Multiple Account Evaluation

Region of Waterloo

Rapid Transit Environmental Assessment

Prepared for the Region of Waterloo

1 June 2009

Executive Summary

This executive summary provides an overview of a Multiple Account Evaluation (MAE) of the proposed Rapid Transit (RT) initiative in Waterloo Region.

This study was completed as part of Phase 2 of the Rapid Transit Environmental Assessment, which began in July 2006. The study area for the environmental assessment is the Central Transit Corridor, as designated in the Regional Growth Management Strategy (RGMS), consisting of a continuous section of the urbanized areas of Waterloo and Kitchener centred on King Street, and on two key corridors in Cambridge, (Coronation Boulevard and Hespeler Road). The purpose of Phase 2 of the EA was to evaluate rapid transit system alternatives to enable the selection of a Preferred Rapid Transit System that best meets the goals set out in the RGMS.

The purpose of a MAE is to provide a broad-based assessment of a potential project or projects, to understand their costs and benefits. However, unlike traditional cost-benefit analysis, MAE is a more flexible framework capable of considering non-monetary and/or qualitative measures of benefits. This produces several advantages over traditional cost-benefit analysis. In addition to allowing the consideration of factors that could not be considered in a traditional analysis; the structuring of metrics into a series of separate accounts allows for a relative assessment of the project's impacts on different aspects of the economy and society. Through the use of a more flexible evaluation framework, MAE provides decision-makers with a broader representation of the project's benefits.

This MAE is being conducted to provide an assessment of the economic costs and benefits of several project scenarios for the Region of Waterloo Rapid Transit Initiative. The scenarios are:

- **Light Rail Transit Scenario 1 (LRT Spurline)** – LRT on the rail spur in north Waterloo, then via King Street, Courtland Avenue, the CPR line, and Hespeler Road;
- **Light Rail Transit Scenario 2 (LRT King Street)** – LRT on King Street in north Waterloo, west on University Avenue to the University of Waterloo, then via the rail spur, King Street, Courtland Avenue, the CPR line, and Hespeler Road;
- **Bus Rapid Transit Scenario 1 (BRT Spurline)** – BRT on the rail spur in north Waterloo, then via King Street, Courtland Avenue, Highway 8/Highway 401, and Hespeler Road;
- **Bus Rapid Transit Scenario 2 (BRT King Street)** – BRT on King Street in north Waterloo, west on University Avenue to the University of Waterloo, then via the rail spur, King Street, Courtland Avenue, Highway 8/Highway 401, and Hespeler Road.

The Study team also evaluated the following staging scenarios:

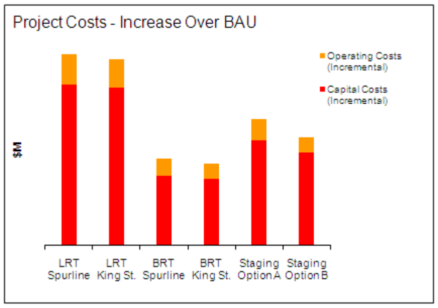
- **Staging Option A** – A mixture of LRT and BRT Spurline options – LRT from Conestoga Mall to Fairview Mall, BRT from Fairview Park Mall to downtown Cambridge.
- **Staging Option B** – LRT in the north portion, and adapted BRT constructed in the south portion of the corridor (from Fairview Park Mall to downtown Cambridge). Adapted BRT could include:
    a. Operational improvements: bus by-pass shoulders, queue jumping, signal priority, additional stations, RT buses, automated ticketing, and real-time passenger information systems.
    b. Urban design improvements at stations – Streetscape, bicycle and pedestrian amenities, connections to intercity transit.

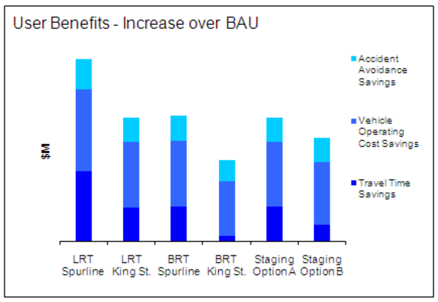
Methodology

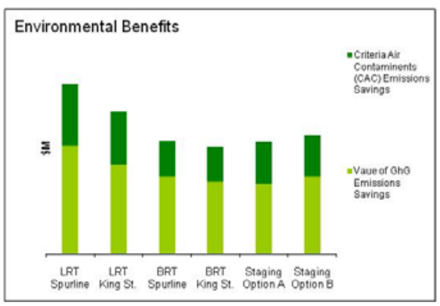
The scope of the MAE is structured into five accounts, which bring together the social and economic impacts projected for the various rapid transit project scenarios. The five accounts are described as follows:

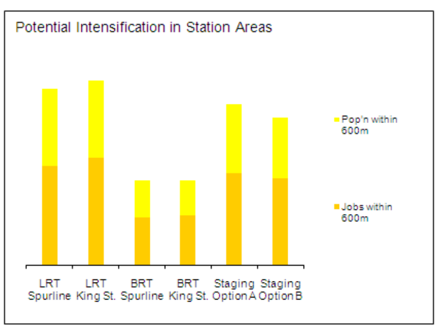
- ***Direct Project and Transportation Account*** – which examines capital and operating costs directly related to the project and the related transportation infrastructure;
- ***Direct Transportation User Benefits Account*** – which reviews the benefits in terms of travel time and vehicle cost savings;
- ***Environmental Account*** – which assesses the environmental impact of the rapid transit project in terms of greenhouse gases (GHGs) and criteria air contaminant (CAC) emissions;
- ***Land Use Economic Development Account*** – which evaluates the degree to which the project supports the land use objectives of the Regional Growth Management Strategy, as well as economic development impacts and land value uplift benefits;
- ***Social and Community Benefits Account*** – which takes into account the benefits in terms of public health and community liveability.

The conduct of the MAE is based on consolidating both quantitative and qualitative data from various sources to provide an overall assessment of the project. The data sources, inputs, and assumptions used in the MAE are summarized in Chapter 2 of this report, and are detailed in the Appendices.









Key Findings and Conclusions

The following are the key findings and conclusions from the MAE of the Rapid Transit Initiative in Waterloo.

First, the MAE clearly indicates the "Spurline" route options are superior to the "King Street" route options. Although there are a few metrics where the King Street routes perform as well or slightly better than the Spurline routes, this option consistently scores lower than the Spurline routes in most accounts.

Overall, in terms of benefits per dollar spent, BRT Spurline is the best value for money *if considering monetary benefits only*. However, the LRT Spurline option returns the highest overall benefits, although it comes at the highest cost. Although BRT has a higher return per dollar spent in terms of user benefits, it does not perform as well in land use metrics. A key aspect of this project is the ability to shape land use through a transportation solution that meets growth management objectives. As a result, when comparing the LRT and BRT options, LRT on the Spurline route is the preferred alternative.

When considering all the accounts and their metrics, Staging Option B represents a good balance of costs vs. benefits, especially if BRT in the south end of the corridor is implemented through transit priority measures and not on an entirely segregated right-of-way. Staging Option B provides a slightly lower level of transportation user benefits than the BRT options and the LRT King Street Option.

However, the non-monetary accounts and metrics within the MAE indicate several reasons why the Staging Options have additional benefits. The anticipated land use benefits of the Staging Options are considerably higher than the BRT, as these options introduce LRT technology into the section of the corridor with the greater potential for intensification. Higher ridership associated with the Staging Options will result in similar environmental benefits and community benefits such as air quality improvements, in comparison to a BRT option. Finally, the Staging Options have considerably greater flexibility in terms of the implementation of the right level of transit service required to meet demand. This is inherently more economically efficient than an option that, by adopting one rapid transit technology from north Waterloo through to downtown Cambridge, would provide too much transit capacity relative to demand in part of the corridor.

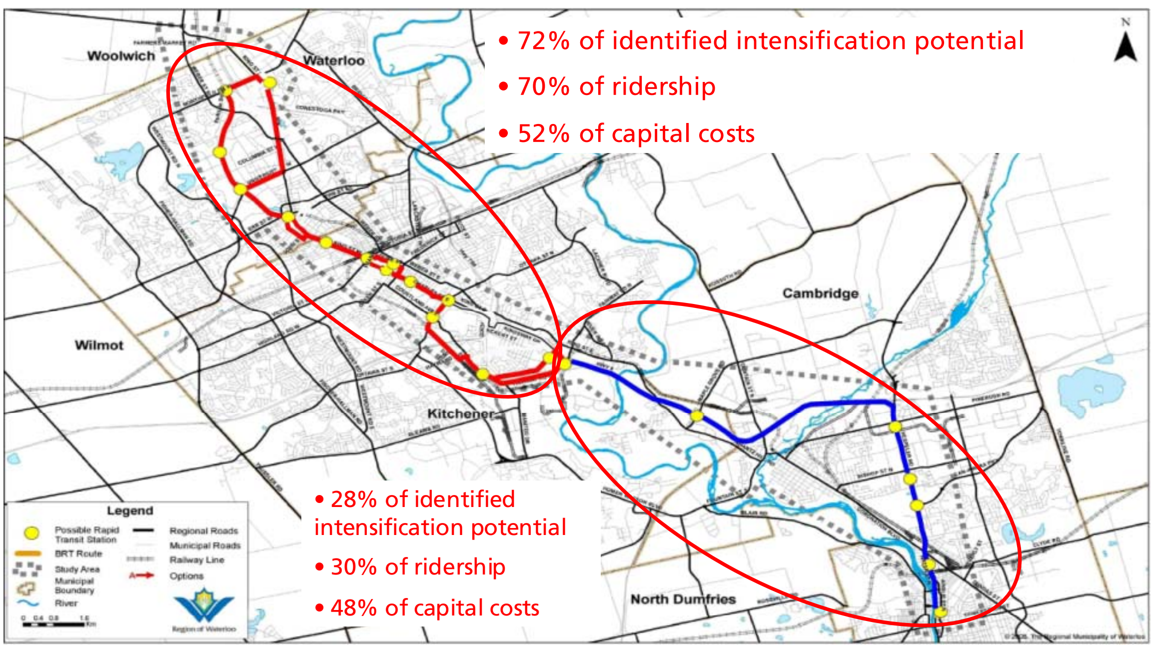
The MAE framework was designed to reflect the goals of the Regional Growth Management Strategy (RGMS). Considering all accounts, a Staging Option provides the most flexible way to "right size" rapid transit service for this diverse Study Area. Staging should be more economically efficient by providing capacity where and when transportation demand requires it.

Staging Option B presents the additional benefit of creating a potential "quick start" to rapid transit in Cambridge, through implementing transit priority measures, which will allow the benefits of RT to be experienced sooner. It also makes later implementation of LRT in Cambridge less expensive and less disruptive than conversion from an existing BRT on a segregated corridor.

The primary reasons for the Staging Option B scenario to be the preferred option can be summed up as follows:

- The majority (70% or more) of the ridership occurs north of Fairview Park Mall, in the north part of the corridor;
- The cost to build LRT to the south end of the corridor from Fairview nearly doubles the cost of the project;
- A BRT system in the north may experience operational problems before 2031, due to demand reaching or exceeding capacity on a bus-based system, and increasing road congestion in the CTC, which will affect busway speed;

In terms of the goals of the RGMS and the framework for the MAE analysis, Staging Option B achieves many of the objectives nearly as well as LRT Spurline, at roughly half the project cost.



Scope and Limitation

The inputs and assumptions used are provided to MKI from various sources, and MKI has not independently audited or verified these data prior to using them in the MAE. All the data used in the MAE were collected between October 2008 and May, 2009, from the sources cited. MKI reserves the right to update or modify this report in the event that more accurate or up-to-date data become available.

Table of Contents

1. Introduction 8

1.1 Multiple Account Evaluation 8

1.1.1 Purpose and Objectives 8
1.1.2 Accounts 8
1.1.3 Sources of Input 9

1.2 Project Scenarios 9

1.3 Purpose and Structure of Report 10

2 Scope and Methodology 12

2.1 Scope and Limitations 12

2.2 Approach 12

2.2.1 Develop the MAE Framework 12
2.2.2 The MAE Model 14
2.2.3 The Business As Usual Scenario 15

2.3 Methodology and Assumptions 16

2.3.1 Direct Project and Transportation Account 16
2.3.2 Direct Transportation User Benefits Account 17
2.3.3 Environmental Account 18
2.3.4 Land Use Economic Development Account 19
2.3.5 Social and Community Benefits Account 21

2.4 General Inputs 22

2.4.1 Basic Economic Variables 22
2.4.2 Value of Time 22

3 Key Findings 23

3.1 Direct Project and Transportation Account 23

3.2 Direct Transportation User Benefits Account 24

3.3 Environmental Account 25

3.4 Land Use Economic Development Account 26

3.5 Social and Community Benefits Account 28

3.6 Summary of Results 29

3.7 Staging Scenarios 30

3.7.1 Project Costs 31
3.7.2 Direct Transportation User Benefits 32
3.7.3 Environmental Benefits 32
3.7.4 Land Use/Economic Development Account 33
3.7.5 Social and Community Benefit Account 33

4 Conclusions 34

4.1 Scenario Comparison – Monetized Benefits 34

4.2 Scenario Comparison – Relative Benefits 36

4.3 Summary of Conclusions 37

Appendix A – Transportation Modelling, Ridership Forecasts, and Consumer Surplus (Halcrow Ltd.) 40

Appendix B – Capital and Operating Cost Estimates 41

Appendix C – Data Sources, Inputs, and Assumptions 45

C.1 General Assumptions 46

C.2 Ridership and Traffic Projections 47

4.3.1 C.2.1 Ridership Projections 47
4.3.2 C.2.2 Traffic Projections 47

C.3 Direct Project and Transportation Account: 47

4.3.3 C.3.1 Capital Costs 47
4.3.4 C.3.2 Operating and Maintenance Costs. 47
4.3.5 C.3.3 Operating Revenues 48
4.3.6 C.3.4 Net Operating Costs 48

C.4 Direct Transportation User Benefits Account 48

4.3.7 C.4.1 Travel Time 48
4.3.8 C.4.2 Vehicle Operating Costs 48
4.3.9 C.4.3 Accident Costs 48
4.3.10 C.5 Environmental Costs 49
4.3.11 C.5.1 Green House Gas Emissions 49
4.3.12 C.5.2 Critical Air Contaminants 49

C.6 Land Use/Economic Development Account 50

4.3.13 C.6.1 Residential and Employment Estimates – PLUM Modelling 50
4.3.14 C.6.2 Land Value Uplift 53
4.3.15 C.6.3 Support to Regional Land Use Objectives 54
4.3.16 C.6.4 Employment Generated 54
4.3.17 C.6.5 Taxes Generated 55

C.7 Social and Community Benefit Account 55

4.3.18 C.7.1 Public Health Benefits – Hospital Admissions 55
4.3.19 C.7.2 Public Health Benefits – Economic Damage 56
4.3.20 C.7.3 Public Health – Active Transportation 56
4.3.21 C.7.4 Community Livability 57
4.3.22 C.7.5 Construction Disruption 57

Appendix D – TREIM Model Runs 58

1. Introduction

The Region of Waterloo Rapid Transit Initiative is a central element of the Region's Growth Management Strategy. The Rapid Transit Project is currently in the latter stages of an Environmental Assessment (EA), a broad planning process that progressively develops route and technology alternatives for the proposed transit facility, evaluates their relative impacts and benefits, and establishes a preferred alternative.

As part of Phase 2, Step 3 of the EA, Metropolitan Knowledge International (MKI) was retained to undertake a multiple account evaluation (MAE) of the rapid transit project scenarios. The purpose of the MAE is to provide decision-makers with a wide-ranging assessment of the benefits and life-cycle costs of each of the project scenarios. This report provides an overview of the scenarios currently contemplated for the project, describes the methodology used for the MAE, and presents the findings and conclusions of the MAE.

1.1 Multiple Account Evaluation

Purpose and Objectives

Assessing the economic benefits of transit projects can be conducted using a number of methodologies. The approach proposed for this project is Multiple Account Evaluation (MAE). MAE evaluates benefits within a series of separate accounts using a broader range of costs and benefits or metrics. It could be considered a variant of traditional cost-benefit analysis and the "triple bottom line" evaluation approach (environmental/economic/social) commonly used in many land use and transportation studies.

MAE is seen as a more flexible approach that develops quantitative measures of economic benefit but does not restrict these measures to only calculations of dollar figures – some accounts are evaluated using other metrics. While this approach does not allow all benefits to be expressed in dollar terms for each alternative, it has the strength of being able to consider certain benefits that are difficult to translate into dollars, in addition to those quantifiable through cost-benefit analysis. Land use impacts can be one such benefit stream.

This produces several advantages over traditional cost-benefit analysis. In addition to allowing the consideration of factors that could not be considered in a traditional analysis, as benefits are calculated using a series of separate accounts, the MAE approach allows for a relative assessment of the project's impacts on different aspects of the economy and society. Through the use of a broad evaluation framework, it provides decision-makers with a more comprehensive representation of the project's benefits.

Accounts

The purpose of the MAE is to prepare an assessment of the transit project using a series of different categories (called "accounts") that include related types of economic benefits. The five accounts are as follows:

- **Direct Project and Transportation Account** – which examines both capital and operating costs directly related to the project and the related transportation infrastructure.
- **Direct Transportation User Benefits Account** – which reviews the benefits expected from the various options of the rapid transit projects (e.g., travel time and parking cost).
- **Environmental Account** – which assesses the environmental benefits of the rapid transit project in terms of greenhouse gases (GHGs) and critical air contaminant (CAC) emissions.
- **Land Use Economic Development Account** – which considers the benefits in employment and land value uplift that may be generated from the rapid transit project.
- **Social and Community Benefits Account** – which takes into account the benefits in terms of public health and community liveability as a result of the rapid transit project.

Within each account are a series of metrics measuring benefits of the project options within each account. Section 2 describes the accounts and metrics in more detail.

Sources of Input

The MAE draws upon inputs from a wide range of sources to develop the various metrics, including several independent modelling exercises. A transportation planning modelling exercise was conducted by Halcrow Ltd, the output of which appears in Appendix A of this report. Capital and operating costs for the MAE scenarios were prepared by Hatch Mott McDonald, and are included in this report as Appendix B. Additional details concerning individual inputs and assumptions are outlined further in Section 2 of this report, and documented in the Appendices.

1.2 Project Scenarios

Scenarios for evaluation were established through public consultation in June, 2008 and project team meetings in July and August of 2008. Four rapid transit system scenarios were initially evaluated through the MAE.

- **Light Rail Transit Scenario 1 (LRT Spurline)** – LRT on the rail spur in north Waterloo, then via King Street, Courtland Avenue, the CPR line, and Hespeler Road;
- **Light Rail Transit Scenario 2 (LRT King Street)** – LRT on King Street in north Waterloo, west on University Avenue to the University of Waterloo, then via the rail spur, King Street, Courtland Avenue, the CPR line, and Hespeler Road;
- **Bus Rapid Transit Scenario 1 (BRT Spurline)** – BRT on the rail spur in north Waterloo, then via King Street, Courtland Avenue, Highway 8/Highway 401, and Hespeler Road;

- **Bus Rapid Transit Scenario 2 (BRT King Street)** – BRT on King Street in north Waterloo, west on University Avenue to the University of Waterloo, then via the rail spur, King Street, Courtland Avenue, Highway 8/Highway 401, and Hespeler Road;

Additional evaluation was also conducted for two scenarios that considered Staging options for implementing RT in the corridor. This analysis looked at implementing different rapid transit technologies in different parts of the corridor to best match RT technology to the forecasted ridership demand.

All the project scenarios were evaluated against a baseline, called the "Business As Usual" or BAU case. The BAU assumes a gradual expansion of the existing iXpress service over time, through increased service frequency in the corridor. Costs and benefits associated with this scenario were identified to establish a point of comparison for each of the project scenarios. A brief description of the BAU is outlined in Section 2, with details of all assumptions and calculations for the BAU case provided in the Appendices.

A map showing the route scenarios is shown on the next page.

1.3 Purpose and Structure of Report

This Report presents the key findings and conclusions on the MAE. It summarizes the data analysis from the various inputs and assumptions completed for this MAE. The remainder of the Report is structured as follows:

- Chapter 2 – Scope and Methodology
- Chapter 3 – Key Findings
- Chapter 4 – Conclusions
- Appendix A – Description of Transportation Modelling, Assumptions, and Results (prepared by Halcrow Ltd.)
- Appendix B – Cost estimates and associated notes (prepared by Hatch Mott McDonald)
- Appendix C – Consumer Surplus Estimates
- Appendix D - List of Inputs and Assumptions
- Appendix E – TREIM Model Runs

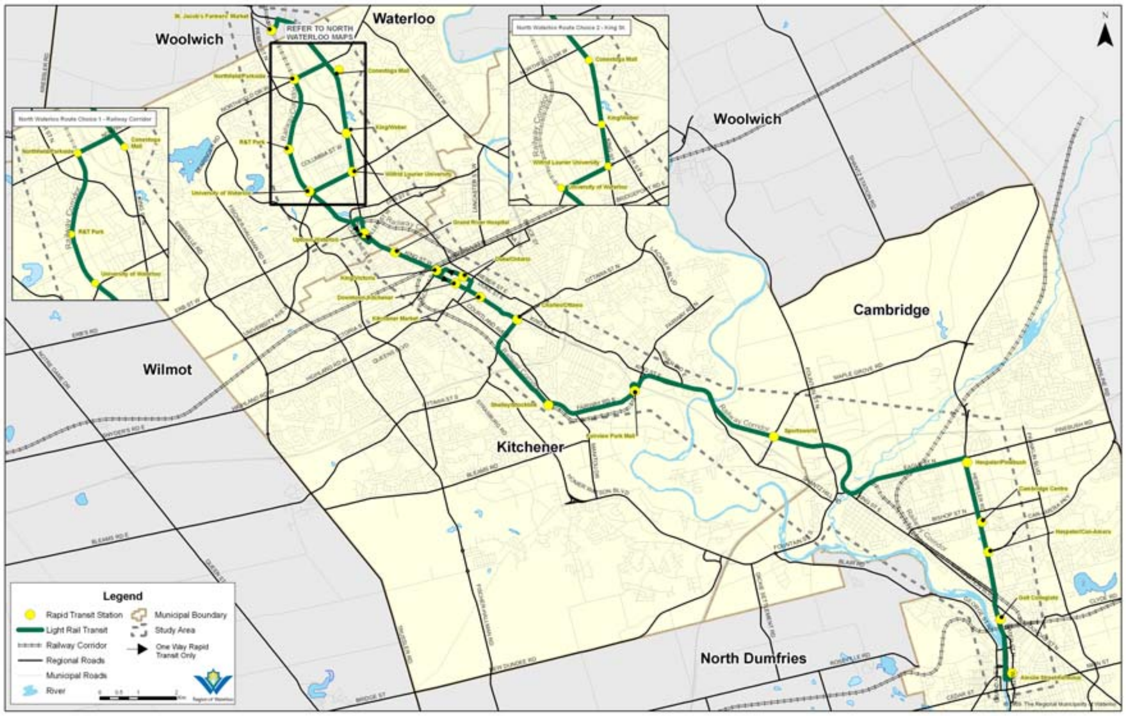


Figure 1: LRT Routing Options

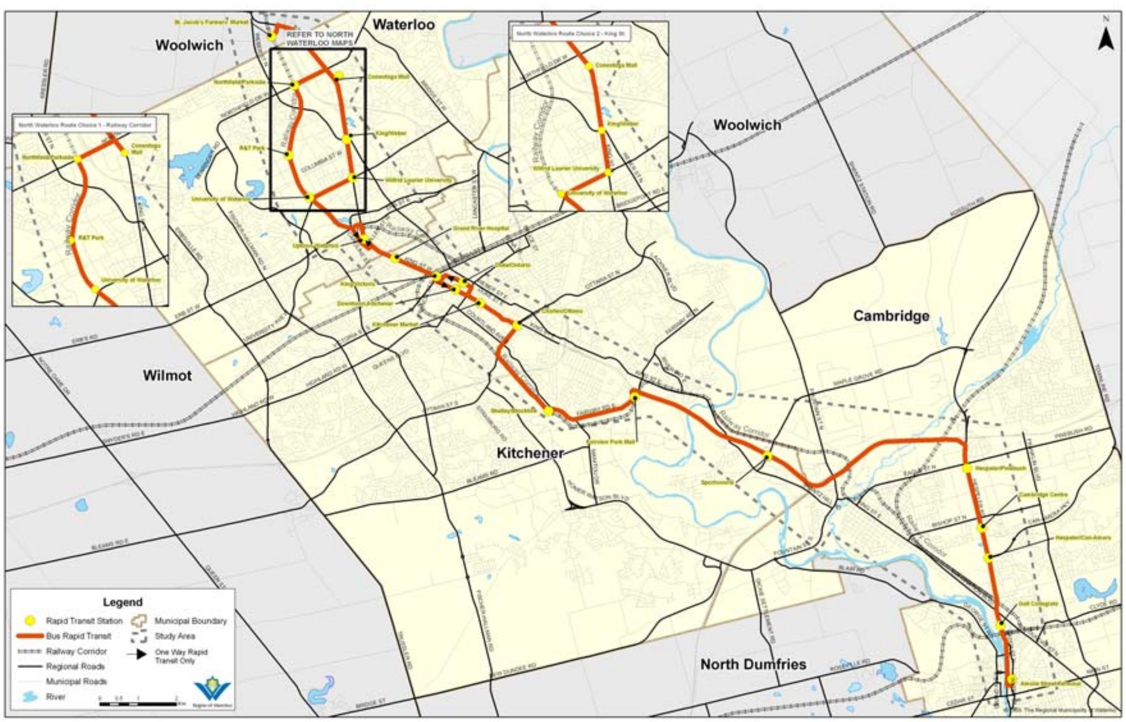


Figure 2: BRT Routing Options

2 Scope and Methodology

This chapter describes the scope of the multiple account evaluation and the methodology undertaken to complete the work.

2.1 Scope and Limitations

The conduct of the MAE is based on consolidating both quantitative and qualitative data from various sources to provide an overall assessment of the project. The inputs and assumptions used are provided to MKI from various sources, and MKI has not independently audited or verified these data prior to using them in the MAE. All the data used in the MAE were collected between July 2008 and April 2009. MKI reserves the right to update or modify this report in the event that more accurate or up-to-date data become available.

2.2 Approach

There were four broad steps to complete the MAE evaluation.

- Develop the MAE framework (June/July 2008)
- Prepare MAE model (July-Sept 2008)
- Prepare MAE Inputs including Transportation and Cost Modelling (August-December 2008)
- Conduct MAE Analysis and Report (December 2008-May 2009)

The MAE was designed to reflect the goals of the Regional Growth Management Strategy, with specific metrics within each account that can be related back to the objectives of the RGMS. Through MAE, a broad range of potential benefits can be considered, including quantitative (monetary and non-monetary), as well as qualitative metrics. The MAE framework is described below.

Develop the MAE Framework

An MAE framework is the list of accounts and the proposed metrics within the accounts. MKI developed a draft MAE framework in consultation with Regional staff and the Project Team during the summer of 2008. The framework is intended to directly reflect the project goals and the goals of the Regional Growth Management Strategy (RGMS).

The table on the next page outlines the metrics within each account. Note that the metrics are a mix of monetary and non-monetary quantitative metrics, and qualitative metrics.

Region of Waterloo Rapid Transit Environmental Assessment Multiple Account Evaluation Framework

Account	Metric	Unit
Direct Project and Transportation Account		
	Capital Costs	$ (Total, NPV)
	Operating/Maintenance Costs	$ (Annual, NPV)
	Summary Metric: NPV of Cash Flows - Costs	**NPV $**
	Additional Metric - Net Operating Costs	$ per ride
	Additional Metric - Operating Revenues (Fares, Parking)	$ (Annual, NPV)
Direct Transportation User Benefits Account		
	Travel Time Savings	Minutes, $ (Annual, NPV)
	Vehicle Operating Cost Savings	$ (Annual, NPV)
	Accident Avoidance Savings	Fatal/Injury/Property, $ (Annual, NPV)
	Parking Cost Savings	$ (Annual, NPV)
	Summary Metric: NPV of Annual Benefits	**NPV $**
	Additional Metric - Consumer Cost per passenger km	$/pass. km
	Additional Metric - Increased transportation choice	qualitative
Environmental Account		
	GhG Emissions	Tonnes/Year, $, (NPV)
	Critical Air Contaminents (CAC) Emissions	Tonnes/Year, $ (NPV)
	Summary Metric: NPV of Annual Benefits	**NPV $**
Land Use/Economic Development Account		
	Residential Development	Units within 600m
	Non-Residential Development	SF within 600m
	Support to Regional Land Use Objectives	Qualitative
	Employment Generated	Direct, Indirect, Imputed jobs
	Land Value Uplift	$ Premium on property values
	Taxes Generated	$ (Annual, NPV)
Social and Community Benefit Account		
	Public Health Benefits - Air Quality	hospital admissions, $
	Public Health Benefits - Active Transportation	qualitative
	Basic Access - Low Income Mobility Benefits	# of low income riders
	Community Liveability	qualitative - noise, fumes, walkability
	Construction Disruption	qualitative

The table on the next page relates each of the RGMS goals to the metrics in the framework.

Foster a Strong Economy	Enhance our Environment
Capital Costs	GhG Emissions
Operating Costs	Critical Air Contaminents (CAC) Emissions
Operating Revenues (Fares, Parking)	Public Health Benefits - Air Quality
Travel Time Savings	Public Health Benefits - Active Transportation
Vehicle Operating Cost Savings	Residential Development
Accident Avoidance Savings	Non-Residential Development
Parking Cost Savings	Support to Regional Land Use Objectives
Employment Generated	
Taxes Generated	
Construction Disruption	

Protect Countryside	Build Vibrant Urban Places
Residential Development	Residential Development
Non-Residential Development	Non-Residential Development
Support to Regional Land Use Objectives	Support to Regional Land Use Objectives
	Community Liveability
	Land Value Uplift

Provide Greater Transportation Choice
Ridership
Consumer Cost per passenger km
Increased transportation choice
Public Health Benefits - Active Transportation

The MAE Model

MKI's MAE model is based on a series of linked spreadsheets referencing both common inputs and metric-specific inputs. For monetary metrics, it is designed to take forecasts for key inputs from a single point in time, or multiple points in time, and extrapolate a 30-year cash flow for the metric. The model escalates inputs using a constant escalation rate to reflect increases in prices over time.

Three independent modelling exercises generated key inputs to the MAE.

First, land use modelling was conducted by the Region of Waterloo, with inputs from MKI, to establish the distribution of population and employment in the Region with the presence of higher order transit. A very detailled land use analysis exercise was conducted in conjunction with staff from the area municipalities to assess the potential for redevelopment (intensification) of lands within the corridor, focussing on the areas around proposed station locations. This exercise generated estimates of future development within seven categories of non-residential development, and five categories of residential development, as inputs to the Region's Population and Land Use Model (PLUM), for various route and technology alternatives. The PLUM model is a detailed forecasting tool that provides housing by type, and employment by industry type, at varying levels of geography, for the entire Region of Waterloo. The model's output was used for several of the land use metrics in the MAE, as well as input to the Transportation Modelling conducted by Halcrow Ltd.

The Transportation Modelling was the second exercise, and was used to generate forecasts of travel patterns for each of the proposed project scenarios. The output of the transportation model includes consumer surplus estimates associated with travel time savings (an MAE metric), as well as several other key MAE inputs including vehicle kilometres travelled (VKT) for automobile travel, emissions, travel times, and ridership (boardings) by station. These inputs are

the basis for a number of the MAE metrics in several different accounts. Outputs from the transportation model are incorporated in the Appendix, including the daily ridership and total vehicle kilometres travelled (Region-wide) for each scenario.

The travel forecasting model used a single, consistent land use scenario as an input. The land use scenario used assumed the highest intensification within the Central Transit Corridor over the forecast period, consistent with the Growth Management Strategy, and the implementation of rapid transit in the corridor. However, as the pace of intensification in the Transit Corridor may vary depending on the transit technology implemented, it is recognized that the potential exists for the ridership associated with BRT technology options and the BAU options could be overstated (the land use inputs assumed levels of intensification typically associated with LRT). However, in the interests of providing a consistent baseline for scenario evaluation, and in line with accepted best practice, the land use inputs to the transportation model have been held constant across all rapid transit scenarios.

Finally, costing of the project scenarios was conducted by Hatch Mott McDonald (HMM). HMM provided capital and operating cost estimates for each of the project scenarios, with the exception of the Base Case (BAU) scenario. HMM's estimates are included as Appendix B of this report. BAU costs were determined separately through consultation with Grand River Transit (GRT), and are included in Appendix B.

The Business As Usual Scenario

The BAU scenario is a baseline against which to compare all other scenarios in the MAE.

Traditional economic analysis has often used a "do nothing" scenario as a baseline for comparison. However, this approach does not reflect the most realistic answer to the question "what is likely to occur if the rapid transit project is not built?" Rather than not making any improvements to transit service whatsoever, in this case, it is assumed that Grand River Transit would continue to operate and attempt to draw more riders onto the existing iXpress service. In this scenario, both as a response to demand, and to stimulate further ridership, there would be a gradual expansion of iXpress service in the Central Transit Corridor.

This scenario was modelled by Halcrow Ltd, assuming the same future land use scenario used for all project scenarios. Demand for transit service in this case warranted a reduction of headways to 7.5 minutes in 2014, and 5 minute headways in 2031. With iXpress operating at 5 minute headways, and assuming the intensification identified in the land use scenario, daily ridership on iXpress would increase to approximately 19,800 by 2031. This compares to about 52,000 to 64,000 riders daily in the various project scenarios (see table in Appendix A). Today, iXpress ridership falls in the range of 8,000 to 10,000 riders on a daily basis.

This BAU scenario was costed assuming a gradual increase in the number of vehicles, and a corresponding reduction in headway, as demand in the corridor increases. Fleet requirement assumptions for the BAU scenario are based on the ridership forecasts from the transportation modelling, and associated per-vehicle capital and operating costs were established in consultation with Grand River Transit. These are documented in Appendix B.

It is also important to note the land use assumptions in the BAU case. Regional and Provincial planning policy place considerable emphasis on the intensification of the Central Transit Corridor, particularly the three Urban Growth Centres defined in the Province's *Growth Plan for the Greater Golden Horseshoe.* These three areas – Uptown Waterloo, Downtown Kitchener, and Downtown Cambridge, have all seen considerable intensification already, a trend which shows few signs of abating. The land use modelling draws from the experience of other urban centres following the implementation of RT to identify an estimate of the degree to which RT will catalyze intensification in the Central Transit Corridor (CTC) and station areas (lands within 600m of RT stations).

While some intensification will occur in the CTC without rapid transit, there would almost certainly be greater focus on suburban development in the event that the RT project does not proceed, and the intensification that does occur will be spread throughout a much broader area. RT will bring a focus to intensification within the CTC, with different potential RT technologies will have land use impacts resulting in different levels of intensification. It should be noted that the land use metrics in the MAE measure only the degree to which RT is expected to imply incremental intensification beyond the substantial amount of intensification that is likely to occur due to planning policy and market trends alone.

2.3 Methodology and Assumptions

This section provides a description of each of the metrics, and the approach taken to developing inputs, for each of the five accounts in the MAE. For each of these metrics, the results for each project scenario were compared against the Business As Usual (BAU) case to determine the incremental cost or benefit associated with the scenario. The specific assumptions and data underlying the Business As Usual case, as well as the project scenarios, are outlined in the Appendices.

Direct Project and Transportation Account

This account includes the capital and operating costs directly related to the project, and the related transportation infrastructure. It is intended to capture the full costs of the project over the thirty-year analysis period.

The metrics in this account are as follows.

- **Capital Costs** – all capital costs associated with the project, including soft costs, project management, all public works, and vehicle purchases. Capital cost estimates for each scenario have been provided by Hatch Mott McDonald, and are detailled in Appendix B. Capital costs are

reported both as a total cost (escalated) and as a Net Present Value, at the discount rate established for the scenario.

- **Operating Costs** – an estimate of the operating costs of the project. Operating costs for the opening year (2014), and for a later year (2031), were provided by Hatch Mott McDonald. Using these two points, MKI extrapolated a cash flow stream that assumes a linear change in the operating expenses through the 30-year analysis period. The operating cost estimates are detailled in Appendix B and are reported both as a net present value, and the annual costs in a typical year (2023)

- **Summary Metric: NPV of Cash Flows** – this metric is simply the Net Present Value of the sum of the two cost streams (capital costs and operating costs). It is a discounted cash flow figure for the full costs of the project.

- **Additional Metric - Operating Revenues (Fares)** - This is an estimate of fare revenue for the project scenario. Grand River Transit provided figures for net fare per ride for 2008 and 2009, based on boardings, for the current iXpress service. Fares are estimated at $0.95 per boarding in 2009 (the observed figure for 2008 was $0.91 per boarding). Fares are estimated to increase by $0.25 every five years. This metric is reported as an annual figure in a typical year (2023), and as a net present value for the 30-year cash flow stream.

- **Additional Metric - Net Operating Costs** – reported as dollars per ride for a sample year (2023). This is the balance of the operating costs less the estimated fare revenues in a given year. The metric is an estimate of the operating subsidy per ride that the project will require.

The evaluation of this account was based on data received up until May, 2009. A list of all the sources reviewed for this account is included in Appendix C, with cost estimates outlined in Appendix B.

Direct Transportation User Benefits Account

This account includes the benefits expected from the various options of the rapid transit projects (e.g., travel time and parking cost).

- **Travel Time Savings** – transit projects typically produce travel time savings in two ways; first, by increasing the speed of travel for transit passengers; secondly, by shifting some travel from cars to transit, it will relieve road congestion in the transit corridor. Transit users will experience considerable travel time savings through the introduction of rapid transit. The time saved per trip has been calculated using the ridership forecasting model, then converted to monetary values using a consumer surplus model. It should be noted that the travel time savings are for trips by all modes of travel – the model calculates auto

travel times (driver and passenger trips), transit travel times, and walk/bike travel times. By doing so, the model captures not only the time savings for transit passengers, but the impact of the project on the transportation network as a whole. This metric is reported in two ways: annual minutes saved in a typical year (2031), and the net present value of the monetary value of these savings for the full 30-year analysis period.

- **Vehicle Operating Cost Savings** – This metric is a calculation of the operating costs avoided for car owners who travel by transit instead. The calculation is the product of vehicle kilometres travelled (VKT), which is an output of the transportation model, and the costs per kilometre of operating a standard four-door sedan in Ontario, as reported by the Canadian Automobile Association (including gas, oil, tire wear, maintenance, insurance, and depreciation). The metric is reported as the net present value of the monetary value of these savings for the full 30-year analysis period.
- **Accident Avoidance Savings** – this metric represents the savings to society resulting from the road accidents avoided through modal shift to transit. The calculation is performed using incident factors for accidents per vehicle kilometre, typical costs of fatal, injury, and property accidents, and the number of vehicle kilometres avoided, which is an output of the transportation model. The metric is reported as the net present value of the monetary value of these savings for the full 30-year analysis period.
- **Summary Metric:** The summary metric totals the net present value of the three categories of user benefits.

The evaluation of this account was based on data received through May, 2009. A list of all the sources reviewed for this account is included in Appendix C, with cost estimates outlined in Appendix B.

Environmental Account

This account includes the environmental impact of the rapid transit project in terms of greenhouse gases (GHGs) and critical air contaminant (CAC) emissions.

- **GhG Emissions Savings** – Greenhouse gas (GhG) emissions are reduced by shifting travel from cars to rapid transit. The emission reductions are an output of the ridership forecasting model. The volume of GhG emission savings is reported in tonnes per year for a typical year (2031). The monetary value of the GhG emission savings are calculated using a per-tonne value of $37 per tonne, calculated by Transport Canada and reported in *Estimating the Costs of Greenhouse Gas Emissions from transportation* (Transport Canada, 2007)
- **Criteria Air Contaminants (CAC) Emissions Savings** – CAC emissions are an output of the ridership forecasting model and are monetized using a per tonne unit cost. The CAC emissions calculated by the

model are carbon monoxide (CO), volatile organic compounds (VOC), nitrous oxides (NOx), sulphur oxides (SOx), and particulate matter (PM). The CAC emission unit values were taken from *Evaluating the Total Cost of Air Pollution due to Transportation in Canada* (Transport Canada, 2007), using the value for Ontario.

- **Summary Metric:** The summary metric totals the net present value of the two monetary categories of environmental benefits.

The evaluation of this account was based on data received through May, 2009. A list of all the sources reviewed for this account is included in Appendix D.

Land Use Economic Development Account

This account includes the benefits of both residential and employment growth and land value uplift that may be generated from the rapid transit project.

- **Residential Development** – this is measured by the incremental number of residents (population) within 600m of proposed station locations. As part of an earlier stage of the Environmental Assessment, land use modelling associated with different transit scenarios was conducted using the Region of Waterloo's Population Land Use Model (PLUM) in 2008, which allocates growth within the Region within various land use scenarios. The modelling allocates population and employment at a highly detailled level, and through its GIS interface, the total forecast population and employment within a given area of the Region was identified. Appendix C provides an outline of the PLUM modelling undertaken for the Waterloo RT EA. These scenarios produced estimates of residential and employment development in the areas surrounding stations on the proposed rapid transit routes. The figure reported is the additional population within 600m of proposed stations, compared to the Base Case scenario.

- **Non-Residential Development** - this is measured by the incremental number of jobs (employment) within 600m of proposed station locations. As with the residential development metric, above, these figures are output of the Region of Waterloo's Population and Land Use Model (PLUM). The figure reported is the number of additional employment within 600m of proposed stations, compared to the Base Case scenario.

- **Land Value Uplift** – land value uplift has been calculated for each scenario, using a range of potential value uplift factors. In each project alternative, the presence of rapid transit is assumed to generate increased demand for lands within walking distance of transit stations. For the purpose of this analysis, the distribution of land uses within station areas along the proposed routes was calculated using data from the PLUM model. Lands were given an approximate value, per hectare, dependent on the existing land use. A percentage uplift factor, which differed by land use, was applied to generate a calculation of value uplift potential. The uplift factors are drawn from a broad survey

of studies of land value uplift surrounding rapid transit stations, documented in Appendix D.

While this method is quite coarse, and is subject to the validity of the input assumptions, it represents a reasonable assessment of the order of magnitude of land value increases. However, three important cautions should be considered when referencing land value uplift. First, the calculation of the amount is subject to very broad assumptions about the actual dollar impact of transit on land use – actual market experience may vary dramatically from location to location, or due to the myriad of other factors affecting land value. Secondly, land value uplift is a benefit that does not recur (as opposed to travel time savings, which continue to occur every day the system is in operation). Rather, land value uplift occurs once, when the real estate market responds to the construction of the system by bidding up the price of land around stations.

Finally, it should be noted that from an economic analysis perspective, land value uplift is not incremental to travel time savings, vehicle operating cost savings, and other transportation user benefits reported in that account – it is likely that consumers and businesses, in choosing to pay more for a location close to transit stations, are incorporating their cost savings on transportation in their calculation of what they are willing to pay for property in a given location. Similarly, existing property owners receive a benefit in terms of increased accessibility and reduced transit travel time. As such, this metric should not (as with any separate MAE account) be considered in addition to the transportation user benefits, due to the risk of double-counting benefits.

- **Support to Regional Land Use Objectives** – this is a qualitative metric measuring the overall degree to which the option reflects the land use objectives of the Regional Plan, including focussing development within the Central Transit Corridor, and linking major land uses with rapid transit. The metric is evaluated using a three-score system:

● Strongly supportive

● Moderately supportive

○ Weakly supportive

- To establish the "score" for each transit scenario, the consultant team examined one or more criteria related to each policy objective, and exercised professional judgement as to the degree to which the scenario is supportive of the policies. Appendix C provides more details.

- **Employment Generated** – this metric represents the number of jobs created by the capital expenditure to build the project. Calculated using the Provincial Government's TREIM (Tourism Regional Economic Impact Model) model, the metric is the total number of direct, indirect, and imputed jobs generated by the capital expenditure associated with the project. TREIM model inputs and outputs are included in this report as Appendix D.

- **Taxes Generated** – also calculated using the TREIM model, this metric reports the total federal, provincial, and municipal taxes paid as a result of the capital expenditure associated with the project. This metric is useful in providing some perspective of the revenues returned to the various levels of government will be able to get as a result of the investment. However, it is not an additive economic benefit that can be considered an economic return of the investment, and is therefore not summed with other monetary economic benefits within the analysis

The evaluation of this account was based on data received until May, 2009. A list of all the sources reviewed for this account is included in Appendix D.

Social and Community Benefits Account

This account includes the benefits in terms of public health and community liveability as a result of the rapid transit project.

- **Public Health Benefits – Air Quality** – The benefits of the project are measured in two ways, as the number of *Hospital Admissions Avoided*, and in terms of the *Economic Damage.* These represent a new metric within MAE for transit projects as we are not aware that this metric has been used elsewhere. Using factors generated by Waterloo Public Health to quantify the health costs of poor air quality, the air quality impacts of each project scenario were isolated in terms of the overall air quality in the Region. They are a product of the emission of criteria air contaminants by mode within each scenario. The number of hospital admissions avoided was calculated using data from the Waterloo Public Health Unit on the costs of poor air quality in the Region. This was converted into an estimate of economic damage by calculating the percentage of air pollutants attributable to vehicle traffic in the Region, and the identified change in emissions resulting from each of the project scenarios.

- **Public Health – Active Transportation/Community Liveability/Construction Disruption** – these three metrics are qualitative measures of three project-related impacts that cannot be quantified. They are evaluated using the three-score system identified above, based on reference to a series of related issues. Details on this scoring process are included in Appendix D.

The evaluation of this account was based on data received to May 2009. A list of the sources of data and calculations for this account is included in Appendix D.

2.4 General Inputs

Basic Economic Variables

The analysis period has been established at 30 years. All cost and revenue streams are therefore assumed for the period 2009-2038.

All costs and revenues have been escalated at a fixed rate of 3%, held common across all inputs and scenarios.

The discount rate for the scenarios has been set at 6% for the purpose of the analysis. This rate is roughly equivalent to the Region of Waterloo's cost of borrowing.

Value of Time

The value of time used in the consumer surplus analysis, prepared by Halcrow Ltd, was $10.30 per hour. This is roughly equivalent to half the hourly wage rate in the Region of Waterloo, the typical benchmark used to establish the value of time spent commuting.

3 Key Findings

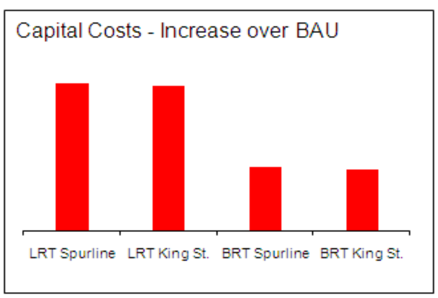
This chapter summarizes the key findings from the analysis of the inputs collected for the MAE of the rapid transit project in Waterloo Region. The four project scenarios were evaluated through each of the five MAE accounts. This section of the report reviews the results for each of the metrics in each account. It is very important to note that **all results reported here are incremental to the base case** – that is, the value is the difference between the specific project scenario, and the Base Case (Business As Usual) scenario.

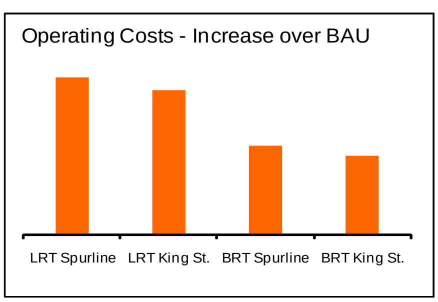
3.1 Direct Project and Transportation Account

The incremental capital and operating costs associated with each of the scenarios, as well as the anticipated fare revenues and the net operating costs, are shown in the table below.

Direct Project and Transportation Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.
Capital Costs (Incremental)	$M (NPV)	$1,213	$1,189	$526	$502
Operating Costs (Incremental)	$M (NPV)	$230	$212	$129	$115
Summary Metric: NPV of Total Project Costs	**$M (NPV)**	**$1,443**	**$1,401**	**$656**	**$617**
Additional Metric - Net Operating Costs (Incremental)	$ per ride (2031)	$1.56	$1.56	$1.92	$1.92
Additional Metric - Operating Revenues (Fares)	$M (Annual, 2031)	$21	$19	$17	$15
Additional Metric - Operating Revenues (Fares)	$M (NPV)	$130	$119	$103	$97





The costs are incremental to the Business As Usual scenario and have been converted to a net present value using the discount rate of 6%.

The total capital and operating costs reflect the transit technologies involved. LRT technology is considerably more expensive from both a capital and operating cost perspective. In terms of capital costs, the LRT options are roughly twice as costly as the BRT options, and roughly twice as expensive in terms of operating costs.

Fare projections are based on the ridership forecasts. The net present value of the incremental operating revenue over the 30-year analysis period, compared to the base case, indicates that although the BRT options will not attract as many riders, they perform proportionately better than the LRT options. This metric calculates the operating revenues net of operating costs per rider. In absolute terms the subsidy that has to be provided in BAU case is estimated at $2.91 per rider. The subsidy required per ride is $1.56 less in the LRT options compared to the BAU option, and $1.92 less in the BRT options compared to the BAU option. In other words this metric reflects the subsidy savings per rider. The subsidy required per ride is $1.56 less in the LRT options than in the base case (BAU) option, and $1.92 less in the BRT options, than in the base case (BAU) option. The modelling would therefore suggest that rapid transit will be fiscally positive compared to the BAU option – rapid transit should be more cost-effective in terms of fare recovery per trip than continuing with the current

service. This does not mean that rapid transit will have lower net operating costs than continuing with the current system, simply that the additional ridership will, on a per-capital basis, provide a stronger return from the farebox than the BAU case.

3.2 Direct Transportation User Benefits Account

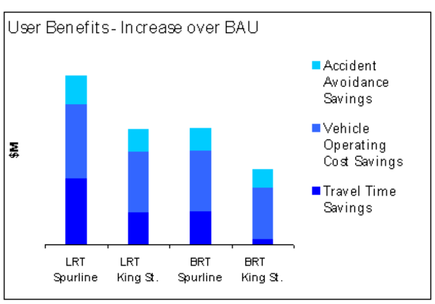
The transportation user benefits calculated within each metric are outlined in the table below.

Direct Transportation User Benefits Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.
Travel Time Savings	Minutes, AM Peak Hr, 2031	42,234	21,537	22,104	6,555
Travel Time Savings	$M (NPV)	$203	$99	$102	$16
Vehicle Operating Cost Savings	$M (NPV)	$232	$187	$187	$158
Accident Avoidance Savings	$M (NPV)	$88	$70	$71	$60
Summary Metric: NPV of Annual Benefits	**$M (NPV)**	**$523**	**$356**	**$360**	**$233**

Travel time savings are clearly strongest for the LRT Spurline option. This is a result of the considerable time savings experienced by transit users in this option. The LRT King Street option, due to routing, does not perform as well, with results more in line with the BRT Spurline results.

Several aspects of these results are worth noting. First, all scenarios experience some increase in travel time for single-occupant vehicle (SOV) and high-occupant vehicle (HOV) trips. This is due to the growth of traffic over the 30-year horizon and reduction in roadway capacity within the Central Transit Corridor associated with the project. However, the number of additional transit riders, combined with the faster transit travel times, produces a much larger time savings associated with transit trips. Once monetized, these savings are equivalent to $21.7M in 2031 for the LRT Spurline scenario, totalling $203M in present value through the forecast period. The LRT King Street and BRT Spurline scenarios are forecast to produce time savings valued roughly the same, whereas BRT King Street does not perform well due to roadway congestion in the north part of the corridor associated with this route, and lower ridership.



Vehicle operating cost savings are strongest in the LRT Spurline option, and there is a marginal difference among LRT King Street, and BRT Spurline options. Vehicle Operating Cost savings are a function of the number of new riders on transit, which in turn affects the number of vehicle kilometres travelled (VKT) forecast by the transportation model.

Accident avoidance savings are also a result of reduced vehicle kilometres travelled (VKT) due to trips being taken by transit instead. The results for these savings follow a similar pattern to the vehicle operating costs, with LRT Spurline providing the largest benefit, followed by similar levels of benefit for LRT King Street, and BRT Spurline.

Overall, the total transportation user benefits are highest for LRT Spurline option. In terms of the relative "value for money" – the transportation user benefits measured against the project costs – the best performing option is BRT Spurline, while LRT Spurline and BRT King Street, are forecast to have similar levels of "return on investment" in this account.

An operational consideration is important to note, however. BRT Spurline performs relatively well in this account, but ridership may be restricted near the end of the forecast period (2031). A BRT system in the north will strain with operational problems before 2031 brought on by limited transit vehicle capacity to accommodate demand and increasing road congestion in the CTC, which will affect busway speed and could cause considerable unreliability in the system.

3.3 Environmental Account

The environmental benefits of the various project options are outlined in the table below.

Environmental Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.
GhG Emissions Savings	Tonnes/Year, 2031	22,260	17,780	12,210	11,280
Vaue of GhG Emissions Savings	$M (NPV)	$12.4	$10.2	$8.8	$8.3
Criteria Air Contaminents (CAC) Emissions Savings	Tonnes/Year, 2031	690	440	350	200
Criteria Air Contaminents (CAC) Emissions Savings	$M (NPV)	$7.0	$6.1	$4.1	$4.0
Summary Metric: NPV of Annual Benefits	**$M (NPV)**	**$19.4**	**$16.3**	**$12.9**	**$12.4**

Greenhouse gas (GhG) emission savings are highest in the LRT Spurline Option, followed by the LRT King Street option, then the BRT options. Given the nature of the transit technology, (electric LRT versus diesel or hybrid-fuel buses), the savings in part reflect the means of propulsion of the transit technologies themselves. However, the bulk of GhG savings are associated with the vehicle kilometres travelled by private cars in each option, as well as the number of trips by auto versus non-auto modes.

Criteria Air Contaminants (CAC's) are pollutants with a variety of impacts on the natural environmental and human health. These are associated with vehicle emissions and as such, are also a function of vehicle kilometres travelled, as forecast by the transportation model. The CAC emissions calculated by the model are carbon monoxide (CO), volatile organic compounds (VOC), nitrous oxides (NOx), sulphur oxides (SOx), and particulate matter (PM). The results indicate that CAC emission reductions are highest for the LRT Spurline option, followed by LRT King Street, as compared to the BRT options.

The dollar values of emissions savings are low due to relatively low prices currently placed on emissions. It is recognized that significant debate exists about carbon pricing and cost of air pollution; this analysis has used a "social cost" calculation for carbon emissions which is higher than current market prices for carbon. Details of this calculation can be found in Appendix D.

Most cost-benefit analyses of transit projects produce low dollar values for environmental benefits for this reason. As one example, a recently completed MAE for an extension to the Scarborough Rapid Transit system in Toronto produced only $1.9M (NPV) in total environmental benefits. Of course, regardless of the dollar value assigned to emissions, arguments are commonly made that environmental benefits such as emission reductions have much broader benefits to society.

3.4 Land Use Economic Development Account

Land use and economic development benefits associated with the options are outlined on the table below.

Land Use/Economic Development Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.
Residential Development (Incremental)	Pop'n within 600m	16,532	16,834	8,051	7,524
Non-Residential Development (Incremental)	Jobs within 600m	21,458	23,078	10,277	10,732
Land Value Uplift (Incremental)	$M - Premium	$361.1	$370.8	$73.7	$74.8
Support to Regional Land Use Objectives	Qualitative	●	●	○	○
Employment Generated (Incremental)	Jobs	9255	9174	4362	4223
Taxes Generated (Incremental)	$M (NPV)	$396.8	$392.2	$186.1	$180.0

The land use and economic development accounts contain a variety of metrics designed to reflect the relative benefit of the project scenario in terms of achieving the Region's land use objectives, and economic development benefits. The number of people living and working within 600m of transit stations is a measure of the degree to which the project scenario is likely to encourage intensification. The results indicate that both LRT Spurline and LRT King Street scenarios have the highest overall potential to encourage intensification.

It should be recognized that although rapid transit is likely to produce considerable intensification in the Central Transit Corridor, there would be some intensification as part of the BAU scenario. In the BAU case, the anticipated intensification due to planning policy and market trends alone are anticipated to imply some intensification of the CTC, although in absence of transit this intensification will be less extensive and would be spread over a larger area. The table below lists the total population and employment forecast for station areas in the PLUM model, for the BAU and the project scenario, for each option.

Forecast Population in Station Areas - 2031

	LRT Spurline	LRT King St	BRT Spurline	BRT King St
BAU	50,158	56,092	47,789	53,804
With RT	71,616	79,170	58,066	64,536

Forecast Employment in Station Areas - 2031

	LRT Spurline	LRT King St	BRT Spurline	BRT King St
BAU	103,194	98,627	94,754	90,282
With RT	119,726	115,461	102,805	97,806

Both Regional and Provincial planning policy place considerable emphasis on the intensification of the CTC, particularly the three Urban Growth Centres defined in the Province's *Growth Plan for the Greater Golden Horseshoe.* The effect of rapid transit, therefore, is to catalyze a higher degree of intensification, sooner, than would occur in the absence of transit. The land use impacts of rapid transit in the CTC were the subject of an extensive and detailed year-long land use analysis early in the EA process (Step 2.12). The final Step 2.12 report documents the land use exercise, and the key outputs from the exercise are incorporated in this report in the description of the land use modelling in Appendix D. RT will be an essential part of achieving the intensification objectives of both the RGMS and the Provincial Growth Plan for the Greater Golden Horseshoe.

Similarly, the calculation of land value uplift reflects the much greater impact of LRT on land value, in comparison to BRT. The land value uplift calculation also reflects the different pattern of land uses in the corridors, with the LRT King Street route serving King Street commercial and institutional uses. This results in a slightly higher estimated land value uplift for the LRT King Street scenario, and for the BRT King Street scenario compared to BRT Spurline. Note that land value uplift calculations must be considered in the context of the cautions expressed in Section 2.3.4, above.

While this straightforward calculation of land value uplift presents a basic estimate, it does not capture the potential effects of long-term change in patterns of investment in the Region. For example, it may prove that investment in RT transforms certain urban neighbourhoods or areas over time, resulting in increased investment occurring beyond the limits of a station area or in addition to that directly resulting from RT. This agglomeration cannot be quantified for the purposes of an MAE; nevertheless, it is one of the potential long-term benefits of the investment that may have positive benefits beyond the confines of the current analysis.

The last two metrics refer to the economic development benefits associated with the project scenarios. These metrics are functions of the capital spending on the project. The first indicates the number of jobs generated through the construction project in terms of the total direct, indirect, and imputed benefits – this captures all employment, from workers employed on the construction site, to those in factories building the vehicles, to those working for companies providing professional services to the companies building the vehicles, and so forth. Due to the scenario having the highest project cost, the LRT Spurline scenario has the highest number of jobs generated, followed closely by the LRT King Street scenario as compared to the BRT scenarios. Taxes generated follow a similar pattern of results among the scenarios.

3.5 Social and Community Benefits Account

This account is the most qualitative of the five accounts. It attempts to capture benefits of the project that are difficult to report quantitatively. The results are outlined on the table below.

Social and Community Benefit Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.
Public Health - Air Quality	Hospital Visits Avoided	61	49	35	31
Public Health - Air Quality - Economic Impact	$M (NPV)	$16.6	$13.5	$9.7	$8.7
Public Health - Active Transportation	Qualitative	●	•	•	○
Community Liveability	Qualitative	●	●	○	○
Construction Disruption	Qualitative	•	•	●	●

The two air quality metrics – calculation of hospital visits avoided and the estimated economic impact associated with poor air quality – are a product of the emission of criteria air contaminants by mode within each scenario. The LRT Spurline scenario performs the strongest, followed by the LRT King Street scenario, and BRT Spurline. In terms of the quantitative metrics, the three metrics represent aspects of the project that are difficult to quantify, although they are in part based on quantified variables.

The *Public Health – Active Transportation* metric refers to the number of walk, bike, and transit trips taken in each of the scenarios, as well as the nature of the project's likely impact on supporting active transportation through intensifying land use and creating pedestrian (and transit) oriented environments. The LRT Spurline option performs most strongly, as it generates the largest number of walk/bike/transit trips, and will offer strong support for transit-oriented development. The "King Street" routes (LRT King Street and BRT King Street) do not produce as many additional trips by active transportation modes. BRT scenarios produce the fewest additional trips by active transportation modes and have weaker land use impacts.

Community Liveability is a metric designed to reflect the intangible, "quality of life" benefits associated with the options, including issues such as noise generated by the transit system, fumes generated, and aesthetic considerations. While certainly subjective, LRT options have fewer fumes and noise associated with them than BRT.

Construction Disruption is again a qualitative measure of the likely disruption to existing residents and businesses in the corridor associated with the construction of the project. In short, the LRT construction will require closing lanes on some City roads for short periods of time to install tracks and catenaries; the BRT option also requires a short period of construction on roads. Due to the nature of the metrics in this account, it's not possible to provide a summary measure. However, on most of the metrics, the LRT Spurline comes out the strongest performer, with BRT King Street the weakest.

3.6 Summary of Results

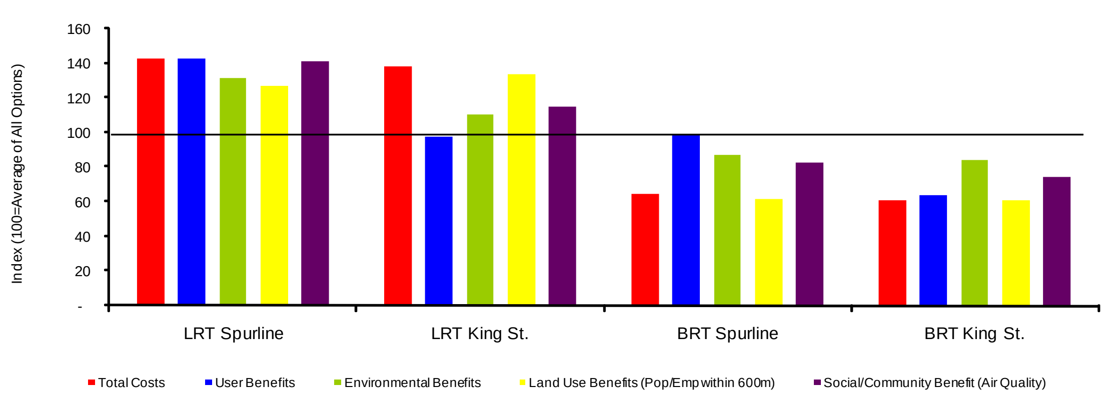
MAE is a series of different measures indicating the strength of each alternative in different accounts. The accounts in this MAE reflect the goals of the RGMS. A comparison of the relative costs and benefits of the Project Options evaluated for the five accounts is summarised below. The results indicate that:

- The LRT options have highest capital and operating costs. They also have the highest monetary and non-monetary benefits. LRT Spurline performs better overall in the MAE than LRT King St;
- BRT has the lowest capital cost and higher return per dollar spent in terms of the transportation user benefits. BRT Spurline performs better overall than BRT King St;
- LRT Spurline has the highest overall benefits, but the highest overall cost; and,
- BRT Spurline is the second lowest cost option but provides significantly less overall benefit. BRT King Street provides even lower benefits.

The indexing approach can be used to look at the relative benefits of each scenario across accounts. This is accomplished by indexing the results **within each account** to assess whether a particular scenario performs above or below average compared to the other project scenarios. This provides a good way of comparing the options using a wide range of metrics, even if measured in something other than dollars.

The chart below indexes the results within each account against the average for the four project scenarios. A bar above the line indicates above-average results in that metric; below the line indicates below average. Note that for the Land Use account, the bar indicates the project in terms of intensification (jobs/population in station areas), and for the Social/Community Benefit account, in terms of the number of hospital visits avoided per year.

Relative Costs and Benefits - Project Options



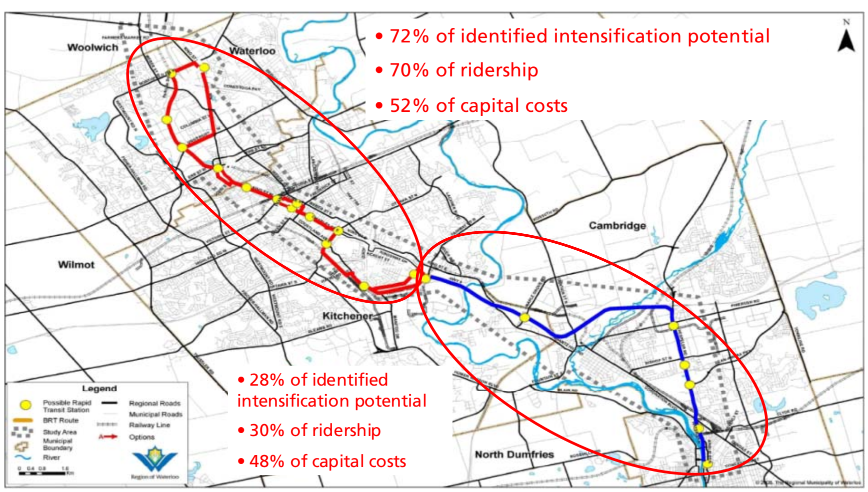
The results in the graph present the results incremental to the BAU scenario and as such all the project options perform better than the BAU case. Overall, based on this evaluation, the LRT Spurline best accomplishes the objectives of the RGMS, and presents the highest overall benefit. Although BRT Spurline has best return relative to cost in the user benefits, it does not perform as well as LRT options in terms of the overall benefit, and performs relatively poorly in terms of land use and economic benefits. As a result LRT is the preferred option for the Region's RT system.

3.7 Staging Scenarios

Following the initial MAE assessment, as noted above, it was determined that the LRT scenario was the preferred option. However, in terms of capital costs, the LRT options are more than twice as costly as the BRT options, and roughly 30% more expensive in terms of annual operating costs. In order to identify variations that could produce a potentially stronger performing option, an analysis of two Staging options was also undertaken. This analysis looked at two Staging options for implementing rapid transit with a view to maximizing benefits to the community, providing rapid transit technology that best meets the level of demand and developing a cost effective approach.

It was noted that the benefits of the various project scenarios accrue differently in different parts of the corridor. For example, the north half of the corridor (from Conestoga Mall to Fairview Mall) produces the majority of the ridership and land use benefits – 70% of ridership, 74% of intensification potential.

However, the costs are about evenly split between the north part of the corridor (Conestoga Mall to Fairview Park Mall) and the south part of the corridor (Fairview Park Mall to downtown Cambridge). These results led the team to develop and consider two Staging options. Both these options allow for future conversion to LRT along the whole corridor.



The following two Staging options were evaluated:

Staging Option A – A mixture of LRT and BRT options – LRT from Conestoga Mall to Fairview Mall, BRT from Fairview Mall to downtown Cambridge;

Staging Option B – A mixture of LRT and Adapted BRT – This scenario considered the BRT operating through transit priority measures rather than on an entirely segregated corridor, in the south portion of the corridor. Adapted BRT could include:

- Operational improvements, such as Hwy 8/401 shoulder bypass lanes, a queue jump lane at intersections, signal priority, additional stations, enhanced shelters, automated ticketing, real-time passenger information systems;
- Urban design improvements at stations, such as pedestrian-oriented streetscape, bicycle and pedestrian amenities; connections to intercity transit, and additional park and ride facilities.

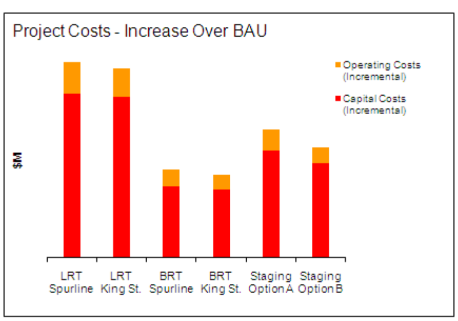
Preliminary cost estimates for the two Staging scenarios were prepared and in order to evaluate the performance of the Staging Options against the short-listed system options and each other, the MAE analysis was completed for both the Staging Options.

Project Costs

Capital cost estimates were developed for both Staging options that include the cost of transit priority measures and station improvements for Staging Option B as noted above. The MAE results for this account are shown below.

Direct Project and Transportation Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
Capital Costs (Incremental)	$M (NPV)	$1,213	$1,189	$526	$502	$792	$701
Operating Costs (Incremental)	$M (NPV)	$230	$212	$129	$115	$158	$114
Summary Metric: NPV of Total Project Costs	**$M (NPV)**	**$1,443**	**$1,401**	**$656**	**$617**	**$950**	**$815**
Additional Metric - Net Operating Costs (Incremental)	$ per ride (2031)	$1.56	$1.56	$1.92	$1.92	$1.93	$2.23
Additional Metric - Operating Revenues (Fares)	$M (Annual, 2031)	$21	$19	$17	$15	$18	$17
Additional Metric - Operating Revenues (Fares)	$M (NPV)	$130	$119	$103	$97	$112	$106



Incremental capital costs for Staging Option A total $792M, or 35% lower than LRT Spurline, and Staging Option B, $701M, which is 42% lower than LRT Spurline. Operating costs associated with Staging Option A are approximately 30% lower than LRT Spurline, and 50% lower for Staging Option B.

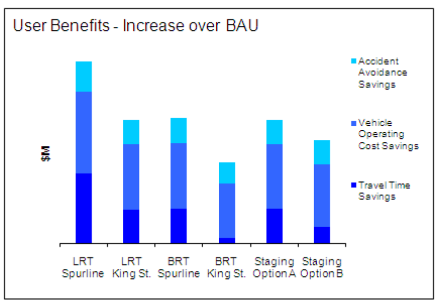
The operating costs are slightly higher in the Staging options relative to BRT. Fiscal performance measured in terms of operating revenues net of costs was the strongest for Staging Option B within the scenarios evaluated. The subsidy required in this scenario is $2.23 less per ride than the base case (BAU) option, significantly outperforming both LRT and BRT. In other words this metric reflects the subsidy savings per rider is highest in case of Staging Option B, significantly outperforming both LRT and BRT.

Direct Transportation User Benefits

A comparative evaluation of the direct transportation user benefits is presented in the table below.

Direct Transportation User Benefits Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
Travel Time Savings	Minutes, AM Peak Hr, 2031	42,234	21,537	22,104	6,555	22,933	18,512
Travel Time Savings	$M (NPV)	$203	$99	$102	$16	$101	$49
Vehicle Operating Cost Savings	$M (NPV)	$232	$187	$187	$158	$185	$179
Accident Avoidance Savings	$M (NPV)	$88	$70	$71	$60	$70	$68
Summary Metric: NPV of Annual Benefits	**$M (NPV)**	**$523**	**$356**	**$360**	**$233**	**$356**	**$296**



For the Staging options, the user benefits of the project will depend on the timing of introduction of transit priority measures and ultimately, the timing for full BRT in the south end of the corridor. However, as approximately 70% of the ridership is in the north (LRT) portion of the corridor, the overall ridership impacts of changing from a BRT on a segregated corridor to BRT through transit priority results in a minor drop in the total benefits from $356M to $296 M.

Vehicle operating cost savings and accident avoidance savings in Staging Option A are as strong as those in LRT King Street and BRT Spurline. They are slightly lower in Staging Option B.

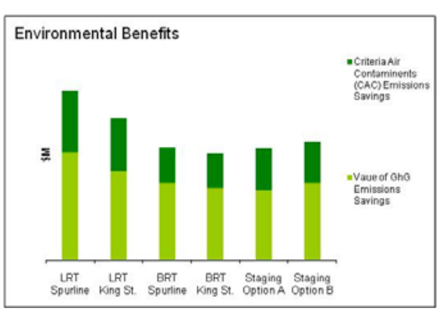
Travel time savings for Staging Option A are about half those for the LRT Spurline option, but are higher than the LRT King Street and BRT Spurline options as Staging Option A has slightly higher ridership. As noted, the ridership for Staging Option B is marginally lower.

Environmental Benefits

The environmental benefits of the various project options including the Staging Options are outlined in the table below.

Environmental Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
GhG Emissions Savings	Tonnes/Year, 2031	22,260	17,780	12,210	11,280	14,520	14,030
Vaue of GhG Emissions Savings	$M (NPV)	$12.4	$10.2	$8.8	$8.3	$8.0	$8.8
Criteria Air Contaminents (CAC) Emissions Savings	Tonnes/Year, 2031	690	440	350	200	380	325
Criteria Air Contaminents (CAC) Emissions Savings	$M (NPV)	$7.0	$6.1	$4.1	$4.0	$4.8	$4.8
Summary Metric: NPV of Annual Benefits	**$M (NPV)**	**$19.4**	**$16.3**	**$12.9**	**$12.4**	**$12.8**	**$13.6**

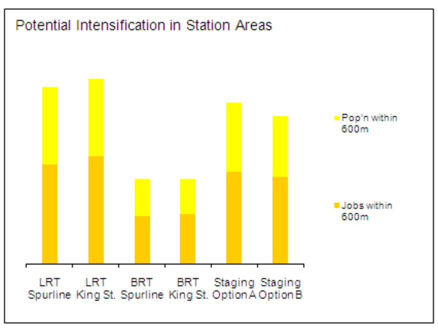


The LRT technology used in the north portion of the corridor in the Staging Options leads to slightly higher emission reductions compared to BRT scenarios. Both the Staging Options perform better than BRT on greenhouse gas emissions reductions, but less than both LRT options. Relative to project cost, Staging Options result in stronger environmental benefits per dollar spent than BRT options.

Land Use/Economic Development Account

Land Use/Economic Development Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
Residential Development (Incremental)	Pop'n within 600m	16,532	16,834	8,051	7,524	15,090	13,068
Non-Residential Development (Incremental)	Jobs within 600m	21,458	23,078	10,277	10,732	19,717	18,784
Land Value Uplift (Incremental)	$M - Premium	$361.1	$370.8	$73.7	$74.8	$242.0	$215.3
Support to Regional Land Use Objectives	Qualitative	⬤	⬤	○	○	⬤	⬤
Employment Generated (Incremental)	Jobs	9255	9174	4362	4223	6588	6006
Taxes Generated (Incremental)	$M (NPV)	$396.8	$392.2	$186.1	$180.0	$282.0	$257.4



Land use benefits remain strong with both the Staging Options, despite the change from a segregated transit corridor to on-street transit priority in the south end of the corridor. This is primarily because the areas that will be served by the LRT segment have the highest intensification potential. Even with the change in BRT technology in the south end of the corridor resulting in less intensification in these station areas, overall, the Staging Options will still achieve 80% to 90% of the forecast overall intensification in station areas associated with the full LRT options. The impacts of the project scenarios are summarized below.

In both Staging Options, land value uplift is much higher than BRT Options. This is due to the fact that the Staging Options introduce LRT technology to the area with the highest intensification potential, and due to the stronger impact of LRT technology in spurring development. As a result, they achieve most of the land use benefit of the full LRT options.

Jobs and taxes generated through capital spending are higher for both the Staging Options than BRT Options – this is a function of the capital cost.

Social and Community Benefit Account

In terms of public health and air quality, the Staging Options perform better than BRT, although their performance is lower than the LRT scenario. Construction of Staging Option B is likely to be less disruptive than LRT and Staging Option A since this option will necessitate less on-road work and/or lane restrictions/temporary closures for construction of structures.

Social and Community Benefit Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
Public Health - Air Quality	Hospital Visits Avoided	61	49	35	31	37	38
Public Health - Air Quality - Economic Impact	$M (NPV)	$16.6	$13.5	$9.7	$8.7	$10.2	$10.5
Public Health - Active Transportation	Qualitative	⬤	●	●	○	●	●
Community Liveability	Qualitative	⬤	⬤	○	○	●	●
Construction Disruption	Qualitative	●	●	⬤	⬤	●	⬤

4 Conclusions

MAE is a multi-variate analysis that builds upon traditional cost-benefit approaches to quantifying economic benefit. The accounts reviewed above include traditional, monetary benefit accounts (transportation user benefits, environmental benefits), and qualitative and/or non-monetary benefit accounts (land use/economic development, social/community benefit).

Some of the metrics are not independent. For instance, land use value uplift is captured as a benefit that accrues partially as a result of the reduced travel times. Hence combining the monetary values for transportation user benefits with the values for land value uplift could involve double counting of benefits, which is why the MAE treats them as separate accounts. Similarly, economic impact measured in terms of jobs created during construction reflects one time benefits only which cannot be added to annual user benefits. There are therefore several ways the results can be summarized and assessed in terms of their implications for a recommended scenario. First, the independent monetary benefits, which include transportation user benefits and environmental benefits, can be added together and/or compared to the project costs to reveal the "absolute" benefits of the project. This provides a traditional cost-benefit way of looking at the results, but misses the important non-monetary benefits of the project scenarios.

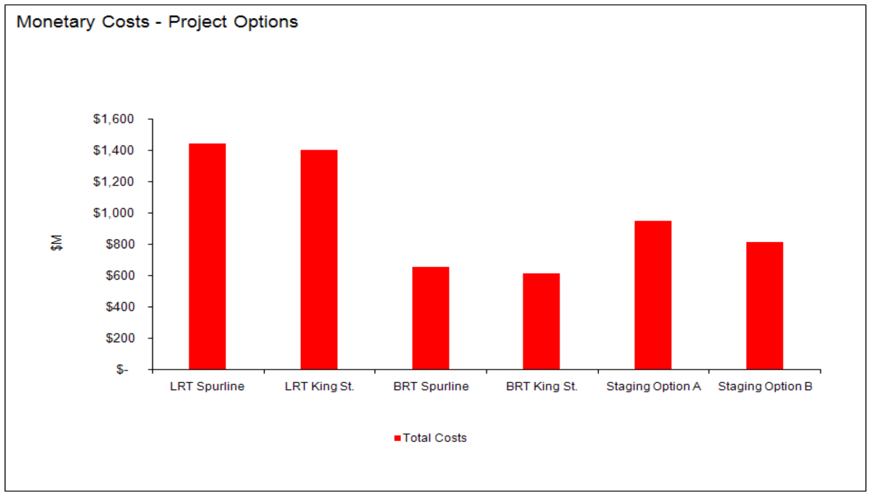
The MAE approach enables evaluators to incorporate assessment of other metrics and study the project's ability to meet the region's Growth Management goals, through metrics that may be quantifiable but are not expressed monetarily. This approach allows the evaluation of the projects in terms of the two most relevant RGMS land use policy themes:

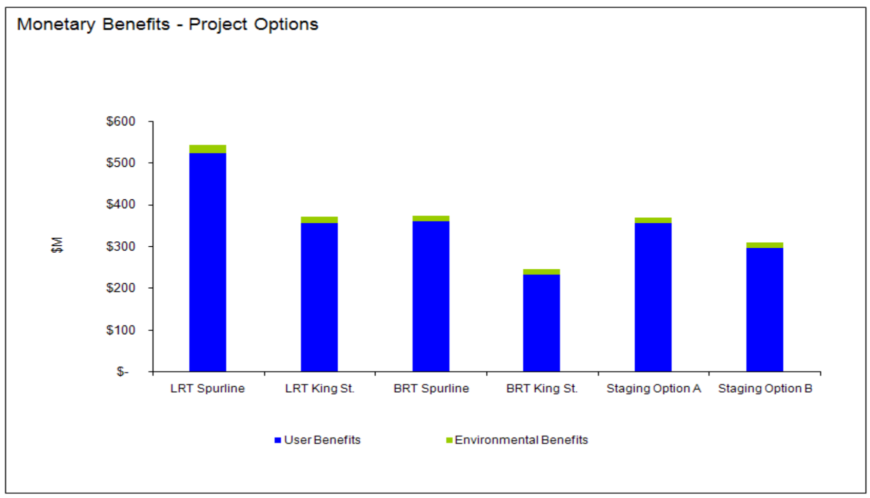
- Centralization of population and employment within the CTC
- Encouraging the use of alternative modes of transportation through pedestrian oriented development

As the central objective of the Region of Waterloo Rapid Transit project is to support the Region's land use objectives, these non-monetary benefits are also important. These benefits can also be compared to the project costs, but only on a relative basis, since most are not monetary. Another way of looking at benefits is to look at the relative benefits of each scenario by indexing the results of some or all of the metrics within each account. Indexing of results presents the relative performance of the evaluation scenarios within each account This approach looks at the "best return per dollar spent" considering the important metrics such as intensification (jobs/population in station areas), or fewer hospital visits (number avoided per year).

4.1 Scenario Comparison – Monetized Benefits

The charts below shows all monetary metrics for the Project Cost, Transportation User Benefit, and Environmental Benefit accounts. They can be compared directly.





The LRT Spurline option has both the highest costs and the highest overall benefits. The BRT Spurline option performs best relative to project cost, followed by the Staging Options, then the LRT Spurline option. The LRT King Street and BRT King Street options have the lowest performance in terms of user benefits relative to project cost.

The table on the next page compiles the non-monetary metrics. Performance can vary across the accounts; however, certain generalizations can be drawn from the data. In the Environmental Account, clearly, the LRT Spurline scenario performs much better than all other scenarios; the Staging Option scenarios are ranked third behind the LRT scenarios.

In the Land Use/Economic Development account, the LRT options perform the strongest, with the Staging Options following close behind. Relative to project cost, the Staging Options perform best on metrics within this account.

In the Social and Community Benefit Account, the LRT Spurline scenario performs the strongest overall, followed by the LRT King Street option, and the Staging Options.

While the individual metrics shown below give a sense of the performance of each of the project scenarios, within the three accounts, a relative comparison provides a broader perspective on which of the options are strongest overall.

Environmental Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
GhG Emissions Savings	Tonnes/Year, 2031	22,260	17,780	12,210	11,280	14,520	14,520
Criteria Air Contaminents (CAC) Emissions Savings	Tonnes/Year, 2031	690	440	350	200	380	380

Land Use/Economic Development Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
Residential Development (Incremental)	Pop'n within 600m	16,532	16,834	8,051	7,524	15,090	13,068
Non-Residential Development (Incremental)	Jobs within 600m	21,458	23,078	10,277	10,732	19,717	18,784
Support to Regional Land Use Objectives	Qualitative	⬤	⬤	○	○	⬤	⬤
Employment Generated (Incremental)	Jobs	9255	9174	4362	4223	6588	5338

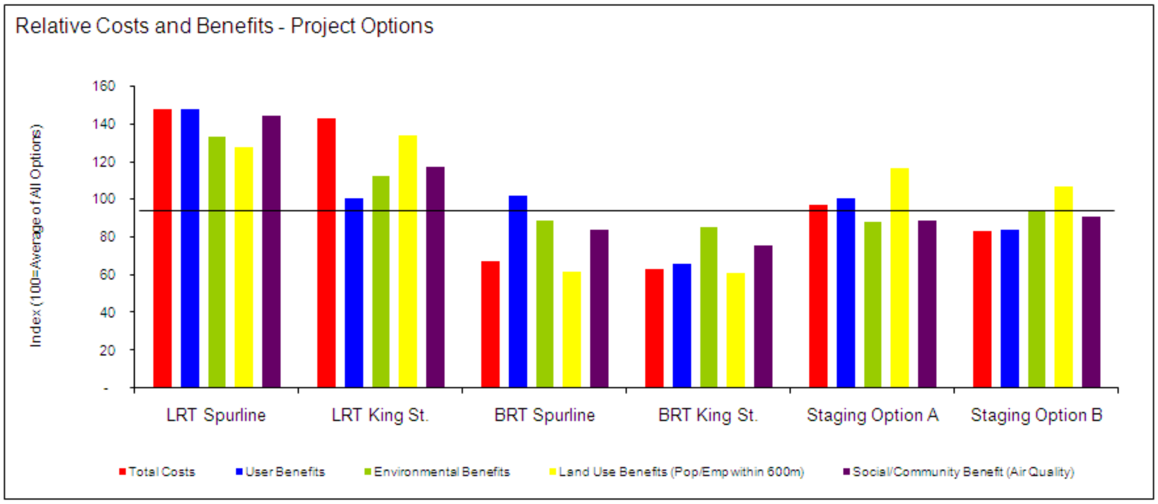
Social and Community Benefit Account

Metric	Unit	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
Public Health - Air Quality	Hospital Visits Avoided	61	49	35	31	37	37
Public Health - Active Transportation	Qualitative	⬤	●	●	○	●	●
Community Liveability	Qualitative	⬤	⬤	○	○	●	●
Construction Disruption	Qualitative	●	●	⬤	⬤	●	●

4.2 Scenario Comparison – Relative Benefits

As noted previously, the indexing approach looks at the relative benefits of each scenario. This is accomplished by indexing the results **within each account** to assess whether a particular scenario performs above or below average compared to the other project scenarios. This provides a good way of comparing the options using a wide range of metrics, even if measured in something other than dollars.

The chart on the next page indexes the results within each account against the average for the six project scenarios. A bar above the line indicates above-average results in that metric; below the line indicates below average. Note that for the Land Use account, the bar indicates the project in terms of only intensification (jobs/population in station areas), and for the Social/Community Benefit account, in terms of the number of hospital visits avoided per year.



The LRT options have the highest capital and operating costs, but also have the highest monetary and non-monetary benefits. LRT Spurline performs better overall than LRT King Street, except under the land use account.

The BRT options have the lowest capital cost. BRT Spurline performs much better overall than BRT King Street, and performs best of all the options on the ratio of transportation user benefits (those expressed in dollars) to project costs.

The Staging Options perform similarly to BRT in terms of transportation user benefits, but at a higher capital cost. However, in terms of environment, social and land use benefits, Staging Option B performs well in terms of the relative return on costs. This is because Staging Option B allows for introduction of the transit technology with the strongest potential for intensifying land use in the north while phasing in rapid transit in the lower-ridership, less intensified southern portion.

Although difficult to quantify as an "economic benefit", the fact that the Staging Options can be phased in over time allows for more flexibility in terms of outlaying infrastructure dollars at the outset, and is more economically efficient by providing capacity where transportation demand requires it.

4.3 Summary of Conclusions

The purpose of a multiple account evaluation is to provide a broad-based assessment of a potential project or projects, to understand their economic costs and benefits. However, unlike traditional cost-benefit analysis, MAE is a more flexible framework capable of considering non-monetized and/or qualitative measures of benefits. In this application, the MAE provides useful conclusions that reflect the effectiveness of the various rapid transit system alternatives in addressing the objectives of the Regional Growth Management Strategy of fostering a strong economy, building vibrant urban places, and providing greater transportation choices.

First, the MAE indicates the "Spurline Options" route options are superior to the "King Street" route options. Although there are a few metrics where the King Street routes perform as well or slightly better than the Spurline routes, this option consistently scores lower than the Spurline routes in most accounts.

Overall, in terms of benefits per dollar spent, BRT Spurline is the best value for money *if considering monetary benefits only*. However this option underperforms in promoting the intensification objectives of the region. It should be noted that none of the project scenarios provide a positive ratio of monetary benefits to project cost. However, when considering costs and other monetized benefits in the various accounts, Staging Option B represents good value for money spent.

Staging Option B provides roughly the same level of transportation user benefits in absolute terms to the BRT Spurline scenario through the 2031 forecast horizon. This means the benefit to Waterloo Region's economy and its residents in terms of travel time savings, accident avoidance, and vehicle operating cost savings, is roughly equal to the best BRT scenario; however at a higher project cost. LRT Spurline produces the highest transportation user benefits but at a much higher cost.

However, the non-monetary accounts and metrics within the MAE indicate several reasons why the Staging Options are superior. The anticipated land use impacts of the Staging scenarios are considerably higher than the BRT, as this option introduces LRT technology into the section of the corridor with the greater potential for intensification. The higher ridership of the Staging Options will result in greater environmental benefits and community benefits such as air quality improvements, in comparison to a BRT option. Finally, the Staging Options have considerably greater flexibility in terms of the implementation of the right level of transit service required to meet demand. This is inherently more economically efficient than a full LRT option from north Waterloo through to downtown Cambridge, that would provide too much transit capacity in the south end relative to demand.

Staging Option B presents the additional benefit of creating a potential "quick start" to rapid transit in Cambridge by implementing transit priority measures, which will allow the benefits of rapid transit to be achieved sooner. Later on, implementation of LRT in Cambridge would be less disruptive and less expensive than with BRT on a segregated corridor (i.e. Staging Option A).

Practical considerations about the extent and diversity of the Central Transit Corridor suggest the strength of the Staging Option. The CTC is nearly 35 km long, includes a wide range of destinations and trip generators, a diversity of land uses and densities, and widely varying levels of transit demand. A Staging Option provides a flexible way to "right size" rapid transit service for this diverse environment.

The primary reasons for Staging Option B to be the preferred implementation option are:

- The highest ridership occurs north of Fairview Park Mall;
- The up front cost to build LRT to the south end of the corridor is prohibitive;

- A BRT system in the north would encounter operational constraints before 2031 that would inhibit ridership growth;
- A Staging approach is the most cost-effective and provides best value when considering all project benefits and the RGMS goals.

The goals of the RGMS provide the framework for the MAE analysis. A Staging system approach achieves the RGMS objectives nearly as well as LRT Spurline, at roughly half the project cost. Further, it leaves the door open for a future LRT system throughout the CTC. Staging Option B is more economically efficient by providing capacity where and when transportation demand requires it.

Appendix A – Transportation Modelling Output

Transportation modelling for the MAE was conducted by Halcrow Ltd, in conjunction with Regional staff. The data below gives key outputs from the transportation model; details concerning the modelling exercise are outlined in the summary report of the modelling exercise, under separate cover.

Waterloo Rapid Transit - Environmental Assessment Study Phase 2 Step 3 - LRT1A LU — Apr-09

2031 and 2014 MAE Indicators (Aggregate)

	MAE Indicators	Timeframe	2014							2031						
			BAU	LRT 1A	LRT 1C	BRT 2A	BRT 2C	Hybrid*	Hybrid2*	BAU	LRT 1A	LRT 1C	BRT 2A	BRT 2C	Hybrid*	Hybrid2
			LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A
Entire Region	Total RT daily boardings	peak hour	11,200	31,000	30,000	26,200	26,300	27,800	26,850	19,800	63,900	59,900	55,600	52,600	58,400	56,250
	Total RT travel time per Direction (min)	peak hour	93.8	78.1	80.6	78.9	80.8	75.4	75.6	102.6	78.1	80.6	78.9	80.8	75.4	76.5
	Total RT trip length per Direction (min)	peak hour	37.8	36.6	35.6	35.7	34.8	35.7	35.7	37.8	36.6	35.6	35.7	34.8	35.7	35.7
	Average RT travel speed (kph)	peak hour	24.2	28.1	26.5	27.2	25.8	28.4	28.3	22.1	28.1	26.5	27.2	25.8	28.4	28.0
	Number of auto trips converted to transit/bike/walk**	peak hour		770	580	560	420	540	495		1690	1350	1320	1060	1370	1245
	Vehicle kilometer travelled (VKT) - Auto Only	peak hour	1,214,300	1,208,370	1,209,770	1,209,920	1,210,670	1,210,240	1,210,145	1,521,230	1,508,230	1,510,640	1,510,520	1,512,130	1,510,440	1,510,915
	Vehicle kilometer travelled (VKT) - Transit Only	peak hour	5,430	4,790	4,720	5,350	5,280	5,060	5,025	6,700	5,740	5,660	6,590	6,500	6,150	6,080
	Vehicle kilometer travelled (VKT) - All Modes	peak hour	1,219,730	1,213,160	1,214,490	1,215,270	1,215,950	1,215,300	1,215,170	1,527,930	1,513,970	1,516,300	1,517,110	1,518,630	1,516,590	1,516,995
	Vehicle hours travelled (VHT) - Auto Only (hrs)	peak hour	24,200	24,090	24,150	24,160	24,210	24,170	24,200	32,760	32,440	32,590	32,620	32,740	32,620	32,640
	Vehicle speed - Auto Only (kph)	peak hour	50.2	50.2	50.1	50.1	50.0	50.1	50.0	46.4	46.5	46.4	46.3	46.2	46.3	46.3
	Average transit in-veh travel time - All Trips (min)	peak hour	18.0	19.1	19.2	19.0	19.1	18.3	18.1	20.3	21.5	21.6	21.5	21.6	20.7	20.5
	Average transit trip length - All trips (km)	peak hour	6.4	7.0	6.9	6.9	6.9	6.7	6.6	6.8	7.6	7.5	7.5	7.5	7.3	7.2
	Average transit in-veh speed - All Trips (kph)	peak hour	21.3	22.0	21.5	21.8	21.6	22.0	22.0	20.2	21.3	20.9	21.1	20.8	21.3	21.2
	Average transit weighted travel cost - All Trips (min)	peak hour	56.4	56.9	57.0	57.0	57.2	56.5	56.4	57.3	57.4	57.8	57.7	58.0	57.0	56.9
	Average Auto Travel Time - All trips (min)	peak hour	11.2	11.2	11.2	11.2	11.2	11.2	11.2	12.3	12.3	12.3	12.3	12.4	12.3	12.3
	Average Auto Trip Length - All Trips (km)	peak hour	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.9	7.9	7.9	7.9	7.9	7.9	7.9
	Average Auto Speed - All Trips (kph)	peak hour	42.0	41.9	41.8	41.8	41.7	41.7	41.7	38.5	38.4	38.3	38.2	38.1	38.3	38.3
	Criteria Pollutants (tonnes)	annual														
	CO	annual	35,990	35,880	35,880	35,760	35,780	35,920	35,905	46,920	46,360	46,580	46,640	46,780	46,620	46,675
	VOC	annual	3,750	3,730	3,730	3,730	3,730	3,740	3,735	4,860	4,800	4,820	4,830	4,840	4,830	4,830
	NOx	annual	5,220	5,190	5,190	5,200	5,200	5,200	5,200	6,470	6,400	6,410	6,430	6,430	6,420	6,420
	SOx	annual	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	PMtot	annual	90	90	90	90	90	90	90	110	110	110	110	110	110	110
	PMtotrd	annual	14,850	14,770	14,780	14,790	14,800	14,790	14,790	18,600	18,430	18,460	18,470	18,490	18,460	18,465
	Greenhouse Gas Emissions (tonnes)	annual														
	CO2	annual	1,073,260	1,065,390	1,065,950	1,063,860	1,063,800	1,068,370	1,065,685	1,356,900	1,338,720	1,342,110	1,347,320	1,347,960	1,345,110	1,345,430
	CH4	annual	110	110	110	110	110	110	110	140	130	130	130	130	130	130
	N2O	annual	140	140	140	140	140	140	140	180	170	170	170	170	170	170
	CO2eq	annual	1,375,770	1,366,420	1,367,220	1,363,770	1,363,780	1,369,930	1,366,515	1,739,550	1,717,290	1,721,770	1,727,340	1,728,270	1,725,030	1,725,520

Appendix B – Capital and Operating Cost Estimates

Project Scenario costs prepared by Hatch Mott MacDonald Inc.

BAU Scenario costs prepared by MKI in conjunction with GRT staff and Halcrow Ltd.

DESCRIPTION
Waterloo Rapid Transit
Individual Environmental Assessment Study
Route Summary

PROJECT NO. **223112**

MADE BY **E. Cone**
DATE 2009-04-21

PURPOSE & CLASSIFICATION OF ESTIMATE
AACE Estimate Class: **Class 4**
Prepared for: **Project Budget Definition**
Expected Accurary: **+50% / -25%**

WBS L3	Discipline		LRT1A		LRT1C	BRT2A	BRT2C	Hybrid #1	Hybrid #2
	Technology: **LRT** **BRT** **ABRT**		Farmer's Market, King St to Northfield, Waterloo Spur, Uptown Waterloo Loop, King St, Duke/Charles Loop, Ottawa St to Huron Park Spur, Hayward to Courtland, Hydro Corridor, CP Waterloo S/D, Eagle St, Hespeler, Water St		Farmer's Market, King St to University, Waterloo Spur, Uptown Waterloo Loop, King St, Duke/Charles Loop, Ottawa St to Huron Park Spur, Hayward to Courtland, Hydro Corridor, CP Waterloo S/D, Eagle St, Hespeler, Water St	Farmer's Market, King St to Northfield, Waterloo Spur, Uptown Waterloo Loop, King St, Duke/Charles Loop, Ottawa St to Huron Park Spur, Hayward to Courtland, Fairway Rd, Hwy 8/Hwy 401 to Hespeler, Water St	Farmer's Market, King St to Erb, Uptown Waterloo Loop, King St, Duke/Charles Loop, Ottawa St to Huron Park Spur, Hayward to Courtland, Fairway Rd, Hwy 8/Hwy 401 to Hespeler, Water St	LRT: Farmer's Market, King St to Northfield, Waterloo Spur, Uptown Waterloo Loop, King St, Duke/Charles Loop, Ottawa St to Huron Park Spur, Hayward to Courtland, Hydro Corridor. BRT: Hwy 8/Hwy 401 to Hespeler, Water St	LRT: Northfield to Waterloo Spur, Uptown Waterloo Loop, King St, Duke/Charles Loop, Ottawa St to Huron Park Spur, Hayward to Courtland, Hydro Corridor. Ixpress: Hwy 8/Hwy 401 to Hespeler, Water St
	System ID:		**LRT1A**		**LRT1C**	**BRT2A**	**BRT2C**	**Hybrid #1**	**Hybrid #2**
	Route Length:		**39144**		**38081**	**38442**	**37379**	**36162**	**36162**
			LRT		**LRT**	**BRT**	**BRT**	**LRT + BRT**	**LRT + ABRT**
00	Property Acquisition		$54M		$49M	$22M	$17M	$22M	$20M
10	Civil Works		$190M		$184M	$39M	$26M	$100M	$106M
11	Staging/Enabling Works		$124M		$120M	$25M	$17M	$65M	$69M
12	Maintenance Yard		$46M		$46M	$25M	$25M	$46M	$46M
13	Parking; Park and Ride Lots		$12M		$12M	$12M	$12M	$12M	$12M
30	Structures		$60M		$58M	$32M	$30M	$32M	$22M
40	Utility Relocations		$161M		$173M	$150M	$162M	$135M	$96M
50	Stations		$20M		$20M	$18M	$18M	$22M	$18M
70	Traction Power		$34M		$33M	$M	$M	$17M	$17M
71	Hydro Supply		$56M		$54M	$M	$M	$28M	$28M
75	Substation Electrical		$26M		$25M	$M	$M	$13M	$13M
77	Line Electrical		$4M		$4M	$M	$M	$2M	$2M
80	Signals		$27M		$27M	$27M	$26M	$25M	$14M
90	Communications & SCADA		$23M		$22M	$23M	$22M	$21M	$12M
	Sub Total:		**$837M**		**$828M**	**$372M**	**$355M**	**$541M**	**$475M**
	Total Cost per km:		**$21M**		**$22M**	**$10M**	**$10M**	**$15M**	**$13M**
	Soft Costs								
	Engineering Design	10%	$84M		$83M	$37M	$36M	$54M	$48M
	Construction Management	8%	$67M		$66M	$30M	$28M	$43M	$38M
	Design Support (Const)	2%	$17M		$17M	$7M	$7M	$11M	$10M
	Construction CO Contin	10%	$84M		$83M	$37M	$36M	$54M	$48M
	Agency Costs	6%	$50M		$50M	$22M	$21M	$32M	$29M
	Project Reserve	10%	$84M		$83M	$37M	$36M	$54M	$48M
	Program Management	3%	$25M		$25M	$11M	$11M	$16M	$14M
	Sub Total:		**$410M**		**$406M**	**$182M**	**$174M**	**$265M**	**$233M**
	TOTAL:		**$1247M**		**$1234M**	**$554M**	**$529M**	**$807M**	**$708M**
	Total Cost per km:		**$32M**		**$32M**	**$14M**	**$14M**	**$22M**	**$20M**
	Additional Costs								
20	Capital Vehicle Costs	2014	$66M		$61M	$18M	$18M	$67M	$67M
20	Capital Vehicle Costs	2031	$80M		$66M	$41M	$37M	$32M	$29M
			$146M		**$127M**	**$59M**	**$55M**	**$100M**	**$95M**
	Escalation to 2009 Dollars	2%	$28M		$27M	$12M	$12M	$18M	$16M
	GRAND TOTAL CAPEX:		**$1421M**		**$1388M**	**$625M**	**$596M**	**$925M**	**$819M**
	Total Cost per km:		**$36M**		**$36M**	**$16M**	**$16M**	**$26M**	**$23M**

WATERLOO LRT/BRT OPERATING AND MAINTENANCE COST BY ROUTE

OPERATION & MAINTENANCE COSTS

2014 - LRT 1A

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
LRT 1A	39.144	$24M		$24M

2014 - LRT 1C

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
LRT 1C	38.081	$23M		$23M

2014 HYBRID #1 - LRT

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
HYBRID LRT	19.922	$13M		$13M

2014 HYBRID #2 - LRT

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
HYBRID LRT	19.922	$13M		$13M

OPERATION & MAINTENANCE COSTS

2014 - BRT 2A (50% 40' BUS + 50% ARTICULATED BUS)

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
BRT 2A	38.442	$17M		$17M

2014 - BRT 2C (50% 40' BUS + 50% ARTICULATED BUS)

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
BRT 2C	37.379	$16M		$16M

2014 - HYBRID #1 BRT(50% 40' BUS + 50% ARTICULATED BUS)

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
HYBRID BRT	16.240	$7M		$7M

2014 - HYBRID #2 Enh. iXpress (50% 40' BUS+50% ARTICULATED BUS)

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
iXpress	16.240	$5M		$5M

WATERLOO LRT/BRT OPERATING AND MAINTENANCE COST BY ROUTE

OPERATION & MAINTENANCE COSTS

2031 - LRT 1A

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
LRT 1A	**39.144**	**$29M**		**$29M**

2031 - LRT 1C

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
LRT 1C	**38.081**	**$28M**		**$28M**

2031 HYBRID #1 - LRT

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
HYBRID LRT	**19.922**	**$16M**		**$16M**

2031 HYBRID #2 - LRT

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
HYBRID LRT	**19.922**	**$15M**		**$15M**

OPERATION & MAINTENANCE COSTS

2031 - BRT 2A (ARTICULATED BUS)

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
BRT 2A	**38.442**	**$22M**		**$22M**

2031 - BRT 2C (ARTICULATED BUS)

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
BRT 2C	**37.379**	**$21M**		**$21M**

2031 - HYBRID #1 - BRT (ARTICULATED BUS)

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
HYBRID BRT	**16.240**	**$7M**		**$7M**

2031 - HYBRID #2 Enh. iXpress - BRT (ARTICULATED BUS)

Route	Km	Annual Operating & Maintaining Cost		Annual Total Cost
iXpress	**16.240**	**$5M**		**$5M**

Capital Costs - BAU Scenario

		Vehicles	Fleet Structure		Source
Current IExpress Fleet		14	12 rolling, 2 spares		Halcrow Fleet Requirements Summary
Needed 2014		24	20 rolling, 4 spares		Halcrow Fleet Requirements Summary
Needed 2031		39	32 rolling, 7 spares		Halcrow Fleet Requirements Summary
Price (2008 Dollars)			$	486,000	Hatch Mott McDonald - Standard Bus
Vehicle Purchases			Price (2008 Dollars)		
	2013	10		4,860,000	
	2021	8		3,888,000	
	2030	7		3,402,000	
			$	**12,150,000**	

Operating Costs - BAU Scenario

	Vehicles	Annual Op. Costs		Total		Source
Add'l rolling stock - 2013	10	$	356,483	$	3,564,830	As Above
Add'l rolling stock - 2021	8	$	356,483	$	2,851,864	As Above
Add'l rolling stock - 2030	7	$	356,483	$	2,495,381	As Above
Operating Cost/Rev Hour	$ 103.00					from John Cicuttin, GRT - CUTA definition of hourly cost
Avg.Rev. Hrs/Vehicle	3461					from John Cicuttin, GRT
Cost/Vehicle Annually	$ 356,483					

Appendix C – Consumer Surplus

The consumer surplus calculation below is an output of the transportation model, which converts time savings by mode (Single Occupant Vehicle – SOV, High Occupant Vehicle – HOV, Transit) associated with each of the scenarios to an estimate of economic benefit or disbenefit (cost). The consumer surplus output is summarized below.

Rapid transit scenarios vs BAU_v2 (common LRT1A land use) 2031						
Test Scenario	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
Network	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
Land Use	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A	LRT1A
Horizon Year	2031	2031	2031	2031	2031	2031
AM Benefits (min)						
SOV	-3,688	-10,057	-11,651	-16,510	-11,182	-11,321
HOV	-665	-1,812	-2,100	-2,975	-2,015	-2,040
Transit	46,587	33,407	35,855	26,040	36,130	31,873
Total	42,234	21,537	22,104	6,555	22,933	18,512
Annual Benefits ($M)						
SOV	-$1.9	-$5.2	-$6.0	-$8.5	-$5.8	-$5.8
HOV	-$0.4	-$1.0	-$1.1	-$1.6	-$1.1	-$1.1
Transit	$24.0	$17.2	$18.5	$13.4	$18.6	$16.4
Total	$21.7	$11.1	$11.3	$3.3	$11.8	$9.5
AM to Annual Factor = 3,000 *Value of Time = $10.3/hr*						

Appendix D– Data Sources, Inputs, and Assumptions

This appendix outlines a summary of data sources and assumptions used to generate values for the inputs required for each account for the purpose of MAE modelling. The inputs include general inputs, which include assumptions about broader economic indicators and relevant rates and indicators, as well as ridership and traffic inputs that are used in calculations in many accounts. Account-related inputs are specific to individual metrics in the MAE modelling.

The inputs can be grouped under the following categories:

- General Assumptions
- Ridership and Traffic Projections
- Direct Project and Transportation Account
- Direct Transportation User Benefits Account
- Environmental Account
- Land Use/Economic Development Account
- Social and Community Benefit Account

A discussion of the sources of data and associated assumptions in each category follows below.

D.1 General Assumptions

The general assumptions include several variables that impact all calculations in the analysis. A 30 year analysis period was taken in conformity with typical infrastructure investment projects. A discount rate of 6% was used, as this approximates the Region of Waterloo's cost of money.

Recent trend data for Consumer Price Inflation (CPI) indices for Canada indicates a rate of 2%. However, most construction cost indexes, wage increases, and other relevant indicators have risen consistently faster than 2%, and even general CPI is anticipated to rise significantly in coming years. As such, a rate of 3% was used to escalate all costs and benefits within the MAE

The investment start year is 2009. The opening year is 2014, following the anticipated completion of construction by that year. In order to study values of certain outputs, 2031 was considered the output year for the analysis.

A discounted cash flow model was developed to provide comparisons of the base case to the five alternatives on a net present value basis. The base case and five alternate scenarios were evaluated at a 6% and 10% real discount rate over a 30-year period (2009-2038). This analysis assumed that the residual values calculated at the end of the evaluation period were zero and salvage value has not been estimated.

D.2 Ridership and Traffic Projections

D.2.1 Ridership Projections

Ridership forecasts for the projects being evaluated are based on estimates generated by Halcrow Ltd., who provided daily RT boarding data for 2014 and 2031.

Conversion of daily to annual ridership used a standard factor of 300.

D.2.2 Traffic Projections

Highway travel data is used to determine overall corridor performance and quantify the impact of transit in improving the congestion condition faced by traffic as a result of the shift of some trips to transit. For the purposes of MAE analysis, figures for peak hour traffic were provided in terms of Vehicle Kilometres Travelled (VKT) for two periods 2014 and 2031 by Halcrow Ltd.

Peak period travel comprises approximately 10% of the daily transit trips on any given system. A factor of 300 was used to convert daily to annual. Growth rates for VKT were estimated from data for 2014 and 2031 for each scenario. These growth rates were used to interpolate data for 2014 to 2031 and extrapolated from 2031 onwards to get annual trends for the period of analysis.

D.3 Direct Project and Transportation Account:

Direct project costs refer to the cost to the infrastructure provider of each alternative being evaluated. The cost estimates included capital costs and annual operating/maintenance costs.

D.3.1 Capital Costs

Capital cost estimates were provided for the project scenarios by HMM (see Appendix B) in current dollars. For the analysis, these costs were escalated by the inflation rate for the 30 year planning period. To obtain present value estimates these cost streams were discounted at 6% to the current year.

For the BAU case, capital costs were calculated for the additional fleet required to meet demand through gradual growth in the iXpress service. These calculations are documented in Appendix B.

D.3.2 Operating and Maintenance Costs.

The operating costs estimates were provided by Hatch Mott MacDonald at current dollar prices (see Appendix B). The present values of these estimates were also estimated by discounting the cost stream at 6%. For the BAU case, operating costs were escalated from 2009 actual cost figures for iXpress, and calculated for the additional fleet required on-road to meet demand through gradual growth in the iXpress service. These calculations are documented in Appendix B.

D.3.3 Operating Revenues

For the purpose of this analysis, fares for each person boarding transit were assumed to be the only source of revenue. An average fare per boarding figure of $0.95 was provided by Grand River Transit, for 2008. Projected future fare structure was based on staggered fare increases of 25 cents every five years for the analysis period.

D.3.4 Net Operating Costs

Net operating costs were estimated from operating revenues net of operating costs per passenger boarding on transit.

D.4 Direct Transportation User Benefits Account

D.4.1 Travel Time

Travel time data is used to determine the overall economic impact of transit in terms of consumer surplus. The benefit is measured in terms of reduction in total time spent by the transportation user. This benefit can be quantified in monetary terms based on value of time.

For this analysis, data on travel time as well as the value of travel time savings, for the base case and project alternatives, was provided by Halcrow Ltd. for the year 2014 and 2031.

Annual values were estimated on the basis of the growth rate from these endpoints. Time values were escalated by the inflation rate for the 30 year planning period.

D.4.2 Vehicle Operating Costs

Total vehicle operating costs were estimated by multiplying per kilometre costs for vehicle operating expenses with vehicle kilometres travelled for automobiles.

According to Canadian Automobile Association (CAA) estimates, the average costs to operate a typical four-door sedan driven 18,000 km annually was 49.7 cents per kilometre in 2008. This cost included variable operating costs including fuel and oil as well as fixed ownership costs such as insurance, licence fees, registration fees, taxes, finance costs, and depreciation.

This value was escalated with the rate of inflation for the analysis period.

D.4.3 Accident Costs

The incident rate for accidents is directly related to the number of vehicle kilometres travelled. In order to estimate the average cost of accidents for each scenario, the incident rate in Ontario was multiplied by the average cost of accidents and the total automobile VKT.

Accident incidents can be categorised into fatal accidents, injury only, and property damage incidents. The average cost of these accidents and average incident rate for accidents in Ontario have been used for the purpose of this analysis and the values are outlined below. The cost data was available for 2004 and was inflated to current values and for the projection period.

Average Cost and Rate of Incidence Accidents by Collision Severity

	Incidence Rates per Billion VKT	Cost of Accident
Fatal Collisions	6	$15,700,000
Injury Only	525	$82,000
Property Damage Only	3670	$8,000

Source: Transport Canada Study – Accidents Analysis and Estimation of the Social Cost of Motor Vehicle Collisions in Ontario, 2006.

D.5 Environmental Costs

Urban transportation is a major contributor of greenhouse gases (GhG) and criteria air contaminants (CAC). Changes in emissions affect ambient air quality and related environmental impacts. For this analysis, data on emissions for the base case as well as project scenarios was an output of the transportation model for two time periods, 2014 and 2031.

D.5.1 Green House Gas Emissions

According to a Transport Canada study, unit cost of GhG emissions is estimated at $37.38 per tonne of CO2 equivalent. This value was updated by applying inflation to get current values for the analysis period.

D.5.2 Critical Air Contaminants

The unit cost of air pollution by pollutant emitted had been estimated by Transport Canada. The unit costs are:

Unit Cost of Air Pollutant Emitted (Ontario)

Pollutant	Unit Cost per tonne
VOC	$877
NOx	$5,940
SO2	$6,520
PM10	$28,600

Source: Transport Canada, Study of Evaluation of Total Cost of Air Pollution Due to Transportation in Canada, 2007

These values were updated by applying the inflation rate to establish current values for the analysis period.

D.6 Land Use/Economic Development Account

D.6.1 Residential and Employment Estimates – PLUM Modelling

Residential development is measured by the incremental number of residents (population) with 600m of proposed station locations. As part of an earlier stage of the Environmental Assessment, land use modelling associated with different transit scenarios was conducted using the Region of Waterloo's Population Land Use Model (PLUM) in 2008, which allocates growth within the Region within various land use scenarios. The modelling allocates population and employment at a highly detailed level, and through its GIS interface, the total forecast population and employment within a given area of the Region was identified.

These scenarios produced estimates of residential and employment development in the areas surrounding stations on the proposed rapid transit routes. The figure reported is the number of additional population within 600m of proposed stations, compared to the Base Case scenario. Non-Residential Development is measured by the incremental number of jobs (employment) with 600m of proposed station locations. As with the residential development metric, above, these figures are output of the Region of Waterloo's Population and Land Use Model (PLUM). The figure reported is the number of additional employment within 600m of proposed stations.

The modelling summarizes the forecasting exercise undertaken as part of step 2.12 of the Rapid Transit EA. The report for this step of the EA documents the forecasting process used to arrive at the estimates of intensification potential associated with each scenario.

The PLUM output supporting these calculations appears on the following pages. The following sheets were created to provide Land Use data by 600m Station Areas (aggregated from PLUM zones) for the RT EA. They summarize the land use employment by sector and population by dwelling type for the years 2006, 2014 (anticipated RT implementation date) and 2031. Data for BAU is included for comparative purposes.

POPULATION WITHIN 600M OF PROPOSED STATIONS - OUTPUT FROM REGIONAL PLUM MODEL

Route 11a LRT Pop by Station (based on PLUM Zones)

Plum 3n Sc5		-	total	-	-
LRT11a	STATION		2006Tot	2014Tot	2031Tot
1	St. Jacobs Market		18	18	16
1	Conestoga Mall		950	1,318	2,761
2	Northfield		1,250	1,539	2,478
3	R&T Park		676	684	717
4	University Campus		1,543	1,817	2,542
6	Uptown		2,456	3,199	5,899
7	Union Grand River H		3,727	4,322	5,340
10	King Victoria		2,006	3,677	7,826
11	Central Downtown		4,181	4,662	6,193
12	Market		4,694	5,258	6,650
13	King Ottawa Charles		1,946	2,999	6,386
15	Courtland Blockline Fairw		2,574	2,915	3,815
17	Fairview Mall		3,975	3,978	3,977
18	Sportsworld		217	364	759
19	Cherry Blossom Fountain		68	71	73
19	Preston		1,655	2,151	2,474
21	Bridgecam Pinebush		11	11	11
22	Hespeler Bishop		438	616	1,496
23	Hespeler CanAmera		1,844	2,450	4,668
25	Galt Collegiate		2,130	2,376	2,979
25	Galt Core		3,492	4,066	4,556
-		-	-	-	-
-	TOTAL		39,851	48,491	71,616

Route 11c LRT Pop by Station (based on PLUM Zones)

Plum 3n Sc628					
LRT11c	STATION		2006Tot	2014Tot	2031Tot
1	St. Jacobs Market		18	18	16
1	Conestoga Mall		950	1,302	2,691
4	Weber & King		2,670	2,956	3,933
4	University Campus		1,543	1,811	2,512
5	King & University WLU		4,170	5,261	7,359
6	Uptown		2,456	3,173	5,785
7	Union Grand River H		3,727	4,313	5,299
10	King Victoria		2,006	3,635	7,648
11	Central Downtown		4,181	4,647	6,129
12	Market		4,694	5,247	6,602
13	King Ottawa Charles		1,946	2,975	6,293
15	Courtland Blockline Fairw		2,574	2,913	3,815
17	Fairview Mall		3,975	3,982	3,992
18	Sportsworld		217	363	758
19	Cherry Blossom Fountain		68	71	74
19	Preston		1,654	2,154	2,484
21	Bridgecam Pinebush		11	11	11
22	Hespeler Bishop		438	609	1,465
23	Hespeler CanAmera		1,844	2,462	4,750
25	Galt Collegiate		2,130	2,380	2,986
25	Galt Core		3,492	4,063	4,568
-		-	-	-	-
-	TOTAL		44,764	54,346	79,170

Route BRT 12a Pop by Station (based on PLUM Zones)

Plum 3n Sc633					
BRT12a	STATION		2006Tot	2014Tot	2031Tot
1	St. Jacobs Market		18	18	16
1	Conestoga Mall		950	1,203	2,140
2	Northfield		1,250	1,432	2,005
3	R&T Park		676	683	714
4	University Campus		1,543	1,748	2,136
6	Uptown		2,456	3,015	4,961
7	Union Grand River H		3,727	4,259	4,999
10	King Victoria		2,006	3,154	5,246
11	Central Downtown		4,181	4,475	5,290
12	Market		4,694	5,102	5,928
13	King Ottawa Charles		1,903	2,529	4,342
15	Courtland Blockline Fairw		2,574	2,798	3,399
17	Fairview Mall		3,975	3,982	3,998
18	Sportsworld		217	337	665
21	Bridgecam Pinebush		11	11	11
22	Hespeler Bishop		438	633	1,440
23	Hespeler CanAmera		1,844	2,238	3,494
25	Galt Collegiate		2,130	2,356	2,789
25	Galt Core		3,492	4,076	4,493
-		-	-	-	-
-		-	-	-	-
-		-	-	-	-
-	TOTAL		38,085	44,049	58,066

Route BRT 12c Pop by Station (based on PLUM Zones)

Plum 3n Sc6		-	total	-	-
BRT12c	STATION		2006Tot	2014Tot	2031Tot
1	St. Jacobs Market		18	18	16
1	Conestoga Mall		950	1,191	2,087
4	Weber & King		2,670	2,857	3,461
4	University Campus		1,543	1,744	2,115
5	King & University WLU		4,170	5,007	6,203
6	Uptown		2,456	2,994	4,861
7	Union Grand River H		3,727	4,251	4,961
10	King Victoria		2,006	3,130	5,136
11	Central Downtown		4,181	4,466	5,250
12	Market		4,694	5,093	5,889
13	King Ottawa Charles		1,946	2,564	4,358
15	Courtland Blockline Fairw		2,574	2,796	3,391
17	Fairview Mall		3,975	3,982	3,998
18	Sportsworld		217	336	661
21	Bridgecam Pinebush		11	11	11
22	Hespeler Bishop		438	625	1,402
23	Hespeler CanAmera		1,844	2,234	3,475
25	Galt Collegiate		2,130	2,354	2,778
25	Galt Core		3,492	4,068	4,483
-		-	-	-	-
-		-	-	-	-
-		-	-	-	-
-	TOTAL		43,042	49,721	64,536

Route Hybrid 1 Pop by Station (based on PLUM Zones)

Plum 3n Scxxx					
Hyb13_	STATION		2006Tot	2014Tot	2031Tot
1	St. Jacobs Market		18	18	16
1	Conestoga Mall		950	1,332	2,740
2	Northfield		1,250	1,548	2,470
3	R&T Park		676	685	716
4	University Campus		1,543	1,830	2,551
6	Uptown		2,456	3,223	5,868
7	Union Grand River H		3,727	4,333	5,330
10	King Victoria		2,006	3,715	7,780
11	Central Downtown		4,181	4,678	6,178
12	Market		4,694	5,273	6,642
13	King Ottawa Charles		1,946	3,039	6,382
15	Courtland Blockline Fairw		2,574	2,923	3,818
17	Fairview Mall		3,975	3,988	4,018
18	Sportsworld		217	342	687
21	Bridgecam Pinebush		11	11	11
22	Hespeler Bishop		438	660	1,485
23	Hespeler CanAmera		1,844	2,301	3,558
25	Galt Collegiate		2,130	2,371	2,811
25	Galt Core		3,492	4,089	4,526
-		-	-	-	-
-		-	-	-	-
-		-	-	-	-
-	TOTAL		38,128	46,359	67,587

EMPLOYMENT WITHIN 600M OF PROPOSED STATIONS - OUTPUT FROM REGIONAL PLUM MODEL

Route 11a LRT Emp by Station (based on PLUM Zones)

Plum 3n Sc548

		total		
LRT11a	**STATION**	**2006Tot**	**2014Tot**	**2031Tot**
1	St. Jacobs Market	564	1,228	1,789
1	Conestoga Mall	5,776	6,571	7,846
2	Northfield	3,767	4,606	6,868
3	R&T Park	3,854	5,449	7,883
4	University Campus	5,251	5,316	5,640
6	Uptown	4,837	5,746	6,930
7	Union Grand River H	8,237	8,858	10,388
10	King Victoria	3,219	3,770	4,472
11	Central Downtown	9,942	10,746	12,798
12	Market	4,869	5,379	6,763
13	King Ottawa Charles	3,293	3,374	3,808
15	Courtland Blockline Fairw	364	489	728
17	Fairview Mall	3,420	3,612	4,240
18	Sportsworld	1,557	2,783	4,092
19	Cherry Blossom Fountain	6,513	6,730	7,236
19	Preston	961	968	1,055
21	Bridgecam Pinebush	5,471	6,653	9,453
22	Hespeler Bishop	6,194	6,588	8,265
23	Hespeler CanAmera	1,402	1,502	2,025
25	Galt Collegiate	1,171	1,212	1,411
25	Galt Core	4,541	5,118	6,036
	TOTAL	85,203	96,698	119,726

Route 11c LRT Emp by Station (based on PLUM Zones)

Plum 3n Sc628

LRT11c	**STATION**	**2006Tot**	**2014Tot**	**2031Tot**
1	St. Jacobs Market	564	1,240	1,837
1	Conestoga Mall	5,776	6,855	8,753
4	Weber & King	3,512	3,853	4,558
4	University Campus	5,251	5,328	5,671
5	King & University WLU	3,066	2,949	2,554
6	Uptown	4,838	5,787	7,011
7	Union Grand River H	8,237	8,904	10,534
10	King Victoria	3,219	3,797	4,568
11	Central Downtown	9,942	10,776	12,896
12	Market	4,869	5,398	6,829
13	King Ottawa Charles	3,293	3,361	3,768
15	Courtland Blockline Fairw	364	488	725
17	Fairview Mall	3,420	3,624	4,282
18	Sportsworld	1,557	3,184	5,453
19	Cherry Blossom Fountain	6,513	6,748	7,326
19	Preston	962	970	1,062
21	Bridgecam Pinebush	5,471	6,704	9,673
22	Hespeler Bishop	6,191	6,612	8,382
23	Hespeler CanAmera	1,402	1,516	2,084
25	Galt Collegiate	1,171	1,212	1,414
25	Galt Core	4,542	5,150	6,081
	TOTAL	84,160	94,456	115,461

Route BRT 12a Emp by Station (based on PLUM Zones)

Plum 3n Sc633

BRT12a	**STATION**	**2006Tot**	**2014Tot**	**2031Tot**
0.5	St. Jacobs Market	564	1,187	1,630
1	Conestoga Mall	5,776	6,474	7,376
2	Northfield	3,767	4,181	5,201
3	R&T Park	3,854	5,334	7,406
4	University Campus	5,251	5,326	5,662
6	Uptown	4,838	5,653	6,568
7	Union Grand River H	8,237	8,766	9,968
10	King Victoria	3,219	3,699	4,217
11	Central Downtown	9,942	10,651	12,404
12	Market	4,869	5,302	6,480
13	King Ottawa Charles	3,208	3,212	3,424
15	Courtland Blockline Fairw	364	446	614
17	Fairview Mall	3,420	3,533	3,963
18	Sportsworld	1,557	2,749	3,921
21	Bridgecam Pinebush	5,471	6,327	7,700
22	Hespeler Bishop	6,191	6,409	7,268
23	Hespeler CanAmera	1,402	1,445	1,700
24.5	Galt Collegiate	1,171	1,200	1,330
25	Galt Core	4,542	5,153	5,973
	TOTAL	77,643	87,047	102,805

Route BRT 12c Emp by Station (based on PLUM Zones)

Plum 3n Sc623

BRT12c	**STATION**	**2006Tot**	**2014Tot**	**2031Tot**
0.5	St. Jacobs Market	564	1,189	1,637
1	Conestoga Mall	5,776	6,497	7,462
4	Weber & King	3,512	3,701	4,006
4	University Campus	5,251	5,332	5,678
5	King & University WLU	3,066	3,062	2,876
6	Uptown	4,838	5,678	6,609
7	Union Grand River H	8,237	8,796	10,067
10	King Victoria	3,219	3,711	4,255
11	Central Downtown	9,942	10,669	12,463
12	Market	4,869	5,307	6,494
13	King Ottawa Charles	3,293	3,288	3,479
15	Courtland Blockline Fairw	364	444	606
17	Fairview Mall	3,420	3,536	3,974
18	Sportsworld	1,557	2,784	4,051
21	Bridgecam Pinebush	5,471	6,346	7,779
22	Hespeler Bishop	6,191	6,423	7,316
23	Hespeler CanAmera	1,402	1,451	1,723
24.5	Galt Collegiate	1,171	1,200	1,329
25	Galt Core	4,542	5,177	6,002
	TOTAL	38,085	44,049	58,066

Route Hybrid 1 Emp by Station (based on PLUM Zones)

Plum 3n Sc644

Hyb13	**STATION**	**2006Tot**	**2014Tot**	**2031Tot**
1	St. Jacobs Market	564	1,228	1,817
1	Conestoga Mall	5,776	6,812	8,639
2	Northfield	3,767	4,673	7,116
3	R&T Park	3,854	5,502	8,082
4	University Campus	5,251	5,332	5,682
6	Uptown	4,838	5,782	7,023
7	Union Grand River H	8,237	8,886	10,461
10	King Victoria	3,219	3,798	4,570
11	Central Downtown	9,942	10,780	12,906
12	Market	4,869	5,384	6,807
13	King Ottawa Charles	3,293	3,334	3,718
15	Courtland Blockline Fairw	364	482	716
17	Fairview Mall	3,420	3,614	4,262
18	Sportsworld	1,557	2,749	4,079
21	Bridgecam Pinebush	5,471	6,363	7,764
22	Hespeler Bishop	6,191	6,427	7,294
23	Hespeler CanAmera	1,402	1,456	1,728
25	Galt Collegiate	1,171	1,198	1,318
25	Galt Core	4,542	5,151	5,957
	TOTAL	77,728	88,951	109,939

D.6.2 Land Value Uplift

Land value uplift has been calculated for each scenario, using a range of uplift factors. In each project alternative, the presence of rapid transit is assumed to generate increased demand for lands within walking distance of transit stations. For the purpose of this analysis, the distribution of land uses within station areas along the proposed routes was calculated using data from the PLUM model. Lands were given an approximate value, per hectare, dependent on the existing land use. A percentage uplift factor, which differed by land use, was applied to generate a calculation of value uplift potential. The uplift factors are drawn from a survey of studies of land value uplift surrounding transit. A key source for this was the Transportation Research Board's *Transit Cooperative Research Program (TCRP) Report 16: Transit and Urban Form Volume 1.* This comprehensive look at transit's impact on land use (and vice versa) was published in 1996 and assessed and summarized the North American literature to date on the subject to draw conclusions about the relationship. Additional sources were as follows:

- APTA 1999 Rapid Transit Conference Proceedings Paper. An assessment of the DART LRT on taxable property valuations and transit oriented development. Bernard L. Weinstein & Terry L. Clower, September 2002.
- Transportation Research Board, 81st Annual Meeting presentation January, 2002.
- Land value impacts of rail transit services in San Diego County. Robert Cervero & Michael Duncan, June 2002.
- Transit's value-added: effects of light and commuter rail services on commercial land values. Robert Cervero & Michael Duncan, November 2001.
- Journal of the American Planning Association V60n1 (Winter, 1994) pages 83-94. American Planning Association 122 South Michigan Ave., Suite 1600 Chicago, IL 60603 Phone: (312) 431-9100
- The Sedway Group, San Francisco, CA http://www.sedway.com/ Regional impact study commissioned by Bay Area Rapid Transit District (BART) July 1999.
- Transportation Research Record (no. 1466) pages 88-98. Transportation Research Board, Washington DC.
- US National Association of Realtors web site: http://www.realtors.org/smartgrowth/
- Impacts of commuter rail service as reflected in single-family residential property values. Robert J. Armstrong, Jr., 1994.
- Overview of Impacts of Rail Transit on Property Values. Roderick B. Diaz, May 1999.
- The effect of CTA and Metra stations on residential property values. A report to the Regional Transportation Authority. June 1997.

- Vessali, Land Use Impacts of Rapid Transit, A Review of the Empirical Literature, Berkeley Planning Journal 11 (1996): 71-105, Summary of Empirical Findings. http://www-dcrp.ced.berkeley.edu/BPJ/PDF/11-VESSALI.PDF

D.6.3 Support to Regional Land Use Objectives

This is a qualitative metric measuring the overall degree to which the option reflects the land use objectives of the Regional Plan, including focussing development within the Central Transit Corridor, and linking major land uses with rapid transit. The metric is evaluated using a three-score system:

⬤	Strongly supportive or positive
●	Moderately supportive or neutral
○	Weakly supportive or negative

To score each of the project scenarios, the Consultant Team evaluated the policies of the Regional Growth Management Strategy to identify those most relevant to the RT project. The two RGMS policy themes are:

1) centralization of population and employment within the CTC;

2) encouraging the use of alternative modes of transportation through pedestrian oriented development;

With regard to the first theme, the land use metrics (in particular the population and employment within station areas) give a quantitative basis for the degree to which the scenario supports the RGMS objective. Another consideration was the strength of the option in terms of likely land use impacts along the RT corridor, but not in station areas, including any potential negative impacts on development resulting from the transit technology or any routing differences.

With regard to the second theme, the scoring consideration is the degree of support for pedestrian oriented development offered by the transit technology. The evaluation of the project scenarios considered each of these elements and the simple scoring system was applied using the study team's professional judgement of the degree to which the scenario supports each policy objective.

D.6.4 Employment Generated

Economic impact analysis was undertaken using a multi-region input-output model developed for the Province of Ontario. Although developed by the Ministry of Tourism, the model applies directly to estimating the economic impact of capital investments for the project influence area. For the purpose of this analysis the project influence area is assumed to be Kitchener CMA which includes the cities of Kitchener, Cambridge, Waterloo, and the townships of North Dumfries and

Woolwich. This model output provided estimates of the direct, indirect and induced impacts of the capital investment on employment generated.

D.6.5 Taxes Generated

The input-output model was also used to provide estimates of federal, provincial and municipal tax revenues accruing from the capital investment in both base case as well as project cases.

D.7 Social and Community Benefit Account

D.7.1 Public Health Benefits – Hospital Admissions

Poor air quality and smog – caused in part by vehicle exhaust – are resulting in increased hospital admissions, heart attacks and strokes, respiratory illnesses and premature deaths particularly in urban areas. In order to assess the related costs to society, within the social and community benefits account, a reduction in the number of hospital admissions as a result of the project scenarios was estimated.

A 2005 report entitled *The Illness Cost of Air Pollution (ICAP)* by the Ontario Medical Association (OMA) provided the background data for estimation of health and related economic damages associated with air pollution exposure in the Region of Waterloo. According to the ICAP report, hospital admissions attributable to poor air quality (increased PM2.5, CO, SO2, No2 and O3) are estimated to increase from 656 in year 2005 to 939 in year 2026.

The underlying assumption is that reduction in GhG and CAC emissions will result in improved air quality and hence reduce the health impact of air pollution. This in turn will impact the number of hospital admissions.

In order to quantify the impact of improved air quality associated with the project scenarios, the following steps were taken.

- Project the share of hospital admissions due to poor air quality.
- Calculate the share of transportation sector on air quality.
- Calculate the share of automobiles in transportation.
- Calculate the reduction of air pollution due to the project scenarios.

According to a study on air pollutant emissions for Ontario, nearly 59% of the criteria air contaminant emissions were attributable to the transportation sector. Data from the same study indicates that out of the total mobile sources of air contaminants, light vehicles were responsible for nearly 45% of the pollution.

Applying these shares to the projected hospital admissions for the period of analysis established the baseline data of hospital admissions attributable to light vehicles. The number of hospital admissions due to improved air quality was then estimated for all the project scenarios.

D.7.2 Public Health Benefits – Economic Damage

The other endpoint evaluated under the social and community account was an estimation of reduction in economic damages as a result of improved air quality. The ICAP report provides estimates of economic damages. A summary of the economic damages for 2005, 2015 and 2026 in constant 2003 dollars for waterloo area is provided below:

Economic Damages for Waterloo Area

	2005	2015	2026
Lost Productivity	$ 16,009,700	$ 17,035,000	$ 19,486,900
Healthcare Costs	$ 19,894,200	$ 21,990,400	$ 26,563,000
Pain and Suffering	$ 22,441,300	$ 24,477,800	$ 29,255,200
Loss of Life	$ 224,411,600	$ 288,951,100	$ 382,458,800
Total	$ 282,756,800	$ 352,454,300	$ 457,763,900

Quantifying the impact of improved air quality associated with the project scenarios in economic terms the following steps were involved.

- Project the share of economic damages due to poor air quality for the analysis period.
- Estimation of share of transportation sector on air quality.
- Estimation of share of automobiles in transportation.
- Estimation of reduction of air pollution due to the project scenarios.

As in the case of hospital admissions, the base case scenario of economic damages that are attributable to light vehicles was established, as a point of comparison.

In order to estimate the reduction of air pollution due to the project scenarios, reduction factors were estimated. The reduction factors were arrived as a share of CAC emissions in project case as compared to base case.

Applying these reduction factors, the reduction in economic damages due to improved air quality was estimated for all the project scenarios.

D.7.3 Public Health – Active Transportation

The Public Health – Active Transportation metric refers to the number of walk, bike, and transit trips taken in each of the scenarios. It considered the degree to which the scenario will encourage the use of alternative modes of transportation (integrating transportation modes to promote walking and cycling, as well as intercity transit, rail and RT as well as walking and cycling in station areas).

The LRT Spurline option performs most strongly, as it generates the largest number of walk/bike/transit trips, will offer strong support for transit-oriented

development, and does not have a transfer between modes within the RT corridor that may inhibit bike trips. The "C" routes (LRT King Street and BRT King Street) do not produce as many additional trips by active transportation modes. BRT scenarios produce the fewest additional trips by active transportation modes and have weaker land use impacts. The Staging Option scenarios produce more trips by active transportation modes than the BRT scenarios and will support pedestrian oriented development in the north part of the corridor, however, trips by the Staging Option modes include a transfer between modes which will likely be somewhat of a barrier for bike-transit trips.

D.7.4 Community Livability

Community Liveability is a metric designed to reflect the intangible, "quality of life" benefits associated with the options, including issues such as noise generated by the transit system, fumes generated, and aesthetic considerations. The basic question asked by this metric is, "to what degree would I notice the presence of the rapid transit line in my neighbourhood, if I lived close by".

The nature of the transit technology is a major consideration here, as noise and fumes are a function of speeds and motive power (LRT is electric, and low-noise; BRT is diesel, noisier and generates more emissions). Aesthetic considerations include the presence of utility poles (caternary), stations, new structures, or other barriers/fences where none exist today. The degree to which these are associated with each option were reviewed through assessing the preliminary functional design, to generate the simple score for each scenario.

D.7.5 Construction Disruption

This is a qualitative measure of the likely disruption to existing residents and businesses in the corridor associated with the construction of the project. Considerations here include the number of road lanes removed from service to construct the project, the creation of temporary barriers on roads or sidewalks which may limit access to businesses, and the overall scale of the construction itself. In conjunction with the functional design consultants on the Project Team, the degree to which these types of impacts are associated with each option were reviewed through assessing the preliminary functional design, to generate the simple score for each scenario.

Appendix E – TREIM Model Runs

The economic impact of the investment spending that Region of Waterloo RT– alternatives are expected to have on Ontario's economy were estimated by using the Ontario Ministry of Tourism's TREIM[1] model. The TREIM model, while used in other applications to estimate tourism spending, is an economic impact model with the capability of calculating standard economic impacts associated with a wide range of types of investment, including capital investment in transportation projects. This model estimated the impact of the investment spending in terms of:

- Estimates of the Direct, Indirect and Induced impacts of the investment spending on Gross Domestic Product (GDP).
- Estimates of the Direct, Indirect and Induced impacts of investment spending on Labour Income and Employment (Number of Jobs).
- Estimates of the Direct and Total impacts of investment spending on Federal, Provincial and Municipal Tax Revenues.

For the purpose of this analysis the model was used to estimate the impact of the investments proposed in each scenario on Kitchener CMA[2]. The analysis was undertaken in 2009 and both induced impacts of household spending as well as business investment were included. The model inputs were customized to reflect the current economic environment and the values used are as follows:

Exhibit E1

General Inputs	**2009**
Ontario Real GDP (% change)	0.00%
Ontario CPI (% change)	1.96%
Ontario Population (% change)	0.87%
Ontario Unemployment Rate(% change)	7.00%
Government of Canada 3 month T-Bill Rate	4.77

The total investment expenditures for the project were grouped under the following categories for estimation of the impact analysis:

Exhibit E.2

The detailed results of the impact analysis are presented in Exhibits D3 through D9.

	BAU	LRT Spurline	LRT King St.	BRT Spurline	BRT King St.	Staging Option A	Staging Option B
Buildings and Renovations	$ -	$ 853,783,650	$ 844,489,440	$ 379,092,986	$ 362,452,254	$ 552,247,426	$ 484,753,202
Transportation Equipment	$ 12,150,000	$ 149,144,400	$ 129,315,600	$ 59,914,800	$ 55,949,040	$ 101,983,680	$ 97,026,480
Other Services	$ -	$ 418,353,989	$ 413,799,826	$ 185,755,563	$ 177,601,604	$ 270,601,239	$ 237,529,069
Total	**$ 12,150,000**	**$ 1,421,282,039**	**$ 1,387,604,866**	**$ 624,763,348**	**$ 596,002,899**	**$ 924,832,345**	**$ 819,308,751**

Exhibit E.3 Economic Impacts of Waterloo RT – Scenario BAU

	Kitchener	Rest of Ontario
Total Visitors' Spending	$ 12,150,000	
Gross Domestic Product (GDP)		
Direct	$ 769,295	$ 928,100
Indirect	$ 10,142	$ 590,115
Induced	$ 9,232	$ 509,973
Total	$ 788,669	$ 2,028,188
Labour Income		
Direct	$ 22,931	$ 555,955
Indirect	$ 7,036	$ 394,687
Induced	$ 5,924	$ 266,386
Total	$ 35,891	$ 1,217,029
Employment (Jobs)		
Direct	0	7
Indirect	0	7
Induced	0	5
Total	1	19
Direct Taxes		
Federal	$ 302,300	$ 186,466
Provincial	$ 441,766	$ 129,987
Municipal	$ 61	$ 1,473
Total	$ 744,127	$ 317,925
Total Taxes		
Federal	$ 307,438	$ 408,842
Provincial	$ 445,310	$ 301,451
Municipal	$ 212	$ 110,015
Total	$ 752,960	$ 820,309

Exhibit E4 Economic Impacts of Waterloo RT – Scenario LRT Spurline

	Kitchener	Rest of Ontario
Total Visitors' Spending	$ 1,421,282,039	
Gross Domestic Product (GDP)		
Direct	$ 611,675,996	$ 87,202,464
Indirect	$ 119,447,573	$ 112,653,666
Induced	$ 156,728,549	$ 135,420,378
Total	$ 887,852,118	$ 335,276,508
Labour Income		
Direct	$ 434,420,611	$ 60,387,372
Indirect	$ 84,488,405	$ 76,788,752
Induced	$ 99,475,018	$ 82,344,200
Total	$ 618,384,034	$ 219,520,323
Employment (Jobs)		
Direct	7,223	951
Indirect	1,533	1,310
Induced	1,824	1,560
Total	10,580	3,822
Direct Taxes		
Federal	$ 142,125,927	$ 19,749,888
Provincial	$ 124,760,545	$ 14,406,199
Municipal	$ 51,863,882	$ 205,571
Total	$ 318,750,353	$ 34,361,658
Total Taxes		
Federal	$ 222,988,230	$ 72,411,770
Provincial	$ 176,323,046	$ 53,965,223
Municipal	$ 54,006,006	$ 14,575,835
Total	$ 453,317,281	$ 140,952,828

Exhibit E5 Economic Impacts of Waterloo RT – LRT King Street

	Kitchener	Rest of Ontario
Total Visitors' Spending	$ 1,387,604,866	
Gross Domestic Product (GDP)		
Direct	$ 481,990,385	$ 49,656,129
Indirect	$ 81,478,388	$ 96,293,884
Induced	$ 119,742,567	$ 100,546,216
Total	$ 683,211,340	$ 246,496,229
Labour Income		
Direct	$ 338,218,033	$ 29,864,769
Indirect	$ 58,135,359	$ 64,524,024
Induced	$ 75,852,008	$ 61,185,594
Total	$ 472,205,400	$ 155,574,387
Employment (Jobs)		
Direct	5,713	389
Indirect	1,070	1,083
Induced	1,391	1,161
Total	8,174	2,633
Direct Taxes		
Federal	$ 110,447,365	$ 10,002,497
Provincial	$ 110,980,561	$ 6,988,686
Municipal	$ 50,947,826	$ 79,598
Total	$ 272,375,753	$ 17,070,781
Total Taxes		
Federal	$ 170,457,321	$ 51,562,607
Provincial	$ 148,642,781	$ 38,014,367
Municipal	$ 52,515,311	$ 10,909,040
Total	$ 371,615,414	$ 100,486,014

Exhibit E6 Economic Impacts of Waterloo RT – Scenario BRT Spurline

	Kitchener	Rest of Ontario
Total Visitors' Spending	$ 624,763,349	
Gross Domestic Product (GDP)		
Direct	$ 271,194,114	$ 38,237,410
Indirect	$ 53,031,282	$ 49,713,595
Induced	$ 69,595,532	$ 59,861,981
Total	$ 393,820,928	$ 147,812,985
Labour Income		
Direct	$ 192,877,484	$ 26,524,295
Indirect	$ 37,510,490	$ 33,890,480
Induced	$ 44,172,234	$ 36,423,540
Total	$ 274,560,208	$ 96,838,315
Employment (Jobs)		
Direct	3,207	419
Indirect	680	578
Induced	810	690
Total	4,697	1,687
Direct Taxes		
Federal	$ 62,950,750	$ 8,672,471
Provincial	$ 55,166,246	$ 6,329,091
Municipal	$ 23,028,260	$ 90,511
Total	$ 141,145,256	$ 15,092,073
Total Taxes		
Federal	$ 98,858,041	$ 31,939,581
Provincial	$ 78,061,011	$ 23,804,622
Municipal	$ 23,979,513	$ 6,413,485
Total	$ 200,898,565	$ 62,157,688

Exhibit E7 Economic Impacts of Waterloo RT – Scenario BRT King Street

	Kitchener	Rest of Ontario
Total Visitors' Spending	$ 596,002,898	
Gross Domestic Product (GDP)		
Direct	$ 259,205,156	$ 36,456,901
Indirect	$ 50,702,297	$ 47,466,483
Induced	$ 66,539,896	$ 57,176,622
Total	$ 376,447,349	$ 141,100,006
Labour Income		
Direct	$ 184,408,379	$ 25,298,860
Indirect	$ 35,863,149	$ 32,359,427
Induced	$ 42,232,825	$ 34,794,608
Total	$ 262,504,354	$ 92,452,895
Employment (Jobs)		
Direct	3,066	399
Indirect	651	552
Induced	774	659
Total	4,491	1,611
Direct Taxes		
Federal	$ 60,154,273	$ 8,271,284
Provincial	$ 52,696,092	$ 6,036,978
Municipal	$ 22,017,398	$ 86,376
Total	$ 134,867,764	$ 14,394,638
Total Taxes		
Federal	$ 94,485,004	$ 30,492,333
Provincial	$ 74,585,546	$ 22,726,313
Municipal	$ 22,926,885	$ 6,119,500
Total	$ 191,997,435	$ 59,338,146

Exhibit E8 Economic Impacts of Waterloo RT – Scenario Hybrid Staging Option A

	Kitchener	Rest of Ontario
Total Visitors' Spending	$ 924,832,345	
Gross Domestic Product (GDP)		
Direct	$ 395,995,577	$ 56,825,776
Indirect	$ 77,266,113	$ 73,134,840
Induced	$ 101,389,529	$ 87,837,963
Total	$ 574,651,219	$ 217,798,580
Labour Income		
Direct	$ 281,003,916	$ 39,312,266
Indirect	$ 54,652,288	$ 49,847,883
Induced	$ 64,351,810	$ 53,390,724
Total	$ 400,008,014	$ 142,550,873
Employment (Jobs)		
Direct	4,672	618
Indirect	991	851
Induced	1,180	1,012
Total	6,844	2,481
Direct Taxes		
Federal	$ 92,069,071	$ 12,859,330
Provincial	$ 80,898,534	$ 9,377,256
Municipal	$ 33,546,751	$ 133,636
Total	$ 206,514,356	$ 22,370,222
Total Taxes		
Federal	$ 144,380,457	$ 47,025,828
Provincial	$ 114,253,885	$ 35,044,822
Municipal	$ 34,932,577	$ 9,479,939
Total	$ 293,566,919	$ 91,550,589

Exhibit E8 Economic Impacts of Waterloo RT – Scenario Hybrid Staging Option B

	Kitchener	Rest of Ontario
Total Visitors' Spending	$ 619,308,751	
Gross Domestic Product (GDP)		
Direct	$ 348,073,357	$ 50,454,114
Indirect	$ 67,829,119	$ 64,561,101
Induced	$ 89,005,527	$ 77,429,021
Total	$ 504,908,003	$ 192,444,235
Labour Income		
Direct	$ 246,674,527	$ 34,851,126
Indirect	$ 47,977,177	$ 43,999,467
Induced	$ 56,491,785	$ 47,036,017
Total	$ 351,143,488	$ 125,886,610
Employment (Jobs)		
Direct	4,101	547
Indirect	870	751
Induced	1,036	891
Total	6,007	2,189
Direct Taxes		
Federal	$ 81,003,702	$ 11,402,909
Provincial	$ 71,284,277	$ 8,311,506
Municipal	$ 29,446,782	$ 118,214
Total	$ 181,734,760	$ 19,832,629
Total Taxes		
Federal	$ 126,925,957	$ 41,533,142
Provincial	$ 100,565,580	$ 30,949,689
Municipal	$ 30,663,365	$ 8,391,518
Total	$ 258,154,903	$ 80,874,349

NOTES