A Report To:

BRITISH COLUMBIA
Ministry of Transportation

GUIDELINES FOR QUANTIFYING VEHICLE EMISSIONS WITHIN THE MINISTRY'S MULTIPLE ACCOUNT EVALUATION FRAMEWORK

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1.0 INTRODUCTION

Concern regarding the magnitudes of both the health and the environmental impacts of the mobile source emissions associated with fossil fuel consumption has incited the Ministry of Transportation to consider these impacts in their evaluation of potential improvement projects.

In order to ensure that a consistent and defensible approach is used in evaluation of these impacts, the Ministry has retained Delcan Corporation to develop guidelines for quantification of vehicle emissions, for application under the Ministry's Multiple Account Evaluation Guidelines for practitioners.

It is important to note that this project is intended to include the impacts of vehicle emissions in the project evaluation process, at a level of effort appropriate to the magnitude of those impacts relative to the other indicators evaluated. Therefore gaining an understanding of the relative magnitude of the anticipated impacts is a key aspect in determination of the appropriate methodology.

1.1 Note to Readers

This project involves the development of new requirements for practitioners of multiple account evaluations of proposed Ministry improvement projects. As a brand new initiative, these requirements should be considered the first stage of a process that can be refined in the future as new research and analysis tools become available.

2.0 PROJECT BACKGROUND

Transportation is one of the largest sources of air pollution and greenhouse gases in British Columbia. Environment Canada's most recent emissions summary indicates that on-road motor vehicle emissions deposited over 600 kilo-tonnes of criteria air contaminants (CACs) into the air in British Columbia in 2005, representing 20% of the total air pollutants generated by all sources [Env. Canada 2007]. Further, Environment Canada's most recently released National Inventory Report indicates that on-road transportation generated 17 million tonnes or 25% of the total annual greenhouse gas (GHG) emissions in British Columbia in 2004. The Inventory also indicates that, over the period from 1990 through 2004, greenhouse gas emissions from all transportation sources increased by 40% in British Columbia, in comparison to a national growth of 27% during the same period.

The impacts of air pollutants and greenhouse gases are well documented. For example, the BC Provincial Health Officer's Annual Report from 2003 "conservatively estimated that the premature death toll from air pollution in BC is between approximately 140 and 400 deaths per year, of which approximately half are due to outdoor air pollution". As a comparison, the number of fatalities due to motor vehicle collisions was about 440 in BC in 2003 [2003 Canadian Motor Vehicle Traffic Collision Statistics, Transport Canada 2004]. And the Intergovernmental Panel on Climate Change (IPCC), whose members include several hundred scientists from around the world and whose reports form the standard scientific reference documents on climate change, has documented 20th century changes in the Earth's climate systems and indicated that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities" [IPCC, 2001].

While the need to reduce emissions is indisputable, it should be noted that motor vehicle emissions are dependent on a wide range of factors, including vehicle characteristics, fuel characteristics, roadway characteristics and climate. This project is focused strictly on evaluation of the impacts of changes in roadway characteristics on vehicle emissions.

2.1 Need for Project

The need to consider vehicle emissions in evaluation of highway improvement projects is supported by current policies and initiatives both internationally as well as at all levels of government, as discussed in the following sections.

2.1.1 Global Policies and Initiatives

The First World Climate Conference was held in 1979 and led to the establishment of the World Climate Program, an initiative designed to investigate the causes and effects of climate change.

The World Meteorological Organization (WMO) and the United Nations Environmental Program (UNEP) subsequently established the Intergovernmental Panel on Climate Change (IPCC) in 1988 with a mandate which includes "understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation" [IPCC, 1998].

The United Nations Framework Convention on Climate Change, which was ratified by 191 nations and entered into force in 1994, is an international treaty which provides a framework for intergovernmental initiatives to address climate change.

"Under the convention, governments:

- gather and share information on greenhouse gas emissions, national policies and best practices;
- launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries;
- cooperate in preparing for adaptation to the impacts of climate change" [UNFCCC].

The commitments under this treaty are quite general, however, and do not include specific targets for reduction of greenhouse gas emissions.

In 1997, an addition to the UNFCCC was adopted, entitled the Kyoto Protocol, which commits industrialized countries (known as Annex 1 Parties) "to individual, legally-binding targets to limit or reduce their greenhouse gas emissions" [UNFCCC]. This treaty has been ratified by 175 members and came into force in 2005.

The following greenhouse gases are covered by Annex A of the Kyoto Protocol:

Gases:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Sulphur hexafluoride (SF_6).

Groups of Gases:

- Hydro fluorocarbons (HFCs); and
- Perfluorocarbons (PFCs).

Canada ratified the Kyoto Protocol in 2002, accepting an emissions target of a 6% reduction in greenhouse gas emissions from 1990 levels by 2008-2012. However, *Canada's Report on Demonstrable Progress under the Kyoto Protocol: Demonstration of Progress to 2005* states that "Canada's efforts to reduce GHG emissions have been out-distanced by growth in its economy, energy exports, and population since signing on to the UNFCCC" [Env. Canada, 2006]

The report further states that "Canada's New Government is developing and will implement a suite of policies and measures to reduce GHG emissions as part of its new environmental agenda" [Env. Canada, 2006]. These policies and measures are discussed in the following section.

2.1.2 National Policies and Initiatives

The federal government's new Regulatory Framework for Air Emissions (April 2007) includes "mandatory and enforceable reductions in emissions of greenhouse gases and air pollutants". The Framework's Clean Air Regulatory Agenda indicates a commitment "to reduce Canada's total emissions of greenhouse gases, relative to 2006 levels, by 20% by 2020 and by 60% to 70% by 2050". While these reductions are aggregate values that cover all sectors, "transportation is one of the largest sources of greenhouse gas and air pollution emissions in Canada", and therefore it can be expected that reductions will be sought from all transport sector sources of emissions in order to achieve these goals.

The Framework also includes policy changes to the Motor Vehicle Fuel Consumption Standards Act to implement a mandatory fuel-efficiency standard by model year 2011. This restriction will address the emitters or the "demand" component of vehicle emissions;

however it is clear that emissions impacts must also be considered in development of the "supply" component, the highway system.

Transport Canada[1]'s Action Plan documented in their Sustainable Development Strategy 2007-2009 includes the following specific emissions target:

> *"Transport Canada will lead the development of an environmental analytical framework, by 2008/2009, to estimate the impact of various transportation-related environmental policies and instruments. This initiative includes the evaluation of the costs of the following emissions: clean air (CO, $PM_{2.5}$, PM_{10}, NO_x, VOCs, O_3, and SO2), GHGs (greenhouse gases) and noise. The emphasis is on human health impacts" [Transport Canada, 2006].*

In this vein, Transport Canada has recently introduced an on-line Urban Transportation Emissions Calculator for estimating annual emissions of criteria air contaminants (pollutants) and greenhouse gases for alternate scenarios.

Transport Canada is also currently in the process of developing a new Cost Benefit Analysis tool for analysis of highway infrastructure investments at the national level that includes estimates of vehicle emissions and the associated costs [HDR/HLB, 2007].

2.1.3 Provincial Policies and Initiatives

The provincial government has established a range of climate change goals and initiatives that demonstrate the high priority of this issue and support the need to consider vehicle emissions in project evaluation. Premier Campbell's 2007 Throne Speech specifically identified the following [B.C., 2007]:

- a target reduction in B.C. greenhouse gas emissions of 33% from current levels by 2020 (equivalent to a 10% reduction from 1990 levels);
- establishment of a Climate Action Team to determine sector targets for 2012 – 2016 and set a long term target for 2050;
- new tailpipe emission standards to be phased in from 2009-2016 for all new vehicles sold in B.C., to reduce carbon dioxide emissions by some 30 per cent for automobiles; and
- establishment of a low-carbon fuel standard for B.C.

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[1] Transport Canada and Infrastructure Canada were combined into the Ministry of Transport, Infrastructure and Communities in 2006.

In addition, the Ministry of Water, Land and Air Protection's 2004 report entitled "*Weather, Climate and The Future: BC's Plan"* documents a 40 step action plan for the province to address climate change and reduce greenhouse gas emissions. While a significant portion of the plan's "actions" directly or indirectly address various components of the transportation sector, the need to consider emission impacts in evaluation of alternative highway improvements is directly reinforced by the following actions:

Action 6: Climate change will be incorporated into B.C.'s transportation planning and investment strategies.

Action 28: The government will encourage ministries and Crown corporations to incorporate emission reducing policies and guidelines in their service plans.

2.1.4 Summary of Project Need

The policies and initiatives described in the preceding sections are focused on the greenhouse gas component of vehicle emissions, reflecting the growing body of scientific evidence and the escalating public concern surrounding this issue; however, the pollutant component of emissions remains a priority.

While improvements in both vehicle and fuel technologies (driven by higher standards) have resulted in significant reductions in pollutant emissions from motor vehicles, several contributing factors ensure that pollutant impacts will remain a concern. These include: the unrelenting trend of growth in vehicle travel; the health costs associated with exposure to air pollution; and the fact that certain pollutants (e.g., $PM_{2.5}$ and ozone) have no identified safe levels [B.C. Min. of Env. 2007].

The importance of both categories of emissions impacts underscores the need to consider these impacts in project evaluation, in order to ensure that the full impacts of investment alternatives are recognized.

In recognition of the need to consider potential air quality and global warming impacts in evaluation of highway improvement projects, the Ministry has elected to include vehicle emissions as a mandatory indicator within their Multiple Account Evaluation framework.

2.2 Inclusion of Vehicle Emissions within the Multiple Account Evaluation Framework

The Multiple Account Evaluation (MAE) framework is designed to provide decision-makers with information on the key advantages and disadvantages of project options from a range of perspectives, represented by accounts. The Ministry of Transportation's MAE framework includes the following accounts: Financial; Customer Service; Environmental; Social/Community; and Economic Development. Within each account, project options are evaluated based on a set of relevant indicators. Some indicators (such as Capital Cost and Travel Time Savings, for example) are mandatory for all projects; other "project specific" indicators may be selected by the project team or requested by the decision-makers to address key project issues.

In light of the need to consider the potential vehicle emissions impacts of project options as described in ***Section 2.1***, above, mandatory indicators have been developed for evaluation of these impacts within the MAE framework. The indicators are described in detail in subsequent sections of this document.

It should be noted that the re-classification of emissions impacts from a "project specific" to a "mandatory" indicator should not require an onerous level of analysis not warranted by an improvement under consideration.

*Rather, vehicle emissions impacts should be considered and evaluated at a level of effort appropriate to the stage of the planning and design process, the project scale, and the potential for emissions impacts, as described in detail in **Section 5.2.2**, below. It is anticipated that the required effort will be generally comparable to that required for other indicators, such as vehicle operating costs.*

The impacts associated with motor vehicle emissions belong in the Environmental Account, as described in ***Appendix 2: Multiple Account Evaluation Guidelines*** and ***Appendix 1-A Multiple Account Evaluation*** of the Ministry's ***MicroBENCOST Guidebook, Guidelines for the Benefit/Cost Analysis of Highway Improvement Projects in British Columbia (July 2005).*** These impacts can be further classified into two categories: health impacts and global warming impacts. Indicators to be evaluated for each of these categories are described in ***Section 5.2***, below.

2.3 Regulatory Requirements

Regulatory responsibilities relevant to the consideration of vehicle emissions are shared amongst the federal, provincial and regional/local governments, and comprise vehicle emission regulations as well as air quality regulations. These regulations include both standards and objectives; the standards are criteria that must be met by a prescribed deadline, while the objectives provide benchmarks for all levels of government in air quality management decisions [Health Can.].

2.3.1 Background on Vehicle Emissions Regulations and Air Quality Regulations

The Canadian Environmental Protection Act (CEPA 1999) gives the federal government the authority to regulate emissions and develop "measures to control vehicle emissions, improve the quality of fuel … limit the release of air pollutants that are assessed as toxic under the Act… and set national ambient air quality objectives" [Env. Canada].

In October 2006, the federal government introduced a new Clean Air Act as an amendment to CEPA 1999, providing additional authority to the government and establishing an integrated approach to the regulation of air pollutants and greenhouse gases [Gov. Canada 2006]. Key components of the new Act include:

- development (in consultation with stakeholders) of a mandatory motor vehicle fuel efficiency standard, starting with the 2011 model year (amending the Motor Vehicle Fuel Consumption Standards Act);
- a requirement for national air quality objectives and monitoring; and
- an amendment to CEPA 1999 to allow regulation of the blending of fuels (towards a goal of 5% renewable fuel content in motor fuels by 2010).

The Clean Air Provisions of the B.C. Environmental Management Act provide authority to the province to regulate motor vehicle emissions; at the time of document preparation, however, no regulations or criteria governing vehicle emissions were available from the Province.

2.3.2 Emission Standards

Motor vehicle emission standards for new vehicles are currently regulated by Environment Canada through the new *On-Road Vehicle and Engine Emission Regulations* (effective January 1, 2004), under CEPA 1999. These regulations are aligned with the US EPA Tier 2 emission standards for light and medium duty vehicles and Phase 1 and Phase 2 programs for heavy duty vehicles. (Previously, new-vehicle emissions were regulated in Canada under the Motor Vehicle Safety Act). The Tier 2 fleet average standards for light and medium duty vehicle classes are summarized in ***Table 2.1***, below:

Table 2.1: Fleet Average NO_x Standards

Model Year	Fleet Average NO_x Standards (grams/mile)	
	Light Duty Vehicles and Light Light-Duty Trucks	Heavy Light-Duty Trucks and Medium Duty Passenger Vehicles
2004	0.25	0.53
2005	0.19	0.43
2006	0.13	0.33
2007	0.07	0.20
2008	0.07	0.14

Source: *On-Road Vehicle and Engine Emission Regulations (SOR/2003-2) (Dec. 12, 2002), Canadian Environmental Protection Act, 1999, Department of Justice, Canada Current to Aug. 28, 2007*

It can be seen from ***Table 2.1*** that the emission standards are increasingly stringent with each subsequent model year. This will have a significant impact on overall motor vehicle emissions as the aging fleet is replaced with new model year vehicles. To put this into more concrete terms, the Canadian Vehicle Manufacturer's Association reports that emissions from one 1993 model year car are equivalent to the emissions from twelve 2004 model year cars [CVMA 2006].

In service vehicle emission standards are currently regulated by the provincial government. In Vancouver and the Fraser Valley, the AirCare Vehicle Emissions Testing Program monitors emissions of Hydrocarbons (HC), Carbon Monoxide (CO) and Nitrogen Oxides (NO_x) for model years prior to 2001[2]. As with the new vehicle standards, the AirCare emission standards are progressively stringent with each subsequent model year.

2.3.3 Air Quality Standards and Objectives

Air quality regulations include both standards and objectives, as described below. Air quality is measured in terms of average ambient concentration levels of a given pollutant at a location over a specified period of time, regardless of the pollutant source(s), as opposed to the source-oriented measurement of emissions. Therefore, air quality standards and

[2] In 2007, testing is required for model year 2000 vehicles and older; new model year exemptions vary over time.

objectives are only relevant in the context of project emissions evaluation as a qualitative indication of which pollutants are monitored, not in quantitative terms.

2.3.4 Canada-Wide Standards for Particulate Matter (PM) and Ozone (O_3)

In response to the significant health and environmental risks posed by particulate matter ($PM_{2.5}$) and ground-level ozone (O_3), Canada-Wide Standards were established for these pollutants in 2000, under the Canada-Wide Accord on Environmental Harmonization [CCME 2000].

As described above, these standards address ambient air concentrations rather than emissions; however, they do indicate the relative importance of these secondary pollutant products of motor vehicle fuel combustion (described in more detail in ***Section 2.3.7***, below).

2.3.5 National Ambient Air Quality Objectives

The federal government has established National Ambient Air Quality Objectives (NAAQOs) for the following pollutants:

- Sulphur Dioxide (SO_2);
- Total Suspended Particulates (TSP);
- Carbon Monoxide (CO);
- Nitrogen Dioxide (NO_2); and
- Ozone (O_3).

Again, these objectives identify the pollutants of particular concern. [Health Can.]

2.3.6 BC Ambient Air Quality Objectives

The BC Ministry of Environment has also established specific ambient air quality objectives for PM_{10}, inhalable particulate matter.

2.3.7 Criteria Air Contaminants

Environment Canada has classified the following key air pollutants as Criteria Air Contaminants (CACs):

- Particulate Matter, including:
    - Total Particulate Matter (TPM);
    - Particulate Matter with a diameter less than or equal to 10 Microns (PM_{10}); and
    - Particulate Matter with a diameter less than or equal to 2.5 Microns ($PM_{2.5}$);
- Sulphur Oxides (SO_x);
- Nitrogen Oxides (NO_x);
- Volatile Organic Compounds (VOC); and
- Carbon Monoxide (CO).

Emission of these substances to the atmosphere is known to affect human health and contribute to problems such as ground level ozone, smog, and acid rain. The Criteria Air Contaminants are tracked via the National CAC Emissions Inventory. (The National Pollutant Release Inventory tracks a total of 300 substances on an annual basis; however, the CACs have been specifically identified as key air pollutants.)

2.3.7 Secondary Pollutants

Secondary pollutants are created by chemical reactions between pollutants in the atmosphere (as opposed to primary pollutants that are emitted directly into the atmosphere). In British Columbia, the two most significant pollutants are the following secondary pollutants:

- Ground-level Ozone (O_3); and
- Secondary Particulate Matter (PM).

The specific Criteria Air Contaminants and Secondary Pollutants that are generated (directly or indirectly) as a result of motor vehicle use and their impacts are discussed in ***Section* 3.2.1**, below.

2.3.8 Greenhouse Gases

Under the provisions of the United Nations Framework Convention on Climate Change (UNFCCC), Canada is required to submit an annual inventory of national greenhouse gas emissions, for the gases covered by Annex A of the Kyoto Protocol and listed in ***Section 2.1.1***, above. Of the Annex A gases, the following gases are required to be reported for non-industrial sources (i.e., transportation): carbon dioxide (CO_2); methane (CH_4); and nitrous oxide (N_2O).

3.0 BACKGROUND ON MOTOR VEHICLE EMISSIONS

Motor vehicle emissions are comprised of a variety of substances and compounds that are generated by various processes associated with the use of motor vehicles. These substances are emitted to the atmosphere in varying amounts and with various impacts depending upon a wide range of factors. The following sections provide a brief description of the processes, substances and impacts involved in motor vehicle emissions.

3.1 Sources of Emissions

On-road motor vehicle emissions can be classified in two categories: exhaust emissions, generated as by-products of the fuel combustion process; and evaporative emissions, generated directly from the fuel in a variety of ways.

3.1.1 Exhaust Emissions

Exhaust emissions refer to the tailpipe emissions generated by the burning of fuel in the vehicle's engine. Gasoline and diesel fuel consist primarily of complex mixtures of hydrocarbons, compounds containing hydrogen and carbon. The combustion or burning of these fuels through the addition of oxygen and heat generates power and exhaust. In complete combustion, oxygen would convert all of the hydrogen to water and the carbon to carbon dioxide. In reality, the burning of the fuel in air results in incomplete combustion due to the lack of oxygen, with byproducts of: unburned hydrocarbons; nitrogen oxides; carbon monoxide; and water. These byproducts are the exhaust emission pollutants.

Exhaust emissions are divided into two types, based on the engine temperature: cold start emissions that are generated from vehicle startup until the engine and emission control system have reached steady state temperature; and hot emissions that are generated when the vehicle operates at steady state temperature. While cold starts generate significantly more pollutant emissions than hot running conditions (due to the sub-optimal performance of emission control systems below steady state temperatures), it is important to note that cold starts are not a factor in the evaluation of most highway improvement projects, as they typically occur on local streets, before vehicles reach the highway network. (*Hot starts, that occur when a vehicle has not completely returned to ambient temperature, are also not considered a factor in project evaluation.)*

3.1.2 Evaporative Emissions

Evaporative emissions result from the direct escape of hydrocarbons from the fuel. These emissions, which are increasingly significant as temperatures rise, occur in the following four ways:

- **Diurnal emissions** – result from hydrocarbon evaporation from the fuel tank as temperatures rise during the day;
- **Running loss emissions** – result from the heating of the engine and the fuel as the vehicle is running;
- **Hot soak emissions** – result from heat remaining in the engine after the vehicle is turned off; and
- **Refueling emissions** – result from vapours forced out of the fuel tanking during refueling.

3.2 Classification and Description of Emissions

Motor vehicle emissions can be classified into two categories according to their impacts: pollutants; and greenhouse gases. One of the key differences between these categories is related to the variability of their impacts. The impacts of pollutant emissions are highly variable, depending upon factors such as population, geography, climate and the exposure and sensitivity of human, animal or plant life. The impacts of greenhouse gas emissions are not as variable[3], as they all accumulate in the earth's atmosphere and contribute to global warming.

The two categories of emissions are discussed in the following sections, along with descriptions of the key vehicle emissions in each category.

3.2.1 Pollutants

Pollutants can be defined as "emissions that have identified health risks at certain concentrations in the atmosphere"; this includes some substances that exist naturally in the atmosphere at concentrations below that harmful to health. While the impacts of air pollutants are generally most intense in the immediate vicinity of emission, geography and climatic conditions may cause dispersion over vast distances.

[3] There is some variability in global warming potential due to factors such as radiative efficiency and abundance in the atmosphere.

The five key pollutants contained in motor vehicle emissions are: nitrogen oxides (NO_x), carbon monoxide (CO); volatile organic compounds (VOCs); particulate matter (PM); and sulphur dioxide (SO_2), all of which are criteria air contaminants. In addition, ground level ozone (O_3) is produced indirectly from vehicle emissions. These pollutants are discussed in further detail, below:

Nitrogen Oxides (NO_x)

Oxides of nitrogen (of which nitrogen dioxide, NO_2, is the most common) are a group of gaseous products of the burning of nitrogen in fossil fuel and nitrogen compounds in air. Nitrogen dioxide can have adverse effects on respiratory systems and vegetation; some NO_x are toxic. Further, nitrogen oxides are a precursor to ground level ozone (O_3) and acid rain. Nitrogen oxide (NO) creates the brown haze of smog. [Env. Canada]

Carbon Monoxide (CO)

Carbon monoxide is a toxic gaseous product of incomplete combustion of gasoline and diesel fuel present in all tailpipe exhaust, more significantly in poorly maintained vehicles. Carbon monoxide emissions, which increase at lower temperatures, have significant health impacts. Carbon monoxide decreases the oxygen-carrying ability of the blood, with particularly high risks for people with heart disease. It can also have a variety of negative impacts on healthy individuals. [Env. Canada]

Volatile Organic Compounds (VOCs)

Volatile organic compounds are a large group of carbon-containing gases and vapours that are products of gasoline combustion. Many of the VOCs (including benzene and dichloromethane) have been identified as toxic and/or carcinogenic to humans. While the VOCs emissions are usually low concentrations, these substances are also precursors to ground-level ozone (O_3) and $PM_{2.5}$. [Env. Canada]

Particulate Matter (PM)

Particulate matter (PM) refers to solid or liquid particles that are released to the atmosphere from a gaseous suspension. Total particulate matter (TPM) is classified into two size ranges, as the particle size is the primary determinant of the health and environmental impacts. Fine particulates ($PM_{2.5}$), are particles smaller than 2.5 Microns in diameter, where as PM_{10} are particles smaller than 10 Microns in diameter. Fine Particulates ($PM_{2.5}$), are generated as secondary products of motor vehicle fuel consumption, formed from gaseous vehicle emissions like NO_x or SO_2. Links between particulate matter and aggravated cardiac and respiratory diseases are indicated in numerous studies. Particulates can also have adverse effects on vegetation and visibility, can remain suspended in the air for days or weeks, and can travel thousands of kilometers from the point of emission. [Env. Canada]

Sulphur Dioxide (SO_2)

Sulphur dioxide is a product of the combustion of fossil fuels that contain sulphur. Vehicle emissions of SO_2 are significantly lower than other pollutants; however they can impact both human health and the environment. Sulphur dioxide itself can affect the human respiratory system and is an eye irritant. Further, sulphur dioxide dissolves in water vapour to form acids (e.g., acid rain) and interacts with other gases and particles to form sulphates and other detrimental products. [Env. Canada]

Secondary Pollutants

As referred to in ***Section 2.3***, the two critical secondary pollutants that are the indirect products of motor vehicle fuel combustion are ground-level ozone (O_3) and particulate matter $PM_{2.5}$.

Ground-level Ozone (O_3)

Ground-level ozone is a colourless gas that is a product of the photo-chemical reaction between the primary pollutants volatile organic compounds (VOCs) and oxides of nitrogen (NO_x) in the presence of heat and sunlight. The production of ozone increases with increasing temperature. Ozone has been linked to significant human health impacts, including pre-mature mortality and a range of respiratory problems. It can also have significant impacts on vegetation. [Env. Canada]

Secondary Particulate Matter (PM)

Secondary particulate matter has been discussed under the general category of Particulate Matter, above.

3.2.2 Greenhouse Gases

Greenhouse gases can be defined as gases in the atmosphere that insulate the planet from heat loss. There is a number of naturally occurring greenhouse gases, including: water (H_2O); carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O) and tropospheric ozone (O_3). The term "greenhouse gases" is derived from the "greenhouse effect", in which the greenhouse gases help to regulate the exchange of radiative energy between the Earth's ecosystem and the sun. The proportion of greenhouse gases in the atmosphere is approximately 1%; increasing this concentration creates the imbalance in the radiative exchange that contributes to "global warming".

The three key greenhouse gases generated by the combustion of motor vehicle fuel are: carbon dioxide (CO_2); methane (CH_4); and nitrous oxide (N_2O). Different greenhouse gases have varying global warming impacts according to their radiative forcing or "heat-trapping" potential, which refers to the amount that the gas alters the energy transfer in and out of the Earth's atmosphere. In order to evaluate the aggregate impacts of greenhouse gas emissions, a standard measure of the global warming potential (GWP) of each gas relative to carbon dioxide is used to convert all greenhouse gas emissions into carbon dioxide equivalents (CO_2 eq.). Different gases will remain in the atmosphere for different amounts of time; however, therefore the global warming potential also varies with the time period under consideration. For a 100 year time period, with carbon dioxide (CO_2) having a GWP equal to 1, methane (CH_4) and nitrous oxide (N_2O) have GWPs of 21 and 310, respectively. [UNFCCC]

Carbon Dioxide (CO_2)

Carbon dioxide, a product of the complete combustion of automotive fuels, is the most significant component of all greenhouse gas emissions in Canada, and represents 97% of greenhouse gas emissions (in CO_2 eq.) from road transportation. [Env. Canada 2004].

Methane (CH_4)

Methane (CH_4) is a flammable gaseous product of fuel combustion and evaporative emissions. While methane has a global warming potential of 21, it represents only 0.2% of greenhouse gas emissions (in CO_2 eq.) from road transportation in Canada. [Env. Canada 2004].

Nitrous Oxide (N_2O)

Nitrous Oxide (N_2O) is a gaseous product of incomplete combustion of automotive fuels as well as a byproduct of catalytic converters. While nitrous oxide has a global warming potential of 310, it represents only 3% of greenhouse gas emissions (in CO_2 eq.) from road transportation in Canada [Env. Canada 2004].

4.0 ESTIMATION OF VEHICLE EMISSIONS FOR PROJECT EVALUATION

In simplistic terms, vehicle emissions can be estimated as the product of vehicle activity data and the aggregate rate of emissions per unit of the activity, as illustrated in ***Figure 4.1***, below:

Figure 4.1 – Simplistic Equation for Estimation of Emissions

Emissions	=	**Activity Data** (e.g., kilometers of travel, fuel consumption)	x	**Emission Factor** (e.g., g/unit of activity)

In reality, however, the estimation of emissions can be quite complex, depending upon the level of accuracy required. Aggregate emissions over a large area (i.e., macroscopic emissions inventories) can generally be estimated more readily than subtle (microscopic) changes in emissions resulting from traffic operational improvements. Therefore it is important to ensure that the level of effort required for analysis is warranted by the intended use of the results.

Further, meaningful activity data is not always readily available and vehicle emission factors are dependent (in varying degrees) upon a wide range of variables, as discussed in the following sections.

Emissions During Construction

A life-cycle project evaluation would also include emissions during the construction stage; however, estimation of these emissions is complex, depending on many factors including: the type of project; the location and accessibility of the project; and the type of construction, among others. Studies are currently underway by a number of agencies to provide some further perspective on this issue; however the variable nature of construction emissions precludes their inclusion in the analysis at this time.

4.1 Activity Data

Activity data provides the quantification of vehicle usage from which emissions can be estimated. In order to evaluate the potential emissions impacts associated with a proposed improvement project, it is necessary to quantify the vehicle usage associated with the improvement alternatives, including the base case. (*It should be noted that vehicle usage may or may not remain constant for a given set of alternatives.)*

At the macroscopic level of analysis, the required activity data typically consists of aggregate travel data such as vehicle kilometres traveled (VkmT) and average speeds; these data may be extracted from a macroscopic transportation planning model such as EMME or TMODEL, if available. Alternatively, aggregate travel data can be estimated from traffic count data. Fuel consumption can also be used at the aggregate level. This level of analysis does not reliably account for differences in vehicle operating modes (e.g., idle, acceleration, deceleration) that may result from certain improvement projects.

At the microscopic level, disaggregate activity data is required to provide a more accurate evaluation of the emissions impacts of improvements. The activity data consists of second-by-second vehicle operating mode characteristics (typically extracted from micro-simulation models such as Paramics or CORSIM). This is a highly data intensive exercise.

In general, the sources of available activity data will depend on the location and scale of the proposed improvement: urban environments will typically have macroscopic planning tools whereas rural areas may only have count data from which annual travel volumes must be factored. Similarly, a large project may have a microscopic travel model such as a Paramics model whereas a smaller project may have only a Synchro model for evaluation of traffic operations.

4.2 Emission Factors

Emission factors provide a quantification of the estimated emissions per unit of activity; these factors are aggregate rates of emission that reflect a given set of values for a large number of variables. These variables that potentially impact vehicle emission rates can be categorized as follows:

- **Vehicle and Fleet Characteristics:** e.g., vehicle class distribution, model type, model year, engine technology and size, and emission control technology;

Factors That Affect On-Road Fuel Consumption

Temperature: At 0°C, fuel consumption is increased about 8 percent while at -30°C, consumption is increased by an average 30 percent.

Terrain and road: Twisting roads in rocky terrain may cause repeated speed up/slow down acceleration which increases fuel consumption. Driving in snow increases fuel consumption because snow increases wheel slippage and resistance to vehicle motion. Rough asphalt, pot-holes and gravel-surfaced roads can increase fuel consumption up to 35 percent.

Vehicle load and condition: Some vehicle options such as air conditioning or a loaded roof rack may be taken into account during the laboratory tests but their effect on fuel consumption can only be estimated. Additional options which add weight to a vehicle (e.g. four-wheel drive) also increase the load on the vehicle engine, increasing fuel consumption. The same holds true for extra passengers and additional weight carried or towed.

Proper vehicle maintenance helps to ensure proper fuel consumption. Low tire pressure, incorrect wheel alignment, brake drag all contribute to increased fuel consumption.

Driving style: Short trips of 10-15 minutes without engine warm-up cause high fuel consumption because the engine does not remain at its operating temperature for any significant length of time. Quick accelerations, fast stops and excessive speed also result in higher fuel consumption for the vehicle.

Source: http://www.tc.gc.ca/programs/environment/fuelpgm/guide/page4.htm

- **Fuel Characteristics:** e.g., type of fuel, chemical composition of fuel, including carbon content;
- **Travel (Trip-Specific) Characteristics**: e.g., travel speed; vehicle operating mode (e.g. idle, acceleration, deceleration);
- **Environmental Characteristics**: e.g., climate, geography;
- **Regulatory Characteristics**: e.g., inspection/maintenance programs; and
- **Driver Characteristics**: e.g., aggressive driving style; use of air-conditioning.

While definition of these variables is required for quantification (and monetization) of emissions impacts, for project level analysis, many of these variables will remain constant for all improvement options and therefore will not impact a comparative evaluation.

In general, the key variables for project evaluation are the "trip-specific" variables, including: travel speed, vehicle operating mode and geography.

4.2.1 Estimation of Pollutant Emissions

Key variables in the determination of emission rates for pollutants are vehicle speed and vehicle engine load (an aggregate variable incorporating many of the characteristics listed above). These relationships are neither linear nor consistent between pollutants, for e.g., emissions rates for volatile organic compounds generally decrease with increasing vehicle speed, whereas emission rates for nitrogen oxides initially drop as speed increases, and then rise again at higher speeds.

Given the highly complex nature of estimation of mobile source emissions, a wide range of modeling tools has been developed for this purpose.

4.2.2 Estimation of Greenhouse Gas Emissions

Motor vehicle greenhouse gas emissions are more easily estimated than pollutant emissions, due to the direct correlation between carbon dioxide (CO_2) emissions and fuel consumption. (CO_2 emissions are also a function of the carbon content of the fuel and the fraction of carbon oxidized, however these would not be variable in a project evaluation.)

Vehicle emissions of the non-CO_2 greenhouse gases, methane (CH_4) and nitrous oxide (N_2O) are also a function of: fuel type; combustion and emission control technologies; vehicle operating conditions; ambient conditions; and vehicle maintenance, making these non-CO_2 emissions far more complex to estimate than CO_2 emissions. [US EPA]

As noted in ***Section 3.2.2*** above, however, the non-CO_2 emissions represent less than 4% of global warming impacts (in CO_2 eq.) of Canadian on-road motor vehicle greenhouse gas emissions, therefore it is considered acceptable to use the CO_2 emissions as a proxy for all greenhouse gas emissions, by increasing the total CO_2 emissions by 1/0.97 (3 %). *"Given the importance of CO_2, it is usually appropriate and acceptable for transportation GHG analyses to focus solely on this gas, particularly if resources are limited and if the analysis is designed to provide a general indication of GHG impacts." [ICF Consulting, 2006]*

4.3 Available Tools for Estimation of Emissions

A comprehensive literature search has been undertaken to review available tools for the estimation of project emissions. A vast range of modeling tools has been developed by various agencies to generate emission factors for use in the estimation of mobile source emissions. The original impetus behind the development of these models came from the need to develop annual emission inventories on a regional or national basis to comply with legislation such as the US Clean Air Act (in the case of pollutants) and the IPCC (in the case of greenhouse gases). As a result, the models and associated methodologies were focused on an aggregate level of analysis suitable for an inventory over a large area. This macroscopic analysis in some cases involves a "top down" approach which incorporates fuel sales as activity data.

As the demand for evaluation of emissions has expanded to include disaggregate levels of analysis, the available modeling tools have evolved to incorporate a more detailed level of analysis. Evaluation of emissions at the project level, however, is a relatively complex undertaking, given the large number of variables affecting emission factors and the potentially minor change in emissions that may occur. Particularly in small projects such as traffic operation improvements, the absolute change in emissions may be very small. Conversely, the resource costs associated with emissions modeling may be very high and, as previously noted, it is important to weigh the value of the anticipated results against the cost of the analysis.

The state of the art and key aspects of these modeling tools in terms of project evaluation are discussed in the following sections.

4.3.1 Macroscopic Emissions Models

Macroscopic emissions models were developed to estimate aggregate emissions over a large area; they are based on the assumption "that the average emissions over a trip vary according to the average speed of the trip" [Pronello and Andre, 2000]. The average speed is essentially used as a proxy to represent the driving pattern or cycle; emission rates are derived for the average speeds given a set of fleet data and vehicle data. Pronello et al. state that "this restricts the approach to regional and national emission estimates" [Pronello, 2000].

The first US EPA emissions model, MOBILE, was developed in 1978 for the purpose of preparing inventories of pollutants. After several refinements and enhancements, the current version, MOBILE6.2 incorporates user control over many of the parameters and includes analysis of PM_{10}, $PM_{2.5}$, and mobile source air toxics (MSATs, defined in ***Section 4.4.2***, below). With respect to greenhouse gases, MOBILE6.2 provides an aggregate level estimate of CO_2 only. MOBILE6.2 is the model currently specified by the EPA for US federal transportation-related air quality assessment requirements.

Copert 4 is a comparable macroscopic model developed under the European Environment Agency for development of annual national emissions inventories of regulated (and a number of non-regulated) pollutants; Copert 4 calculates emissions of greenhouse gases N_2O and CH_4 , and estimates CO_2 based on fuel consumption. [AUT 2007]

In terms of project evaluation, the macroscopic models are not capable of accurately estimating the emissions impacts associated with traffic operations improvements and other improvements that do not impact average speeds or travel distance. While large projects on un-signalized and uncongested corridors may be modeled with reasonable confidence, for many projects, the amount of time spent accelerating versus at a steady speed will be the determining factor in emissions impacts.

4.3.2 Microscopic Emissions Models

Microscopic emissions models were developed to evaluate the impact on emissions of localized changes in a transportation network. These models are based on a dis-aggregate approach to the estimation of emissions, and therefore require a correspondingly large amount of data. Microscopic models (also referred to as modal emissions models) use various approaches to incorporate the vehicle operating mode (i.e., idle, steady-state cruise, or acceleration/deceleration) together with the vehicle speed to estimate emissions. One common approach is to develop an "emissions matrix" which correlates to the various operating mode states, with activity data distributed to each cell on a temporal basis. Alternatively, an instantaneous (second by second) data set of speed and engine power can be developed, which incorporates all variables contributing to engine load. Two major weaknesses are attributed to both of these methodologies: only steady state emissions are modeled (rather than transient operation); and the lack of accuracy for conditions lying between actual data-points [Barth et al. 2000].

In recognition of the need for more detailed emissions analyses for project evaluation and other micro-scale applications, the EPA is currently in the testing stage of the second implementation of a comprehensive mobile emissions model, MOVES-HVI (Motor Vehicle Emissions Simulator: Highway Vehicle Implementation) which includes micro-scale analysis. (The first implementation of this model was called MOVES2004). The EPA reports that MOVES will incorporate second-by-second speed traces and vehicle specific power (which accounts for acceleration, speed, grade and road load) to allow project level dis-aggregate analysis of emissions. The long term plan is for MOVES to replace MOBILE6.2 as the official tool for estimation of criteria pollutant emissions. Preliminary documentation for MOVES indicates that greenhouse gases will be estimated at the aggregate level. The scheduled release date for MOVES-HVI is 2009.

Microscopic models have been under development in Europe since the early 1990's, however the intense data requirements have presented issues in calibration. Validation studies indicate that the legislated driving cycles (e.g., similar to the US Federal Test Procedure (FTP) Driving Cycle) as used in the models (instead of collecting vast quantities of data on "real world" driving dynamics) can significantly underestimate emissions [Sturm et al. 1998].

The Artemis Project (Assessment and Reliability of Transport Emission Models and Inventory Systems), a major European initiative set up by a consortium of 36 leading organizations in transport emissions research and funded by the European Commission, was established in 2000 "to combine the experience from different emission calculation models and ongoing research in order to arrive at harmonized methodology for emission estimates at the national and international level." One of the final reports (published in March 2006) identified a number of outstanding issues with respect to development of a microscopic emissions model, primarily related to a lack of sufficient data and the need for validation [Andre et al. 2006].

In California, the Comprehensive Modal Emissions Model (CMEM) was developed by CE-CERT[4] in a four year project under the sponsorship of the National Cooperative Highway Research Program (NCHRP Project 25-11) for the estimation of emissions from light-duty vehicles as a function of the vehicle operating mode. This innovative approach to modal emissions modeling uses a deterministic model based on the mathematical relationships between emissions and the critical parameters that affect them. By defining these relationships, the model is less prone to interpolation error than previously discussed approaches. And while the initial development of the model is data-intensive, subsequent applications require far less data collection than other approaches [Barth et al. 2000]. Development of this model began in 1996; a 2003 validation study noted that "CMEM

[4] University of California, Riverside, College of Engineering-Center for Environmental Research & Technology (CE-CERT)

exhibits abnormal behaviours when compared with ORNL (Oak Ridge National Laboratory) data and EPA data" [Rakha et al. 2003]. However, reports indicate that CMEM has undergone numerous enhancements including calibration from on-road data and the addition of heavy duty diesel vehicles [Barth et al. 2005]. CMEM is also designed to be integrated with all scales of transportation models (macro, meso and micro-scale). CMEM appears to reflect the state-of-the-art in the micro-scale emissions modeling, however the model has been calibrated to California conditions including an ambient temperature of 75°F, and so is not directly transferable to other environments.

While microscopic modeling of emissions has the potential capability to measure emissions impacts of localized improvement projects, it would appear that the intensive resource and data requirements of this analysis tool likely preclude it from use in most project evaluation exercises.

4.3.3 Travel Demand / Traffic Models with an Emissions Component

STEP *(Systematic Traffic Evaluation and Planning Model)*

STEP is a travel demand modeling package based on micro-simulation that contains an emissions modeling module. Developed in California, this model has been used in a number of locations throughout the US. STEP is reported to include an emissions module, which is based on the MOBILE model.

TRANSIMS *(Transportation Analysis Simulation Systems)*

TRANSIMS is a suite of integrated travel and air quality models developed by the FHWA's Department of Transportation at the Los Alamos National Laboratory. TRANSIMS includes (among other elements): a macroscopic transportation planning model, a micro-simulation traffic model, and a microscopic emissions model that incorporates a power-demand approach similar to CMEM. This suite of programs is resource intensive but potentially very powerful. Metro Portland has been a test site for TRANSIMS.

SYNCHRO 7

SYNCHRO is a macroscopic traffic modeling tool for intersection analysis and optimization that provides a highly simplistic estimate of CO, VOC and NO_x pollutant emissions based on empirical fuel consumption formulae and default emission factors (one factor for each pollutant). The documentation for the most recent version (SYNCHRO 7) indicates that emission estimates will incorporate fuel and emissions tables from the FHWA's

TSIS/CORSIM model (discussed below); however, these enhancements are still under development.

CORSIM

CORSIM is a microscopic traffic simulation system that is a component of the US Federal Highway Administration's TSIS (Traffic Software Integrated System) suite of programs. CORSIM estimates emissions of CO, HC and NO_x based on sets of default tables of fuel consumption and emission factors. CORSIM documentation indicates that the data has not been recently updated and recommends that the results be used for comparative analysis on a relative basis (i.e., % difference) only [FHWA 2007].

PARAMICS

Paramics is a suite of microscopic traffic simulation tools that can be used to analyze single intersections through to complex networks. Version 6 of the suite includes Monitor, a pollution evaluation framework module that integrates directly with the core Paramics simulation. Monitor calculates the levels of traffic emission pollution for every link in the network by summing the emissions for all vehicles on the link. The development of Monitor was partly based on work carried out on behalf of the Department of Transport (DTp) in the UK and therefore reflects vehicle types and emission rates in the UK. User generated emission rates that are sensitive to variables such as vehicle speed, acceleration, and link grade can be used in place of the UK rates; however, development of these rates would require the application of a suitable analysis tool (e.g. MOBILE 6.2C).

VISSIM

VISSIM is a microscopic, behavior-based multi-purpose traffic simulation program. VISSIM has an optional emissions module that includes emission rates based on EU standards for personal vehicles, light-duty and heavy-duty commercial vehicles.

4.4 Current Practices in Other Jurisdictions

An extensive literature search and review of government agency web pages was undertaken to identify current practices in other jurisdictions with respect to project level estimation of emissions impacts. Notable models, key practices, and significant issues are highlighted in the following sections.

4.4.1 Transport Canada

As noted in ***Section 2.1.2***, Transport Canada is incorporating estimates of vehicle emissions in a Cost Benefit Analysis tool currently under development. Preliminary documentation indicates that the model will estimate emissions of carbon monoxide (CO), volatile organic compounds (VOCs), total hydrocarbons (THCs) and oxides of nitrogen (NO_x) based on lookup tables of MOBILE6 emission factors derived from a specified set of parameters. [HDR|HLB 2007]

Based on this information, emissions of greenhouse gases CO_2 and N_2O, particulate matter and the criteria air contaminant SO_2 will not be included in the analysis.

Somewhat concurrently, however, Transport Canada has introduced an on-line Urban Transportation Emissions Calculator for estimating annual emissions of criteria air contaminants (pollutants) and greenhouse gases for alternate scenarios.

This model incorporates emission factors derived from Environment Canada's MOBILE6.2C model. The model user is able to select an evaluation year from 2006 to 2031 by five year increments, and also to specify a Province or Territory. CAC emission rates are adjusted to match these input parameters and take into account the improvements anticipated due to emission regulations covering new vehicles. Fuel efficiencies in the calculator take into account the age profile of the fleet by vehicle class at the national scale as well as the marginal improvements in fuel efficiency in the MOBILE 6.2C forecasts. The fuel efficiency values do not take into account proposed fuel efficiency regulations.

The user of the model can also specify:

- peak hour kilometers travelled (VKmT) by vehicle type;
- the distribution of VKmT and average speeds by road type and time period (peak versus off-peak) for three different vehicle types (the calculation of GHGs is sensitive to the proportion of VkmT occurring at speeds below 40 km/h);
- expansion factors to convert peak hour values to annual values;
- the breakdown of light duty passenger vehicles between automobiles and light trucks; and
- vehicle fuelling characteristics in terms of a percent distribution by fuel type (including ethanol blends and hybrids).

As a result, this tool can be used to provide a reasonable estimate of the emissions associated with a variety of transportation projects.

4.4.2 US Federal Highway Administration (FHWA) / Environmental Protection Agency (EPA)

Available literature indicates that in the United States, the evaluation of emissions impacts has been driven by both federal regulatory requirements on air quality and benefit /cost analysis of improvement projects, as described in the following sections:

Estimation of Emissions for Air Quality Conformance

Under the US Clean Air Act, State Implementation Plans (SIPs) are required to demonstrate how National Ambient Air Quality Standards (NAASQ's) will be met and maintained. The Transportation Conformity Rule of the Act requires that regionally significant and federal projects must be consistent with NAAQSs for criteria pollutants (ozone, CO, NO_2, PM_{10}, $PM_{2.5}$) and precursor pollutants (VOC, NO_x, SO_x, and NH_3). [FHWA]

The EPA designates the approved emissions models for use in SIP and conformity determinations. As of the last updating in 2005, MOBILE6.2 was the "latest approved emissions factor model for use outside of California…" [FHWA].

It is of note that the following project types (among others) are exempt[5] from the Regional Emissions Analysis that forms the basis of the conformity determination:

- Intersection channelization projects;
- Intersection signalization projects at individual intersections;
- Interchange reconfiguration projects; and
- Changes in vertical and horizontal alignment.

This would indicate that EPA considers the magnitude of the air quality impacts of these types of improvements insufficient to warrant evaluation.

[5] Unless identified by EPA, FHWA or FTA to have potential regional impacts. [FHWA]

There has been recent focus in the US on the demand for project level evaluation of the six "Mobile Source Air Toxics" (MSATs)[6] that have been linked to serious human health impacts including cancer and respiratory diseases. The MSATs are distinct from the US Criteria Air Pollutants for which there are National Ambient Air Quality Standards.

FHWA analysis indicates that EPA's new vehicle emission standards are a major mitigating factor in MSAT emissions. A recent Environmental Impact Statement for a new 29 kilometre highway in Maryland predicted a reduction in MSAT emissions of over 80% between 2000 and 2030 over the study network in a "no-build" scenario (as a result of more stringent emission standards). In comparison, the "build" scenarios were forecast to generate a one to six percent increase in emissions forecast relative to the "no-build" scenario in 2030. [Houk, 2007]

FHWA has issued an interim guidance policy requiring quantitative analysis of MSATs for "projects with higher potential MSAT effects" including:

- New (or significantly altered) major inter-modal facilities with potential for high emissions of diesel particulate; or
- New (or significant capacity increase to) urban highways or facilities with design year AADT of 140,000 or more per year.

These projects must also be in proximity to populated areas or sensitive rural areas.

Estimation of Emissions for Benefit / Cost Analysis

HERS-ST (Highway Economics Requirements System - State Version) is an engineering/economic analysis software package developed under the FHWA for use by state highway agencies in benefit/cost analysis of infrastructure investment at both the system and the project level. Emissions of six pollutants (CO, VOCs, NO_x, SO_x, PM_{10} and road dust) are estimated, based on emission rates derived from EPA models (MOBILE6 and PART5) for a varied range of parameters. The costs (based on health and property damages) are estimated, with adjustments according to the density of development and the dispersive tendencies of each pollutant.

[6] The US Clean Air Act identified 188 hazardous air pollutants, of which 21 were identified by the EPA as mobile source air toxics. The EPA further identified a subset of six priority MSATs (referred to as "Mobile Source Air Toxics" which consist of benzene, formaldehyde, acetaldehyde, diesel particulate matter/diesel exhaust organic gases, acrolein, and 1,3-butadiene. [FHWA]

4.4.3 The Province of Alberta

The Alberta Infrastructure and Transportation Ministry's Project Administration Manual indicates that a Comparative Rating System (CRS) is used to rank projects for selection purposes, however available documentation does not indicate that emissions are considered in this evaluation [Alberta 2006].

4.4.4 Washington State Department of Transportation

In April 2007, HDR|HLB Decision Economics Inc. completed a benefit-cost analysis of a proposed new 10 kilometre multi-lane divided Cross-Base Highway Project (and alternatives) for the Washington State DOT. This project incorporated a similar methodology for estimation of emissions to that of the model that HDR|HLB is currently developing for Transport Canada. Emissions of hydrocarbon, carbon monoxide and nitrogen oxides were estimated from rates tables for vehicle class and type of emission included in *StratBENCOST.* The analysis results indicated a significant increase in user benefits from construction of the new route ("build" scenario) relative to the existing congested facilities. One key aspect of the results, however, was that the estimated difference in the costs (or benefits) of emissions was between 1% and 4% of the estimated difference in the costs (or benefits) of vehicle operating costs relative to the "no-build" alternative for all scenarios tested. While this did not include greenhouse gas emissions, a significant fuel consumption savings was indicated for the "build" scenario, which would decrease greenhouse gas emissions accordingly. [HDR|HLB 2007]

4.4.5 State of California

The State of California Air Resources Board has developed their own emissions model, EMFAC, which is used for emission inventories and project level air quality analysis. EMFAC2007 is a macroscopic model that estimates major pollutants and CO_2 on an hourly basis; EMFAC2007 is currently under review by the FHWA for air quality conformity requirements.

California has a benefit / cost model (Cal-B/C) that incorporates emission factors derived from EMFAC, however Caltrans web-page documentation notes the deficiencies in driving-cycle-based models and refers to the precision of CMEM (as described in ***Section 4.3.2***). The documentation specifically states that: "Detailed emissions modeling should be considered for use in any benefit-cost analysis for which the outcome will depend predominantly on emissions consequences. (Note that many benefit-cost analyses obtain the majority of their benefits from time savings, and emissions are a relatively small component, sometimes showing small dis-benefits.)" [Cal. 2007].

4.5 Valuation of Emissions

As discussed in previous sections, motor vehicle emissions can be quantified via estimates of vehicle activity and emission factors that reflect the aggregate impacts of a wide range of variables affecting the chemical processes of emission. The accuracy of the quantification is a function of the level of detail of the analysis. The quantified impacts belong in the Environmental Account of the Multiple Account Evaluation Framework, as these impacts are borne by society rather than the road user. The quantified impacts provide decision-makers with relative information on the different improvement options, in terms of emissions, for comparative analysis.

Valuation (or monetization) of the quantified impacts is a separate exercise, which provides a frame of reference for comparison to different categories of impacts, but which also introduces a new set of assumptions and variables into the evaluation.

While the quantified impacts can be considered more accurate, without the uncertainty associated with unit costs, it may be necessary to provide monetized impacts on occasion, in order to include the emissions in the larger context of project evaluation. In any case, these impacts should remain in the environmental account.

Two different methodologies are typically used to evaluate the cost of emissions: evaluation of damage costs; and evaluation of marginal control or "avoidance" costs. While damage costs are calculated based on the adverse effects of pollutants, control costs are based on achieving defined air quality standards. The inherent differences between these two approaches, compounded with the uncertainties and assumptions involved in each can result in unit cost estimates that are highly variable between agencies and even between studies from one agency.

The categorization of motor vehicle emissions into pollutants and greenhouse gases according to their impacts is also appropriate in consideration of their costs to society. Pollutant impacts are primarily monetized as health costs, and greenhouse gases are monetized as "environmental costs". The valuation of pollutant and greenhouse gas impacts are quite separate issues, as discussed in the following sections.

4.5.1 Health Costs

The health costs of emissions are highly variable, and a function of many factors, including: climate conditions and geography; population density (i.e., exposure of receptors); sensitivity of receptors; and type of pollutant. The complexities in the estimation of health costs and, in particular, the site specific nature of the resulting estimates, are key factors which limit the availability of relevant cost data for application in this context. As previously discussed, estimates may also vary as a result of methodological differences.

An extensive literature search for relevant cost data revealed a limited number of published references. The sources reviewed included documents prepared for or by: Transport Canada; the FHWA; Caltrans; the European Commission; and VTPI among others. Of the available data, some of the costs have been developed for Europe rather than North America. Further, some sets of unit costs do not specifically address the CACs previously identified for quantification.

A recent Transport Canada study entitled: *The Cost of Urban Congestion in Canada,* Delcan, ADEC and iTrans, March 2006 (Rev. July 2007), incorporates air emission values adapted (Litman, 1995) from the following source: Convergence Research, *Zero Impact Energy: Mitigating Emissions from the Hermiston Generating Project, (Bell 1994).* This report documented median cost values for pollutants developed from a survey of 37 studies and US government agencies. While it is expected that some factors will have changed since the original survey, the magnitude of the database provides a strong justification for its use, hence adapted values have been incorporated in the summary of unit costs provided in ***Section 4.5.3***, below.

The only exceptions are the costs for particulate matter, which were not broken down into PM_{10} and $PM_{2.5}$ in the above reference. Costs for these CACs have been adapted from those used for the Ministry's Gateway Program *Environmental Assessment Certification Application for the Port Mann/Highway 1 Project* (RWDI, 2007). The high unit cost associated with $PM_{2.5}$ reflects the extreme health impacts of this CAC.

4.5.2 Environmental Costs

The environmental costs of greenhouse gases are much less variable than health costs as the impacts are global and therefore independent of location and the other factors that affect the health costs.

Current estimates for the environmental costs of greenhouse gas emissions vary according to assumptions regarding climate change policy (e.g., compliance with the Kyoto Protocol) and strategies (including flexibility of emissions trading schemes). In general, domestic abatement costs rise with increasing emissions reduction targets, and with increased restrictions in emissions trading.

As described in ***Section 4.5.1***, above, an emission value for CO_2 has been adapted from that used in *The Cost of Urban Congestion in Canada,* Delcan et al (2007). This adapted value (37 $/tonne.) has been validated against the Nov. 12, 2007 closing price (21.9 €/tonne) for European Union Allowance (carbon trading unit) on the European Climate Exchange and is considered within an acceptable range.

4.5.3 Summary of Unit Costs

A summary of unit costs of emissions (adjusted to 2007 C$), as described in ***Sections 4.5.1*** and ***4.5.2,*** is provided in ***Table 4.1,*** below:

Table 4.1: Unit Costs of Emissions

	CO_2 eq.	CO	VOC	NO_x	SO_x	PM_{10}	$PM_{2.5}$
2007 C$ / tonne	$37[1]	$1,700[1]	$6,100[1]	$7,700[1]	$3,300[1]	$3,300[2]	$330,000[2]
1 - Adapted from Convergence Research, 1994, in Litman, 1995, and Delcan, iTRANS and ADEC, July 2007. 2 - Adapted from MoT Gateway Program *Environmental Assessment Certification Application for the Port Mann/Highway 1 Project* (RWDI, 2007).							

5.0 RECOMMENDED GUIDELINES FOR QUANTIFICATION OF EMISSIONS

The objective of the environmental account of the Ministry's MAE process is to document the nature, magnitude, significance and mitigation of major environmental impacts of the options under consideration. These environmental impacts include vehicle emissions, the focus of these guidelines.

In the past, the vehicle emissions of interest have been Criteria Air Contaminants (CACs) such as carbon monoxide (CO), nitrous oxides (NOx), volatile organic compounds (VOC), and particulate matter (PM). As previously indicated, these emissions are a function of a variety of factors including engine technology, engine load, engine temperature, vehicle speed, ambient temperature, and road conditions. Not withstanding the impact of these various factors, given that many of these factors will remain unchanged across the options being compared in an MAE analysis (e.g. engine technology and temperature), the marginal impact of a highway improvement on CAC emissions will be closely related to the impact on fuel consumption. At the same time, fuel consumption is closely related to distance traveled and engine load events (e.g. acceleration).

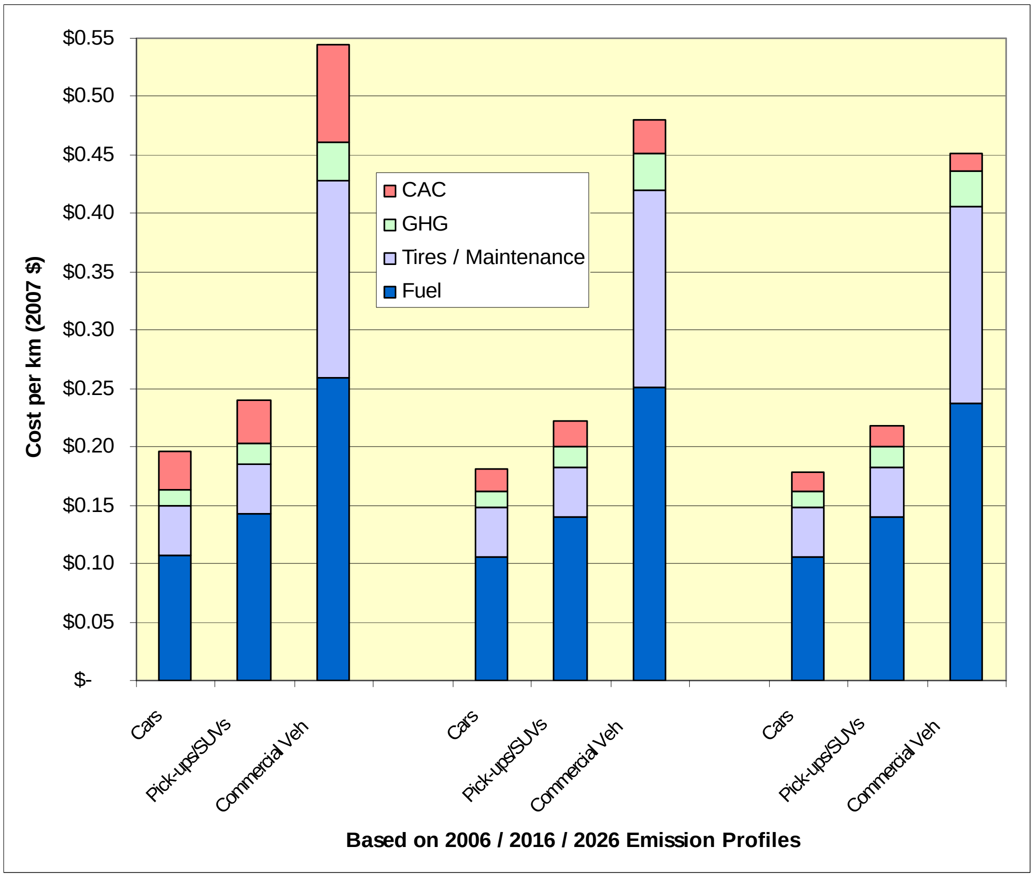
Given their impact on global warming, greenhouse gas (GHG) emissions must also be considered in any assessment of vehicle emissions. The emission of CO_2, the primary component of GHGs, is directly related to fuel consumption.

5.1 Relative Cost of Emissions

Prior to developing recommendations on what methodologies should be used to estimate the CAC and GHG impacts of transportation projects, it is important to understand the potential scale of these impacts relative to other accounts used in the MAE process. Unit costs estimates for the societal impacts of CACs and GHGs associated with vehicle emissions have been presented earlier in this report.

Figure 5.1 (below) illustrates the estimated societal costs of CACs and GHGs relative to a user's vehicle operating costs in terms of cost per kilometre for current and future (2016 and 2026) conditions. The emission rates are based on an application of Transport Canada's Urban Transportation Emissions Calculator using default values for BC. The fuel costs are based on a price of $1.00 per litre, while the vehicle maintenance costs in the table have been taken from BCAA's estimates of operating costs for passenger vehicles and Transport Canada's report on Operating Costs of Trucks.

Figure 5.1: Relative Costs per Vehicle Kilometre



The chart shows relative costs in 2007 dollars for typical cars and light trucks (e.g. pick-ups, SUVs), and commercial vehicles based on emission rates implicit in the Transport Canada Urban Transportation Emissions Calculator for BC. Default values were used for the distribution of VkmT by road and vehicle type.

The current societal costs of CACs per vehicle kilometre are estimated to be about 20% of user operating costs for the different vehicles based on 2006 fleet characteristics. The societal costs of GHGs are estimated to be about 7% to 10% of user operating costs for the different vehicles.

Emission rates for CACs are expected to drop over the coming years due to more stringent tailpipe emission standards for new vehicles. The Urban Transportation Emissions Calculator indicates that emission rates per kilometre will drop to 20% to 70% of current values by 2026 due to a turnover in the vehicle fleet. The relative costs for the 2016 and 2026 fleets are also presented in the chart.

Based on the revised emission rates, the societal costs of CACs per vehicle kilometre would drop to about 4% to 11% of user operating costs by 2026. The costs of GHGs will remain relatively unchanged since the Calculator does not include any significant improvements to vehicle fuel efficiency.

Given the relative values of vehicle operating costs and societal costs for CAC and GHG emissions, the level of effort required for the assessment of the emission impacts of transportation projects should be at the same scale as the effort devoted to estimating vehicle operating costs.

As noted in previous sections, the increasingly stringent regulatory controls on vehicle emissions (in terms of both emission standards and fuel efficiency standards) will continue to reduce the impacts of emissions and the associated costs. Based on this reduction in emission costs relative to other project costs, it follows that the role of emissions in project evaluation is likely to diminish over time. One caveat to this conclusion would be that in the event of significant increases in the market value of carbon emissions, the relative impact of greenhouse gas emissions would increase at a corresponding rate.

5.2 Recommended Guidelines

The recommended guidelines for quantification of vehicle emissions and the accompanying rationale are described in the following sections. It should be emphasized that these guidelines have been developed in consideration of the following key principle: *the recommended methodologies should reflect key project parameters and support consistent application by all practitioners, with a required level of effort appropriate to the relative value of the results.*

While it is clear that tools are currently available or under development to enable the assessment of vehicle emission impacts at a high level of accuracy, the resource costs associated with the use of those tools would preclude their use in the majority of the MAE evaluations required.

As such, the guidelines have been developed to provide clear, commonsense methodologies for quantification of emissions at an appropriate level of accuracy. The methodologies are referenced in the following sections and described in ***Section 6.***

A fundamental component of the MAE tool is to provide a consistent framework against which option evaluation can be undertaken; each option must be evaluated for each indicator.

5.2.1 Indicators to be Evaluated

The indicators to be included in the guidelines are separated into the two categories of emissions: pollutants and greenhouse gases. The following insert is recommended to be included under the category of emissions in the environmental account of the Guidelines for Preparing MoT Business Cases, ***Appendix 2: Multiple Account Evaluation Guidelines.***

The following vehicle emissions impacts are required, and shall be quantified in the units noted over the analysis period (unless otherwise noted in the methodology description included in ***Section 6****):*

Emission Categories	*Measure*
• *Criteria Air Contaminants (CO, NO_x, VOC, PM_{10}, $PM_{2.5}$, and SO_2)*	*tonnes or kilo-tonnes*
• *Greenhouse Gases (CO_2, CH_4, N_2O)* *(estimates of both direct and indirect emissions)*	*kilo-tonnes of CO_2eq*

In addition to the estimates of emissions, the potential impacts on GHG emissions should also be presented in terms of the equivalent number of passenger vehicles that would have to be taken off the road annually to achieve the same benefit (or the equivalent number added if emissions increase relative to the base case). Information on the methodology(ies) to be used in the estimation of emissions is contained in: The Guidelines for Quantifying Vehicle Emissions within the Ministry's Multiple Account Evaluation Framework.

A typical passenger car (excluding Trucks and SUVs) travels about 20,000 kilometres per year, consumes about 2,000 litres of fuel, and directly generates about 5 tonnes of GHGs. This value can be used to estimate the passenger vehicle equivalency of changes in GHG emissions. Due to the anticipated improvements in emission rates for CACs and significant variations by vehicle type, CAC emissions can not easily be expressed in terms of passenger vehicles taken off or added to the road.

In addition, it is recommended that ***Exhibit 1.1*** of the Multiple Account Evaluation Guidelines be revised to include the above noted indicators under the Environmental Account.

5.2.2 Categorization of Option Evaluation

The graphic (***Figure 5.2***) on the following page, taken from the Ministry's MicroBENCOST Guidebook, illustrates the relationship between stages of project development and

Business Case submissions. It also illustrates the different levels of detail required for option evaluation for each of the three Business Case submissions. In addition to variations in requirements for option assessment relating to the stages of project development, there are differences in the level of detail required to estimate emission impacts that are related to project scope. Smaller projects, with options that are likely to result in similar vehicle operating costs and fuel consumption, should not require the same level of analysis as those with greater likelihood of differences among the options. Furthermore, large projects that require air quality analysis to meet the requirements of the provincial Environmental Assessment process may need project specific analysis.

The relationships between stages of project development, project scope, and recommended methods for vehicle emissions analysis are presented in ***Table 5.1,*** *below*.

Figure 5.2: Stages of Project Development / Business Case Submissions / MAEs

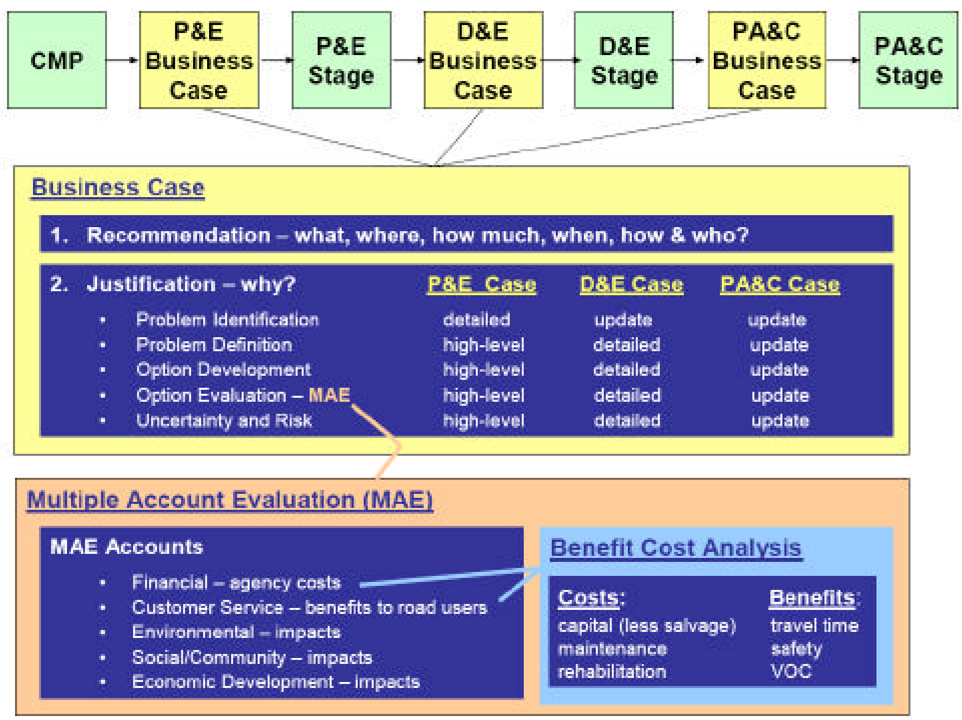


Table 5.1 - Analysis Requirements versus Project Stage and Potential Magnitude of Emission Impacts

Potential Magnitude of Emission Impacts	Small	Medium	Large
Characteristics	• Limited impact on vehicle operating costs and overall fuel consumption • Low capital cost	• Options differ with respect to vehicle operating costs and fuel consumption • Low to Medium Capital Cost	• Likely to require EA submission • Medium to High Capital Cost
Planning and Evaluation (P&E) Business Case	• Method 1 - Qualitative assessment	• Method 1 - Qualitative assessment	• Method 1 – Qualitative assessment • Method 2b - Emissions Calculator using available data
Design and Engineering (D&E) Business Case	• Method 2a - estimates based on fuel consumption • Method 2b - Emissions Calculator if analysis warranted	• Method 2b (Emissions Calculator)	• Method 2b - Emissions Calculator initially • Method 3 - project specific analysis if impacts are large and changes in fuel consumption are significant
Property Acquisition and Construction (PA&C) Business Case	• Update of above	• Update of above	• Update of above

Changes in fuel consumption are affected by variables such as traffic volumes, route length, and vehicle speeds. These factors should be considered when estimating the magnitude of emission impacts and selecting the appropriate methodology. The outputs of the analysis methods are either qualitative statements regarding vehicle emissions or quantitative estimates of the annual emissions.

5.2.3 Valuation of Impacts

Projects that could fall into the Small category include intersection geometric and access control improvements, climbing lanes and other projects that are likely to have a limited impact on VkmT and the distribution of travel speeds (particularly below 40 km/h). These types of projects are likely to neither affect travel patterns nor generate induced travel.

The Medium category includes projects that will result in measurable changes to VkmT such as major changes to highway alignments and/or significant changes to the proportion of travel that occurs at average speeds below about 40 km/h (e.g. projects that remove congested bottlenecks in the road network). These projects may affect travel patterns due to new routing options, and may result in traffic growth due to induced travel. If the induced travel is sufficiently significant to be included in the calculation of travel time benefits, it should also be considered in the calculation of vehicle emissions.

A variety of factors could suggest that a project be placed in the Large category, including close proximity of the project to schools, hospitals, or concentrations of residential population (and the potential for measurable health impacts associated with CACs), very high VkmT (e.g. over 500 million km per year) where even a small change in travel patterns or speeds could have a significant impact on emissions, or specific requirements defined through a formal Environmental Assessment process. Once again, any induced traffic considered in the calculation of user benefits should also be included in the emissions analysis.

If monetization of emission impacts is required, the unit costs included in Table 5.2 (given in $2007) could be used to derive estimates of the costs for the quantified pollutants and greenhouse gases. These values represent external societal costs that have typically not been included in the benefit cost analysis of projects.

The practitioner must confirm with appropriate Ministry staff prior to using these values.

Table 5.2 – Unit Costs of Emissions

Emission	Cdn $(2007) per tonne
Greenhouse Gases (CO_2 equiv.)	37[1]
Carbon Monoxide (CO)	1,700[1]
Nitrous Oxides (NOx)	7,700[1]
Sulfur Oxides (SOx)	3,300[1]
Volatile Organics (VOC)	6,100[1]
Particulate Matter (PM_{10})	3,300[2]
Particulate Matter ($PM_{2.5}$)	330,000[2]
1 - Adapted from Convergence Research, 1994, in Litman, 1995, and Delcan, iTRANS and ADEC, July 2007. 2 - Adapted from MoT Gateway Program *Environmental Assessment Certification Application for the Port Mann/Highway 1 Project* (RWDI, 2007).	

6.0 METHODOLOGIES TO BE USED IN THE ESTIMATION OF EMISSIONS

6.1 Method 1

This method is suitable for the initial assessment of projects as part of the first stage of project development and for the assessment of small projects where emission impacts are likely to be low. The objective of this methodology is to classify a project's emissions impact as positive, neutral, or negative relative to the base case. Two variables need to be considered in this simplified analysis:

- Likely impact of the project on vehicle kilometers travelled;
- Likely impact of the project on fuel consumption rates.

The two most common sources of changes in VkmT are changes to the route length and changes to traffic volumes. The expected combined impact of these changes relative to the base case should be qualitatively categorized as lower, similar, or higher.

In a similar manner, the expected impact of the project on fuel consumption rates should also be categorized. For example, fuel consumption rates will decrease if the number of vehicle acceleration events decreases (e.g. reduced stop/starts with improved signal coordination) while they will increase if speeds increase above 90 k/h.

Based on a qualitative assessment of these variables, the impact of the project on emissions can be defined as described in **Table 6.1**, below:

Table 6.1 - Qualitative Impact on Vehicle Emissions

Impact of Project on Fuel Consumption Rates	Impact of Project on VkmT		
	Lower	**Similar**	**Higher**
Lower	positive	positive	neutral
Similar	positive	neutral	negative
Higher	neutral	negative	negative

In most instances, the scale of the impact of the project on vehicle emissions will be similar in percentages terms to the impact on fuel consumption. This method of assessment may be very suitable for safety related projects where the impact on traffic volumes and operating costs is expected to be minimal.

6.2 Method 2a

This method takes advantage of the estimates of fuel consumption included in MicroBENCOST output (or from an alternative reliable source). Due to the direct correlation between fuel consumption and GHG emissions for vehicles using conventional fuels, it is possible to develop a reasonable estimate of the annual amount of CO_2 equivalent emissions by multiplying the annual litres of fuel consumed by 2.5 kg/l. This factor is suitable for the consumption of gasoline. If a separate estimate is available for diesel fuel consumption, that estimate should be multiplied by 2.8 kg/l. These emission estimates are for direct emissions of GHGs and should be increased by 30% to include the indirect emissions associated with the refinement and transportation of the fuels. .

The estimated impact of the project on CAC emissions can be defined qualitatively based on differences in fuel consumption as outlined in Method 1.

6.3 Method 2b

This method is suitable for most projects where MicoBENCOST is being applied and where quantitative estimates of project impact on both GHGs and CACs are required. The intent of this method is to provide a reasonable estimate of vehicle emissions based on a level of effort that is comparable to that required for the estimation of vehicle operating costs. Another objective of this method is to make use of existing efforts by others where appropriate and to provide flexibility for future developments.

In order to expedite the consideration of vehicle emissions in the analysis of transportation projects, it is recommended that Transport Canada's Urban Transportation Emissions Calculator be used to estimate both GHG and CAC emissions. The Calculator is available at the following Transport Canada webpage:

http://www.tc.gc.ca/programs/environment/UTEC/Default.aspx

By building on this tool, the Ministry can use the fuel, GHG, and CAC emission rates included in the Calculator, and focus their efforts on developing standard input parameters for different types of projects and different regions of the province.

Since the Calculator is a web-based application it is available immediately to all practitioners. It is well documented and easy to use. Default values are available for most of the input fields if the required data are not available for the options being analyzed. The calculator also has emission rates for selected future years to facilitate the assessment of how vehicle emissions may change over time. Interpolation of either the emission rates or aggregate emissions per year can be used to obtain values for years not available within the Calculator.

The Calculator is designed to use the output of travel demand models, which typically estimate passenger travel during a peak hour. The Calculator can also be applied using micro-simulation model results, aggregated by speed ranges. Further, the Calculator can be used in situations where only daily vehicle kilometres are available through adjustments to the expansion factors. Sample applications of the Emissions Calculator are provided in an Appendix to this report.

The Calculator is not without its limitations. The emission rates for CACs are not sensitive to vehicle speeds, thus the potential benefits of projects that reduce congestion delay may not be accounted for to their full extent. The impact of this limitation decreases over time for a number of the CACs since emissions rates are expected to decrease and the relationship between speeds and emission rates per kilometre is expected to flatten.

The impact of induced trips on additional cold starts is not captured. These limitations are no more significant, however, than the limitations of MicroBENCOST in estimating similar impacts on vehicle operating costs.

The experience and understanding of vehicle emissions gained by using the Calculator will be useful as other analysis packages become available, such as the MOVES Model currently under development by the EPA, and tentatively scheduled for official release in fall 2009.

6.4 Method 3

In the case of large projects that require submissions to the Environmental Assessment Office (EAO), it may be necessary to undertake project specific analysis of vehicle emissions. This is particularly true if vehicle emissions are required as input to dispersion models for calculation of local health impacts. Nevertheless, because of the relatively low additional effort required, it is suggested that Method 2b also be undertaken in order to provide a reference point for the more detailed analysis. The results of the detailed analysis can help to validate the results of the emissions Calculator and to identify situations where the Calculator results may not be sufficiently accurate.

Detailed project specific analysis of vehicle emissions will typically use the results of either a transportation planning model or an operational traffic model as the source of vehicle kilometre and speed data. If a transportation planning model is used, speed specific emission rates can be applied to each link to determine local emissions. The speed specific rates can be developed using MOBILE 6.2C to take into account local climate conditions and fleet mix. Since MOBILE 6.2C does not produce speed sensitive emission rates for CO_2, the speed adjustment factors in the Transport Canada Calculator can be applied. Depending upon the formulation of the transportation planning model, the analysis can take into account project impacts on mode of travel and induced trips.

If the primary tool for analyzing the impacts of the project is an operational traffic model (e.g. a traffic micro-simulation model such as VISSIM or Paramics), software modules for estimating vehicle emissions may be available. Emission rates provided with the software module may have to be adjusted to account for local climate conditions and the fleet mix. Emissions are typically calculated based on the performance of individual vehicles with aggregation possible to specific links in the model. Currently, one of the most widely used sources for emission rates in North America is the MOBILE 6.2 model. Unfortunately the speed specific emission rates available from this model cannot take advantage of the acceleration and grade information that is often available from a traffic micro-simulation model. The development of North American emission rates that take into account these operating characteristics will be facilitated by the release of microscopic emission models such as MOVES.

Another consideration in the application of emission rates to both planning and operational model results is the combining of emission rates for specific vehicle types generated by emission models to develop a blended rate that can be applied to the vehicle kilometre estimates generated by the traffic models.

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APPENDIX A

Sample Application of Methodologies

Highway 97 – Winfield to Oyama

Vehicle Emissions Analysis

The assumptions for the vehicle emissions analysis were based on information presented in the Business Case for this project prepared by Urban Systems dated June 2007 (This business case document is attached as a reference to this report). Two options were assessed with respect to vehicle emissions: a base case of the existing alignment (including some reroutes due to potential road closures), and the "Short Highline" option, which departs the Highway 97 alignment at Oceola Road to the south reconnecting south of Oyama Road.

Base Case

The Base Case consists of a 7.2 km section of 2 lane highway along Wood Lake. The 2006 AADT for this section of highway was estimated to be 22,000 vehicles per day. Based on the vehicle length distribution at a permanent count station in the area, it was further estimated that the traffic stream consists of 87% personal vehicles, 8% light commercial vehicles, and 5% heavy commercial vehicles. The business case applied a 3% annual growth rate to the traffic volumes. Using these assumptions, the following daily vehicle kilometres were used as input into the Urban Transportation Emissions Calculator:

	2006	2011	2016	2021	2026	2031
Personal Vehicles	137,808	159,732	185,414	214,855	249,307	288,770
Light Trucks	12,672	14,688	17,050	19,757	22,925	26,554
Heavy Trucks	7,920	9,180	10,656	12,348	14,328	16,596

It was further assumed that the average speed for this option would range from about 75 km/h in 2006 to 70 km/h in 2031. Since there are no emission adjustments over the range of speeds from 44 km/h to 99 km/h, these average speed assumptions are not critical. It was further assumed that these conditions would apply 364 days per year. In addition, the equivalent of one day of traffic would be subject to a reroute due to road closures. The length of the reroute was estimated to be 10 km with average travel speeds of 20 km/h over 20% of the route and 60 km/h over the remaining 80% of the route.

The default values for British Columbia were used for the breakdown of Light-Duty Passenger Vehicles (LDPV) and for vehicle fueling characteristics. No public transit vehicles were considered in this analysis. The calculator was applied for each of the 6 horizon years listed in the table above for both the base and re-route scenarios.

Based on these assumptions, the combined annual vehicle emissions output by the emissions Calculator were as follows:

Pollutant	2006	2011	2016	2021	2026	2031
Direct GHG	17.93	20.45	23.68	27.33	31.51	36.23
Indirect GHG	5.24	6.07	7.04	8.13	9.39	10.81
CO	674.73	596.51	547.30	562.37	631.03	695.58
NOx	53.38	39.77	26.06	18.81	17.04	16.82
VOC	40.31	31.04	23.32	21.27	22.34	23.05
S02	0.47	0.30	0.35	0.41	0.48	0.54
TPM	1.47	1.36	1.38	1.51	1.71	1.92
PM10	1.46	1.35	1.36	1.50	1.69	1.89
PM2.5	0.90	0.74	0.68	0.71	0.79	0.86

Units are annual kilo-tonnes of CO2 equivalent for green house gases (GHG) and annual tonnes for all other pollutants.

Short Highline

Traffic volumes were assumed to be the same for the Short Highline option; however, the travel distance increased from 7.2 to 7.8 km. As a result, the daily vehicle kilometres increased to the following:

	2006	2011	2016	2021	2026	2031
Personal Vehicles	149,292	173,043	200,866	232,760	270,083	312,835
Light Trucks	13,728	15,912	18,470	21,403	24,835	28,766
Heavy Trucks	8,580	9,945	11,544	13,377	15,522	17,979

The average travel speed was assumed to increase to 95 km/h. This speed falls into the range where there are no speed related adjustments to emissions. Given the improved geometrics of this option, it was further assumed that there would be no re-route impacts. Based on these assumptions, the annual emissions for this option were as follows:

Pollutant	2006	2011	2016	2021	2026	2031
Direct GHG	19.40	22.12	25.61	29.57	34.09	39.20
Indirect GHG	5.67	6.57	7.61	8.80	10.16	11.70
CO	730.18	645.53	592.28	608.59	682.89	752.74
NOx	57.77	43.04	28.20	20.36	18.44	18.20
VOC	43.62	33.59	25.24	23.02	24.17	24.95
S02	0.51	0.33	0.38	0.44	0.51	0.58
TPM	1.59	1.47	1.50	1.64	1.85	2.08
PM10	1.58	1.46	1.47	1.62	1.83	2.05
PM2.5	0.98	0.80	0.74	0.77	0.85	0.93

Vehicle Emission Impacts

The estimated net vehicle emission impacts of the Short Highline option versus the base case are summarized in the following table:

Pollutant	2006	2011	2016	2021	2026	2031
Direct GHG (kt)	1.47	1.67	1.94	2.24	2.58	2.97
Indirect GHG (kt)	0.43	0.50	0.58	0.67	0.77	0.88
Total GHG (kt)	1.90	2.17	2.51	2.90	3.35	3.85
CO (t)	55.45	49.02	44.98	46.22	51.86	57.16
NOx (t)	4.39	3.27	2.14	1.55	1.40	1.38
VOC (t)	3.31	2.55	1.92	1.75	1.83	1.90
S02 (t)	0.04	0.03	0.03	0.03	0.04	0.04
TPM (t)	0.12	0.11	0.11	0.12	0.14	0.16
PM10 (t)	0.12	0.11	0.11	0.12	0.14	0.16
PM2.5 (t)	0.07	0.06	0.06	0.06	0.06	0.07

These increases in emissions are directly correlated to the higher vehicle kilometres travelled associated with the Short Highline option versus the Base Case.

If these values are interpolated for each intermediate year and summed over the 25 years from 2007 to 2031 inclusive, the total net impact on emissions over the 25 year evaluation period are as follows:

Pollutant	2007 - 2031
Direct GHG (kt)	54.0
Indirect GHG (kt)	16.0
Total GHG (kt)	70.0
CO (t)	1,243
NOx (t)	54.7
VOC (t)	52.6
S02 (t)	0.8
TPM (t)	3.2
PM10 (t)	3.1
PM2.5 (t)	1.5

The direct GHG impact is equivalent to adding about 430 passenger cars annually to the road network.

The interpolated annual values can also be monetized using the per tonne values suggested in section 5 and then discounted to current dollars based on the discount rate used for the benefit cost analysis of the project (in this case 10%). Based on these assumptions, the monetized value of the additional emissions associated with the Short Highline option is about \$0.8 million for GHGs and \$1.3 million for CACs with a combined value of about \$2.1 million (2007\$). The combined value is about 20% of the vehicle operating cost impacts of the Short Highline option. Given that both the base case and the Short Highline option go primarily through rural areas, the financial impact associated with the CACs may be overstated.

Highway 97 – Simon Fraser Bridge Twinning Prince George

Vehicle Emissions Analysis

The assumptions for the vehicle emissions analysis were based on information presented in the Business Case for this project prepared by Apex Engineering Limited dated September 2007. Two options were assessed with respect to vehicle emissions: a base case of the existing bridge (including reroutes during bridge rehabilitation), and the Twinning option, which involves the construction of a new 2 lane bridge parallel to the east of the existing bridge.

Base Case

The Base Case consists of a 1.32 km section of Highway 97 crossing the Nechako River in Prince George. The 2006 AADT for this section of highway was estimated to be 22,330 vehicles per day. It was assumed that the traffic stream consists of 90% personal vehicles, 5% light commercial vehicles, and 5% heavy commercial vehicles. The business case applied a 1.5% annual growth rate to the traffic volumes. Using these assumptions, the following daily vehicle kilometres were used as input into the Urban Transportation Emissions Calculator:

	2006	2011	2016	2021	2026	2031
Personal Vehicles	26,528	28,631	30,888	33,264	35,878	38,610
Light Trucks	1,474	1,591	1,716	1,848	1,993	2,145
Heavy Trucks	1,474	1,591	1,716	1,848	1,993	2,145

The business case included the following assumptions with respect to operations on the existing 2 lane bridge:

Time Period	Average Speed	Percent of Daily Traffic
Peak	20	20%
Shoulder	60	45%
Low	70	35%

In addition, it was assumed that during one year (2016 for this analysis), there would be an incremental detour of 1.8 km during bridge rehabilitation. The distribution of travel speeds was assumed to be the same as for the base case.

The default values for British Columbia were used for the breakdown of Light-Duty Passenger Vehicles (LDPV) and for vehicle fueling characteristics. No public transit vehicles were considered in this analysis. The calculator was applied for each of the 6 horizon years listed in the table above for both the base and detour scenarios.

Based on these assumptions, the combined annual vehicle emissions output by the emissions Calculator were as follows:

Pollutant	2006	2011	2016	2021	2026	2031
Direct GHG	3,551	3,770	8,144	4,349	4,660	4,979
Indirect GHG	1,039	1,121	2,425	1,296	1,391	1,487
CO	123.05	101.78	175.79	83.75	87.46	89.81
NOx	9.79	6.77	8.24	2.74	2.31	2.13
VOC	7.34	5.26	7.40	3.13	3.06	2.95
S02	0.09	0.05	0.11	0.06	0.07	0.07
TPM	0.27	0.23	0.45	0.23	0.24	0.25
PM10	0.27	0.23	0.44	0.22	0.24	0.25
PM2.5	0.16	0.12	0.22	0.11	0.11	0.11

Units are annual tonnes of CO2 equivalent for green house gases (GHG) and annual tonnes for all other pollutants.

Twinned Bridge

Traffic volumes were assumed to be the same for the Twinned Bridge option, including the daily vehicle kilometres.

The business case included the following assumptions with respect to operations for the Twinned Bridge option:

Time Period	Average Speed	Percent of Daily Traffic
Peak	70	20%
Shoulder	70	45%
Low	75	35%

The improvement in average speed during the peak period would result in a decrease in GHG emissions. Given that the new bridge could be used during the rehabilitation of the existing bridge, there were no detour impacts associated with this option. Based on these assumptions, the annual emissions for this option were as follows:

Pollutant	2006	2011	2016	2021	2026	2031
Direct GHG	3,286	3,491	3,755	4,027	4,315	4,610
Indirect GHG	962	1,038	1,118	1,200	1,288	1,377
CO	123.05	101.78	87.51	83.75	87.46	89.81
NOx	9.79	6.77	4.10	2.74	2.31	2.13
VOC	7.34	5.26	3.69	3.13	3.06	2.95
S02	0.09	0.05	0.06	0.06	0.07	0.07
TPM	0.27	0.23	0.22	0.23	0.24	0.25
PM10	0.27	0.23	0.22	0.22	0.24	0.25
PM2.5	0.16	0.12	0.11	0.11	0.11	0.11

Vehicle Emission Impacts

The estimated net vehicle emission impacts of the Twinned Bridge option versus the base case are summarized in the following table:

Pollutant	2006	2011	2016	2021	2026	2031
Direct GHG (kt)	-265	-279	-4389	-322	-345	-369
Indirect GHG (kt)	-77	-83	-1307	-96	-103	-110
Total GHG (kt)	-342	-362	-5696	-418	-448	-479
CO (t)	0.00	0.00	-88.28	0.00	0.00	0.00
NOx (t)	0.00	0.00	-4.14	0.00	0.00	0.00
VOC (t)	0.00	0.00	-3.72	0.00	0.00	0.00
S02 (t)	0.00	0.00	-0.06	0.00	0.00	0.00
TPM (t)	0.00	0.00	-0.22	0.00	0.00	0.00
PM10 (t)	0.00	0.00	-0.22	0.00	0.00	0.00
PM2.5 (t)	0.00	0.00	-0.11	0.00	0.00	0.00

These decreases in green house gas emissions are a function of the increase speeds during the peak periods and the elimination of the detour in 2016. There are no changes to the emission of other pollutants in other years since the Emissions Calculator relates these emissions directly to vehicle kilometres with no adjustments for operating speeds.

If these values are interpolated for each intermediate year (accounting for the one-time benefits in year 2016) and summed over the 25 years from 2007 to 2031 inclusive, the total net impact on emissions over the 25 year evaluation period are as follows:

Pollutant	2007 - 2031
Direct GHG (kt)	-12.0
Indirect GHG (kt)	-3.5
Total GHG (kt)	-15.5
CO (t)	-88.28
NOx (t)	-4.14
VOC (t)	-3.72
S02 (t)	-0.06
TPM (t)	-0.22
PM10 (t)	-0.22
PM2.5 (t)	-0.11

The direct GHG impact is equivalent to removing about 100 passenger cars annually to the road network.

The interpolated annual values can also be monetized using the per tonne values suggested in section 5 and then discounted to current dollars based on the discount rate used for the benefit cost analysis of the project (in this case 10%). Based on these assumptions, the monetized value of the reduced emissions associated with the Twinned Bridge option are about $0.2 million for GHGs and $0.10 million for CACs with a combined value of about $0.3 million (2007$). The combined value is about 6% of the vehicle operating cost savings of the Twinned Bridge option.

APPENDIX B

Business Case: Highway 97: Winfield to Oyama

A Report Prepared for

BC Ministry of Transportation

BRITISH COLUMBIA
The Best Place on Earth

Highway 97 Winfield to Oyama

BUSINESS CASE

This report is prepared for the sole use of Ministry of Transportation. No representations of any kind are made by Urban Systems Ltd. or its employees to any party with whom Urban Systems Ltd. does not have a contract.

1961.0220.06 / June 2007

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EXECUTIVE SUMMARY

Highway 97 is the primary and only continuous north-south corridor in the Okanagan Valley. Connecting the US border to the Trans-Canada Highway, it is a vital transportation corridor for both regional and provincial trade, and provides connectivity between several key communities, notably Kelowna and Vernon. Since 2004, this segment of Highway 97 has been included as part of the National Highway System (NHS). The section of Highway 97 of interest is located within the District of Lake Country and extends from Winfield in the south to Oyama in the north.

This segment is an important year round commercial truck route, in addition to accommodating heavy seasonal tourist traffic, and daily commuter traffic between Kelowna and Vernon. To the north and south of this segment, Highway 97 is a four-lane cross section with limited access control through to both Kelowna and Vernon. This approximately 8 km segment of Highway 97 reduces to a two-lane cross section with numerous direct private driveway and lake accesses onto the highway. Running along the western shoreline of Wood Lake, the existing highway is challenged by steep terrain and significant rock cuts to the west and the lake itself to the east.

With increasing levels of highway activity mobility, safety and reliability issues along this segment of Highway 97 have become apparent. Given the importance of Highway 97 to the region and the Province, the upgrading of the segment from its current configuration to a modern, safer and more appropriate four lane standard has been proposed.

The purpose of this study is to revisit the recommendations of past work and update the economic analysis of the proposed improvements. New construction cost estimates and property cost assessments have also been included. The study will seek to establish the business case justification for improvements to the Highway 97 corridor between Winfield and Oyama, determine key issues/constraints, and recommend the necessary next steps/strategy required to move toward implementation.

Based upon an evaluation of the existing highway corridor the following performance deficiencies can be confirmed:

- Mobility performance has reached the limit of acceptable performance.
- Collision rates indicate a safety problem primarily due to tight horizontal geometry and numerous uncontrolled accesses.
- The reliability of this section of Highway 97 is considered poor due to frequent collision and rock slide events.

With increasing traffic volumes each of these performance indicators can be expected to degrade without improvements to the highway corridor. The physical geometry of the existing two-lane corridor between Winfield and Oyama does not meet current Transportation Association of Canada (TAC) highway design guidelines. In particular, horizontal geometry, lane width, shoulder width, and clear zone provisions through the two-lane section do not adequately serve the traffic volumes and contribute to the safety problem. In addition, due to the significance of the Highway to regional mobility and its location between higher order four-lane facilities, there is an expectation for a continuous highway that is safe, efficient, and reliable. The existing two-lane segment is inconsistent with the remainder of the highway corridor, and does not meet these expectations.

The 'Short Highline' improvement option considered, was based on the functional design option developed in the 2001 *Highway 97 Winfield to Oyama Improvement Options*. This option considers the use of a new high route to the west and above the existing alignment. This option eliminates impacts to the foreshore of Wood Lake, but results in increased property and agricultural impacts. In addition, due to the topography to the west of the highway, grades up to 6% would be required. Key aspects of this option are as follows:

- Re-alignment of Highway 97 away from existing alignment at Oceola Road
- Controlled Access throughout
- Maintains the existing alignment along Wood Lake for local access
- Re-connects with existing Highway 97 south of Oyama Road
- At-grade connections with existing alignment

A Multiple Account Evaluation summary is provided in **Table ES-1**. This includes both quantitative measures used for the benefit-cost evaluation of the project and qualitative measures of potential impact. Key economic indicators such as, Net Present Value (NPV) and Benefit-Cost Ratio (B/C) are included for a 25 year period and reflect the base assumptions for traffic growth (3.0%), discount rate (10% and 6%), and cost estimate (100%). A sensitivity analysis of these key assumptions is provided in Section 6.0.

The 'Short Highline' was found to provide significant benefits to the mobility and safety of highway users. In addition, this new four lane corridor can be expected to significantly improve reliability of this key corridor and is more consistent with the expected performance at this section of Highway 97. Other benefits of the 'Short Highline' include the reduced risk of adverse impacts to Wood Lake, redevelopment opportunities along Wood Lake, and the overall positive economic impact of an enhanced highway corridor.

Depending on the base assumptions used for the benefit-cost calculation, the key economic indicators were found to be both above and below a resulting net positive economic outcome. In particular, the discount rate specified for federal business case submissions (10%) resulted in a negative net present value of -$14.8 Million. On the other hand, using a discount rate assumption of 6%, as is preferred by the British Columbia Ministry of Transportation, resulted in a positive net present value of $3.2 Million. Keeping in mind that the justification of any particular project should not be based solely on the benefit-cost evaluation, this project can be considered a viable solution to an on-going highway performance problem. This document has detailed that an existing mobility, safety and reliability problem exists on this segment of Highway 97 and that these problems will persist with continued traffic growth. Alternate options for improvements to this segment of Highway 97, including the 'Long Highline' and online 'Lakeshore' widening found to be undesirable based upon previous conclusions, as described in Section 3.0. At this time, the 'Short Highline' represents the best solution available and warrants further planning and engineering work.

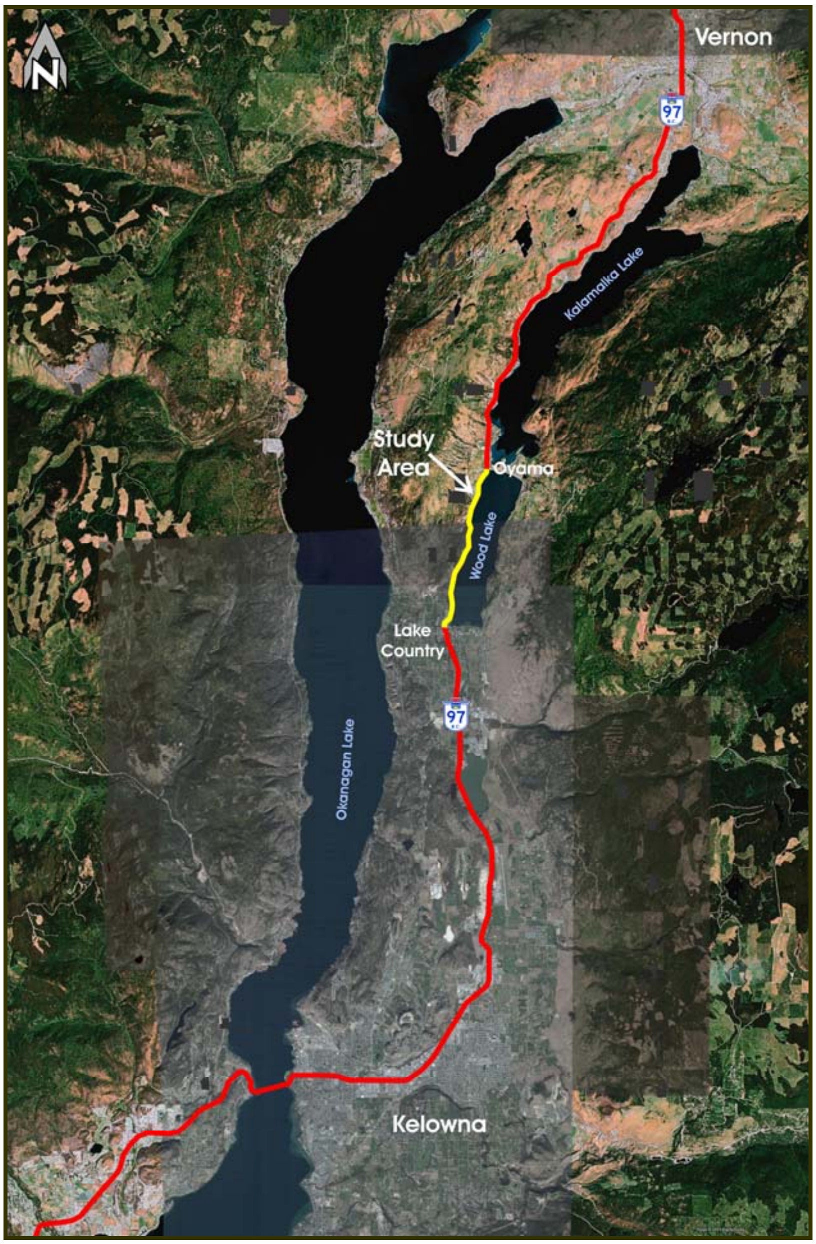
Table ES-1: Summary Multiple Account Evaluation

Account	Discount Rate	
	10%	6%
Financial		
Discounted Project Cost	$50.5M	$57.3M
Maintenance	$0.9M	$1.3M
Salvage Value	($3.6M)	($10.7M)
Total	**$47.8M**	**$47.9M**
Customer Service		
Travel Time	$25.8M	$40.6M
Vehicle Operating Costs	($10.9M)	($15.6M)
Safety	$18.1M	$26.1M
Total	**$33.0M**	**$51.1M**
Social / Community		
Noise, Visual, Pollution Impacts	Negative	
Community Displacement	Negative	
Community Severance	Neutral	
Consistency with Community Plans	Positive	
Environmental		
Fuel Consumption Savings (Mill. Gal.)	(56.75)	
Carbon Monoxide Reduction (Mill. Kg.)	(0.989)	
Wood Lake Impacts	Positive	
Habitat, Wetlands, ALR Lands Impacts	Negative	
Economic Development		
Local / Regional	Positive	
Provincial / National	Positive	
Key Economic Indicators		
Net Present Value (NPV)	($14.8M)	$3.2M
Benefit-Cost Ratio	0.69	1.07

1.0 BACKGROUND

Highway 97 is the primary and only continuous north-south corridor in the Okanagan Valley. Connecting the US border to the Trans-Canada Highway, it is a vital transportation link for both regional and provincial trade, and provides connectivity between several communities, most notably the Cities of Kelowna and Vernon. Since 2004, this segment of Highway 97 has been included as part of the National Highway System (NHS). The section of Highway 97 of interest is illustrated in **Figure 1.1**, located within the District of Lake Country and extending from the communities of Winfield in the south to Oyama in the north.

Figure 1.1: Study Area



This segment of Highway 97 is an important year round commercial truck route, in addition to accommodating heavy seasonal tourist traffic and daily commuter traffic between Kelowna and Vernon. To the north and south of this segment, Highway 97 is a four-lane cross section with limited access control through to both Kelowna and Vernon. This segment (~8km) reduces to a two-lane rural cross section with numerous direct private driveway and lake accesses onto the highway. Running along the western shoreline of Wood Lake, the existing alignment is challenged by steep terrain and significant rock cuts to the west and the lake itself to the east. While the vertical profile is generally flat, the existing horizontal alignment includes reduced speed curves, limited shoulder and clear zone provisions, and limited passing opportunities throughout. **Figure 1.2** illustrates the significant rock cuts and the proximity to Wood Lake that are typical for this segment of Highway 97.

Figure 1.2: Highway 97 between Winfield and Oyama

The segment is bound on both ends by signalized at-grade intersections at Oceola Road and Oyama Road to the south and north respectively. Falling within the District of Lake Country the highway segment has limited adjacent residential development, some agricultural activity (including ALR lands), and numerous recreational lake access points. With increasing levels of highway activity both mobility and safety issues along this segment of Highway 97 have become apparent. Given the importance of Highway 97 to the region and the Province, the upgrading of the segment from its current configuration to a modern, safer and more appropriate four lane standard has been proposed.

The purpose of this study is to revisit the recommendations of past work and update the economic analysis of the proposed improvements. New construction cost estimates and property cost assessments have also been included in the evaluation. The study will seek to establish the business case justification for improvements to the Highway 97 corridor between Winfield and Oyama, determine key issues/constraints, and recommend the necessary next steps/strategy required to move toward implementation.

2.0 PROBLEM DEFINITION

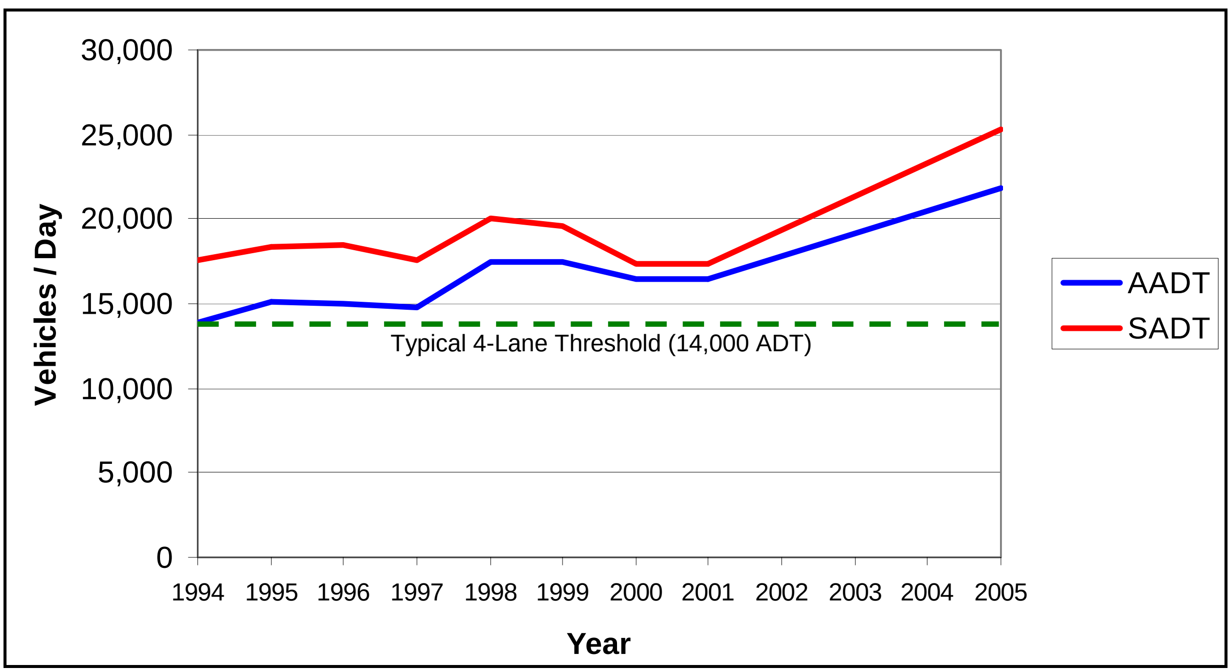
The segment of Highway 97 between Oceola Road and Oyama Road is a two-lane rural undivided highway with a posted speed limit of 80 km/h. While vertical alignment is generally flat, the horizontal alignment includes several reduced speed curves with limited passing opportunities. Running along the foreshore of Wood Lake and constrained by steep banks and high rock cuts on the west side, minimal shoulder and clear zone width is provided in several locations. Numerous uncontrolled accesses are also present and several informal recreational boat launching and parking areas directly adjacent to the highway are heavily used in the summer months. As the only segment of Highway 97 between Kelowna and Vernon which reduces to two lanes, this section of highway stands out as a constraint to north-south mobility and a design inconsistency. In addition, due to increasing traffic volumes, safety concerns on this segment of Highway 97 continue to present themselves and improvements to this area have long been considered necessary.

In order to understand the existing conditions and the existing highway performance deficiencies, the performance of the highway as it relates to mobility, safety, and reliability was analyzed and summarized.

2.1 Mobility

Historic traffic count data was taken from the Ministry of Transportation's traffic count station (24-010N and 24-010S) located approximately 0.3 km south of Oyama Road on Highway 97. A summary of Average Annual Daily Traffic (AADT) and Summer Average Daily Traffic is shown in **Figure 2.1**.

Figure 2.1: Historic Daily Traffic Volumes (Hwy 97 South of Oyama Rd)



Using Highway Capacity Manual methodology for the analysis of two-lane rural highways, the existing mobility performance of Highway 97 between Winfield and Oyama was determined. Taking into account peak hour traffic volumes, cross-sectional geometry, passing opportunities, and access density the performance of this segment of Highway 97 was found to be **Level of Service = E** with a **Volume to Capacity Ratio = 0.80**. In this case, mobility can be considered to have reached the limit of acceptable performance during peak hours. The performance of the highway can be expected to degrade as traffic volumes increase, resulting in reduced travel speed, limited gaps for turning movements, and limited passing opportunities.

2.2 Safety

The safety performance of Highway 97 between Oceola Road and Oyama Road was analyzed based on historic collision data provided by the Ministry of Transportation. Collision data was extracted from the Highway Accident System (HAS) database for the 2001 to 2005 period. Using this data, typical safety performance indicators, including collision rate and severity index, were determined, in addition to an investigation of primary causal factors and occurrences for the highway segment. The historic collision data for Highway 97 (Segment 1119 LKI 19.1 to 26.73) is summarized in **Table 2.1**.

Table 2.1: Historic Collision Frequency and Severity (2001-2005)

Year	Fatal	Injury	Property Damage	Total
2001	2	12	17	**31**
2002	1	15	12	**28**
2003	0	12	16	**28**
2004	0	12	17	**29**
2005	1	11	20	**32**
Total	**4** (2.7%)	**62** (41.9%)	**82** (55.4%)	**148**

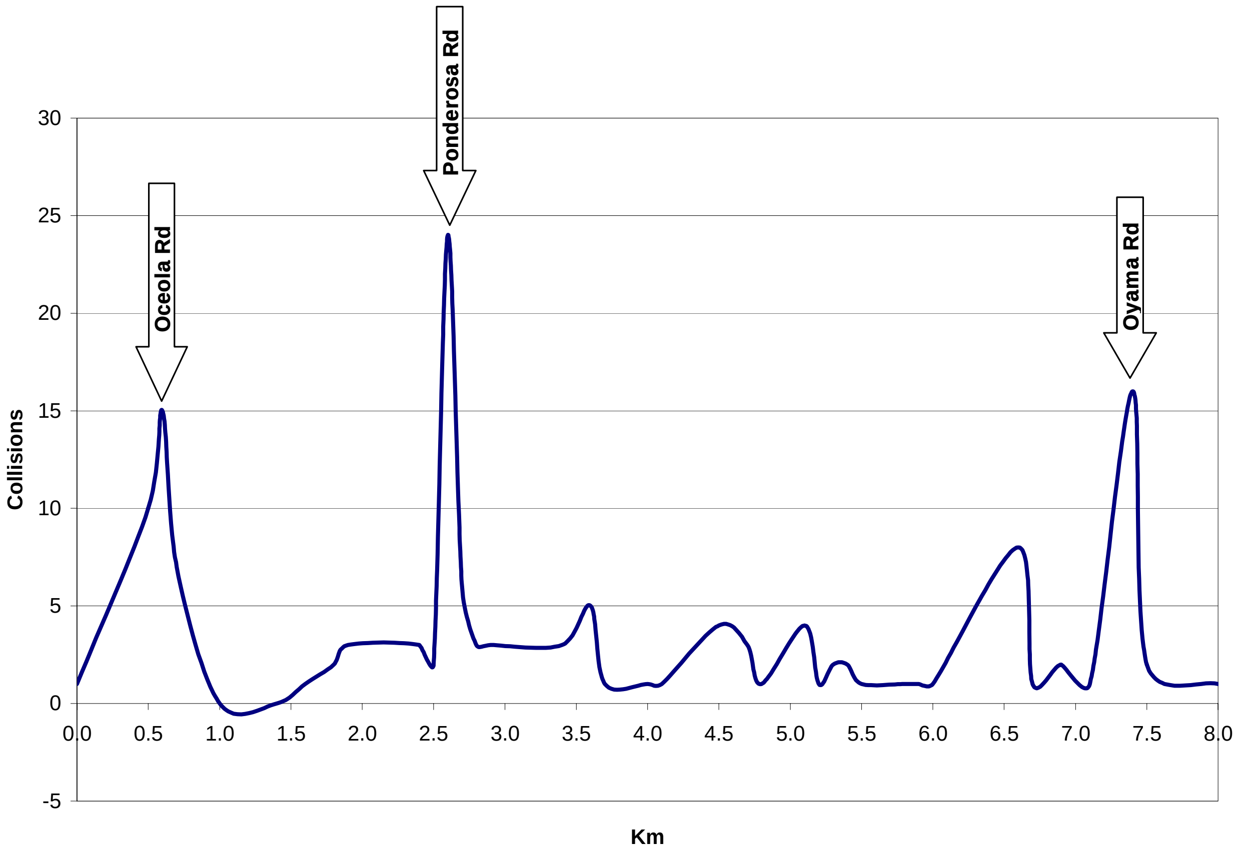
Based on this data typical safety performance indicators were calculated and compared to provincial benchmarks for similar facilities. In this case, the similar highway facility as defined by the Ministry of Transportation's classification is 'Rural Arterial Undivided 2 Lanes' or (RAU2) and is further refined by its average daily traffic volume. A summary of the key safety performance indicators and corresponding provincial benchmarks is detailed in **Table 2.2**.

Table 2.2: Safety Performance Indicators (2001-2005)

Performance Indicator	Highway 97 - Segment 1119 (LKI 19.1 to 26.73)	Provincial Average (RAU2) – 15,001 - 20,000 vpd
Collision Rate (A/MVK)	0.56	0.44
Critical Collision Rate (A/MVK)	0.64	n/a
Severity Index	7.45	7.89

The collision rate for this segment was determined to be higher than both the provincial average rate for similar facilities and the critical collision rate. The collision severity index was found to be somewhat lower than that of similar facilities. While not appearing in the HAS database, it should be noted that at least three additional fatal collisions are known to have occurred in this section of Highway 97 in 2006, suggesting an increase in collision severity and frequency. The spatial distribution of collisions between 2001 and 2005 is illustrated in **Figure 2.2**.

Figure 2.2: Spatial Distribution of Historic Collisions (2001 – 2005)



Identifiable 'spikes' in collisions along the corridor can be seen at the signalized intersection at Oceola Road (immediately prior to the reduction from four to two lanes), Oyama Road, and at the unsignalized intersection at Ponderosa Road. A summary of the primary occurrence and primary contributing factors for the segment is illustrated in **Figures 2.3 and 2.4**.

Figure 2.3: Primary Occurrence Categories of Historic Accidents (2001 – 2005)

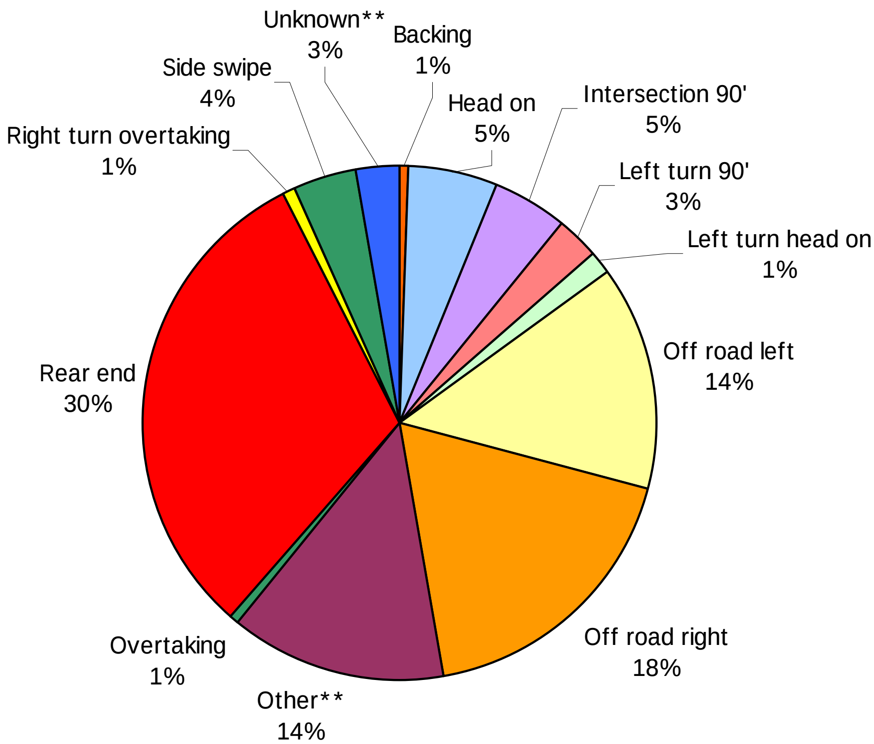
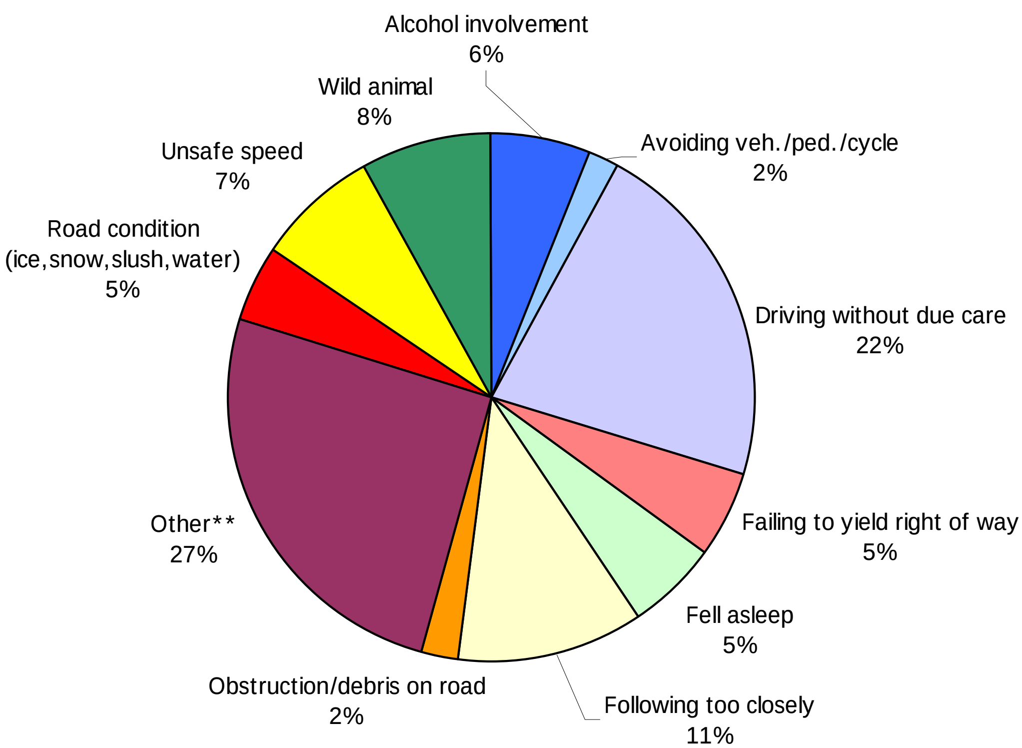


Figure 2.4: Primary Contributing Factors of Historic Accidents (2001 – 2005)



Rear end, off-road right, and off-road left occurrences were found to be the most predominant. Rear end collisions in this situation are likely a result of the numerous uncontrolled accesses along this segment of highway, where auxiliary turn lanes are not provided and visibility can be limited. Off-road right and left occurrences in this situation can be attributed to the severity of horizontal curvature and limited lane/shoulder/clear zone width through the two-lane segment. These are often compounded by poor road conditions, excessive speed, and 'driving without due care' as shown by the summary of contributing factors in **Figure 2.4.** With increasing traffic volumes and corridor congestion, the frequency and severity of collision can be expected to continue to increase due to reduced headways and increased driver frustration.

Due to the relatively high volume of traffic on this two-lane undivided section of Highway 97, the importance of this route to north-south travel in the Okanagan Valley, and the significant commercial truck traffic along this route, the frequency and severity of safety issues in this area are perceived to be quite high. Given that the section of Highway 97 between Winfield and Oyama is located between higher order four-lane facilities to the north and to the south, the expectation for safety performance is likely higher than would be the case in a more remote location. A summary of recent major collision events, including photos provided by MoT staff, is provided in **Appendix A**.

2.3 Reliability

The significance of Highway 97 to north-south mobility between Kelowna and Vernon means that any closure of the highway results in significant delays to traffic and a high level of public inconvenience and frustration. As is summarized in **Appendix A**, collision events along the segment of Highway 97 between Winfield and Oyama often result in lengthy closures of the Highway. Requirements to accommodate emergency services, clean-up, and accident investigation can take up to 12 hours (in particular when heavy vehicles are involved). Based on informal records provided by the Ministry of Transportation, this segment of Highway 97 was closed due to collisions for a total of:

- 18 hours in 2005
- 27 Hours in 2006

In 2007, a closure of 12 Hours has already occurred due to a single event on January 25, 2007 (a newspaper article of this event is included in **Appendix A**). Assuming an average of four 6-hour closures per year, the total cost of highway closures with respect to travel time delays is estimated to be approximately $1.1 Million per year or $11.4 Million discounted over 25 years.

In addition to closures due to collisions, rock slides are also a concern for this segment of Highway 97. Due to the proximity of the rock cuts to the highway, slides can block travel lanes and represent an additional hazard, as is illustrated in **Figure 2.5**. The Ministry of Transportation Rockwork Engineering Section has ranked over 22,000 rock slopes adjacent to provincial highways. Of these, 1,162 are considered 'A' rated or 'High Risk' rock slopes, and there are 6 'A' rated rock slopes within this study area (the two worst being ranked 33rd and 57th overall). According to the Ministry of Transportation, an average year will include single lane closures lasting about 10 hours approximately twice a year, while a full closure of about 6 hours can be expected every second year. Geotechnical stabilization requirements phased over 5-10 years are estimated to cost approximately $2.0 Million (2006±).

Figure 2.5: Partial Road Closure Due to Rock Slide

Options to detour traffic around closures on this section of Highway 97 are limited. In some cases, highway traffic can be diverted via Woodsdale Road and Oyama Road on the east side of Wood Lake. This route offers significantly less capacity than the highway and is not considered suitable for high traffic volumes and heavy trucks, as is shown in **Figure 2.6**.

Figure 2.6: Diverted Traffic on Oyama Road

Due to the importance of this corridor to north-south travel between Kelowna and Vernon and in the rapidly growing Okanagan Valley in general, the expectation for reliability of this corridor is higher than on other routes. Given the length of individual closures, the relatively high traffic volumes affected, and the increasing frequency of events, the reliability of Highway 97 between Winfield and Oyama is considered 'Poor'.

2.4 Problem Definition Summary

Based upon an evaluation of the existing highway corridor the following performance deficiencies can be confirmed:

- Mobility performance has reached the limit of acceptable performance for the Highway 97 corridor.
- Collision rates indicate a safety problem primarily due to tight horizontal geometry and numerous uncontrolled accesses.
- The reliability of this section of Highway 97 is considered poor due to frequent collisions, unsuitable detour routes and rock slide events.

With increasing traffic volumes each of these performance indicators can be expected to degrade without improvements to the highway corridor. The physical geometry of the existing two-lane corridor between Winfield and Oyama does not meet current Transportation Association of Canada (TAC) highway design guidelines. In particular, horizontal geometry, lane width, shoulder width, and clear zone provisions through the two-lane section do not adequately serve the traffic volumes and likely contribute to the safety problem. In addition, due to the significance of the Highway to regional mobility and its location between higher order four-lane facilities, there is an expectation for a continuous highway that is safe, efficient, and reliable. The existing two-lane segment is inconsistent with the remainder of the highway corridor, and does not meet these expectations.

3.0 OPTIONS GENERATION

In 1991, the Ministry of Transportation developed a four-lane design concept along the existing alignment. This option was found to have significant impacts to the foreshore of Wood Lake with reduced access. These impacts would trigger the British Columbia Environmental Assessment Act (BCEAA) and the Canadian Environmental Assessment Act (CEAA) processes with significant impacts to both project schedule and costs. The District of Lake Country requested, in 1995, that MoT consider other 'off-line' four-lane alignments which would reduce the impact to Wood Lake and would retain the existing alignment for local access to the Lake. In response to continuing interest in the segment of Highway 97, the Ministry of Transportation completed the *Highway 97 Winfield to Oyama Improvement Options*. This study developed functional design options for this segment of Highway 97 and evaluated selected options in order to determine a preferred alternative. Using a four-lane, 100km/hr design criteria the following options were developed and evaluated:

Table 3.1: Four-Laning Options

Option	Length	Description
Four-Lane 'Lakeshore'	7.2 km	A variation on the 1991 design with updated design standards and reduced impact to the foreshore of Wood Lake.
'Short Highline'	7.8 km	Departing the existing Highway 97 alignment at Oceola Road to the south, this alignment climbs above the lakeshore reconnecting south of Oyama Road.
'Long Highline'	8.9 km	Similar to the 'Short Highline' option, however reconnecting to the existing alignment north of Oyama Road (at Evans Road).

Based on the results of a multiple account evaluation, the *Highway 97 Winfield to Oyama Improvement Options* concluded that the Four-Lane 'Lakeshore' option was not recommended due to the significant environmental, recreational access, constructability, traffic management, and community impacts. Both the 'Short' and 'Long Highline' options were advanced to a design refinement stage where the 'Long Highline' option was selected as the preferred option given that it resulted in the strongest Benefit-Cost Ratio and Net Present Value. However this option had a significantly higher initial cost as well. The 'Short Highline' option was not able to meet the 100 km/hr design criteria since the at-grade signalized intersection at Oyama Road was maintained (an interchange configuration was not considered feasible at that time).

Since 2001, the four laning of Highway 97 between Winfield and Oyama has remained as a recommended improvement; however, the economic conditions required to justify such a project had not materialized. In 2002, the Ministry of Transportation commissioned the *Value Analysis Report for Project No. 21347 Highway 97 – Winfield to Oyama* to conduct an independent review of the identified alternatives. This study sought to *"…recommend the best possible alignment that meets the established design criteria, while optimizing capital and life cycle costs."* The results of the study indicated that:

- *"The Team felt that …the Short Highline Route, while not completely meeting the 100kph design speed criteria (the posted speed will be reduced to 90kph primarily due to the intersection at Oyama Road being retained) could be modified to offer the best value for money."*

In 2004, the *Okanagan Valley Transportation Corridor – An Assessment of Select Projects and Initiatives Study (USL)* and the *Okanagan Highway 97 Investment Strategy (USL)* both recommended the advancement of a 'Highline' Option. While mobility and safety concerns have continued to be present with increasing traffic levels the advancement of this project has been stalled due to uncertainty regarding construction and property costs, in addition to the scope of environmental and community impacts.

The 'Long' Highline Option was selected based on the fact that it met all the established design criteria and resulted in the highest economic indicators, including benefit-cost ratio. However, with an estimated construction cost nearly 45% higher than the 'Short Highline' Option it also required a significantly greater initial investment. As stated in the VA report, while the 'Long' Highline option was initially recommended, the 'Short Highline' could be modified to offer similar benefits to both mobility and safety at a reduced capital cost. Based on the recommendations of these recent reports and studies, the 'Short Highline' Option has been revisited and re-evaluated based on updated cost estimates and a new benefit-cost analysis, and is the recommended project scope moving forward.

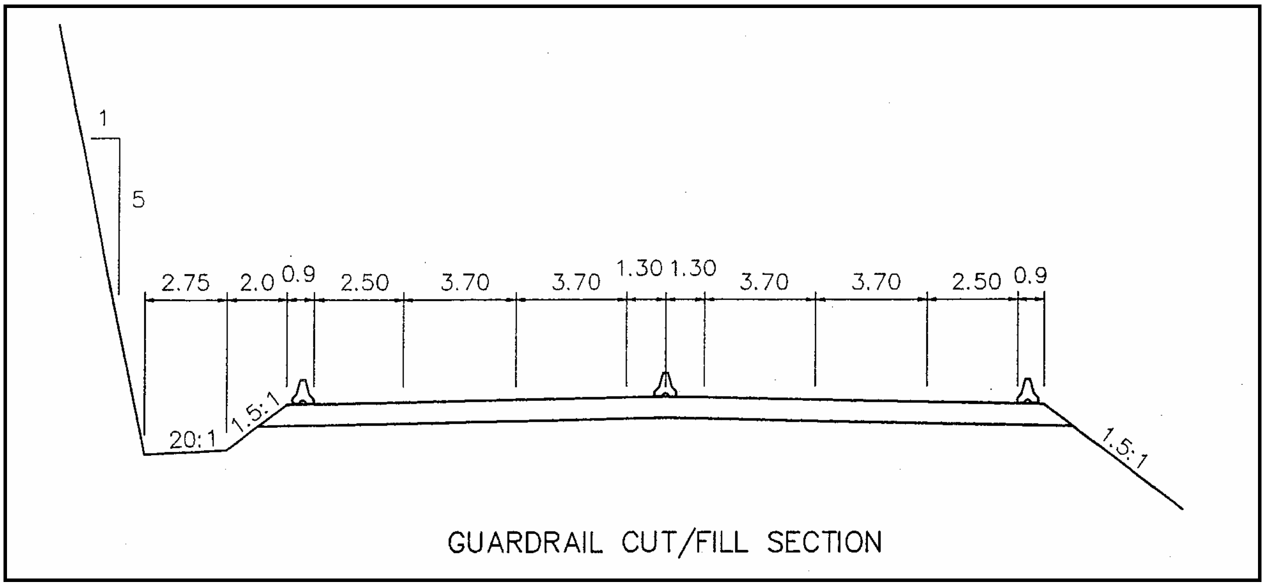
4.0 PROJECT DESCRIPTION

The 'Short Highline' improvement option considered was based on the functional design option developed in the 2001 *Highway 97 Winfield to Oyama Improvement Options*. The design criteria established at that time was as follows:

- Four-Lane Rural Divided Expressway Standard
- Design Speed of 100km/hr
- 6% Maximum Gradient
- Level of Service 'C'

A typical cross section for the Four-Lane Rural Divided Expressway standard is represented in **Figure 4.1**.

Figure 4.1: Typical Section for 4-Lane Rural Divided Expressway



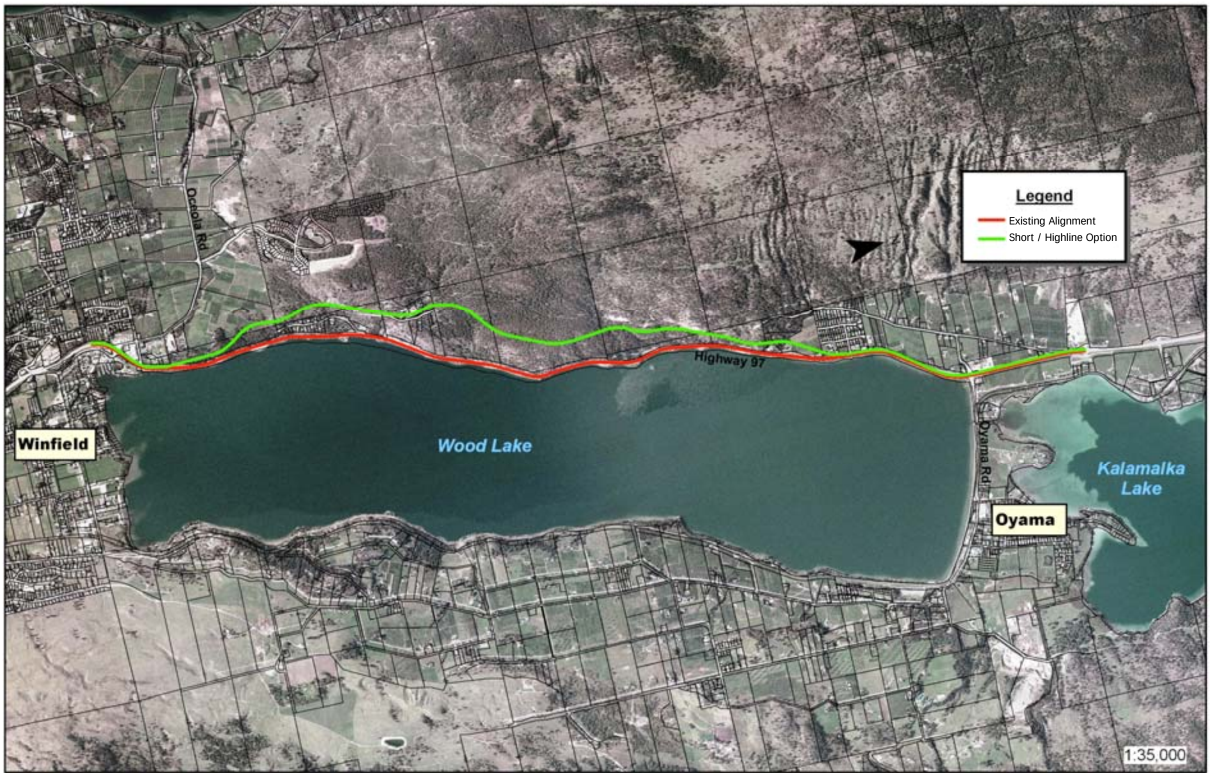
Reid Crowther (2001)

This option considers the use of a new high route to the west and above the existing alignment. This option eliminates impacts to the foreshore of Wood Lake, but results in increased property and agricultural impacts. In addition, due to the topography to the west of the highway, grades up to 6% would be required. Key aspects of this option are as follows:

- Re-alignment of Highway 97 away from existing alignment at Oceola Road
- Controlled access throughout
- Maintains the existing alignment along Wood Lake for local access
- Re-connects with existing Highway 97 south of Oyama Road
- At-grade connections with existing alignment
- Approximate length of 7.8km

The general alignment of the 'Short Highline' option is depicted in **Figure 4.2**.

Figure 4.2: Scope of Proposed Improvement Options



Based on the results of the *Value Analysis Report for Project No. 21347 Highway 97 – Winfield to Oyama*, potential modifications to the original 'Short Highline' option were considered. It was recognized that the primary value of the 'Long Highline' was that it avoided the impact of the signal at Oyama Road and therefore permitted a higher travel speed. Alternative options for eliminating the signal at Oyama Road were investigated and recommendations were as follows:

- Replace signalized intersection at Oyama Road with a 'Protected T' configuration for the east side of Highway 97 and Right In / Right Out for the west side
- A Pedestrian overpass would be provided in place of signalized cross-walks at Oyama Road

These recommendations were included in the Multiple Account Evaluation of the 'Short Highline' option. The slightly modified alignment and a 'Protected T' configuration at Oceola Road recommended in the *Value Analysis Report (2002)* was not included, since detailed engineering and cost estimates were not available at this time. Further planning and engineering work should be conducted if these modifications are to be considered.

5.0 MULTIPLE ACCOUNT EVALUATION (MAE)

In order to prioritize competing projects and to assist in the evaluation of proposed improvement options, a multiple account evaluation (MAE) framework was developed for this project. Both the Ministry of Transportation and Transport Canada use a similar MAE methodology which is intended to capture both the quantifiable measures of cost and benefits, in addition to more qualitative measures. For this assignment the following accounts were considered:

- **Financial**
  - Project Costs (construction, engineering, property)
  - Maintenance (annual and periodic rehabilitation)
  - Salvage Value
- **Customer Service**
  - Mobility (travel time and vehicle operating cost savings)
  - Safety (collision reductions)
- **Social / Community**
- **Environmental**
- **Economic**

5.1 Financial

The financial account of a project represents the discounted life-cycle cost, typically over 25 years. These include the initial investment (construction, property acquisition, engineering, and project management), annual maintenance and rehabilitations costs, and finally the salvage value at the end of the projects life cycle. In order to represent common dollars the Present-Value method is typically used to discount future costs. A discount rate of 10% was assumed for this evaluation, as is consistent the Federal Business Case guidelines. Alternate discount rates (including 6% discount, typical for BC Ministry of Transportation benefit-cost evaluations) will be considered with sensitivity analysis of the key economic indicators.

The estimated construction cost for the 'Short Highline' option was developed by Wolski Consulting Inc., under the direction of the Ministry of Transportation. Property cost estimates for this option were also determined separately. Both construction costs and property impacts were based on a 4-Lane Rural Divided Expressway cross-section and on the design shown in the *Highway 97 Winfield to Oyama Improvement Options Report*. The Total Escalated Costs reflecting the distribution of project costs over the construction period were provided by the Ministry of Transportation and used in the calculation of Discounted Project Costs; these are summarized in **Appendix B**. A summary of the Present Value 2007 estimated costs and discounted costs for the 'Short Highline' option is provided in **Table 5.1**.

Table 5.1: Cost Estimate Summary

Activity	Cost Estimate
Project Management	$422,847
Planning	$72,589
Engineering	$4,395,093
Environment	$235,500
Property Acquisition	$6,300,000
Construction	$38,575,000
Contingency	$13,020,000
TOTAL (2007)	**$63,021,029**
Discounted Project Costs (10%)	**$50,500,000**

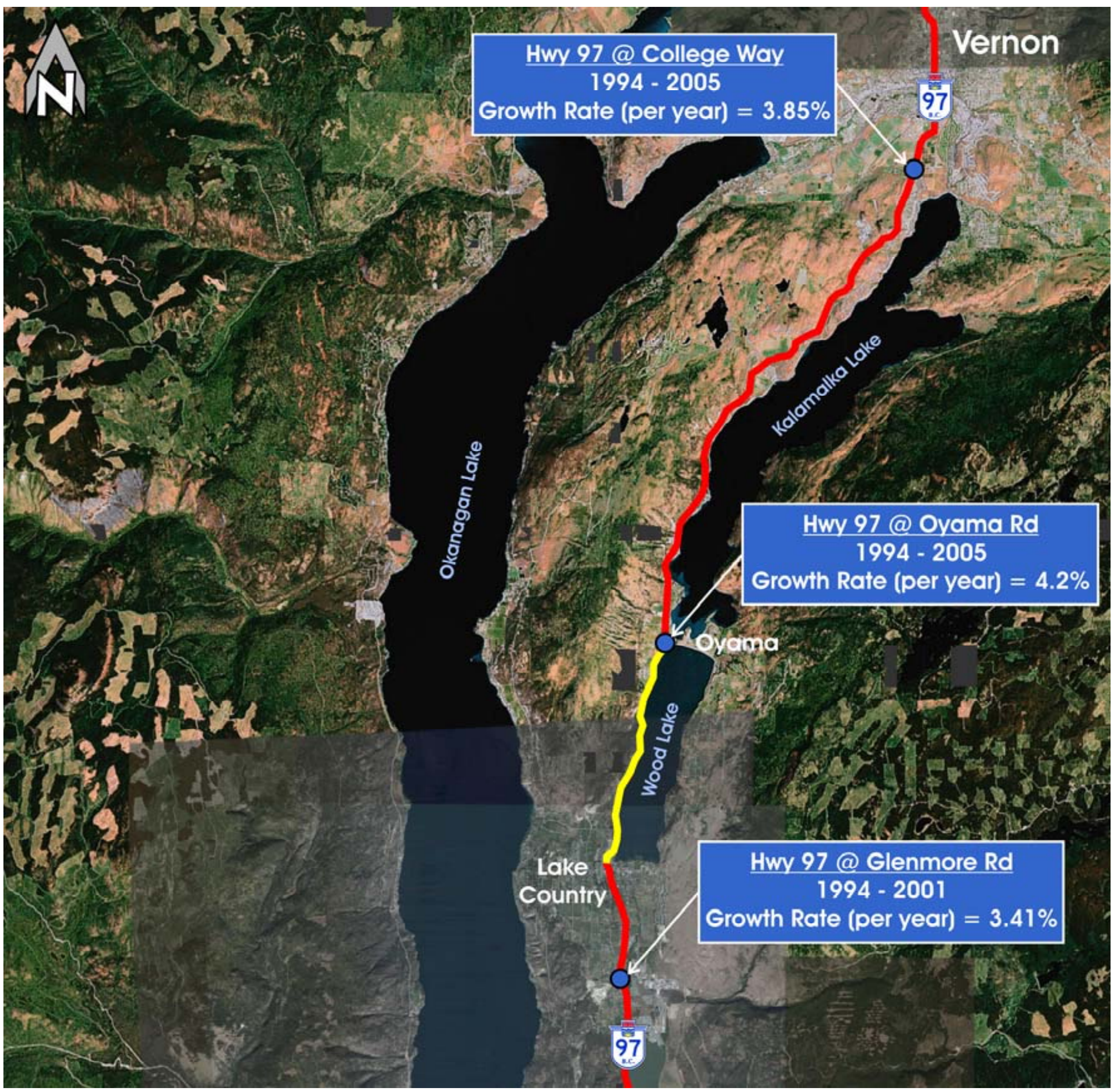
Annual maintenance costs are represented by default values described in the *Ministry of Transportation MicroBENCOST Guidebook (2005)*. Given that the 'Short Highline' option would represent a new corridor and that the existing Highway 97 alignment along Wood Lake would be maintained for local use, additional maintenance costs (net increase) would be required. The default value for annual maintenance of new roads is approximately $4,110 per lane kilometre according to the 2004-2005 Ministry of Transportation Service Plan Update. Periodic maintenance costs including cold mill ($25,000 per lane kilometre every 7 years) and hot mix ($50,000 per lane kilometre every 15 years) resurfacing have also been included throughout the life span of the roadway. Although the existing Highway 97 alignment would be devolved from the Ministry of Transportation road network to local jurisdictions, the cost of maintaining the existing roadway is not typically removed from the benefit-cost calculation. The cost of maintenance will be paid at some level, and therefore remains a cost to society. On the other hand, the cost of annual rockwork conducted by the Ministry of Transportation along the existing alignment (approx. $2.0 Million over 5-10 years) is assumed to be reduced. With the devolution of the existing alignment to a local jurisdiction, the requirements for extensive rockwork can be expected to be significantly reduced. This reduction in maintenance costs has been included in the calculation of overall maintenance requirements. The increased maintenance requirements for a new alignment minus the reduced rockwork costs results in a net increase of approximately $0.9 Million discounted over 25 years.

5.2 Customer Service

The customer service account represents the cost to highway users over the life cycle of the project. This includes values for travel time, vehicle operating costs, and collisions accrued and discounted over 25 years. Improvements to highways that result in improved mobility, with reduced travel time and reduced vehicle operating costs (in terms of fuel, oil, tires, depreciation, and maintenance), or improved safety, with reduced collision rates or severity, can then be compared to the financial account of the project.

Given that the customer service account reflects the benefits of proposed improvements to highway users over 25 years, this account is particularly sensitive to traffic growth rate assumptions. Based on historic traffic volume growth in this segment of Highway 97 and a review of recent Census data, an annual traffic growth rate of **3.0%** was considered in this analysis. Historic traffic volumes and the resulting annual growth rate for various locations along Highway 97 between Kelowna and Vernon are summarized in **Figure 5.1**. Given that a growth rate of 4.2% (historic growth rate 1994-2005) is greater than would be considered typical in the Okanagan Valley (2.0% to 2.5% per year) and that high traffic growth rates are unlikely to be sustained over long periods of time, a review of recent (2006) Census data and population projections was conducted. According to the *Population Extrapolation for Organizational Planning with Less Error* document, produced by BC Stats (May 2006), population growth in the Central Okanagan has been an average of 3.2% per year over the last 20 years. Population growth is expected to decrease to approximately 1.6% per year over the next 25 years. Taking into account both observed traffic growth on Highway 97 and projected population growth, an annual growth rate of 3.0% was assumed. Both increased (4.0%) and decreased (2.0%) growth rates will be considered during sensitivity analysis.

Figure 5.1: Average Annual Growth Rate



5.2.1 Mobility

Mobility benefits to highway users, in terms of reduced travel time and vehicle operations costs, were calculated using the MicroBENCOST software. The value of travel time, as described in *MoT MicroBENCOST Guidebook (2005)*, is summarized in **Table 5.2**. Values for typical vehicle operating costs are included in the MicroBENCOST calculations.

Table 5.2: Value of Travel Time

Vehicle / Driver Type	Value (per hour)
Automobile	$11.17
Single Unit Truck	$20.90
Combination Truck	$23.41

The proposed 'Short Highline' improvements were compared to existing conditions using MicroBENCOST software. The proposed improvement included modifications recommended by the *Value Analysis Report for Project No. 21347 Highway 97 – Winfield to Oyama*. Mobility benefits to highway users were accrued over a 25 year period and discounted using a 10% discount rate. Travel time savings to highway users for the 'Short Highline' were determined to be approximately **$20.1M** over 25 years. Travel time was found to be reduced due to increased design speeds, continuous passing opportunities, and restricted access. Vehicle operating costs were found to increase ($10.9M over 25 years) due to the new vertical grades and increased overall length of the 'Short Highline' option when compared to the existing alignment. A significant reduction in delay due to highway closures can be expected with the improvement of the corridor and the addition of a parallel route along Wood Lake. Assuming an average of four 6-hour closures per year, a conservative estimate of a 50% reduction in closures would result in a time delay savings of approximately $5.7M discounted over 25 years. The total mobility benefits to highway users (including travel time savings, reduced closures and increased vehicle operating costs) were determined to be $25.8M over 25 years.

5.2.2 Safety

Safety benefits were estimated by comparing the historic collision rates for this rural two-lane undivided highway (RAU2) to the provincial average collision rates for a rural four-lane divided highway (RAD4), as summarized in **Table 5.3**.

Table 5.3: Average Collision Rate by Facility Type

Severity Type	RAU2 (Existing Hwy 97)	RAD4 (Provincial Average)
Fatal	0.015	0.008
Injury	0.235	0.234
Property Damage Only	0.310	0.258

The value of various collisions (by severity), as described in the *Ministry of Transportation MicroBENCOST Guidebook (2005)* is summarized in **Table 5.4**. Total safety benefits were accrued over 25 years and discounted to present dollars.

Table 5.4: Value Collisions to Society

Severity Type	Cost to Society
Fatal	$5.7 Million
Injury	$100,000
Property Damage Only	$7,300

With the addition of two travel lanes in each direction, median separation, access control, shoulder and clear zone width, and improved horizontal curvature significant benefits to highway safety can be expected for the ‘Short Highline’ option. In this case, total safety benefits over 25 years were determined to be **$18.1 Million**.

5.3 Social / Community

The social / community account assesses the potential effect of the highway improvement on community and social values. These are generally qualitative measures, but are considered in combination with the more quantifiable economic indicators when evaluating a proposed project. Factors that are typically considered include:

- Noise, Visual, and Pollution Impacts – exposure and magnitude
- Community Displacement – property takings, partial and full
- Community Severance – the ‘barrier effect’ of the highway on local and pedestrian traffic
- Consistency with Community Plans – degree of support the project provides to local planning goals

When evaluating competing options, these factors are usually considered using a simple qualitative measure of low, moderate, or high impact, with low being the most desirable and high being the least desirable. However, in this case, only the ‘Short Highline’ option is being evaluated and therefore comparative measures such as this are not as useful. For this reason, social / community impacts will be discussed as they relate to the ‘Short Highline’ option and evaluated based on their estimated positive, neutral or negative impact to key stakeholders. These conclusions reflect the evaluation detailed in the *Highway 97 Winfield to Oyama Improvement Options* document, but were reviewed as part of this assignment in order to account for modified options and present day community issues.

For the ‘Short Highline’ option, noise, visual, and pollution impacts can be considered to increase when compared to existing conditions. With the construction of an entirely new road corridor, additional noise impacts can be expected to nearby residents, keeping in mind that there are few existing residents near the proposed corridor. The use of noise attenuation measures may be possible in select location to mitigate this impact. On the other hand, with significantly reduced traffic volumes, residents adjacent to the existing Highway 97 alignment will benefit from reduced noise impacts. The new corridor will require both ‘cut’ and ‘fill’ sections which will negatively impact the visual character of the area. While potential pollution impacts will be increased along the new corridor (where no roadway previously existed), the risk of pollution impacts to Wood Lake may be reduced with the diversion of most traffic and, in particular, heavy trucks away from the lakeshore.

Community displacement impacts will be incurred by the ‘Short Highline’ option given that a number of property acquisitions will be required for the new alignment. A small number of local businesses may be negatively affected by the diversion of Highway 97 traffic away from the existing alignment. However, local access will be maintained to these businesses on the existing roadway and these impacts may be offset by opportunities to redevelop properties along Wood Lake. Community severance impacts to residential development are not considered significant given that little development exists on the west side of the proposed ‘Short Highline’ alignment. Some severance of agricultural lands will be required in addition to the removal of some lands from the Agricultural Land Reserve. Access to Wood Lake will be maintained and likely improved in the proposed scenario, therefore recreational access can be considered unaffected and/or improved. With the devolution of the existing Highway 97 alignment along Wood Lake to a local roadway, pedestrian access to Wood Lake can also be considered to be improved.

The ‘Short Highline’ option is considered to be consistent with the plans and objectives of the local community, namely the District of Lake Country’s Official Community Plan. In combination with a desire for improved safety in this area, this option is supported by the District of Lake Country as it maintains access to Wood Lake and may include opportunities for redevelopment along the existing alignment.

5.4 Environmental

The environmental account is intended to identify any significant environmental impacts resulting from the proposed improvement. This is not intended to replace an environmental assessment, if required, but only as a qualitative measure of potential impact. In addition, qualitative measures of reduced carbon monoxide emissions and fuel consumption savings have also been included.

For the ‘Short Highline’ option, a full environmental impact assessment under BCEAA legislation is not likely to be required since the alignment does not significantly impact Wood Lake; on the other hand, if federal funding is used for this project, CEAA legislation will apply. With the construction of a new road corridor environmental impacts should be considered. While a detailed environmental investigation has not been conducted in the context of this assignment, impacts to wildlife habitat, wetlands, and agricultural/protected lands are likely. While the proposed alignment does not go through what would be considered prime wildlife habitat, mitigation measures will be required to minimize some or all of these impacts. Some environmental benefit can be expected with the diversion of the majority of traffic (especially trucks) away from Wood Lake as potential impacts from fuel spills, emissions, brake dust, etc., will likely be reduced.

Using the MicroBENCOST software, vehicle emissions and fuel consumption impacts for the 'Short Highline' were estimated. MicroBENCOST calculated carbon monoxide and fuel consumption output based on average travel speed, grades, road curvature, vehicle mix, and total vehicle miles traveled. For the 'Short Highline' estimated output over 25 years are as follows:

- Fuel Consumption (Mill. Gal.) = -56.75 (net increase)
- Carbon Monoxide (Mill. Kg.) = -0.989 (net increase)

Increased fuel consumption and carbon monoxide emissions reflect the increased vehicle operating costs due to the significant grades and somewhat longer length of the 'Short Highline', in comparison to the existing alignment.

5.5 Economic Development

This account addresses the **Provincial/Federal** benefits of the proposed project. Since local benefits (including some economic benefits) are typically captured qualitatively in the social / community account, they are not considered here. For example, while the income and employment generated by the construction of a highway improvement project represent an economic benefit to the local area, these benefits are typically achieved at the expense of another potential project in another local region in the Province and therefore represent no net provincial/federal gain. In addition, according to federal benefit-cost methodology, economic impacts derived from transportation projects such as improved private business opportunities, are excluded from consideration. Given that the source of these benefits are captured by reduced travel time, vehicle operating costs, and collision costs in the customer service account, the inclusion of additional economic benefits that arise from spending those savings would counted twice. For this reason, the 'multiplier effect' of secondary economic benefits is not included in the benefit-cost evaluation of this project.

While these secondary economic benefits are excluded from the strict benefit-cost equation, they do represent potential benefits to the provincial/national economy and can be included as a qualitative measure of project viability. The *Okanagan Valley Transportation Corridor – An Assessment of Select Projects and Initiatives (Urban Systems Ltd, 2004)* document includes an analysis of economic development impacts for the Highway 97 Four-Laning project at Wood Lake. It should be noted that this analysis considered the 'Long Highline' option, as opposed to the 'Short Highline' option under consideration here. However, the order of magnitude impacts can be expected to be similar for either option. In this case, the indirect impacts on the Provincial economy (in 2004 $) were estimated to be as follows:

- $65.8 Million impact of Gross Output for the Provincial economy over the 1-year construction period, and GDP at factor cost will increase by over $27 Million;
- Approximately 549 direct and indirect person years of employment generated by the construction of the proposed bypass;
- During the operational phase impact on the provincial economy will be approximately $300,000 per year of gross output, $124,000 per year of GDP at factor cost, and 3 person years of employment per year.

In addition to the impact of construction on the provincial economy, economic benefits to provincial/national trade can be expected with the improvement of this segment of Highway 97. Given the existing mobility, safety, and reliability problems found on the existing corridor, the proposed improvements can be expected to positively impact commercial trade, tourism, and local development opportunities.

5.6 Multiple Account Evaluation Summary

A summary of all Multiple Account Evaluation accounts is provided in **Table 5.5**. These include both quantitative measures used for the benefit-cost evaluation of the project and qualitative measures of potential impact. Key economic indicators such as, Net Present Value (NPV) and Benefit-Cost Ratio (B/C) are included for a 25 year period and reflect the base assumptions for traffic growth (3.0%), discount rate (10%), and cost estimate (100%). A sensitivity analysis of these key assumptions is provided in Section 6.0.

Table 5.5: Summary Multiple Account Evaluation

Financial Account	
Discounted Project Cost	$50.5M
Maintenance	$0.9M
Salvage Value	($3.6M)
Total	**$47.8M**
Customer Service Account	
Travel Time	$25.8M
Vehicle Operating Costs	($10.9M)
Safety	$18.1M
Total	**$33.0M**
Social / Community	
Noise, Visual, Pollution Impacts	Negative
Community Displacement	Negative
Community Severance	Neutral
Consistency with Community Plans	Positive
Environmental	
Fuel Consumption Savings (Mill. Gal.)	(56.75)
Carbon Monoxide Reduction (Mill. Kg.)	(0.989)
Wood Lake Impacts	Positive
Habitat, Wetlands, ALR Lands Impacts	Negative
Economic Development	
Local / Regional	Positive
Provincial / National	Positive
Key Economic Indicators	
Net Present Value (NPV)	($14.8M)
Benefit-Cost Ratio	0.69

As summarized in **Table 5.5**, with a negative Net Present Value (-$14.8M) and a Benefit-Cost Ratio less than 1.0 (0.69) over a 25 year period, the key economic indicators required to justify this project are not ideal. While these economic indicators should not represent the only factor in determining project viability, these results do indicate that the projected benefits of this project will not overcome the significant estimated project cost at this point in time. Secondary economic benefits to local, provincial, and federal interests have not been included in the benefit-cost evaluation, and the overall benefits of this project may not be fully captured herein. In addition, this evaluation includes various assumptions based on the best available data; sensitivity analysis of key variables is detailed in Section 6.0.

6.0 RISKS / SENSITIVITY ANALYSIS

When evaluating any type of transportation improvement project at a strategic/planning level, such as in this case, there is a level of uncertainty inherent in the results. The calculation of financial costs and benefits related to the project rely upon numerous assumptions, estimations, and secondary sources. While all assumptions made as part of this review were based on the best information available at the time, given the constantly changing economic conditions in this region there will always be a certain level of risk with the results presented.

In order to consider the risks and uncertainties inherent in this type of evaluation appropriately, a sensitivity analysis was conducted. This approach considers a range of uncertainty for key factors in the project assessment. The result is that the conclusions reached can be tested for resiliency against potentially changed economic conditions. For this assignment, sensitivity analyses were conducted for several key variables including: traffic growth rates, discount rate, and the cost estimates.

The prediction of mobility and safety benefits is heavily dependant on traffic volumes and the estimation of future traffic conditions at the end of the forecast horizon. In this case, historic daily traffic volumes and population projections indicated an annual growth rate of approximately 3.0% per year. The results of this analysis are summarized in **Table 6.1**.

Table 6.1: Growth Rate Sensitivity

Discounted Life Cycle Costs	Growth Rate		
	3%	2%	4%
Project Cost	$50.5M	$50.5M	$50.5M
Maintenance	$0.9M	$0.9M	$0.9M
Construction Salvage Value	($3.6M)	($3.6M)	($3.6M)
Total	*$47.8M*	*$47.8M*	*$47.8M*
Customer Service Benefits (over 25 years)			
Travel Time	$25.8M	$14.7M	$30.7M
Vehicle Operating	($10.9M)	($11.1M)	($9.9M)
Safety	$18.1M	$16.6M	$19.7M
Total User Benefits	*$33.0M*	*$20.2M*	*$40.5M*
Key Economic Indicators			
Net Present Value	($14.8M)	($27.6M)	($7.3M)
Benefit-Cost Ratio	0.69	0.42	0.85

In order to test the sensitivity of the results to modified traffic growth rate assumptions, both reduced (2%) and increased (4%) assumptions were considered.

This analysis indicates that the traffic growth rate significantly affects the magnitude of customer service benefits over 25 years. A reduced growth rate assumption results in reduced economic indicators, as would be expected.

In order to convert future project related costs and benefits to a common present value for comparison, a discount rate was used in the benefit-cost evaluation. This rate is typically set to reflect the rate of inflation, and is therefore subject to changes depending on overall economic circumstances. In this type of evaluation the discount rate is of particular importance for future benefits (mobility and safety). However, project costs are also affected, where future costs must also be discounted to represent present value. According to the *BC Ministry of Transportation's Benefit-Cost Guidebook*, a discount rate of 6% should be used for benefit cost evaluation. On the other hand, the *Transport Canada – Guide to Benefit-Cost to Analysis* indicates that a rate of 10% is appropriate. In order to test the sensitivity of the results of this evaluation, the benefit-cost analysis was re-calculated using the original 6%, as specified by BC Ministry of Transportation, 10% as preferred by Transport Canada, and an additional 8% scenario for comparison. The results of this analysis are summarized in **Table 6.2**.

Table 6.2: Discount Rate Sensitivity

Discounted Life Cycle Costs	Discount Rate		
	10%	6%	8%
Project Cost	$50.5M	$57.3M	$53.7M
Maintenance	$0.9M	$1.3M	$1.1M
Construction Salvage Value	($3.6M)	($10.7M)	($5.9M)
Total	*$47.8M*	*$47.9M*	*$48.9M*
Customer Service Benefits (over 25 years)			
Travel Time	$25.8M	$40.6M	$32.0M
Vehicle Operating	($10.9M)	($15.6M)	($12.9M)
Safety	$18.1M	$26.1M	$21.5M
Total User Benefits	*$33.0M*	*$51.1M*	*$40.6M*
Key Economic Indicators			
Net Present Value	($14.8M)	$3.2M	($8.3M)
Benefit-Cost Ratio	0.69	1.07	0.83

This analysis indicates that the resulting economic indicators are sensitive to a reasonable range in discount rate. In particular, when using a reduced 6% discount rate, as would be typical for provincial benefit-cost analysis, the key economic indicators of Benefit-Cost Ratio is greater than 1.0 and the Net Present Value is positive.

While estimated project costs are based on the best engineering data available, a preliminary property impact appraisal, and a reasonable contingency, without detailed engineering, the magnitude of potential risks may not be completely captured. In this case, a range of factored cost estimates is analysed and summarized in **Table 6.3**.

Table 6.3: Cost Estimate Sensitivity

Discounted Life Cycle Costs	100%	75%	110%
Project Cost	$50.5M	$37.8M	$55.5M
Maintenance	$0.9M	$0.9M	$0.9M
Construction Salvage Value	($3.6M)	($2.7M)	($4.0M)
Total	*$47.8M*	*$36.0M*	*$52.4M*
Customer Service Benefits (over 25 years)			
Travel Time	$25.8M	$25.8M	$25.8M
Vehicle Operating	($10.9M)	($10.9M)	($10.9M)
Safety	$18.1M	$18.1M	$18.1M
Total User Benefits	*$33.0M*	*$33.0M*	*$33.0M*
Key Economic Indicators			
Net Present Value	($14.8M)	($3.0M)	($19.4M)
Benefit-Cost Ratio	0.69	0.92	0.63

As expected, a reduced project cost estimate results in improved economic indicators and in this case improves the key economic indicators to nearly positive Net Present Value and a Benefit-Cost Ratio nearly greater than 1.0. On the other hand, an increase to the cost estimate assumption will result in worsened economic indicators.

7.0 ADVANCEMENT OF FEDERAL/PROVINCIAL TRANSPORTATION STRATEGIES AND PLANS

In 2004, a significant length of Highway 97 (including the segment between Winfield and Oyama) was added to the National Highway System (NHS). Initially established in 1988, the NHS is defined by routes that provide for inter-provincial and international trade/travel by connecting capital cities, major provincial populations, commercial centres, ports of entry, and other transportation modes. As part of the NHS, improvements to this segment of Highway 97 would be consistent with federal transportation strategies and may be eligible for specific federal funding sources. For example, Transport Canada's Strategic Highway Infrastructure Program (SHIP) supports major capital improvements on east-west and north-south trade routes in Canada's NHS (including Highway 97). Projects that can be shown to improve transportation efficiency, safety, and reliability in order to support trade, tourism, and investment in Canada are eligible for federal funding. The selection criteria for SHIP funding include an evaluation of how the project supports economic productivity and efficiency, safety improvements, and federal visibility, all of which are key aspects of this project.

As a key provincial highway, improvements to Highway 97 also support provincial transportation objectives and strategies. The province of British Columbia's existing transportation plan identifies the need to improve the safety and reliability of existing transportation systems, free up the movement of goods, and expand transportation infrastructure to meet the needs of a growing population. In particular, the "Heartlands Transportation Strategy" detailed in the *Opening Up BC – A Transportation Plan for British Columbia* document recognizes the importance of Highway infrastructure improvements to the province's 'Heartland' (areas outside of the Lower Mainland and Victoria). Highway 97 in the Okanagan is identified as a key transportation route which is critical for supporting access to the province's resources, industry and investment, and growing sectors such as adventure tourism. In addition, the 'Highline' improvement of Highway 97 from Winfield to Oyama is consistent with local/regional land use plans for the District of Lake Country. Finally, the Thompson-Okanagan Regional Transportation Advisory Committee has also indicated support for the 'Highline' improvement.

Both provincial transportation strategies (including *Opening Up BC – A Transportation Plan for British Columbia*) and federal transportation policies (including *Partnering for the Future – A Transportation Vision for Canada*) support the advancement of partnering relationships as they relate to transportation investment. The continued expansion of cost-sharing initiatives between the Government of Canada and the Province of British Columbia is supported by both levels of government as an effective means to ensuring continued economic growth and quality of life improvements for all Canadians.

8.0 PROJECT IMPLEMENTATION & RECOMMENDATIONS

This document is intended to establish the business case justification required to advance this project towards implementation. The 'Short Highline' was found to provide significant benefits to the mobility and safety of highway users. In addition, this new four lane corridor can be expected to significantly improve reliability of this key corridor and is more consistent with the expected performance at this section of Highway 97. Other benefits of the 'Short Highline' include the reduced risk of adverse impacts to Wood Lake, redevelopment opportunities along Wood Lake, and the overall positive economic impact of an enhanced highway corridor.

Depending on the base assumptions used for the benefit-cost calculation, the key economic indicators were found to be both above and below a resulting net positive economic outcome. In particular, the discount rate specified for federal business case submissions (10%) resulted in a negative net present value of -$14.8 Million. On the other hand, a discount rate assumption of 6%, as is preferred by the British Columbia Ministry of Transportation, resulted in a positive net present value of $3.2 Million. Keeping in mind that the justification of any particular project should not be based solely on the benefit-cost evaluation, this project can be considered a viable solution to an on-going highway performance problem.

This document has detailed that an existing mobility, safety and reliability problem exists on this segment of Highway 97 and that these problems will persist with continued traffic growth. Alternate options for improvements to this segment of Highway 97, including the 'Long Highline' and online 'Lakeshore' widening were found to be undesirable based on previous conclusions, as described in Section 3.0. At this time, the 'Short Highline' represents the best solution available and warrants further planning and engineering work.

In order to move this project forward the following implementation steps and timeline are required:

- Submission of Business Case Justification for Federal Funding – completed (this document)
- Preliminary / Functional Design (2007/2008)
- Detailed Design (2008/2009)
- Public Input, Land Acquisition, ALR Negotiations (2009/2010)
- Construction (2010 – 2012)

Based on the estimated distribution of project costs over the anticipated schedule, the total escalated costs required are $70.275M, as summarized in **Appendix B**. Although the performance of this two-lane segment of Highway 97 is degraded by high traffic volumes, mobility issues, and safety concerns, it appears that relatively high estimated construction costs per kilometre have inhibited the improvement of the corridor. Preliminary design and engineering work currently underway is expected to further enhance the confidence in the required project costs and corresponding business case.

APPENDIX A

Recent Major Collision Events

Head on Collision: Fatal & Injuries
Highway Closure: 6 hours
Date: October 25, 2005

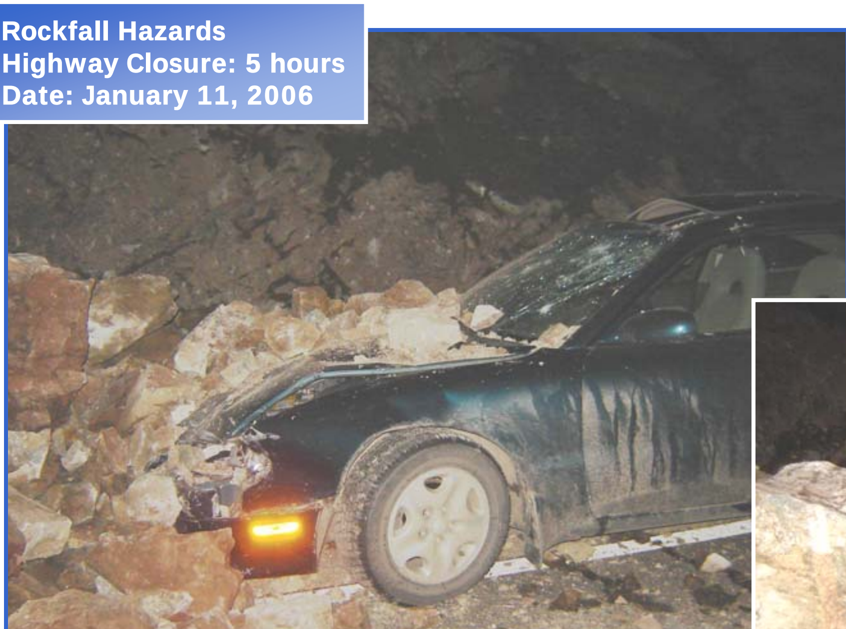
Head on Collision: Serious Injuries
Highway Closure: 3.5 hours
Date: January 6, 2006

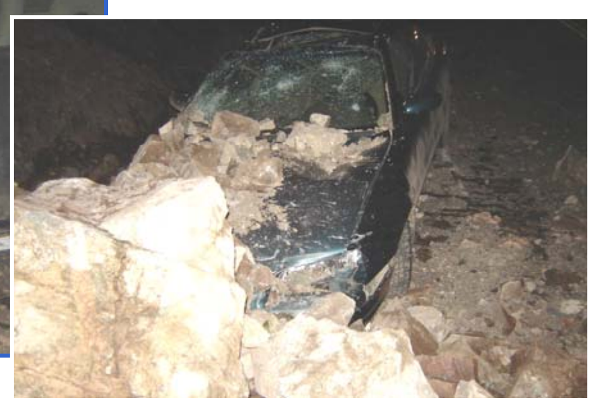
Truck Cut-off by Passing Vehicle (Late Night)
Highway Closure: 9 hours
Date: June 14, 2006

Single Vehicle Accident: Serious Injuries
Highway Closure: 5.5 hours
Date: June 22, 2006

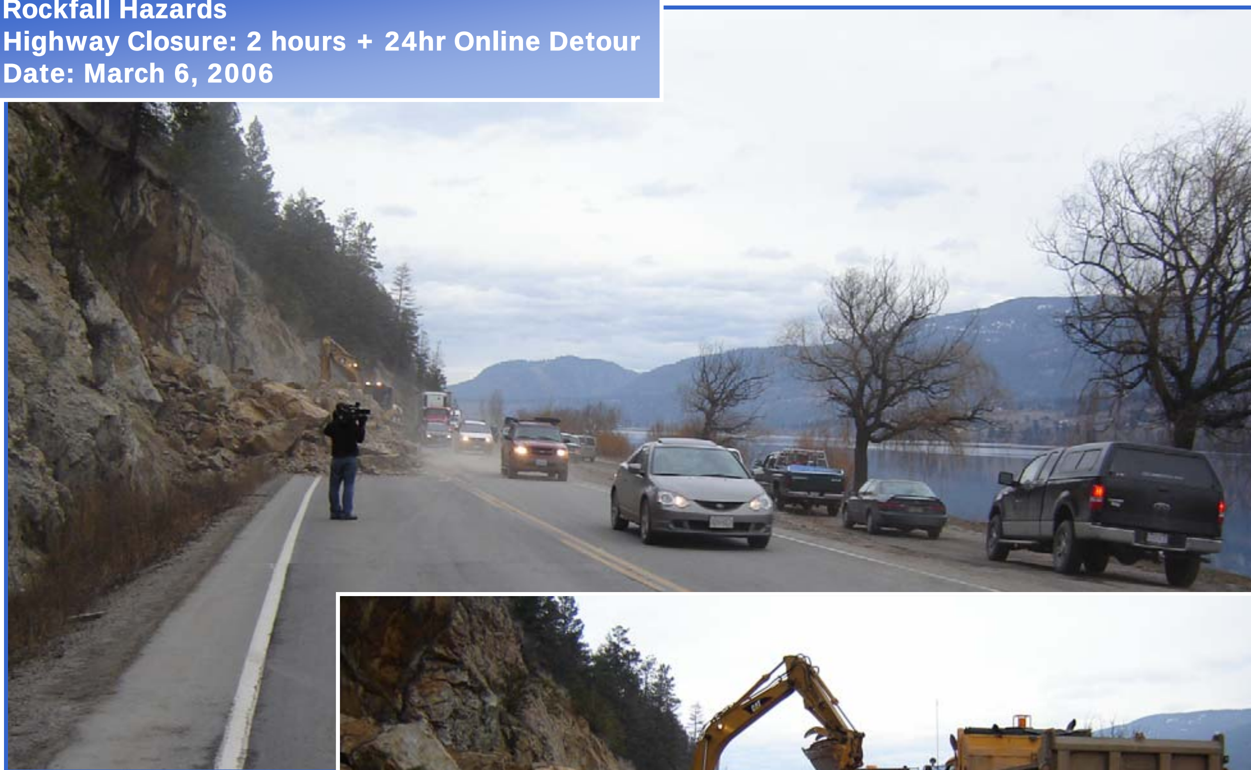
Two Vehicle Accident: Serious Injuries
Highway Closure: 5.5 hours
Date: July 6, 2006

Rockfall Hazards
Highway Closure: 5 hours
Date: January 11, 2006





Rockfall Hazards
Highway Closure: 2 hours + 24hr Online Detour
Date: March 6, 2006



www.kelownadailycourier.ca

Friday, January 26, 2007, Kelowna, B.C.

KIP FRASZ/The Daily Courier

Highway 97 traffic is backed up for kilometres beside Wood Lake Thursday after a collision between two tractor-trailers. The route was blocked for 12 hours.

Highway blocked – again

Tractor-trailers collide in foggy, icy conditions on notorious stretch of highway

By J.P. SQUIRE
The Daily Courier

Highway 97 was blocked or partially blocked north of Winfield for almost 12 hours Thursday, frustrating Lake Country motorists, commuters and politicians who have lobbied unsuccessfully for improvements.

At one point, the lineups on either side stretched more than seven kilometres.

At 2:30 a.m., a northbound tractor-trailer loaded with wood chips came around a corner near Wood Lake and clipped the back of another tractor-trailer that had slid into its lane. The first rig then crashed into a rock wall.

Both trucks were demolished and blocked both lanes for several hours, forcing all Highway 97 traffic to detour onto Oyama Road. Removing the vehicles, cleaning up wood chips and dealing with diesel fuel leaking into the ditch took until 2:15 p.m.

"One chip truck was crumbled like an accordion, so an excavator was brought in to load the chips into another truck," said Lake Country RCMP Sgt. Reg Burgess.

The accident occurred almost halfway between Oceola and Oyama roads, which are seven kilometres apart. At one point, the lineups extended beyond those points.

KIP FRASZ/The Daily Courier

An excavator removes the load of wood chips from a crashed tractor-trailer on Thursday.

Neither driver was hurt. Roads in the area were described as "very icy" and visibility was poor due to fog, according to Kelowna RCMP.

The Kamloops driver who clipped the other rig said afterward he had no choice.

"I came around the corner and there he was, blocking my lane, so I clipped the back of his trailer and smashed into the rock wall. I just closed my eyes and hoped for the best," said the driver, who did not want his name published.

Lake Country Mayor James Baker described the closure of the main thoroughfare through his municipality as "crazy" and noted the economic impact.

Ironically, he was attending a Central Okanagan Regional District economic development commission meeting on Thursday morning.

"That's what I've been trying to tell the regional district, because widening the highway is a regional thing," he said.

"It may not be as important as the three-laning (of Highway 97) through Kelowna, but it is a deadly area. Fortunately, nobody died today."

It's the longest highway closure or partial closure that he or Burgess can recall, but there have been many others. About 25 per cent of the Lake Country fire department's calls to motor vehicle accidents involve the narrow, winding, two-lane stretch between Winfield and Oyama.

Three people have died and several more have been injured during the past year while Lake Country officials pleaded for upgrading.

"It does have an impact. All of that traffic is diverted onto roads past schools which don't normally have that much traffic, where big trucks are trying to go around sharp corners," said Baker.

Lake Country officials have tried the emotional route in pleading with the provincial Highways Ministry.

"We're now working on getting the stats, the meat and potatoes, of accidents from ICBC, RCMP and fire department," said Baker.

Every time there is an accident on that section, he adds it to statistics he has and sends another letter to Kelowna-Lake Country MP Al Horning and the ministry.

Thursday's accident involved spilled wood chips, but Baker said an accident involving a chemical spill could have a long-term environmental impact on Wood Lake.

APPENDIX B

Project Information Sheet (MoT)

Federal Highways and Borders Infrastructure Program
Candidate Project Information Sheet
Project 21347: Hwy. 97 – Winfield to Oyama

EDR	3 (Thompson Okanagan)	**Highway #**	97
Location:	Lake Country	**LKI/LRS/GPS:**	LKI Segment 1119, km 19.76 to km 29.00
Provincial Electoral District:	(24) Kelowna – Lake Country		
Federal Electoral District	(11) Kelowna – Lake Country	**Total Capital Cost:**	$ 70.275 million

Project Purpose: Upgrade Highway 97 to four lanes from Winfield to Oyama, which will remove the last two lane section of Highway 97 between Highway 97C (the Okanagan Connector) and Vernon.

Project Background: This section of Highway 97 is currently a two-lane highway that follows the western edge of Wood Lake for approximately nine kilometers. Steep, high rock bluffs with a narrow, shallow ditch line the west edge of the highway. Narrow shoulders (less than 0.5 metres wide on average, in some locations 0.1 metres wide) line both sides of the highway. Numerous pullouts are located on the east (lake) side of the highway which are frequented by people fishing recreationally, however due to several accidents involving southbound traffic trying to turn off the highway into these pullouts left turns off the highway are no longer permitted. Where there are no pullouts the highway is very close to the lake. There are very few safe passing opportunities along this section of highway. The highway is posted at 80 km/h, however the average traveling speed is significantly higher (typically 100 – 110 km/h).

The current Average Annual Daily Traffic (AADT) is 22,600 vehicles per day (vpd) with the Summer Average Daily Traffic (SADT) at 26,150 vpd. This value has been growing on average by 765 vpd per year. The theoretical threshold for when a four lane highway is required is approximately 14,000 vpd.

Several accidents have occurred along this section of highway. The Collision Rate for this area is 0.41 a/Mv (km) which is above the provincial average of 0.30 a/Mv (km). The Accident Severity Index between 1996 and 2000 was 7.2 and between 2001 and 2005 was 8.3, which is also above the provincial average of 7.0. Between 1996 and 2005 there was an average of 17 accidents per year, with 4 fatalities occurring between 2000 and 2005. In the last year, three fatal accidents, two head-on accidents involving serious injuries and two major accidents involving semis hitting the rock bluffs have occurred, all of which closed the highway for several hours and forced traffic to detour onto a municipal road along the east side of Wood Lake. The detour road (which is part of the District of Lake Country and not a Ministry road) was not designed to accommodate large vehicles or large volumes of traffic and is starting to show signs of deterioration.

Several large volume rock slides have also occurred on this section of highway. In the last year three major rockfalls have occurred in this area, with one incident burying a vehicle and causing 3 additional vehicles to collide into the rock debris. These rockfall incidents also closed the highway for several hours and caused traffic to detour onto the east side of Wood Lake.

Using the Ministry's provincial Rock Hazard Rating System (RHRS) where a low hazard slope is rated at 'C' and a high hazard slope is rated at 'A', there are six slopes within the project area that are rated as an 'A' hazard (there are only 1,162 out of 22,000 slopes ranked in the province that have an 'A' hazard rating). The cost of the geotechnical stabilization requirements along the existing rock cuts (assuming no upgrading along this highway occurs) phased over the next five to ten years is estimated at approximately $2 million.

The recent events over the last year have prompted a lot of public pressure and media coverage for the Ministry to upgrade this section of highway. This has been reinforced by the local governments in the area (such as the City of Vernon, the District of Lake Country and the District of Coldstream) sending formal requests to the local MP, the two local MLA's and both the Provincial and Federal Ministers of Transportation to upgrade the highway.

Based on the recurring safety concerns along this section of highway a Preliminary Design study for this project was conducted in the fall of 2001 by Reid Crowther and Associates for the Ministry. The study concluded that upgrading the existing two lane highway in this area to four lanes is not feasible due to high construction costs, environmental issues and traffic management concerns during construction. The study recommended creating a new four-lane alignment west of the existing alignment over mostly undeveloped land. Two alignment options were presented (the "long highline" and the "short highline"). A Value Analysis on the study was completed in the Spring of 2002, which recommended the "short highline" option as the most value for the cost.

Project Scope: Construct an approximately 9 km long new four-lane section of highway west of the existing two-lane highway that follows Wood Lake. The highway will tie into existing four-lane highway in the community of Winfield at the south end and the community of Oyama at the north end of the project. The existing two-lane highway will be turned over to the District of Lake Country for use as a municipal access road to the shore of Wood Lake. The majority of the new highway alignment crosses undeveloped Crown Land, however some private and commercial properties will be impacted at the tie-in locations.

Project Cost Estimate: A review and updating of the cost estimate for the "short highline" alignment provided in the Preliminary Design report was completed. The cost breakdown with a level of confidence is provided below:

Category	**Total Cost Constant Dollars 2007**	**Cost in Current Dollars (includes escalation)**		
		Total	**Eligible**	**Non- eligible**
Proj Mgmt	$0.423M	$0.454M		$0.454M
Planning	$0.092M	$0.092M		$0.092M
Engineering	$4.376M	$4.660M	$3.697M	$0.962M
Environment	$0.236M	$0.246M	$0.210M	$0.036M
Property	$6.332M	$6.820M		$6.820M
Construction	$38.575M	$43.400M	$40.019M	$3.381M
Contingency	$12.988M	$14.604M	$14.516M	$0.088M
Total	$63.021M	$70.275M	$58.441M	$11.835M
Current TIP	$0.000M			

	Cost in Current Dollars (includes escalation)							
	Past	07/08	08/09	09/10	10/11	11/12		Total
Total	$0.297 M	$0.856 M	$11.564M	$22.541M	$18.360M	$16.659M		$70.275M

The above cost estimate was calculated using the quantities provided in the Preliminary Design report from 2001 with an update to the unit prices determined using Wolski Consulting's Elemental Parametric Method of estimating and has a medium-high level of confidence.

The level of confidence in the cost estimate will go up as the design progresses, becoming high when the Functional design is complete in the fall of 2007.

Of the costs provided above, $58.441M is considered eligible for cost sharing with the Federal government.

A detailed cost estimate is provided in Appendix 'A' and a spreadsheet showing the cost escalation is provided in Appendix 'B'.

Project Schedule:

Fiscal Year	Major Activities and Deliverables
Current (2007/08)	Commence Preliminary/ Functional Design (complete in Fall ’07), continue into Detailed Design.
2008/09	Complete Detailed Design (Fall ’08). Start property acquisition.
2009/10	Complete property acquisition, commence construction (Summer ’09).
2010/11	Continue construction.
2011/12	Complete construction Fall ’11

CEAA Screening Report: A preliminary review of the environmental issues has been completed for the project area. A summary of the review is provided in Appendix ‘C’.

Conclusions from the preliminary review state that a widening along the existing alignment at the lakeshore is considered a high environmental risk. However, a realignment inland (as recommended in the Preliminary Design report) drops the environmental risk to moderate based on the current information available. These risks will likely drop to low as more information is obtained.

Federal Business Case: A Federal Business Case has been completed by Urban Systems Ltd with E.Wolski Consulting Inc. undertaking the cost estimation work to provide a more accurate project cost. The Business Case is attached in Appendix ‘D’.

Risk Assessment:

RISK	CONSEQUENCES	Mitigation Strategy
Resistance from property owners during negotiations	Potential delay to the project until required property is secure	Early contact with affected property owners and continued communication with the owners during the design
Resistance from the ALC to remove land from the ALR	Delay to project, or only a portion of the project can be completed	Start early consultation with the ALC and have them involved as the project progresses to ensure buy-in on the project.
Occurrence of an environmentally sensitive area or species	Delay to project or increase in project costs for environmental remediation.	Complete the CEAA Screening as soon as possible to identify any potential issues, if issues arise undertake a detailed environmental assessment to determine mitigation strategies and costs.

First Nations and Property Impacts: There are two First Nation groups that have traditional territory within the project area, the Westbank First Nation and the Okanagan Indian Band, however there are no actual Indian Reserves impacted by the project.

The majority of the properties in the project area are titled Fee Simple and there is minimal impact on Crown Land. The properties impacted consist of small and large residential with some development/subdivision potential, various commercial and some agricultural/orchards.

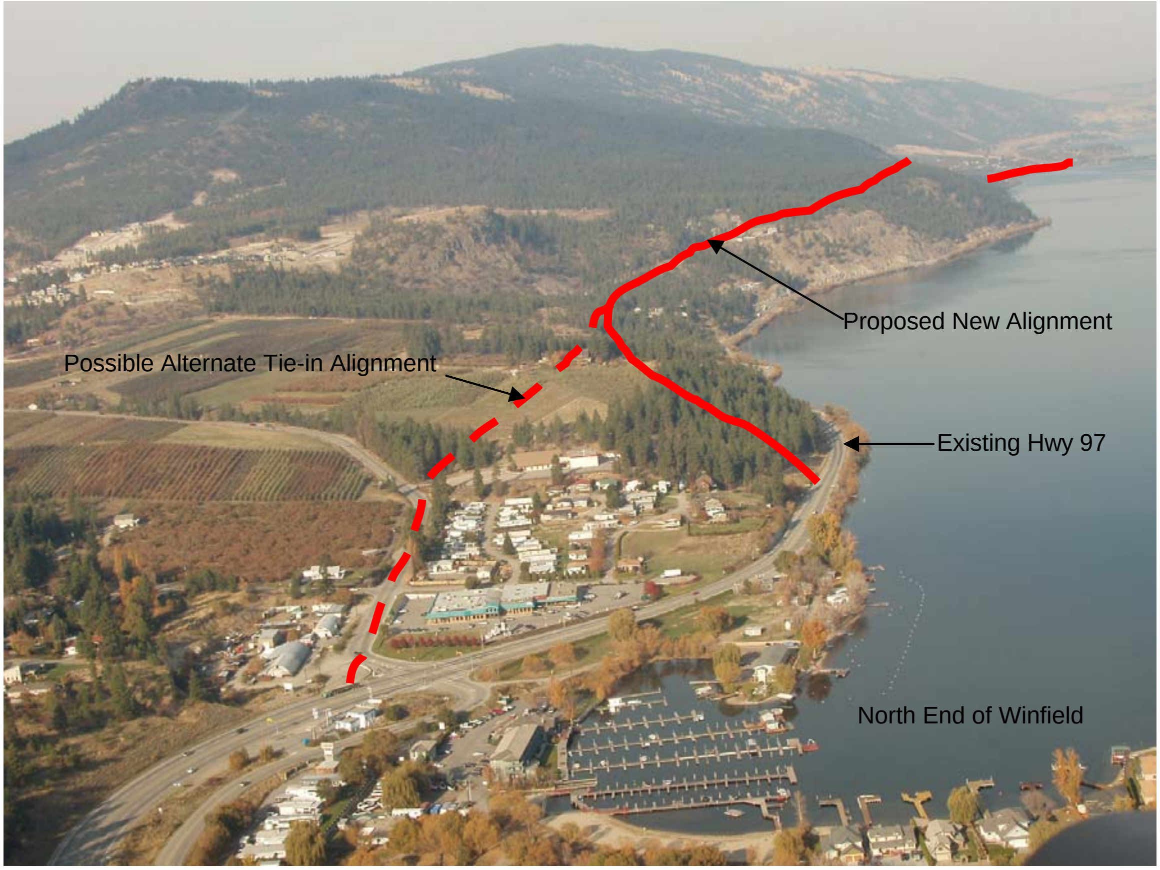
The overall First Nations risk is considered to be medium, however recent requests by other First Nations on other projects for accommodation as a result of the impact on their traditional territory has occurred and accommodation may be necessary depending on the strength of the First Nations claim. Therefore, it is recommended to initiate the consultation process in accordance with Provincial MOT guidelines with the noted First Nations groups as soon as possible.

An Archaeological Overview Assessment (AOA, which is a desktop historical review exercise) was completed in the fall of 2006 which identified some areas that have moderate to high potential to contain undocumented archaeological sites. An Archaeological Impact Assessment (AIA, which is an actual field investigation) is currently underway on those sites and will be completed this summer.

Other Potential Partnerships: (e.g. Municipal, ICBC): None identified at this time.

Relevant Photos or Schematics to add clarity

Key Plan



South end of project, looking north

North end of project, looking south

Photo within project area. Compare to photo below showing conditions at either end of the project area

Photo of conditions north of project area. South of project area is similar. The dramatic difference in highway standards between the project area and either side of the project (shoulder widths, site distance, number of corners, width of cross-section etc.) may be the cause of the numerous accidents within the project corridor.

March 6/06 rockfall event. Northbound traffic is being detoured along one of the ‘fishing access’ pullouts

APPENDIX 'A'

Cost Estimate

APPENDIX 'B'

Escalation Worksheet

APPENDIX 'C'

CEEA Screening Report

(See attached environmental info on next page)

APPENDIX 'D'

Federal Business Case

APPENDIX 'C'
SUMMARY OF PRELIMINARY ENVIRONMENTAL REVIEW

A preliminary review of the environmental issues has been completed for the project area. Reference material that has been reviewed includes:

Biophysical Inventory: Highway 97, Winfield to Oyama (Reid Crowther, 1998)

Wood Lake Environmental Assessment (Thurber Environmental Consultants Ltd., 1991)

Archaelogical Resource Inventory and Impact Assessment of Highway Projects in the Thompson-Okanagan and Kootenay Highways Regions (Heritage Consulting, 1990)

Conclusions from the preliminary review are as follows:

<u>General Habitat Overview:</u> The existing highway alignment parallels the western shore of Wood Lake and a portion of Kalamalka Lake. The project area lies in transition zone between the Ponderosa Pine biogeoclimatic zone and the Interior Douglas Fir zone. Most forested sites consist of open and sparsely vegetated to somewhat dense Douglas fir and Ponderosa Pine The shoreline of Wood Lake has a single line of mostly willow trees.

<u>Fish and Aquatic Resources:</u> Species occurring in Wood Lake include Kokanee, Whitefish and Rainbow Trout. Other fish species expected to be present in Wood Lake include carp, suckers, squawfish and chub. Multiple watercourse crossings occur along the route and further investigation will be required to determine their significance.

<u>Wildlife:</u> Minimal information is available for this area. Further investigations will be required.

<u>Rare and endangered species:</u> The Peach Leaf Willow (Salix amygdaloides), a red-listed species was noted in the area. Several Red and Blue-listed and/or SARA Schedule 1 species may be affected so further investigation work will be required.

<u>Archaeological resources:</u> There are three recorded archaeological sites of Aboriginal importance on the current Highway 97 alignment. Results of investigations on the current alignment and upland options should be available by the end of the year.

Based on the above information, a widening along the existing alignment at the lakeshore is considered a high environmental risk. However, a realignment inland (as recommended in the P+E report) drops the environmental risk to moderate based on the current information available. These risks will likely drop to low as more information is obtained.

APPENDIX C

Multiple Account Evaluation: Highway 97
Simon Fraser Bridge Twinning Prince George

Multiple Account Evaluation

Highway 97
Simon Fraser Bridge Twinning
Prince George

MoT Project 36191

Prepared for:

BC Ministry of Transportation
Northern Region

Prepared by:

Peter Lyall P.Eng.
Apex Engineering
Vancouver, BC

Project No. MOT-75

19 September, 2007

Apex Engineering Limited

Executive Summary
Highway 97 - Simon Fraser Bridge
Prince George

The Simon Fraser Bridge #1513 is a 390 m, 2 lane bridge across the Fraser River on Highway 97 at the south approach to Prince George. The bridge links Prince George to the airport and industrial areas south of the river and to Highway 97, the main north/south Provincial corridor. Traffic volume is 22,000 AADT, well over the normal capacity of a 2 lane facility.

The scope of the project is to build a second two lane bridge parallel to the existing two lane bridge at an estimated cost of $43.9 million (as-spent dollars) before recoverables of $1.1 million.

Traffic is operating at LOS 'E' with peak hour vehicles of 1,100 veh/hr, at a volume to capacity ratio of 0.7. Capacity is 1,600 veh/hr. During shift changes at the mills south of the bridge, traffic queues and delays are now starting to occur south of the bridge. With the bridge twinned, effective capacity increases to over 6,000 veh/hr, which is adequate for the foreseeable future. Accidents will be reduced by about 2 accidents per year and by 1 fatal accident every 5 years.

Prince George lies at the junction of Highway 97 and Highway 16. With the exception of the Simon Fraser Bridge, all of the approaches to the City are now 4 lanes. This is a critical deficiency in establishing Prince George as a major transportation hub. This will become a greater impediment to growth as transportation patterns evolve in response to the Mountain Pine Beetle epidemic and the development of Prince George as a major transportation hub in the Asia Pacific Gateway Strategy.

The Simon Fraser Bridge Twinning Project is a critical link in the Asia Pacific Gateway Strategy. The project connects a major industrial site south of the Fraser River to CN Rails new Inland Container Terminal (ICT) on the north side of the Fraser River. The industrial area is home to several of the mills in the Prince George area. As well, backhaul forest products from Dunkley, Quesnel and Williams Lake will all need to access the ICT along Highway 97 via the Simon Fraser Bridge.

Twinning the bridge is consistent with long term vision for the Cariboo Connector between Cache Creek and Prince George which is an established Provincial Strategy. The Cariboo Connector will support growth in mining, oil and gas, forest industry activity related to pine beetle kill, development of the Port of Prince Rupert and encourage economic diversification in the north. The south approach to Prince George is the highest volume section of the corridor and may be considered the highest priority for the Cariboo Connector.

This project has a positive impact on greenhouse gas emissions by reducing emissions by 240 tonnes/year plus a one time saving of about 5,000 tonnes associated with avoided detour fuel consumption.

At a 10% discount rate, the project returns a B/C ratio of 0.82 and NPV = -$5.6 million. This is better than typical bridge projects which are always capital intensive compared to other highway projects. At the Provincially accepted 6% discount rate, B/C = 1.2 and NPV=$6.1M.

In summary the Simon Fraser Bridge Project is a key piece of Asia Pacific Gateway Transportation Infrastructure needed to fully realize the potential of the Port of Prince Rupert Expansion and the Intermodal Container Terminal in Prince George. In addition, it will also support diversification of the northern economy which is critical to mitigate the long term impacts of the Mountain Pine Beetle epidemic.

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Multiple Account Evaluation
Highway 97 Simon Fraser Bridge
Prince George

1 Background

Prince George is a major regional service centre for Northern BC with a population over 80,000. It is located on the National Highway System at the junction of Highways 97 and 16 and lies at the confluence of the Fraser and Nechako Rivers. Highway 97:

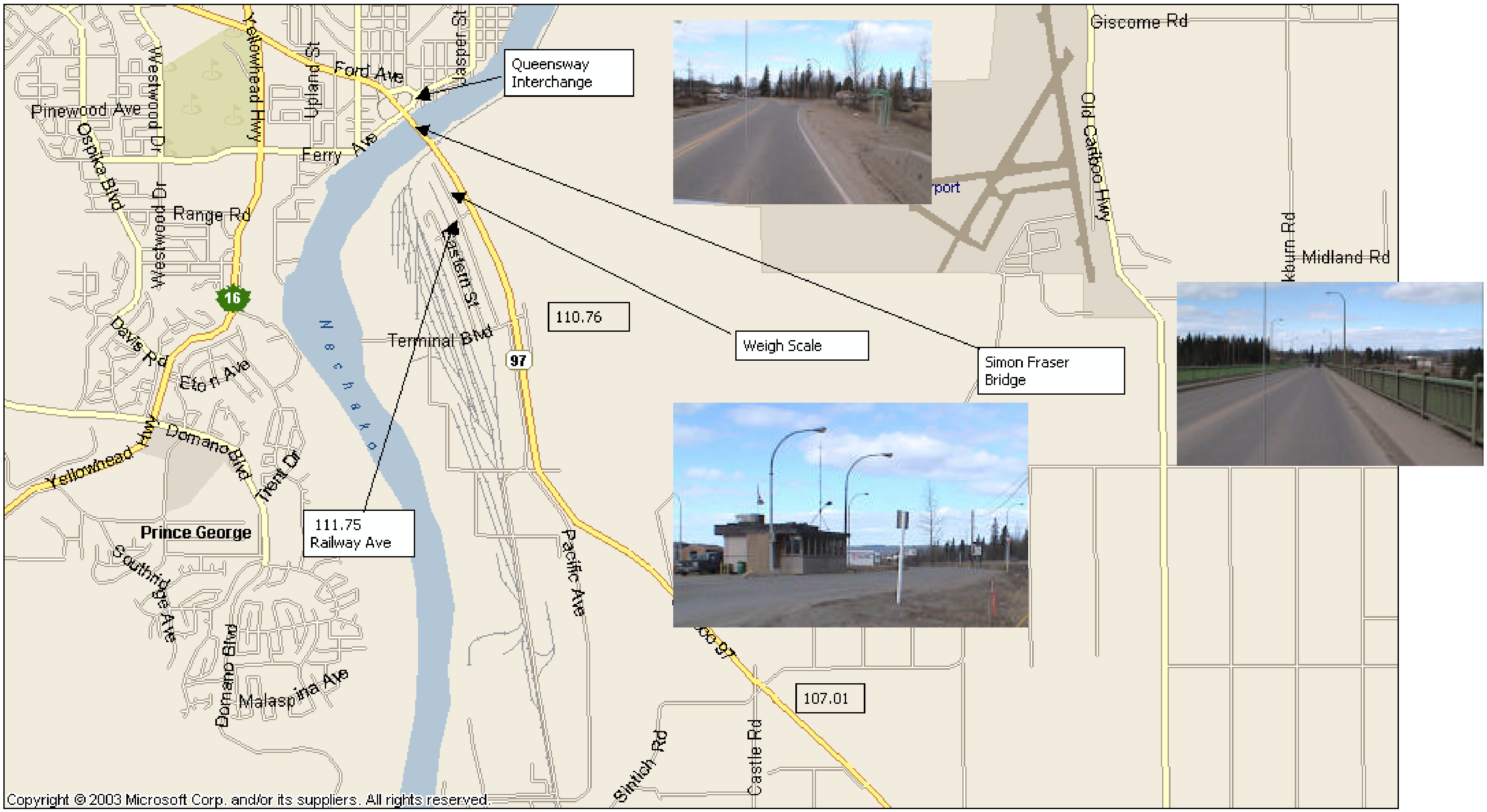
- Links the Highway 97 corridor to the proposed CN Rail Inland Container Terminal for consolidating backhaul container traffic to Asia adding about 200 trucks/day to current truck volume.
- Links the Lower Mainland to the Central Interior serving the Cariboo, North Central Interior, the North and Central Coast, and the Peace River area (three quarters of the land area of the Province).
- Is a major haul route for forest products to local mills and regionally to the Lower Mainland and US.
- Is the primary link from the Lower Mainland to oil and gas development in the northeast and to the developing deep water port at Prince Rupert.

Traffic volume over the 2-lane Simon Fraser Bridge is about 20,000 AADT with 1.5% annual growth. Traffic patterns are characterized by intermittent peaks during shift changes at mills located south of the bridge imposed over a background of commuter and regional/long distance traffic. The bridge is operating at capacity during these periods.

The bridge and interchange are an integral component of the "Cariboo Connector", an established Provincial strategy for a 4-lane highway form Cache Creek to Prince George. Consistent with this vision, the highway south of the bridge has a high priority for 4-laning. As other capacity bottlenecks are removed, this puts increasing pressure on the bridge if it is not also 4-laned.

The intention of the project is to reduce delay and improve safety consistent with traffic volumes in this section of the corridor.

Exhibit 1-1 General Location



2 Options Generation

Options considered for the bridge included:

- Widen the existing structure
- Replace the existing structure with a new 4-lane bridge
- Twin the existing structure with a new 2-lane bridge
- Rehabilitate the existing bridge

And the options considered for the interchange include:

- Partial cloverleaf - 40 km/hr ramps
- Partial cloverleaf - 50 km/hr ramps
- Tight diamond, Queensway underpasses Highway 97
- Tight diamond, Queensway overpasses Highway 97

The selected option is to twin the bridge. Previous planning studies have recommended twinning the Simon Fraser Bridge in order to increase capacity across the Fraser River and address intersection delay along Highway 97 on the south approach to the Bridge[1]. Twinning the bridge will allow Highway 97 to be widened to 4 lanes over a distance of nearly 6 km from the north side of the bridge at the Queensway Interchange to Sintich Road which is a major access to the Airport south of the bridge.

3 Project Description

The scope of work in this business case includes constructing a new 2-lane bridge parallel to the east of the existing bridge and tying back in to the existing Queensway interchange on the north side of the Fraser River. The existing bridge will require rehabilitation in the future but the scope of costs in this business case does not include the rehabilitation.

In the future when the existing bridge is closed for rehabilitation, traffic will continue to use the new bridge during the closure. If the twinning project does not proceed, the existing bridge will still have to be closed for rehabilitation but traffic will have to detour to the Old Cariboo Highway to the east and use the Yellowhead Bridge on Highway 16.

[1] "Prince George Transportation System Planning Study" Prepared by UMA Engineering Ltd for the Ministry of Transportation and Highways and the City of Prince George, May 2001

4 Multiple Account Evaluation

4.1 General Assumptions

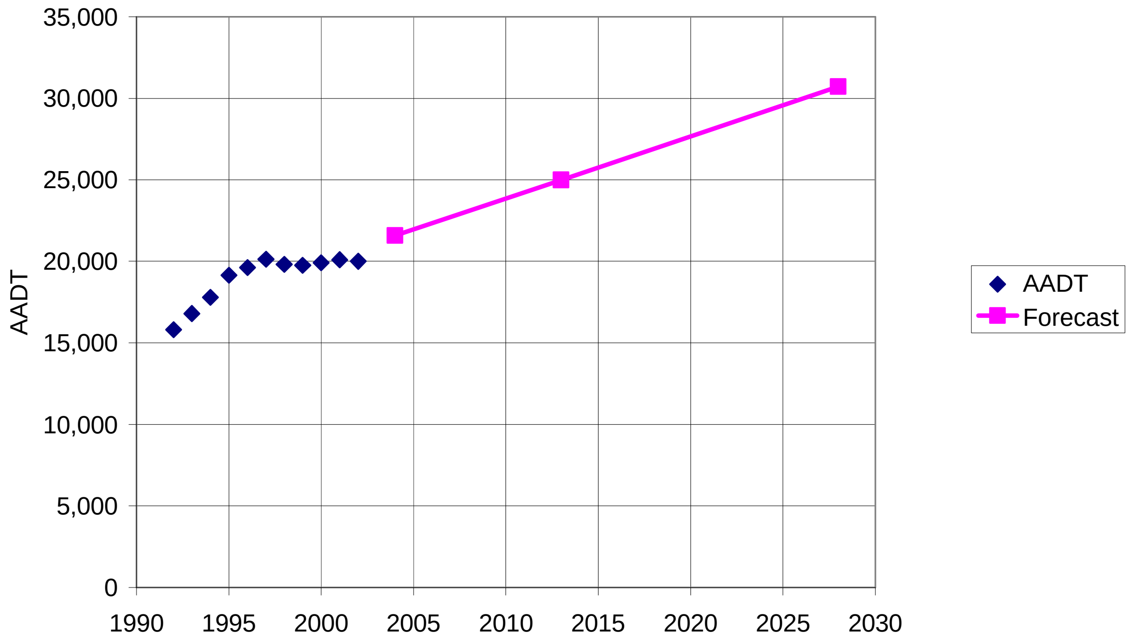
Incremental benefits and costs are calculated over a 25 year planning period and discounted at 10% to calculate the benefit cost ratio and net present value.
The analysis includes benefits to Highway 97 traffic between the south end of the bridge and the north end of the interchange.

The base case assumes no new bridge and traffic will have to detour if the old bridge is rehabilitated. The proposed case assumes the new bridge is built and no detour is necessary if the old bridge is rehabilitated. Exhibit 4-1 presents the general assumptions used for analysis and the traffic volume projections are presented in Exhibit 4-2.

Exhibit 4-1 Highway 97

	Base	Proposed
Segment 1150		
from LKI	111.92	
to LKI	113.24	
Length (km)	1.32	
Detour	1.8 km incremental	None
Est'd AADT 2006	22,329	
Est'd SADT 2006	22,776	
Counter	42-018	
Compound Growth Rate	1.5%	
Linear Growth Rate (veh/yr)	381	
% Trucks	10%	
Running Speed	70	80
Cross section	2 Ln undivided	4 Lane Divided
Lane width (m)	3.5	3.6
Shoulder Width (m)	0.5	2.0
Median (m)	none	2.4 m raised

Exhibit 4-2 Historical and Projected Traffic

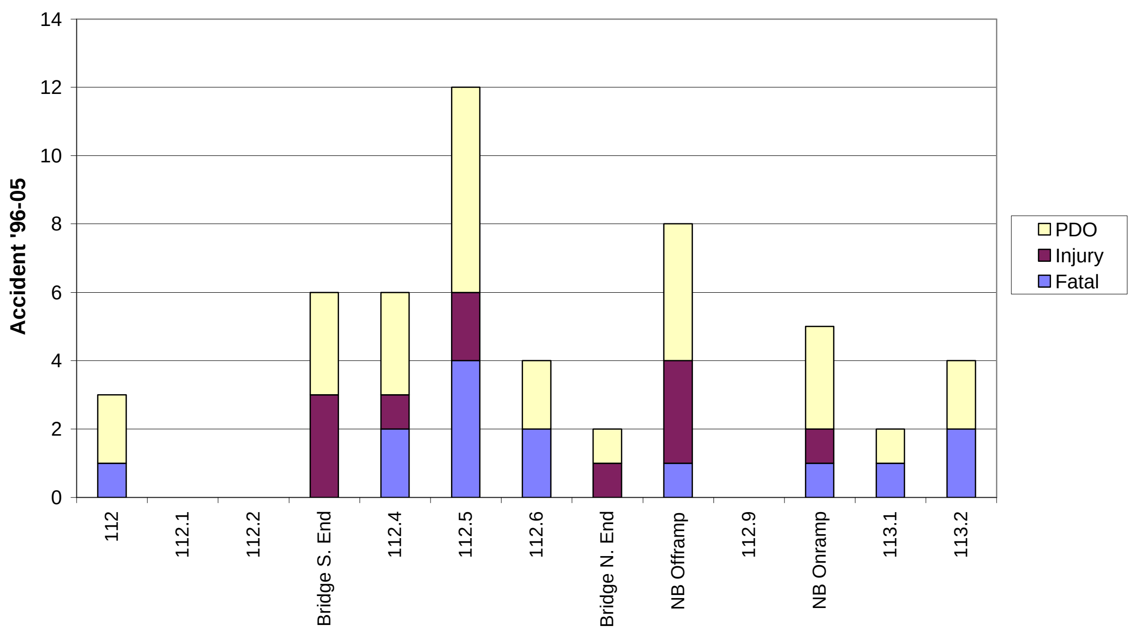


4.2 Customer Service Account

4.2.1 Safety

The accident analysis for Highway 97 uses data for 10 years from 1996 to 2005. During this period there were 27 accidents over the 1.32 km section from the south end of the bridge to the north end of the interchange. The estimated accident rate is 0.28 acc/mvk.

Exhibit 4-3 Accident Histogram 1996 - 2005



The new divided 4-lane potential accident reduction is estimated to reduce the accident rate to 0.13 acc/mvk with more generous shoulders, wider alignment and a median barrier. Median barriers generally increase the accident rate and decrease the severity as the barrier itself becomes a target. In this instance the existing lanes are already in close proximity to the barriers and the more generous lateral clearance in the proposed case should reduce the overall rate while the median barrier reduces the severity. The proposed case safety performance was estimated using typical Provincial accident reduction factors for each accident type when switching from 2 lane to 4 lane divided.

Exhibit 4-4 Highway 97 Safety Performance

Observed Base Case Accidents

RAU2 1996 to 2005

Segment	1150			
Start LKI (264th)	111.92			
Finish LKI (24th Av)	113.24			
Length (km)	1.32			
Average AADT1996-2005	20,208			
Years	10			
Exposure (mvk)	97.36			
	Fat	Inj	PDO	All
Number	2	14	11	27
Observed Rate (a/mvk)	0.021	0.14	0.11	0.28
Observed Severity	7.4%	51.9%	40.7%	100.0%
Prov. Avg. Severity RAU2	2.84%	49.5%	47.7%	100%

Accident Modification Factor Estimate

Accident Type	Observed	AMF	Predicted RAD4
Head on	3	0.186	0.56
Intersection 90	2	0.739	1.48
Off road left	3	0.360	1.08
Off road right	3	0.483	1.45
Other**	5	0.470	2.35
Rear end	10	0.500	5.00
Side swipe	1	0.489	0.49
Total Number	27		12.40
		Reduction	54%

Proposed Case Accidents

UAD4

	Fat	Inj	PDO	All
Rate (a/mvk)	0.001	0.063	0.063	0.13
Prov. Avg. Severity RAUD4	1.04%	49.7%	49.2%	100%

4.2.2 Mobility

With the exception of shift changes at the mills located south of the bridge, traffic moves across the bridge with minimal delay. During shift changes and peak periods, traffic queues begin to form at signalized intersections approaching the bridge and traffic on the bridge slows to 20 km/hr, which is characteristic of a road reaching capacity.

AADT over the bridge is about 20,000 veh/day with peak hour vehicles of 1,100 veh/hr, LOS 'E' and capacity of about 1,600 vehicles per hour. NB volume onto the bridge is effectively metered by the signals at Railway Avenue immediately south of the bridge with only one NB through lane. This constraint will be removed in the future as the 4-laning is extended south of the bridge to the airport. This puts increasing pressure on the bridge which is already operating at a volume to capacity ratio of 0.7. Beyond V/C=.8, traffic flow becomes unstable and small traffic disturbances will cause rapid queue formation and a tendency for the queues to persist in the absence of reserve capacity to dispel the queues. With the bridge twinned, effective capacity increases to over 6,000 veh/hr, which is adequate for the foreseeable future.

The assumptions used for analysis are presented in Exhibit 4-5.

Exhibit 4-5 Highway 97 Mobility Assumptions

	Existing 2-lane	Proposed 4-lane
	Km/hr	
Peak	20	70
Shoulder	60	70
Low	70	75
	% of Daily Traffic	
Peak	20%	20%
Shoulder	45%	45%
Low	35%	35%

4.3 Financial Account

The estimated cost for the new bridge is $42.5 million (2007 dollars) or $43.9 million current dollars when escalation is added in. Exhibit 4-6 presents the capital cost assumptions. The remaining costs after sunk costs are the relevant costs for analysis in the business case.

Exhibit 4-6 Project Costs (1997 Dollars)

Project Cost	
Property	$300,000
Engineering	$6,149,000
Construction	$36,081,000
Total	$42,530,000
Sunk Costs to Sep 07	$5,727,788
Remaining Costs Used for Analysis	
Property	$0
Engineering	$5,358,674
Construction	$31,443,538
Total	$36,802,212

Annual maintenance is based on $10,000/2-Ln-km and $14,000/4-Ln.km plus $7.30/sq.m.fpr the bridge. Salvage value assumes 60% of the value of initial construction remains in year 25 for the new bridge and 80% for other construction associated with bridge approaches etc.

4.4 Social/Community Account

This account is intended to identify external effects of highway projects on community and social values. Social, environmental and economic accounts are scored subjectively on a scale of -2 to +2 relative to the existing case as follows:

Scoring	Relative to Base Case
-2	Significantly worse
-1	Slightly Worse
0	Neutral
+1	Slightly Better
+2	Significantly better

Noise and Pollution Impacts –The second bridge does not impact noise levels significantly. There may be some changes in buffer zones with future ramp changes but these are not included at this stage. There are some minor greenhouse gas savings totaling 13 tonnes/yr. The overall impact is rated neutral (score 0).

Community Displacement - This is measured by the number and type of property takings associated with each option. The only residential property takings are associated with the interchange reconstruction which is excluded from this analysis. (score 0)

Barrier Effect - Constructing a new transportation right of way through an existing community can impact access to pedestrian or local vehicle traffic to major traffic generators and attractors in the community. In this case there is no change to the barrier effect of the existing interchange and bridge. Local vehicle traffic will generally benefit from improved access. The overall rating is neutral (0).

Community Acceptance and Consistency with Community Plans - This account measures the support from local stakeholders for the project or project options. The improvements are supported by the City of Prince George, industry and emergency response groups. The support generally relates to resolving the congestion at the bridge approaches. This account is rated (+2).

4.5 Environmental Account

This account is intended to identify impacts to the natural environment.

Fish and Fish Habitat - This is a major river crossing and environmental mitigation will be an integral part of the project. There is a policy of no net loss of fish habitat and it is assumed that major impacts will be mitigated as part of the project cost. The impact is rated neutral (score 0).

Wildlife - Impacts are minor since the project area lies within the City and is already developed. The project does not bisect new habitat area and existing habitat value is low. The rating is neutral (0).

Recreation and Archeological - No impacts have been identified. (0)

Agricultural Land Reserve - There is no ALR in the project area. (score 0)

Greenhouse Gas Reduction – There is a reduction of about 240 tonnes/yr, due to reduced congestion delay at the bridge plus a one time saving of about 4,170 tonnes by avoiding the excess fuel consumption associated with a detour while the existing bridge is closed for rehabilitation. The recurring reduction is:

Carbon Dioxide	208
Nitrogen Oxide	22
Hydrocarbons	11
Annual Saving (tonnes/yr)	240
Fuel Saving (L/yr)	87,257

4.6 Economic Account

The economic account is intended to identify net economic benefits to the Province beyond the direct benefits assessed to existing highway users (time, accident and vehicle operating cost savings). This may include economic development such as opening up access to new resources, industry or increased tourism access.

In this case, the bridge contributes to the overall “Cariboo Connector” vision for a 4-lane highway form Cache Creek to Prince George. It is likely the most important component of the vision since it alleviates congestion in the heaviest volume section of the corridor. There is little benefit to 4-laning Highway 97 south of the bridge if the bridge is not also twinned.

The Cariboo Connector supports both economic and Provincial equity goals for future economic diversification and development in Northern BC. Increasing harvests from pine beetle forest, oil and gas activity in the northeast, development of the deep water port at Prince Rupert and mining interests in the north all depend on and are stimulated by development of a reliable high speed road network. The bridge also connects the Highway 97 corridor to the proposed CN Rail inland container terminal in Prince George for consolidating container freight for the growing backhaul market to Asia.

5 Summary of Results

5.1 Multiple Account Evaluation

Exhibit 5-1 summarizes the results of the MAE using dollar values for the financial and customer service accounts and qualitative scores for the other accounts. No weights have been assigned to the scores.

The dollar values are the present value of stream of benefits or costs qualitative discounted at 10% per annum over a 25 year analysis period. The qualitative assessments of the Social, Environmental and Economic accounts are scored subjectively on a scale of -2 to +2 relative to the base case as follows:

Scoring	Relative to Base Case
-2	Significantly worse
-1	Slightly Worse
0	Neutral
+1	Slightly Better
+2	Significantly better

The benefit cost ratio is the ratio of direct benefits to highway users and direct costs to infrastructure providers. In this case the project returns a benefit cost ratio of 0.82 at a 10% discount. This is relatively good performance for bridge projects which are generally much more costly than an equivalent section of road. In this case, the twinning project generates an additional $4.5 million in benefits stemming from reduced time, accident and vehicle operating costs attributed to avoiding the need for traffic to detour when the existing bridge is eventually closed for rehabilitation.

The project returns excellent benefits, due to high traffic volume and the detour costs. The time savings derive from an increase in capacity over the bridge and the avoided detour. Accident savings derive from lower severity and rate associated with the wider divided 4-lane cross section and again the avoided exposure on the detour which is an incremental 1.8 km. Vehicle operating cost savings derive from reduced congestion fuel consumption are minor but the savings associated with the detour are about $2.4 million.

Exhibit 5-1 Multiple Account Evaluation Simon Fraser Bridge

QUANTITATIVE ACCOUNTS

FINANCIAL (25 yrs, 10% discount)			2007 Millions $
		Discounted Cost	$33.5
	+	Maintenance and Pvmt. Rehab.	$0.5
	-	Salvage	$2.0
	=	Present Value	$33.5
CUSTOMER SERVICE (present value)			2007 Millions $
		Time Savings	$15.5
		Vehicle Operating Cost Savings	$5.9
		Accident Savings	$4.8
		Present Value	$26.3
		Benefit/Cost Ratio	**0.82**
		Net Present Value	($5.6)

QUALITATIVE ACCOUNTS

SOCIAL/COMMUNITY		
	Noise and Pollution	0
	Displacement	0
	Barrier Effect	0
	Community Support	2
ENVIRONMENTAL		
	Fish and Fish Habitat	0
	Wildlife	0
	Agricultural Land Reserve	0
	Recreation	0
	Archeological	0
	Greenhouse Gas Reduction	
	Annual Saving (tonnes/yr)	240
	One Time Saving (tonnes)	4,170
	Fuel Saving (L/yr)	87,257
ECONOMIC		
	Provincial/National	2

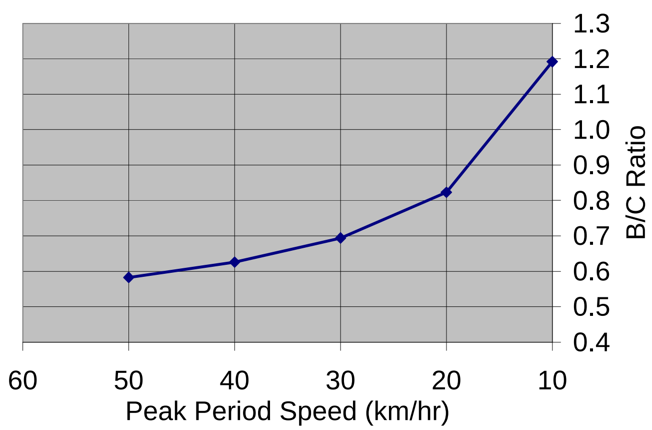
5.2 Risks/Sensitivity Analysis

The sensitivity analysis is intended to show the impact of alternative project assumptions on direct benefits and costs as measured by the Net Present Value. In this case, the Net Present Value is positive at the Provincially accepted 6% discount rate.

Exhibit 5-2 Sensitivity Analysis

Baseline NPV 10% Discount	6% Discount Rate	8% Discount Rate	+10% Construction Cost	+25% Construction Cost	Traffic Growth 2.0%	Traffic Growth 1.0%
Net Present Value (millions $)						
-5.6	6.1	-0.6	-9.3	-14.8	-4.5	-6.7
B/C Ratio						
0.8	1.2	1.0	0.7	0.5	0.9	0.8

The results are also sensitive to the amount of congestion at the bridge. The baseline assumption is a peak period capturing 20% of daily traffic. If this were 40% the B/C ratio = 1.24 instead of 0.8.



There is also some sensitivity to the assumed peak period speed on the bridge. This chart shows how the B/C ratio varies with speed assumptions.

6 Project Implementation

The scope of the current project includes building a new 2 lane bridge parallel to the existing bridge:

Functional Design	Complete
Bridge Detailed Design	January 2007- July 2007
Bridge Construction	October 2007 – September 2009

7 Advancement of Federal and Provincial Transportation Strategies

Federal Strategy	***Simon Fraser Bridge***
• Asia Pacific Gateway and Corridor Initiative	• The Simon Fraser Bridge Twinning Project is a critical link in the Asia Pacific Gateway Strategy. • Connects lumber manufacturing facilities to CN's Inland Container Terminal, Highway 16 and the Port of Prince Rupert
• Building Canada Fund	• Improvement to the core national highway system • Helps ensure goods get to market quickly and seamlessly.
• Greenhouse Gas Reduction (tonnes/yr)	• Annual saving of 240 tonnes/yr • One time saving of 4,000 tonnes due to avoided detour
• Pine Beetle Initiatives	• Prince George is in the heart of pine beetle Impacted forests and is a center for forest products mills

In the Provincial context, this project is consistent with the vision for the 4-lane Cariboo Connector from Cache Creek to Prince George. It also addresses one of the highest volume locations on the corridor. Linkages to Provincial Plans include:

Provincial Strategy	***Simon Fraser Bridge***
• Cariboo Connector	• Lies within the Cariboo Connector and supports this vision • Highest priority project in the program
• Mountain Pine Beetle Strategy - Includes $90 million for rehabilitation of highways impacted by increased logging traffic carrying beetle-killed timber	• Highway 97 between Prince George and Cache Creek is heavily impacted by Pine Beetle forest products traffic. Many of the major mills are located in and around Prince George. • Connects lumber manufacturing facilities to CN's Inland Container Terminal, Highway 16 and the Port of Prince Rupert
• Safety	• Saves about 2 accidents/yr
• Mobility	• Removes a system choke point.

8 Conclusions and Recommendations

From the network perspective, the bridge addresses congestion in the highest volume section of the Cariboo Connector. There is little reliability or congestion benefit to 4-Laning Highway 97 south of the bridge if the bridge is not also twinned. This should be one of the first projects in the Cariboo Connector plan.

The project returns excellent benefits due primarily to the high traffic volume coupled with congestion relief and accident reduction. At a 10% discount rate, the project returns a B/C ratio of 0.82 and NPV = -$5.6 million. This is better than typical bridge projects which are always capital intensive compared to other highway projects. At the Provincially accepted 6% discount rate, B/C = 1.2.

Other social and economic considerations support the project. Highway 97 is the major north/south trade route through British Columbia and links the US, Interior and Northern BC to the Yukon and Alaska. It supports growth in mining, oil and gas, forest industry activity related to pine beetle kill, development of the Port of Prince Rupert and encourages economic diversification in the north.

The safety performance suggests a potential 55% reduction in accidents in the corridor as well as a reduction in severity due to the wider cross section and median barrier. This is a total reduction of about 2 accidents per year and a reduction of 1 fatal accident every 5 years.

In summary the Simon Fraser Bridge Project is a key piece of Asia Pacific Gateway Transportation Infrastructure needed to fully realize the potential of the Port of Prince Rupert Expansion and the Intermodal Container Terminal in Prince George. In addition, it will also support diversification of the northern economy which is critical to mitigate the long term impacts of the Mountain Pine Beetle epidemic.