result in the high speed rail option receiving a low (1) score for the cost criterion[26].

Table 22: Capital and Operating Costs of High Speed Rail

Cost Category	Description	Cost
Capital costs	materials and services to build the high speed line and associated facilities	$5,314,401,610
Purchase of Rolling stock	Train cars and engine	$453,695,100
Total Capital Cost		$5,768,096,710

Implementation Complexity. The size of land acquisition required by a high speed rail line would place the project among the largest in the provinces history. The negotiations establish the right of way for the high speed rail line would be a long process. The length of the right of way will bisect many private actors' properties. This

[26] Operating costs and revenue for the project can be found in appendix F.

will result in numerous negotiations, with the possibility of having to use the expropriation act extensively. High speed rail appears to lack the necessary municipal support. The Capital Region Board's Transportation Master Plan only mentions high speed rail once at the end of its report and is not included in any of the maps of the proposed future transportation network (Capital Region Board, 2011). The Calgary Regional Partnership has some long term planning and includes a high speed rail design in maps of their long term transportation plan; however, the Mayor of Calgary Naheed Nenshi agrees with a report from the Alberta Assembly that high speed rail is not viable in the short term for the corridor and that regional light rail transport needs to be prioritized instead (Legislative Assembly of Alberta, 2014, Canadian Broadcast Corporation 2014). Besides lack of support from the major municipal regions, there is also potential of significant municipal resistance from smaller municipalities and counties due to reduced east-west access from the high speed rail. Not all east west routes will get crossing points from the high speed rail. Were these crossings are located will be a point of contention in the future. As result, high speed rail will also have a municipal negotiation implementation issue. Therefore, high speed rail ranks low (1) in the implementation criterion.

Government Acceptability. High speed rail will require some expansion of the government. Currently, the Alberta Rail Act does not contain and regulations or standards for high speed rail. Regulations and standards could follow more recent examples from the United States; however, the main example of the Acela express train is significantly slower than options this report and the report from the Legislative Assembly of Alberta recommends. Staffing requirements would need to increase at least temporarily to establish regulatory environment for high speed rail. The full extent that high speed rail will require expansion of government staff is difficult to establish. There are many moving parts to establishing high speed rail line. Even if the actual operations of the high speed rail line is done through a public private partnership, there will still be gap in current engineering, finance and oversight capabilities within the Alberta government. With no high speed rail specialists within the Alberta Transportation it is assumed some staff will need to be acquired to establish the necessary expertise. Also considering the considerable liabilities and revenues associated with high rail line there maybe need for some addition staffing in treasury board and finance. Furthermore, there are ongoing intergovernmental attributes to a high speed rail option. This demand can increase the staffing requirements of the Ministry of Municipal Affairs. Despite the uncertainty surrounding staffing requirement, there is potential need to expand the civil service. Therefore, staffing will be a recognized as a potential government action required. Overall, high speed rail has been given a low acceptability score (1).

Chapter 10.

Final Assessment of Policy Options and Recommendation

The final analysis and comparison provides a dominant choice. Bypasses are the most effective for reducing congestion on QE2 Highway. The three bypasses are the best option to address the policy problem of declining commercial traffic travel. However, while additional capacity upgrades option can prevents traffic failure, it does so at nearly a tenth of the cost of bypasses. High speed rail is the most expensive from a capital cost perspective and offer the least congestion reduction.

Table 23: Policy Option Rankings and Score

Criteria		Option 1 Additional Capacity	Option 2 Bypasses	Option 3 High speed rail
Effectiveness				
To what extent does a policy option improve the level of service on the QE2 highway.	S > 20% High = 3 pts 20% >S> 10% Medium = 2 pts S < 10%, Low = 1 pt	1	3	1
Cost				
The capital costs of a policy option.	CC < $2.25 bn High = 3 pts $2.25 bn <CC < $2.75 bn Medium = 2 pts CC > $2.75 bn, Low = 1 pt	3	2	1
Implementation Complexity				
The complexity of negotiations required to implementing a policy option.	No issues present High = 3 pts One issue present Medium = 2 pts Both issues present Low = 1 pt	3	1	1
Government Acceptability				
Does the policy option require significant government actions?	No action required High = 3 pts One action required Medium = 2 pts Both actions required Low = 1 pt	3	3	1
Total Score		10	9	4

While effectiveness might be a primary concern for the province there are other important issues. Unless Effectiveness is given addition weight, travel times along the ECTC should be allowed to decline to respect other criteria. The deciding factor that made bypasses unviable compared to additional road upgrades was there inability to fit with the Calgary region's transportation plan and higher capital costs. If travel times on the QE2 are to be preserved near the current level of service, it is recommended that Provincial government increases communication with the Calgary region. Otherwise, this papers analysis finds current travel times increasing does not out weight cost or potential municipal conflict.

Chapter 11. Conclusion

This study used an aggressive projection of what future traffic along QE2 highway could be in the future. However, the ten year period that growth rates were projected from contained two significant recessionary periods, but still produced high overall traffic growth in the ECTC. This study's projections show that current strategies to add capacity by a few kilometers of one lane at a time will preserve overall traffic flow, but at a level of service much lower than is currently experienced by corridor travelers. This means that if alternative routes such as the proposed bypasses are not pursued that current commercial traffic flow in a major transportation corridor will be significantly impacted. The increased travel time and transportation costs will have extended impacts on major industries in the ECTC such as retail, manufacturing and oil and gas extraction. These impacts may result in effectiveness outweighing cost and municipal concerns in the future. In addition, Municipalities that current oppose more effective policy options such as bypasses may change their position as congestion grows. Similarly

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Appendix A.

Projections of ADDT and Growth Rates for Control Sections 20, 22, and 26

CS	TCS	Location Description	2013 AADT	Growth Rate used	Estimated 2023 AADT	Estimated 2033 AADT	Estimated 2038 AADT
20	4	N OF ACME RD	30260	3.7%	43406	62263	74571
		S OF 581 E OF CARSTAIRS	30260		43406	62263	74571
	8	N OF 581 E OF CARSTAIRS	30340	3.6%	43139	61336	73138
		S OF BERGTHAL RD	30340		43139	61336	73138
		N OF BERGTHAL RD	30210		42954	61073	72825
		S OF 582 E OF DIDSBURY	30210		42954	61073	72825
	12	N OF 582 E OF DIDSBURY	29470	3.9%	43061	62920	76057
		S OF BERGEN RD	29470		43061	62920	76057
		N OF BERGEN RD	29440		43017	62856	75979
		S OF AMERADA RD	29440		43017	62856	75979
		N OF AMERADA RD	29440		43017	62856	75979
		S OF 27 E OF OLDS	29440		43017	62856	75979
22	4	N OF 27 E OF OLDS	29510	3.1%	40176	54698	63823
		2.0 KM N OF 2 & 27 OLDS	29370		39986	54439	63520
		S OF WIMBORNE RD	29510		40176	54698	63823
		N OF WIMBORNE RD	29520		40190	54717	63844
		S OF NETOOK RD	29520		40190	54717	63844
		N OF NETOOK RD	29530		40204	54735	63866
		S OF 2A & 587 E OF BOWDEN	30070		40939	55736	65034
	12	N OF 2A & 587 E OF BOWDEN	31900	3.0%	42680	57102	66049
		S OF 54 S OF INNISFAIL	31900		42680	57102	66049
		N OF 54 S OF INNISFAIL	30760		41155	55062	63689
	16	S OF 590 AT INNISFAIL	30760	3.1%	41889	57043	66567
26	2	N OF 11A AT RED DEER	40240	4.2%	60712	91600	112514
		0.1 KM N OF 2 & 11A RED DEER	40120		60531	91327	112178
		S OF 597 W OF BLACKFALDS	40240		60712	91600	112514
	4	N OF 597 W OF BLACKFALDS	33580	3.6%	47932	68418	81741
		S OF 12 W OF LACOMBE	33580		47932	68418	81741
	8	N OF 12 W OF LACOMBE	26710	2.6%	34380	44252	50205
	12	3.5 KM N OF 2 & 2A LACOMBE	30170	3.1%	40945	55568	64734
		S OF 2A SW OF MORNINGSIDE	30280		41094	55770	64970
	16	N OF 2A SW OF MORNINGSIDE	25520	3.5%	35964	50683	60166
		S OF 604 W OF MORNINGSIDE	25520		35964	50683	60166
	20	N OF 604 W OF MORNINGSIDE	25160	3.3%	34853	48281	56826
		S OF MATEJKA RD	25160		34853	48281	56826
		N OF MATEJKA RD	25240		34964	48435	57006
		S OF GEE RD	25240		34964	48435	57006
		N OF GEE RD	25360		35130	48665	57277
		S OF 53 W OF PONOKA	25360		35130	48665	57277

Appendix B.

Projections of ADDT and Growth Rates for Control Sections 28 and 30

CS	TCS	Location Description	2013 AADT	Growth Rate used	Estimated 2023 AADT	Estimated 2033 AADT	Estimated 2038 AADT
28	4	N OF 53 W OF PONOKA	26910	3.4%	37727	52893	62629
		1.7 KM N OF 2 & 53 PONOKA	26800		37573	52677	62373
		S OF MENAIK RD	26910		37727	52893	62629
		N OF MENAIK RD	26810		37587	52697	62396
		S OF 611 E OF USONA	26810		37587	52697	62396
	8	N OF 611 E OF USONA	27170	3.6%	38607	54858	65393
		S OF LOUIS BULL FLYOVER	27170		38607	54858	65393
		N OF LOUIS BULL FLYOVER	27170		38607	54858	65393
		S OF 13 W OF WETASKIWIN	27170		38607	54858	65393
30	4	N OF 13 W OF WETASKIWIN	26440	3.0%	35521	47722	55314
		S OF CORRECTION LINE RD	26440		35521	47722	55314
		N OF CORRECTION LINE RD	26540		35656	47903	55523
		S OF 616 W OF MILLET	26540		35656	47903	55523
	8	N OF 616 W OF MILLET	27660	3.0%	37059	49652	57473
		S OF KAVANAUGH/GLEN PK RD	27660		37059	49652	57473
		N OF KAVANAUGH/GLEN PK RD	29220		39149	52453	60714
		2.0 KM S OF 2 & OLD 2A LEDUC	29090		38975	52219	60444
		S OF OLD 2A AT LEDUC	29220		39149	52453	60714
	12	N OF OLD 2A AT LEDUC	39050	3.0%	52627	70926	82338
		S OF 50 AVE AT LEDUC	39050		52627	70926	82338

Appendix C.

Level of Service for Control Sections 20, 22, and 24

CS	TCS	Segment Description	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
18	4	N OF 566 E OF BALZAC	C	C	C	C	C	D	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F
18	4	4.6 KM S OF 2 & 567 AIRDRIE	C	C	C	C	C	D	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F
18	4	S OF BIG HILL SPRINGS RD	C	C	C	C	C	D	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F
18	4	N OF BIG HILL SPRINGS RD	B	B	B	C	C	C	C	C	C	C	C	D	D	D	D	D	E	E	F	F	F	F	F	F	F	F
18	4	S OF TWP RD 272, AIRDRIE	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	D	D	D	D	E	E	F	F
18	8	N OF TWP RD 272, AIRDRIE	A	A	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	D	D	D	D	E
18	8	S OF 2A & 72 SE OF CROSSFIELD	B	B	B	C	C	C	C	C	C	C	C	D	D	D	D	D	E	E	F	F	F	F	F	F	F	F
18	12	N OF 2A & 72 SE OF CROSSFIELD	B	B	B	B	B	B	B	C	C	C	C	C	C	C	D	D	D	D	E	E	F	F	F	F	F	F
18	16	S OF ACME RD	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	D	D	D	D	E	E	E	F	F	F	F
20	4	N OF ACME RD	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E
20	4	S OF 581E OF CARSTAIRS	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E
20	8	N OF 581E OF CARSTAIRS	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
20	8	S OF BERGTHAL RD	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
20	8	N OF BERGTHAL RD	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
20	8	S OF 582 E OF DIDSBURY	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
20	12	N OF 582 E OF DIDSBURY	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E
20	12	S OF BERGEN RD	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E
20	12	N OF BERGEN RD	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E
20	12	S OF AMERADA RD	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E
20	12	N OF AMERADA RD	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E
20	12	S OF 27 E OF OLDS	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E
22	4	N OF 27 E OF OLDS	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
22	4	2.0 KM N OF 2 & 27 OLDS	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
22	4	S OF WIMBORNE RD	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
22	4	N OF WIMBORNE RD	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
22	4	S OF NETOOK RD	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
22	4	N OF NETOOK RD	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
22	4	S OF 2A & 587 E OF BOWDEN	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D
22	12	N OF 2A & 587 E OF BOWDEN	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D
22	12	S OF 54 S OF INNISFAIL	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D
22	12	N OF 54 S OF INNISFAIL	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D
22	16	S OF 590 AT INNISFAIL	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D
24	4	N OF 590 AT INNISFAIL	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	C	D	D
24	4	S OF OLD POLE RD	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	C	D	D
24	4	N OF OLD POLE RD	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D
24	4	S OF 42 E OF PENHOLD	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D
24	8	N OF 42 E OF PENHOLD	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	D	D	E
24	8	2.6 KM N OF 2 & 42 PENHOLD	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	D	E
24	9	S OF GAETZ AVE IN RED DEER	A	A	A	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
24	10	N OF GAETZ AVE IN RED DEER	A	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D
24	10	S OF 2A & TAYLOR DR IN RED DE	A	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D
24	11	N OF 2A & TAYLOR DR IN RED DE	B	B	C	C	C	C	C	C	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F
24	11	5.9 KM S OF 2 & 11RED DEER	B	B	C	C	C	C	C	C	C	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F
24	11	S OF 32 ST IN RED DEER	B	B	C	C	C	C	C	C	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F
24	12	N OF 32 ST IN RED DEER	C	C	C	C	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
24	12	S OF 11AT RED DEER	C	C	C	C	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
24	16	N OF 11AT RED DEER	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	E	E	E	F	F	F	F	F	F
24	16	S OF 11A AT RED DEER	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	E	E	E	F	F	F	F	F	F

Appendix D.

Level of Service for Control Sections 26, 28, 30, and 32

CS	TCS	Segment Description	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
26	2	N OF 11A AT RED DEER	B	B	B	C	C	C	C	C	C	C	C	D	D	D	D	E	E	E	F	F	F	F	F	F	F	F
26	2	0.1KM N OF 2 & 11A RED DEER	B	B	B	C	C	C	C	C	C	C	C	D	D	D	D	D	E	E	F	F	F	F	F	F	F	F
26	2	S OF 597 W OF BLACKFALDS	B	B	B	C	C	C	C	C	C	C	C	D	D	D	D	E	E	E	F	F	F	F	F	F	F	F
26	4	N OF 597 W OF BLACKFALDS	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E	E	F
26	4	S OF 12 W OF LACOMBE	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	E	E	F
26	8	N OF 12 W OF LACOMBE	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C
26	12	3.5 KM N OF 2 & 2A LACOMBE	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
26	12	S OF 2A SW OF MORNINGSIDE	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D
26	16	N OF 2A SW OF MORNINGSIDE	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C
26	16	S OF 604 W OF MORNINGSIDE	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C
26	20	N OF 604 W OF MORNINGSIDE	A	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C
26	20	S OF MATEJKA RD	A	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C
26	20	N OF MATEJKA RD	A	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C
26	20	S OF GEE RD	A	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C
26	20	N OF GEE RD	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C
26	20	S OF 53 W OF PONOKA	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C
28	4	N OF 53 W OF PONOKA	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D
28	4	17 KM N OF 2 & 53 PONOKA	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D
28	4	S OF MENAIK RD	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D
28	4	N OF MENAIK RD	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D
28	4	S OF 611 E OF USONA	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D
28	8	N OF 611 E OF USONA	A	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
28	8	S OF LOUIS BULL FLYOVER	A	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
28	8	N OF LOUIS BULL FLYOVER	A	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
28	8	S OF 13 W OF WETASKIWIN	A	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D
30	4	N OF 13 W OF WETASKIWIN	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C
30	4	S OF CORRECTION LINE RD	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C
30	4	N OF CORRECTION LINE RD	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C
30	4	S OF 616 W OF MILLET	A	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C
30	8	N OF 616 W OF MILLET	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C
30	8	S OF KAVANAUGH/GLEN PK RD	A	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C
30	8	N OF KAVANAUGH/GLEN PK RD	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	C
30	8	2.0 KM S OF 2 & OLD 2A LEDUC	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	C
30	8	S OF OLD 2A AT LEDUC	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	C
30	12	N OF OLD 2A AT LEDUC	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	D	E	E	E	F
30	12	S OF 50 AVE AT LEDUC	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	D	E	E	E	F
32	4	N OF 50 AVE AT LEDUC	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D
32	4	S OF 50 ST, LEDUC	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D
32	8	N OF 50 ST, LEDUC	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	D	E	E	E	F	F
32	8	S OF AIRPORT RD	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	D	E	E	E	F	F
32	12	N OF AIRPORT RD	C	C	C	C	C	C	C	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F
32	12	S OF 19 & 625 W OF NISKU	C	C	C	C	C	C	C	D	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F
32	16	N OF 19 & 625 W OF NISKU	C	C	C	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
32	16	5.9 KM N OF 2 & 19 NISKU	C	C	C	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
32	16	S OF ELLERSLIE RD	B	B	B	B	B	B	C	C	C	C	C	C	C	D	D	D	D	E	E	F	F	F	F	F	F	F
32	16	N OF ELLERSLIE RD	B	B	B	B	B	C	C	C	C	C	C	C	D	D	D	D	E	E	F	F	F	F	F	F	F	F
32	16	S OF 216 S OF EDMONTON	C	C	D	D	D	E	E	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

Appendix E.

Detailed Cost of Bypasses

Nisku Bypass	
Right of way purchsase	
Length(km)	20.00
Width(m)	160.00
area(m2)	3,200,000.00
Area (acres) = m2 *0.000247105	790.74
Systems interchange area (acres)	300.00
*2 planned	600.00
Service interchange area (acres)	160.00
*4 planned	640.00
Total interchange right of way	1,240.00
Total RW	2,030.74
At rough estimate of market price	$50,000
	$101,536,800
Interchange construction	
Systems interchanges construction costs	$200,000,000
*2	$400,000,000
Service interchanges construction costs	$50,000,000
*4	$200,000,000
Total Interchange construction cost	**$600,000,000**
Road Construction	
4 lane highway per Km	$7,000,000
*20km	$140,000,000
Lane Addition per km	$2,000,000
*20km	$40,000,000
total Highway construction cost	**$180,000,000**
Total Bypass Cost	$881,536,800
cost per Km	$44,076,840
Total cost for bypasses	**$2,538,378,800**

Airdrie Bypass	
Right of way purchsase	
Length(km)	25.00
Width(m)	160.00
area(m2)	4,000,000.00
Area (acres) = m2 *0.000247105	988.42
Systems interchange area (acres)	300.00
*2 planned	600.00
Service interchange area (acres)	160.00
*3 planned	480.00
Total interchange right of way	1,080.00
Total RW	2,068.42
At rough estimate of market price	$50,000
	$103,421,000
Interchange construction	
Systems interchanges construction costs	$200,000,000
*2	$400,000,000
Service interchanges construction costs	$50,000,000
*3	$150,000,000
Total Interchange construction cost	**$550,000,000**
Road Construction	
4 lane highway per Km	$7,000,000
*25km	$175,000,000
Lane Addition per km	$2,000,000
*0km	$0
total Highway construction cost	**$175,000,000**
Total Bypass Cost	$828,421,000
cost per Km	$41,421,050

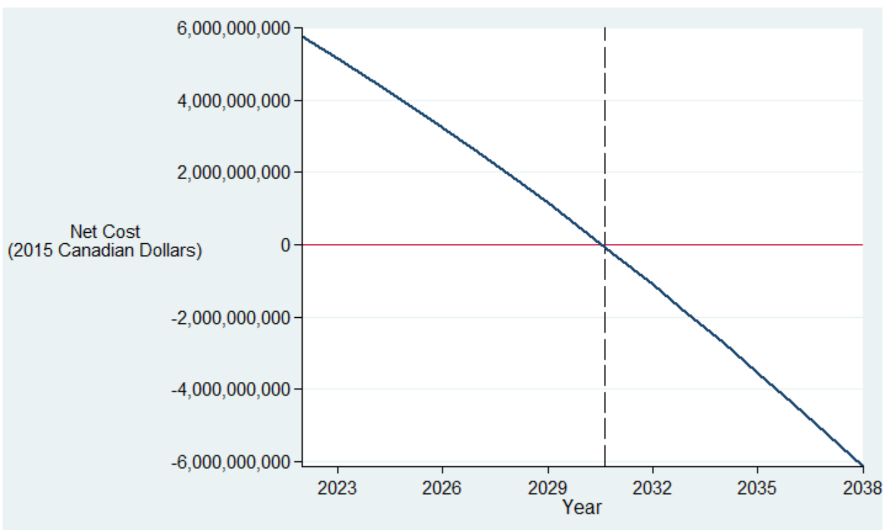
Red deer Bypass	
Right of way purchsase	
Length(km)	25.00
Width(m)	160.00
area(m2)	4,000,000.00
Area(acres) = m2*0.000247105	988.42
Systems interchange area (acres)	300.00
*2 planned	600.00
Service interchange area (acres)	160.00
*3 planned	480.00
Total interchange right of way	1,080.00
Total RW	2,068.42
At rough estimate of market price	$50,000
	$103,421,000
Interchange construction	
Systems interchanges construction costs	$200,000,000
*2	$400,000,000
Service interchanges construction costs	$50,000,000
*3	$150,000,000
Total Interchange construction cost	**$550,000,000**
Road Construction	
4 lane highway per Km	$7,000,000
*20km	$175,000,000
Lane Addition per km	$2,000,000
*0km	$0
total Highway construction cost	**$175,000,000**
Total Bypass Cost	$828,421,000
cost per Km	$41,421,050

Appendix F.

Annual Cost and Revenue figures of High Speed Rail

High speed Rail has the ability to generate significant revenue. TEMS, Inc.'s market analysis of high speed rail between Calgary and Edmonton provides plausible revenue projections. Their projections show that demand for high speed rail could generate $14 billion in revenue between the operation periods of 2023 to 2038. This means that the high speed rail could generate revenue for the government after paying of the initial capital costs. Figure shows the net cost of running high speed rail over time. TEMS Inc.'s revenue projections show that the initial investment could be paid back in third quarter of 2030, only after 7 years of operation. The year of payback is depicted in figure as the total cost curve dropping below zero in year 2030 marked by the dashed line. At the end of the period of analysis the total net revenue from the high speed rail line would be $6.1 billion. The revenue after break even period could be used to finance future re-investment into the high speed rail line such as major capital and rolling stock replacement. Alternatively, the net revenue could be reinvested into the transportation network of the ECTC funding the other options discussed within this study.

Figure F1: Net financial Costs of High Speed Rail



Source: Transportation Economics & Management Systems, Inc. and Oliver Wyman. (2008)