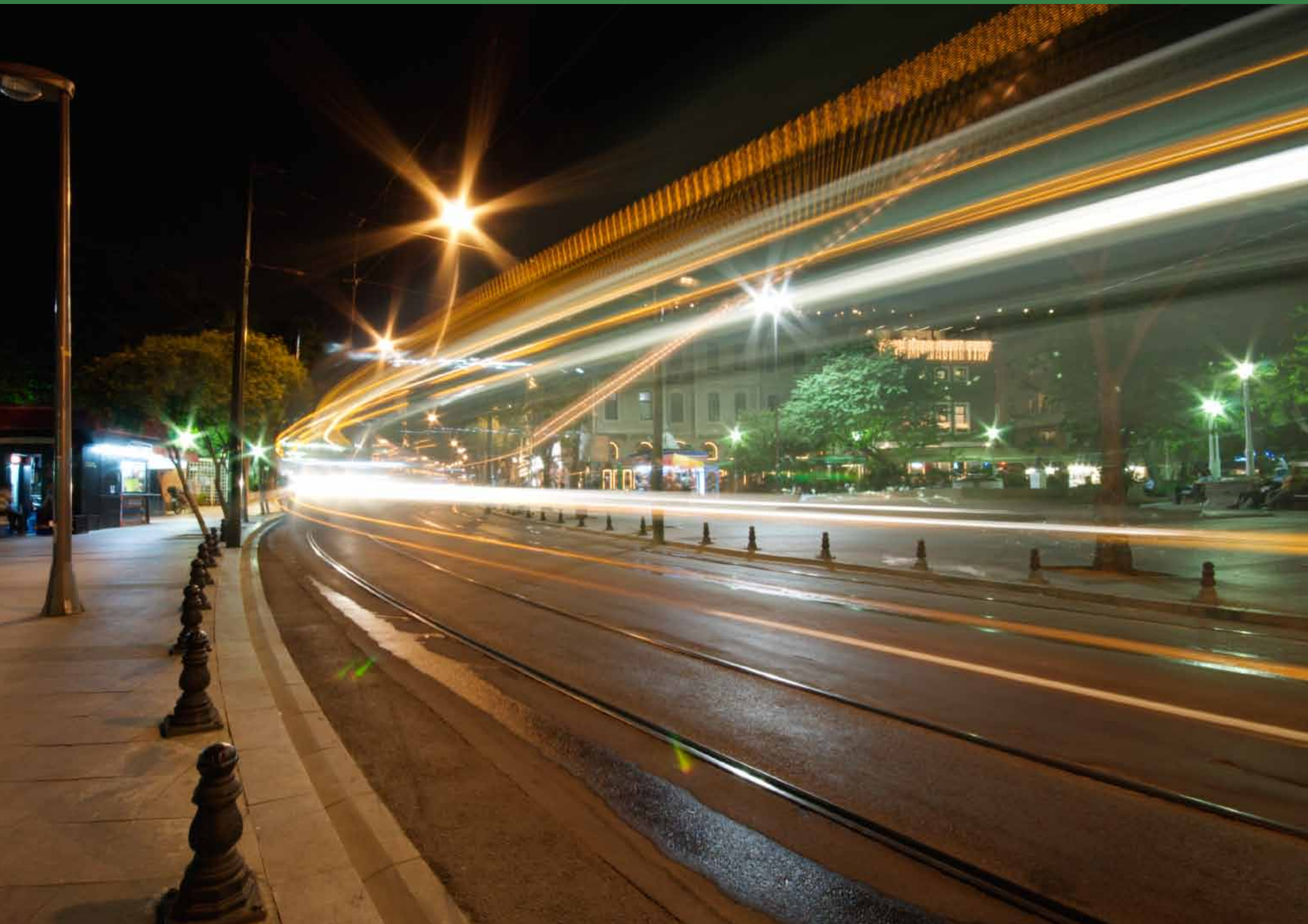
HAMILTON KING-MAIN BENEFITS CASE

February 2010



Hamilton King-Main

Rapid Transit

Benefits Case

February 2010

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Executive Summary

In 2006 the Province of Ontario created the Greater Toronto Transportation Authority, renamed Metrolinx in December 2007. The primary responsibility of the new organisation is to provide leadership in the planning, financing and development of the Greater Toronto and Hamilton Area's (GTHA) multi-modal transportation network and to conform to the objectives and vision set out in the Places to Grow Act, 2005.

Part of Metrolinx' mandate and one of its first deliverables was the development of the Regional Transportation Plan (RTP), known as *The Big Move*, a 25-year plan that presents the road map for the implementation of the Province's MoveOntario 2020 vision of 52 new rapid transit projects in the GTHA by 2020.

As the rapid transit projects contemplated in *The Big Move* progress closer to implementation, a Benefits Case will be prepared for each project. The purpose of the Benefits Case is to undertake a comparative analysis of feasible options for a specific rapid transit project and present the results in such a way that it will assist decision makers to select a preferred option for implementation.

The Hamilton B-Line Rapid Transit project is one of the projects contemplated in MoveOntario 2020, and was identified as a Top 15 priority project in *The Big Move*. The project involves the provision of rapid transit between Eastgate Square and McMaster University along the Main Street/King Street corridor.

The city believes that rapid transit in Hamilton, starting with the B-Line corridor, will help achieve the goals of *The Big Move*, the Provincial Growth Plan, the Hamilton Transportation Master Plan and City's new Official Plan and result in enhanced prosperity, environmental sustainability and improved quality of life in the City of Hamilton. Rapid transit service along the B-Line corridor will deliver:

- Accessible rapid transit within 800 metres to close to 20 percent of the City's residents and employment including important government facilities in the downtown;
- Access to McMaster University and Hospital, one of Canada's top teaching and research institutions boasting a full and part-time student population of over 23,000 and having a significant economic impact on the Hamilton area;
- Improved access to the downtown and regional rail facilities; and
- An enhanced image and prosperity for the city.

Three options have been identified for this corridor. They are:

- **Option 1:** Full BRT
- **Option 2:** Full LRT
- **Option 3:** Phased LRT

Each of the options is compared to the Base Case, which is defined as the committed municipal bus network and GO Transit services (namely planned and funded existing and proposed services) that serve Hamilton. The table below summarizes the key characteristics of the options.

SUMMARY OF OPTIONS

	Option 1	Option 2	Option 3
Opening Year	2015	2015	2015/2030
Headway	2.5 min	4 min	4 min
Capacity (phpd)[1]	2200	1950/ 3900	1950 /3900
LRT Vehicles	n/a	30	20/30
BRT Vehicles	36	n/a	n/a
Travel time (end-to-end)	34	26	17[2]

The assessment of the options is done using a Multiple Account Evaluation (MAE) methodology. The MAE is a framework that provides a systematic identification and analysis of broader public policy implications and criteria of an option, not only costs and user benefits. The MAE framework is based on a number of evaluation "accounts" that together address the most significant project performance and policy considerations for a specific project:

- Transportation User Benefits
- Financial Impacts
- Environmental Impacts
- Economic Development Impacts
- Socio-Community Impacts

[1] Per Peak Hour Peak Direction capacities for LRT are shown for both one-car and two-car trains.

[2] Approximately 30 minute travel time from McMaster University to Eastgate Square, with BRT service connecting the eastern LRT terminus to Eastgate Square.

The assessment is done by comparing each option to the Base Case and identifying any incremental impacts, costs or benefits that are generated by each option. The analysis is done over a 30-year period (2009-2038). In order to compare the options on a "like-to-like" basis the monetized values are discounted to today's value. The values are discounted at a real discount rate of 5% and expressed in net present value in 2008 dollars.

The table below summarizes the results from the MAE.

MULTIPLE ACCOUNT EVALUATION SUMMARY

	Option 1	Option 2	Option 3
Transportation User Account			
Transportation User Benefits (PV $m)	313	**852**	748
Qualitative User Benefits	✓	✓✓✓	✓✓
Financial Account			
Costs (PV $m)	**(220)**	(784)	(655)
Benefits Less Costs (PV $m)	93	**69**	93
Benefit-Cost Ratio	**1.4**	1.1	1.1
Environmental Account			
GHG Emissions (PV $m)	0.6	**2.6**	2.5
Economic Development Account			
Economic Impacts During Construction			
Employment (person-years)	1,837	5,793	4,308
GDP ($m)	129.4	487.5	362.5
Income ($m)	53.4	201.3	149.7
Long-term Economic Impacts			
Employment (person-years)	48	187	187
GDP ($m)	4.1	15.8	15.8
Income ($m)	1.7	6.5	6.5
Development Potential ($m)	38 - 77	50 - 144	38 - 106
Social Community Account			
Land Use Shaping	✓	✓✓✓	✓✓
Road Network	✓✓✓	✓	✓✓
Construction Implications	✓✓✓	✓✓	✓

The analysis of the Hamilton rapid transit options reveals that the highest cost option (the full LRT along the Main Street-King Street corridor), with estimated capital and operating costs of $784 million in net present value terms, also generates the highest Transportation User Benefits.

These are estimated at more than $850 million resulting in a benefit-cost ratio of 1.1. By comparison, Option 1 (the full BRT option), generates an estimated $313 million in Transportation User Benefits less than one-half of that generated by of Option 2. However the estimated cost of $220 million for Option 1 in net present value terms is also much lower than either LRT option, resulting in a strong benefit-cost ratio of 1.4. By deferring a portion of the capital investment, the net present value of Option 3 is reduced by almost $130 million from the cost of the full LRT option. The Transportation User Benefits of this option are also lower than the full LRT option resulting in the same benefit-cost ratio (1.1).

For each option, the majority of benefits are derived from the travel time savings thus highlighting the importance of the operating speed of the rapid transit system to the success of the project. Given the supportive transit signal priority/pre-emption measures proposed under each of the options, the City of Hamilton has an opportunity to establish a new performance standard for the region to fully realize the benefits from the rapid transit investment.

None of the options generate sufficient incremental fare revenues to cover the incremental operating cost associated with the introduction of the new rapid transit line. The greatest incremental fare revenues are generated by Option 2 which is also the most costly to operate on an annual basis. However, the operating costs used in this comparative analysis are considered to be conservative and estimated at the higher end of the range. Lowering these costs would result in better revenue to cost ratios for all three options. The relatively low incremental fare revenues however indicate that much of the travel time savings are associated with improved travel times for existing riders which does not contribute to additional fare revenue for the operator.

All of the options are somewhat effective in attracting people out of their cars and reducing automobile usage. Option 2, which has the largest effect, will result in a reduction of greenhouse gas emissions by approximately 3,449 tonnes annually by 2021 increasing to 8,532 tonnes by 2031. In net present value terms, this equates to $2.6 million for Option 2 compared to $0.6 million and 2.5 million for Options 1 and 3 respectively.

As expected the options with the highest capital costs generated the most significant economic development effects. Option 2, which has the highest capital cost will have the largest impact on employment, income and GDP during construction, is estimated to generate approximately 5,793 person-years of employment[3]. Option 3 defers some of the capital and on-going operating costs but still generates relatively strong employment, income and construction GDP effects. By contrast, the lower cost BRT option produces the lowest overall economic development and employment benefits during construction as well as during the on-going operations.

[3] Includes both direct and indirect impacts.

All of the options support the City of Hamilton's land use and economic development objectives to revitalize the corridor by enhancing and supporting complementary planning and densification initiatives. LRT demonstrates a greater ability to attract investment and redevelopment than the BRT alternative and consequently provides higher property value uplift. At the upper end of the range of estimated uplift, Option 2 produces double the uplift of Option 1 at $144 million versus $77 million. At the lower end of the range, the difference is less dramatic with Option 1 producing an estimated $38 million in property value uplift versus $50 million for Option 2. Option 3 by comparison defers the implementation of a portion of the line and postpones potential development opportunities in the vicinity of up to five of the proposed LRT stations. As a consequence the potential uplift is constrained and is estimated to be in the range of between $38 million and $106 million.

Finally, the results of the comparative analysis presented in this report are based on the assumption that the current one-way street system through the downtown core is converted to a two-way traffic system where both Main Street and King Street are converted to two-way streets. In the absence of this conversion, the incremental benefits generated by the introduction of a rapid transit system are greater than those presented in this report, reflecting the different trip characteristics under each scenario. The one-way system typically supports longer cross town trips rather than the shorter trips encouraged by the two-way streets. As a consequence, the travel time savings resulting from the introduction of rapid transit under a two-way street scenario are less significant than under a one-way scenario as individual trip patterns already reflect the shorter trip distances. However, as the results show, the introduction of rapid transit under the two-way scenario does present positive travel savings as rapid transit is able to offer faster and more competitive travel times for the shorter trips. Furthermore, the two-way street system is more supportive of the City's objective to create a healthy, more pedestrian-friendly downtown.

In addition to the merits of the two-way conversion, the ability of the rapid transit system to compete with the automobile and generate travel time benefits is directly related to the operating speed of the rapid transit system. For each option assessed in this study, the majority of the benefits are derived from the travel time savings. If the City of Hamilton provides the supportive transit signal priority/pre-emption measures proposed under each of the options, the results indicate that the city can leverage the benefits from a rapid transit investment while establishing a new performance standard for rapid transit in the region.

Part A Project Rationale

Introduction

Purpose of Report

In 2006 the Province of Ontario created the Greater Toronto Transportation Authority, renamed Metrolinx in December 2007. The primary responsibility of the new organization is to provide leadership in the planning, financing and development of the Greater Toronto and Hamilton Area's (GTHA) multi-modal transportation network and to conform to the objectives and vision set out in the *Places to Grow Act*, 2005.

Part of Metrolinx' mandate and one of its first deliverables was the development of the *Regional Transportation Plan* (RTP), known as The Big Move, a 25-year plan that presents the road map for the implementation of the Province's *MoveOntario 2020* vision of 52 new rapid transit projects in the GTHA by 2020.

As the rapid transit projects contemplated in The Big Move move closer to implementation, a Benefits Case will be prepared for each project. The Benefits Case will describe a range of feasible options for each project, be it different technology, capacity or length of alignment, and demonstrate the benefits and costs associated with each of the options.

The Hamilton B-Line Rapid Transit initiative is one of the projects contemplated in *MoveOntario 2020* and was identified as a Top 15 priority project in The Big Move. The project involves the provision of a higher order rapid transit service along the existing B-line corridor which currently runs from a western terminus at University Plaza, a privately owned retail mall west of McMaster University, eastward via the King Street / Main Street corridor to an eastern terminus at the Eastgate Square shopping mall. The Bus Rapid Transit lite version which is currently in-service is scheduled for short term improvements as a result of "Quick-Wins" funding from Metrolinx.

Three options were identified for this corridor and this document presents the comparison of these options against the Base Case. The assessment of the options includes the relative strengths and weaknesses of each option on people, the economy and the environment compared to the cost of implementing the option. The objective of the assessment is to clearly outline the trade-offs among the criteria to enable decision makers to make an informed decision.

Report Structure

This report is structured as follows:

- **Part A - Project Rationale**: This section describes the policy context, the broader regional and project objectives, the characteristics of the corridor and the issues and opportunities to be addressed by the proposed project.

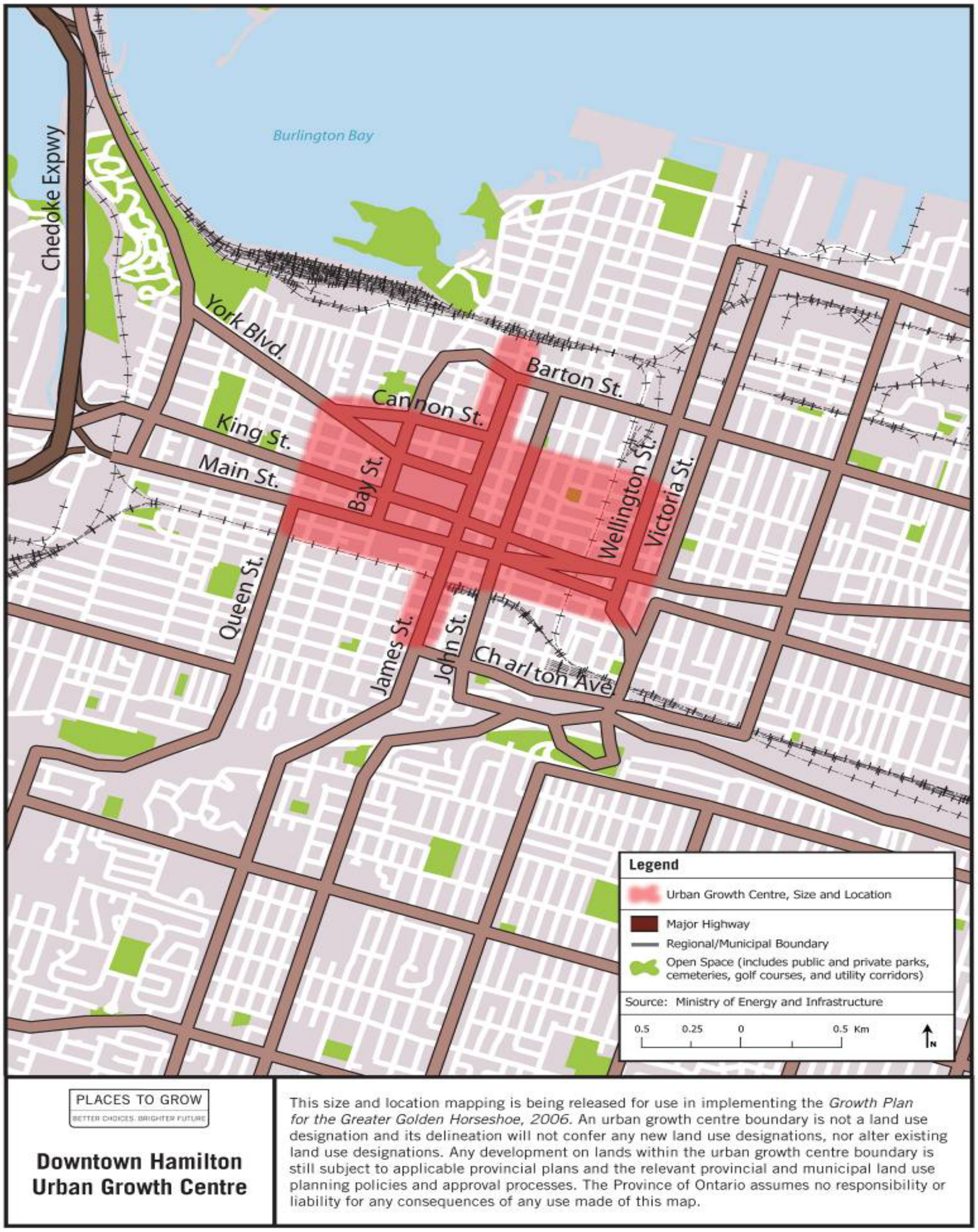
- **Part B – Project Options**: This section describes the options that are evaluated.
- **Part C – Project Assessment:** This section describes the evaluation methodology, the analysis and the summary results.

Project Rationale

Context and Need

The City of Hamilton is forecast to experience significant population growth over the next 20 years. The population of the city is planned to grow from the current 500,000 residents to an anticipated population of 660,000 residents while employment is expected to grow to 300,000 jobs by 2031. Much of this residential and employment growth is expected to occur in the Downtown Hamilton Urban Growth Centre and is illustrated in Figure 1. It is anticipated this growth will primarily be focused around specific development nodes and along the major urban corridors.

FIGURE 1 DOWNTOWN HAMILTON URBAN GROWTH CENTRE[4]



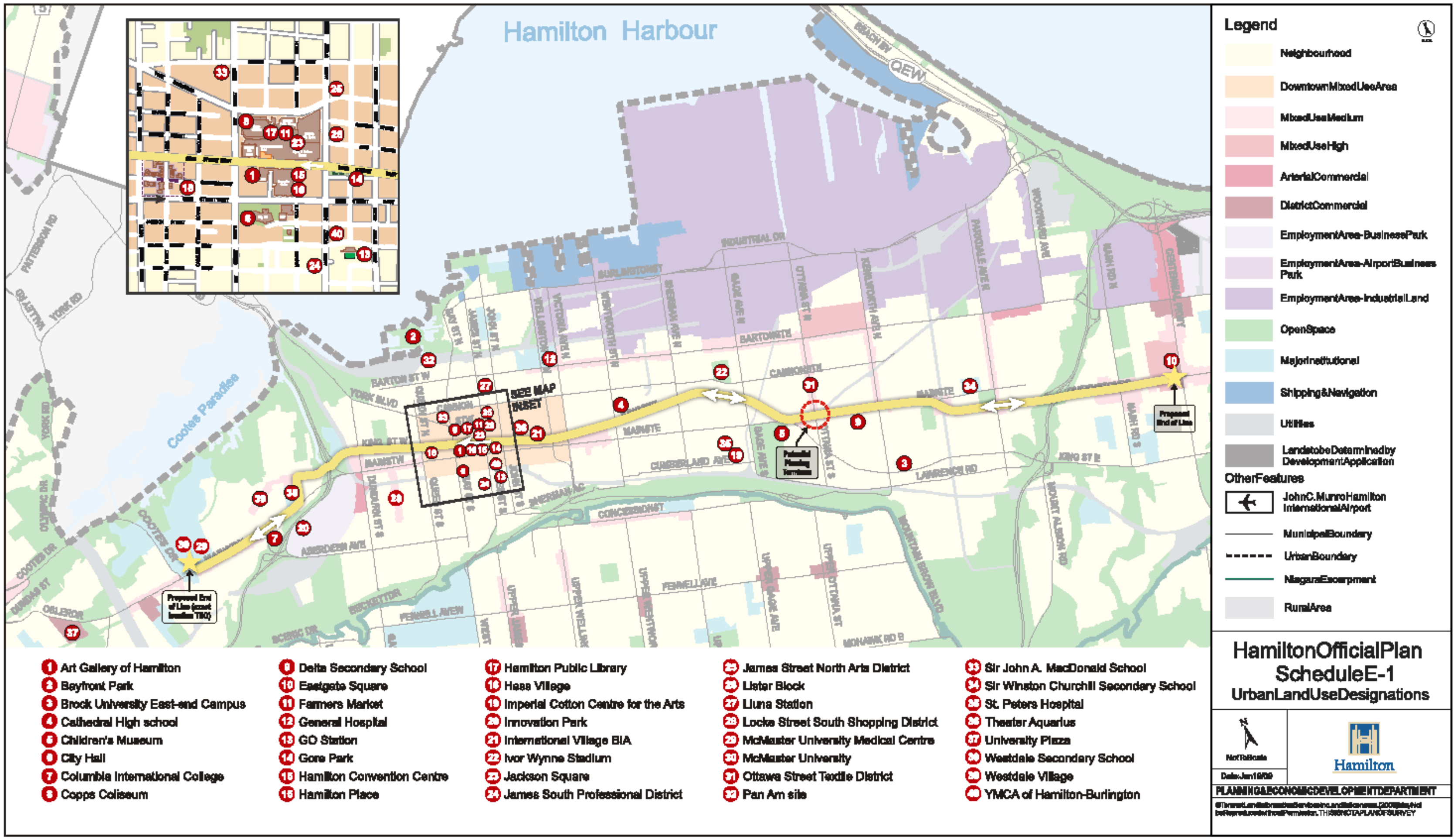
[4] SOURCE: 'Size and Location of Urban Growth Centres in the Greater Golden Horseshoe' (2008), Ministry of Energy and Infrastructure

In addition to the challenges associated with the anticipated growth, the City of Hamilton is also experiencing economic and cultural change as it transitions to relying less on traditional industrial activities in favour of a more knowledge-based economy. This transition, combined with external economic factors, has caused some short term challenges for the City, particularly in the downtown core, where redevelopment is necessary to support the City's plan to rejuvenate the downtown core and aid the transition.

In response to the planned growth, and to assist in the city's transition, the City embarked on a series of technical studies to examine the role of transit to promote, support and manage the growth of Hamilton in a sustainable manner. This culminated in February 2007 when the city's Public Works Committee and Council endorsed the Hamilton Transportation Master Plan (TMP) which defined a transit strategy that included for the provision of "higher order transit" within the City of Hamilton.

In June 2007, the Province of Ontario announced the MoveOntario 2020 vision, a multi-year rapid transit action plan for the GTHA. The B-Line corridor was one of the 52 projects identified by MoveOntario 2020, and was subsequently identified as a Top 15 "early implementation" priority project in the Metrolinx Regional Transportation Plan known as *The Big* Move. Figure 2 illustrates the B-Line corridor and activity centres.

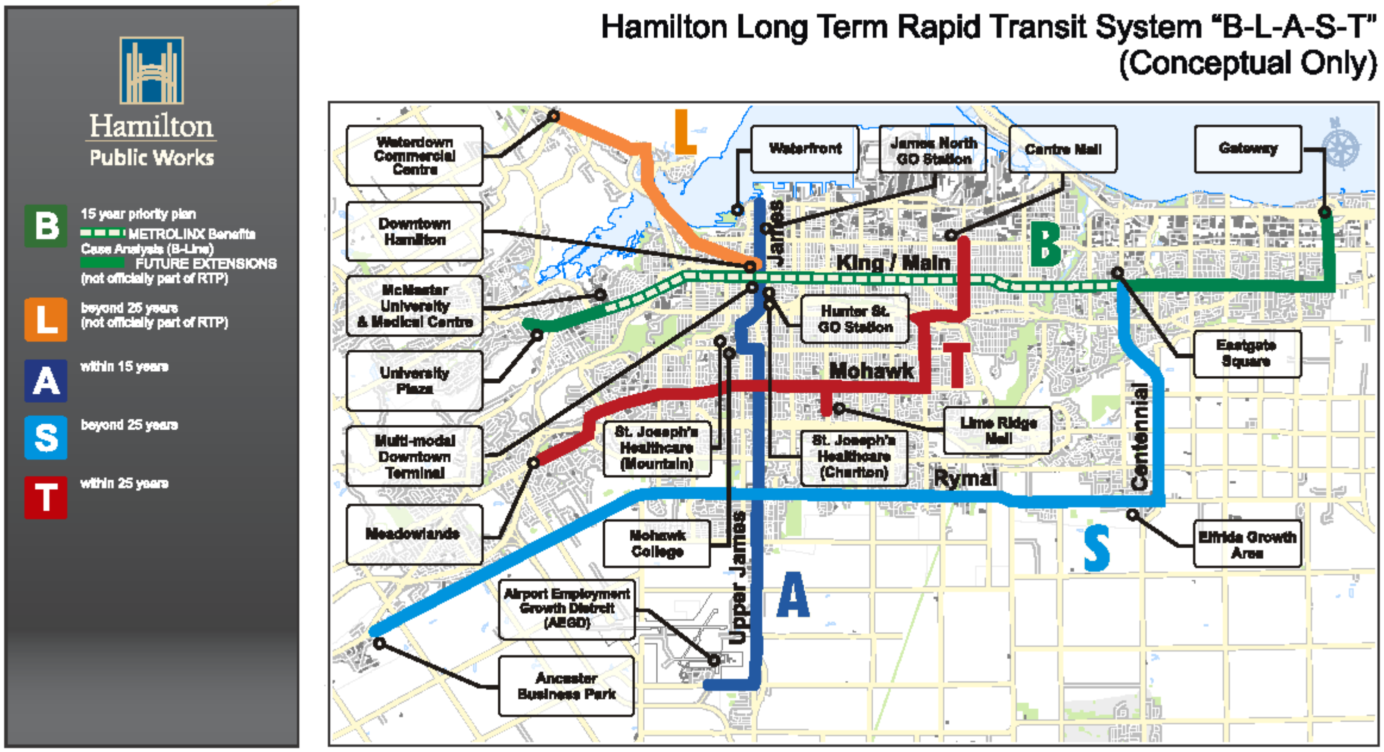
FIGURE 2 B-LINE CORRIDOR AND ACTIVITY CENTRES



The existing B-Line (BRT–lite) bus service was introduced in 1982 to serve demand along the east-west corridor of the lower city. The westbound service runs west from the eastern terminus at Eastgate Square along Queenston Road/Main Street and King Street East through the Downtown core connecting with Main Street West at Paradise Road where it continues westward to a western terminus at University plaza (west of McMaster University). Eastbound service runs along Main Street from University Plaza, past McMaster University and through the downtown core to the eastern terminus at Eastgate Square. Success of this service has lead to increased service levels and the recognition that the function of this Main/King Corridor is key to the daily operation of the city. Ridership on the B-Line has grown over the years reaching almost 850,000 passenger trips in 2008. In addition to the B-line service along King Street/Main Street, the city's most significant transit corridor, there are a number of other regular local bus services that provide integrated services along the B-Line corridor or portions thereof. When combined, a very frequent service is provided and it is estimated that the B-Line and local bus services carry some 10 million passengers per year. Furthermore, transit ridership in general, and specifically along the corridor, can also be expected to increase as the city is redeveloped and land uses in the urban centre are intensified. As a consequence of this intensification, it is anticipated that the current supply of parking in the urban core will decrease while the cost of the remaining stalls increases, thus providing an additional incentive to find an alternative to the automobile.

The B-line corridor fits into a long range vision that the City of Hamilton has for a rapid transit network referred to as the B-L-A-S-T network. This proposed long term rapid transit network is illustrated in Figure 3.

FIGURE 3 PROPOSED B-L-A-S-T RAPID TRANSIT NETWORK



As part of its rapid transit strategy, the City has also embarked on a significant public consultation program to determine public opinion regarding the rapid transit initiative. Among the findings, the feedback received during the public consultation sessions revealed strong support for the proposed enhancement of the existing B-Line service to provide rapid transit service along the B-Line corridor.

The city believes that rapid transit in Hamilton, starting with the B-Line corridor, will help achieve the goals of The Big Move, the Provincial Growth Plan, the Hamilton Transportation Master Plan and City's Official Plan and will result in enhanced prosperity, environmental sustainability and improved quality of life in the City of Hamilton. Rapid transit service along the B-Line corridor will deliver:

- Accessible rapid transit within 800 metres to close to 20 percent of the City's residents and employment including important government facilities in the downtown;
- Access to McMaster University, one of Canada's top teaching and research institutions boasting a full and part-time student population of over 23,000 and having a significant economic impact on the Hamilton area;
- Improved access to the downtown and regional rail facilities; and
- An enhanced image and prosperity for the city.

Located at the western corner of Lake Ontario, Hamilton is positioned uniquely as the western centre of the Greater Golden Horseshoe, and functions as a western gateway to the Greater Toronto Region. Hamilton is well positioned to exploit its geographical proximity to Toronto, the largest business centre in the country, particularly considering the proposed electrification of the GO Lakeshore Line and improved travel experiences for the estimated 92,000 commuters that travel between Toronto and Hamilton. The B-line rapid transit in conjunction with the GO Lakeshore improvements will provide Hamilton strong transit-oriented commuting options as well as provide the opportunity to revitalize the city as an attractive, dynamic, and environmentally sound community for people and businesses to visit, work and live.

An investment in rapid transit is also an important piece of the City's plan to rejuvenate the urban core and support its economic and cultural transition. Hamilton's traditional and pedestrian friendly street grid, combined with its stock of heritage and older buildings, waterfront and escarpment topography, make for an urban fabric that is well-suited to a transit-oriented and sustainable lifestyle. Given these natural and historic characteristics, Hamilton is well positioned to attract and accommodate the significant growth expected in the Greater Toronto Region over the next 25 years. A higher-order transit corridor will connect key activity centres, destinations, and link key areas of future economic development. However, such an investment must be made within the context of an overall strategy where a transit investment alone is not sufficient to fully capitalize on this advantage. Together with appropriate city planning and economic development initiatives, rapid transit can play an important role in the transition to a knowledge-based and sustainable community and economy.

The City of Hamilton also has a number of documents, previously developed, that support rapid transit with policies, by-law and strategies that are all complementary to the implementation of rapid transit. These documents include:

- Corporate Strategic Plan - "To be the best place to raise a child, promote innovation, engage citizens and provide diverse economic opportunities";
- Public Works Business Plan – "Innovate Now";
- Corporate Energy Policy;
- Air Quality and Climate Strategic Plan;
- Vision 2020;
- GRIDS (Growth Related Integrated Development Strategy);
- Official Plan (June 2009);
- Zoning By-laws (in process);
- Residential Intensification Study;
- Commercial Strategy Study;
- Ridership Growth Plan;
- Transportation Master Plan;
- Rapid Transit Feasibility Study (Phase 1, 2 & 3); and
- Long Term Conceptual Rapid Transit Vision ("B-L-A-S-T").

The City of Hamilton has made an effort to ensure all plans and strategies are pro-active in enhancing the city as a successful urban centre. In addition to the documents listed above, the City of Hamilton is in the process of updating its economic development strategy. The strategy will target multiple areas of city-building, including business development, community revitalization, and attracting a 21st century labour force. A rapid transit line could contribute to all of these goals. Aside from the obvious community and quality of life impacts, an investment in rapid transit also fits particularly well with the approach to infrastructure for innovation, which will link the existing and future nodes of research and technology commercialization in Hamilton. By facilitating such linkages along the city's primary east-west corridor, an investment in rapid transit is likely to enhance the attractiveness of the city to potential developers who will benefit from the marketability and increased demand for prospective development sites along the corridor. Overall, a rapid transit line has the potential to generate many synergies with other complementary initiatives in the City of Hamilton.

Project Objectives

The City of Hamilton Rapid Transit Initiative has several broad objectives in conjunction with MoveOntario 2020 and Metrolinx RTP including:

- To promote new development and investment along its key corridors and at strategic nodes (GRIDS);
- To support opportunities to redevelop and / or intensify existing developments;
- To support and revitalize existing and future development areas (McMaster University, West Hamilton Innovation Park, Downtown Area including the Central Library, Farmer's Market, Hamilton Art Gallery, Copps Coliseum, potential new stadium etc.) and businesses;
- Provide a choice of travel modes that support and inter-connect to each other at both a local (trails, cycling, walking) and inter-regional level (GO);
- Improve access to key activity centres such as recreation/sporting facilities, arts centre and convention centre;
- To achieve local and regional environmental objectives; and
- To promote a sustainable community.

In addition to these broad objectives, the proposed enhancements to the rapid transit network, beginning with the implementation of rapid transit service along the B-Line corridor, also aim to achieve more specific goals including:

- To increase transit ridership;
- To put pedestrians and transit first in planning the corridor by enhancing the streetscape and creating a more pedestrian-friendly environment;
- To improve the City's business, tourist and development appeal; and
- To provide effective connections to neighbouring transit systems.

Project Overview

Context

As indicated above the City of Hamilton has undertaken considerable work on the rapid transit initiative and specifically the B-Line Corridor. Since 2007 the City has completed a three-phase Rapid Transit Feasibility Study (RTFS) that compared BRT and LRT technologies and discussed what BRT and LRT could potentially look like. The primary purpose of the study was to provide Council, staff and the public with the initial view of the opportunities that rapid transit can present, and the constraints that need to be addressed in making a decision to pursue either an LRT or BRT rapid transit option.

As a part of the Hamilton Transportation Master Plan, the Metrolinx Regional Transportation Plan and Phases 1, 2 and 3 of the RTFS, different potential alternative technologies were initially considered. The list was screened based on best practices, safe and efficient operation, potential impacts and expected investment. Based on these studies the City of Hamilton focused its efforts and planning on three options: an enhanced and expanded version of the existing Bus Rapid Transit, one-way LRT operation in reserved lanes and two-way median LRT in reserved lanes.

Rapid transit along the B-Line corridor could be a contributing component to revitalization and development. Increased transit use goes hand in hand with enhanced economic opportunities, better land use, intensification, improved urban design, healthier, more active lifestyles and a more pedestrian-friendly urban environment. Through consultation conducted by the City of Hamilton, the public has expressed a preference for LRT over enhancing the existing BRT service.

Transit Corridor Considerations

In addition to the B-line service along King Street/Main Street, the city's most significant transit corridor, there are a number of other regular local bus services that provide integrated services along the B-Line corridor or portions thereof. When combined, a very frequent service is provided and it is estimated that the B-Line and local bus services carry some 10 million passengers per year. The existing limited stop express service ("BRT-lite") along the B-Line corridor operates on a 10 minute headway during peak periods and afternoons, and headways of approximately 15 minutes in the off-peak period. It alone attracts almost 850,000 trips per year as the express service within the most popular transit corridor in the city. The City's initiative to develop a rapid transit network is aimed at providing an alternative to the single occupancy vehicle, making non-auto-oriented lifestyles possible for existing and future residents and workers. Such a transit facility would build on Hamilton's heritage and mixed-use fabric, while promoting population and employment growth along the King-Main spine which runs through the centre of Hamilton's Lower City.

Opportunities and Issues

Improvements to the B-line could not only enhance transit service along this corridor, but also provide many related direct and indirect opportunities for urban transformation and revitalization of developments in the area as described in the Context and Needs section of this report. The main features that will be directly impacted by improvements to the B-line are outlined below with relation to the presented opportunities and related issues (See Figure 2 for the locations of these features).

GO Transit

Connectivity is a key piece to transit network planning. A convenient passenger connection between Hamilton's rapid transit network and the GO regional rail service could improve and facilitate the regional connectivity envisioned by The Big Move. The GO Lakeshore West line to Hunter Street in downtown Hamilton is relatively close to the proposed B-Line corridor and may warrant a direct connection. At the present time, GO Transit provides peak hour commuter rail service to Toronto for Hamilton residents along with regular GO Bus services that depart from the station and provide regional bus services to other destinations. The proposal to electrify the GO Lakeshore corridor could greatly enhance the commuter rail service and provide frequent and reliable two-way service to and from Hamilton. This service would improve service frequencies and travel times making GO Transit an even more attractive alternative to the automobile.

Increasing connectivity by creating a convenient transfer point between Hamilton's rapid transit network and the GO service will further enhance the attractiveness of transit. However, it should be recognized that one trade-off with this deviation from the main route is the impact to the operating speed of the line resulting in longer travel time. In addition to the Hunter Street GO station, there are other opportunities in central Hamilton for new GO stations and/or multi-modal transit facilities that could include local buses and new/additional inter-regional rail. These opportunities should be examined as part of more detailed design phase to identify possible locations for such facilities and to determine whether they could generate additional significant benefits to both local communities and the wider region. Given the overall strategy to grow transit use and maximize ridership, any effort to integrate local rapid transit with regional service such as the GO Train must balance the benefits of improved connectivity with the objectives of the new rapid transit line. These aspects should be considered during the route level design stage of this project's development.

McMaster University & McMaster University Medical Centre

As one of Canada's leading education and research institutions, McMaster University is a significant part of the economic landscape of Hamilton. With over 23,000 students, plus faculty and staff, the university campus is a key place of interest and trip generator for transit particularly because students make up a large portion of the transit market. Additionally, the student union has incorporated transit passes into the McMaster student fees making transit service to the campus more integral. McMaster also has a university medical centre that has a significant flow of patients, visitors and employees that would also benefit from the introduction of rapid transit to this location.

At the present time, the university administration policy restricts transit vehicles movement on campus to the perimeter of the property. As a consequence, for many of the transit patrons, bus facilities for both HSR and GO Transit are located a considerable distance from their ultimate destinations, which can be viewed as a poor service.

Given the desire to increase transit ridership, it is important that the passenger access to this important activity centre be optimised. More detailed investigation should be undertaken to determine the best long-term options for transit access to the campus as part of a more detailed design phase.

West Hamilton Innovation District

West Hamilton Innovation District (WHID) is a 15 acre site located halfway between McMaster University and Mohawk College, and in the future is planned to be a significant trip generator. Specifically, the site is located to the south of Main Street West, west of Dundurn Street South and the CP railway line, north of Aberdeen Avenue, and east of Highway 403. The site is the former location of Camco/Westinghouse and includes the McMaster Innovation Park which welcomed its first tenants, Trivaris Ltd. into the first renovated building in April 2009. The federal government has also committed a $60M investment to build a new 155,000 square foot materials technology laboratory, scheduled to open in 2010. McMaster Innovation Park expects to complete 14 buildings and be the workplace for 3,000 people over the next 15 years. The entire WHID has the capacity to house as many as 6,000 workers once completed. This development has the potential to become an important activity centre which has merit for transit service.

The City of Hamilton has investigated opportunities to provide door-to-door service to the site with rapid transit. However, similar to the GO Transit connection, there are operational trade-offs, such as longer operating times, and vehicle operating costs. As well, access to the site will also require a substantial additional capital investment including the need for more vehicles resulting from the longer travel times. All options examined in this Benefits Case include a stop at Longwood Road and Main Street. The Innovation Park falls within a comfortable catchment area of the stop. However, appropriate pedestrian-friendly links between WHID facilities and the proposed rapid transit corridor should be further explored at the detailed design level.

Maintenance Facility

The new rapid transit line will require a new or enhanced operations and maintenance facility. The specific location of this facility can vary depending on the rapid transit technology and the end points of the new line.

Hamilton Street Railway (HSR) currently maintains and stores the existing fleet of B-Line buses at its bus maintenance facility, Mountain Transit Centre, on Upper James Street, some 9 kilometres from the B-Line corridor. It is anticipated that in the short term HSR will be able to accommodate the enhanced fleet proposed for implementation in September 2009 at this existing facility. However, in the event that the new rapid transit line is BRT, it is likely that HSR may have to expand existing facilities or build additional capacity at a new location (ideally close to the B-Line corridor).

In the event that LRT is selected as the rapid transit technology, HSR will require a new operations and maintenance facility to accommodate the LRT vehicles. In anticipation of this requirement, the City of Hamilton investigated potential sites near the corridor that provided sufficient capacity and were within an appropriate distance to the mainline to minimize the cost of providing infrastructure to connect the mainline to the yard and also to limit the operating costs associated with the necessary connection.

Under either technology scenario, the exact location of the storage and maintenance facility will be determined as part of the more detailed project definition phase.

Road Operations (One Way versus Two Way)

At present one way traffic in the downtown core on Main Street and King Street provides efficient traffic flow entering and leaving downtown Hamilton with traffic flowing eastbound on Main Street and westbound along King Street. While this one-way street configuration facilitates efficient traffic flow for passenger vehicles and longer trips traveling through the downtown, it is not ideal for pedestrians, transit users, and people generally using and experiencing the downtown area. Recognizing these challenges, the City of Hamilton established a corporate working team to undertake an assessment of the rapid transit options within this street environment. The team concluded that a two-way system on King Street is the preferred rapid transit route alternative for the following reasons:

- Greater potential and concentration of community development, which will revitalize Downtown Hamilton, resulting in greater increase in property values and greater potential for economic spin-offs;
- Improved accessibility for residents, workers and visitors, allowing them to travel in both directions on both King and Main Streets creating a better urban experience;
- Safer pedestrian environment, as a median transit way allows sidewalk improvements in both directions and bi-directional LRT results in slower and less traffic on King Street;
- Lower costs as less LRT infrastructure is required;
- Less disruption during construction as only one corridor is directly affected; and
- Fewer negative impacts to properties abutting the corridor as there would be less need to close driveways and create cul-de-sacs on local streets at non-signalized intersections.

The City of Hamilton Corporate Working Team also evaluated potential corridor-wide impacts and while several were identified and mitigation proposed, there are no significant impediments that would prevent the City from pursuing rapid transit along the B-Line corridor via King Street.

In addition to the reasons given by the Corporate Working Team, additional issues relating to the construction and on-going operation of a rapid transit line arise when considering a one-way system on King and Main Streets.

From a construction perspective, a one-way system will incur greater construction costs and public inconvenience as two major routes through the downtown core will be interrupted for the duration of construction. Specifically a split rapid transit corridor will result in:

- Greater utility impacts (two corridors);
- Additional electrical substations if constructed over an extended distance (1.5/2km);
- Additional overhead line infrastructure (support poles);
- Separate cabling system for each route (power and communications);
- A duplication of stop control equipment as it is required on each line; and
- Increases the cost of providing crossovers, which are emergency turn back locations for LRT vehicles, as these would need to be along connecting streets.

From an operations perspective, one of the most significant deterrents to a split corridor is passenger legibility. Under a split corridor scenario, transit passengers utilizing the system to travel between their home and work would be required to access and exit the system from geographically distinct stations. Furthermore given the distance between Main Street and King Street this would imply that at some points on the corridor (with walking distances as much as 500m between the inbound and outbound stations) would create a significant deterrent for some passengers. Similarly, the split corridor is likely to dilute the positive impacts from economic development that may be motivated by the introduction of the new rapid transit line.

In addition to the passenger deterrent, the split route would also present challenges for the system operator. These include:

- Splitting of the routes would operationally hinder service recovery and short working due to limited turn back locations;
- The unfeasibility of temporary service operation along a single track section while the other track section is out of service; and
- Parallel routes would affect consecutive crossing arterial road intersections which would make mitigation of LRT priority on arterial road traffic more difficult.

Also, the interchange system connecting the 403 to Main and King Streets is about to undergo significant rehabilitation and reconstruction. There is an opportunity, with the potential implementation of a rapid transit service and reconfiguring of King and Main Streets into two-way arterials, to simplify this interchange.

In a central downtown location there are cases where parallel routes and small loops may function reasonably well where more than one route runs through the centre. However this would not be the case over an extended length as would be required on the King and Main Street corridors.

Clearly, the need for two-way operation is essential for the successful operation of this transit line given the findings presented above. Therefore, the conversions of King Street and Main Street to two-way operations have been assumed for the purposes of this analysis.

Part B Options

Project Options

The following three options have been identified for the Hamilton Rapid Transit Project for comparison against the Base Case. A summary description of each option is provided below.

- **Base Case:** Business as usual
- **Option 1:** Full BRT
- **Option 2:** Full LRT
- **Option 3:** Phased LRT

Base Case

The Base Case assumes that the City of Hamilton will re-orient the current one-way operations of King Street and Main Street to two-way streets for the reasons already detailed in Part A of this report. Within this new street configuration, the Base Case is defined as an expanded B-Line Lite Express Service as proposed for September 2009 with buses operating in the curb lanes of King Street. This represents a change from the existing BRT Lite service which currently operates in the curb lanes of both King Street and Main Street in the direction of the one-way traffic.

This BRT Lite service runs westward from Eastgate Square through downtown and continues west past McMaster University to a western terminus at University Plaza. There are 15 stations along the B-Line route between University Plaza and Eastgate Square including a station adjacent to McMaster University campus.

Under this Base Case scenario Hamilton Street Railway (HSR) operates articulated buses in mixed traffic with no signal priority. Bus operations vary within segments of the B-Line alignment. Between University Plaza and McMaster University, buses operate with peak headways of 15 minutes. Buses on the segment between McMaster University and Eastgate Square operate more frequently in the peak operating with peak headways of 7.5 minutes. The segment between University Plaza and McMaster University adds another 5 minutes to the one way trip.[5]

[5] Travel times are based on the current one-way street operations and may change under the two-way street operating scenario where travel times will likely increase. For the purposes of this analysis both a one-way and two-way street configuration were modelled for the Base Case to provide the range of costs and benefits associated under each option. The results of the different scenarios are summarized on pages 47-48.

There are a number of local bus services that operate along the corridor that are assumed to remain in-service under the Base Case scenario. These include route numbers 1, 5, 51, 52 and 55. These bus routes remained in service under the Option scenarios as well.

Options

Option 1 – Full BRT

This option includes an on-street exclusive BRT system running along a median within the existing road right of way from an eastern terminus at Eastgate Square to a western terminus on the McMaster University campus. In total, the alignment is approximately 14 kilometres in length and is proposed to be operational in 2015.

Unlike the current BRT system defined by the Base Case, the Full BRT will operate within an exclusive right-of-way. Specifically the Full BRT alignment proposed for this assessment is described as follows:

- **East Section** – turning from a segregated terminus adjacent to Eastgate Square the alignment travels westward in a median transitway via Queenston Road to the Main Street / Ottawa Street Intersection.
- **Downtown Section** – the alignment continues westward from the Main Street/Ottawa Street Intersection along a median of King Street East across John Street and James Street through downtown. [6] The alignment continues along King Street West across Highway 403 to Longwood Road South where it provides convenient access to Westdale Village and the McMaster Community. At Longwood Road South the alignment runs southbound to Main Street.
- **West Section** – From Longwood Road South the alignment transitions into the centre of Main Street and continues westward towards the McMaster University Medical Centre before turning north towards the terminus station on the McMaster University campus.

At the present time, King Street and Main Street operate as one-way streets. Given the operational challenges and passenger inconvenience associated with operating a rapid transit line along a split corridor, it is assumed for the purpose of this comparative assessment that the BRT route would run on King Street utilizing existing rights-of-way. Under this scenario both Main Street and King Street would be converted to two-way streets for general purpose traffic. However, as a result of the reduced number of traffic lanes on both streets, traffic capacity on both streets would decrease. In addition to these traffic capacity constraints, there may also be

[6] During a more detailed project definition phase, consideration should be given to providing a more direct connection to the GO Transit station on Hunter Street in downtown Hamilton. This could be accomplished by rerouting the proposed King Street alignment via John Street, Hunter Street and James Street. This would add up to 4 minutes to the travel time.

physical limitations along specific sections of King Street, where the existing right-of-way is too narrow to enable two-way traffic operations alongside a two-way rapid transit service. The design and right-of-way requirements for the reoriented streets will be addressed during the more detailed project definition phase. However, for the purpose of this comparative analysis it is assumed that King Street can accommodate two-way traffic and a two-way BRT service. The Full BRT line includes 17 stations at the following proposed locations that are to be confirmed as part of a more detailed design exercise:

TABLE 1 OPTION 1 STOPS (BRT)

	Station Locations (East to West)	
East Section (Eastgate to Ottawa Street)	1. Eastgate Square 2. Nash Road 3. Parkdale Road	4. Queenston Traffic Circle 5. Kenilworth Avenue
Downtown (Ottawa street to Longwood Road South)	6. Ottawa Street 7. Gage Avenue 8. Sherman Avenue 9. Wentworth Street 10. First Place	11. Gore Park 12. Bay Street 13. Queen Street 14. Dundurn Road
West Section (Longwood Road South to University)	15. Westdale 16. Longwood Road/Main Street	17. McMaster University

The physical location and configuration of each station will vary depending upon the specific characteristics and constraints at each location.

The average speed of the BRT along the 14 kilometre alignment is assumed to be 25 kph. Assuming 17 stations with average dwell times of 20 seconds, the estimated travel time from end to end of the BRT line is approximately 34 minutes via Longwood Road South. The segregated operations combined with signal priority at major intersections will be required and will help minimize the potential delays to the BRT service. However, despite these measures, at-grade crossings at intersections may still result in service delays. The average speeds and travel times for each section are provided in the following table:

TABLE 2 OPTION 1 – BRT AVERAGE SPEED AND TRAVEL TIMES

	Distance	Average Speed	Station Spacing	Travel Time
East Section (Eastgate to Ottawa Street)	4.9 km	25 kph	≈900 m	12 min
Downtown (Ottawa Street to Longwood Road South)	7.2 km	25 kph	≈800 m	17 min
West Section (Longwood Road South to University)	2.1 km	25 kph	≈1,150 m	5 min
TOTAL ROUTE	**14.2 km**			**34 min**

For the purposes of this assessment, it is assumed that articulated buses are 18 metres in length and have a capacity of 90 passengers per vehicle. This is consistent with service planning guidelines elsewhere in the region and would provide a high-level service to the passengers. The service has been assumed to provide a 2.5 minute peak frequency, which would provide a peak design load of 2,200 passengers per hour per direction which is projected to be sufficient to meet the anticipated demand along the corridor.

The minimum operable frequency of a BRT service would be approximately 2 minutes based upon the priority and effect on intersection capacity. This would provide a peak capacity of 2,700 passengers per hour per direction and would require significant levels of priority at intersections that are beyond those envisioned for the Hamilton BRT.

TABLE 3 OPTION 1 – VEHICLE REQUIREMENTS AND CAPACITY

Headway	Number Vehicles	Capacity
5 minutes	18	1,100
4 minutes	23	1,350
3 minutes	30	1,800
2.5 minutes	36	2,200
2 minutes	45	2,700

Based upon the 2.5 minute headways planned for the BRT service, a total of 36 BRT vehicles would be required including spares. As this new BRT service represents a significant expansion and improvement over the current B-Line service, it is assumed that, in the long term with the expanding fleet of BRT and regular service buses, the additional BRT vehicles could not be accommodated at the existing bus maintenance and storage facilities. It is anticipated that there would likely be sufficient storage to accommodate the BRT fleet for the first few years of operation, however, as the bus fleet expands, Hamilton will be required to build additional storage facilities. Therefore, for the purpose of this assessment it is assumed that the introduction of the new BRT Line as proposed under this option would require a new or expanded bus storage and maintenance facility within approximately 10 years of opening or earlier.

Option 2 – Full LRT

This option includes an on-street segregated LRT system operating along the same alignment as described for Option 1. As with Option 1, the 17 station locations proposed for that BRT option are also assumed for this LRT option. Similarly, as proposed, the introduction of the LRT along the King Street corridor will be accompanied by the re-orientation of traffic operations on both King Street and Main Street such that both streets operate as two-way streets. LRT will operate along the median of the King Street corridor alongside two lanes of traffic. As discussed under Option 1, the design and right-of-way requirements for the reoriented streets will be addressed during the more detailed project definition phase. However, for the purpose of this comparative analysis it is assumed that King Street can accommodate two-way traffic and a two-way LRT service. The Full LRT Option is also planned to be in service in 2015. Main Street is also assumed to function as a two-way arterial road.

Similar to the Full BRT Option, the physical location and configuration of each LRT station will vary depending upon the specific characteristics and constraints at each station location.

The estimated travel time from end to end of the LRT line is 26 minutes via Longwood, assuming 17 stations, and an overall average speed of 34 kph with appropriate signal priorities and/or pre-emption. The average speeds and travel times for each section are provided in the following table:

TABLE 4 OPTION 2 – LRT AVERAGE SPEEDS AND TRAVEL TIMES

	Distance	Average Speed[7]	Station Spacing	Travel Time
East Section Eastgate to Ottawa Street	4.9 km	35 kph	≈900 m	9 min
Downtown Ottawa Street to Logwood Road South	7.2 km	33 kph	≈800 m	13 min
West Section Longwood Road South to University	2.1 km	35 kph	≈1,150 m	4 min
TOTAL ROUTE	**14.2 km**			**26 min**

For the purposes of this assessment, it is assumed that 30 metre LRT vehicles with a capacity of approximately 130 per vehicle are used providing a capacity of 1,950 as a one car train and 3,900 as a two car train. The service has been assumed to provide a peak 4 minute service frequency requiring 30 LRT vehicles. Operation of a route at as low as a 2 minute headway is achievable, but would require significant levels of priority at intersections and could result in an increased travel time with greater LRT delays at intersections. However, this level of LRT service is not envisioned as required and so the operational risk of such tight LRT headways is low.

As discussed in Section A, the introduction of an LRT service in Hamilton will require the construction of a new LRT operations and maintenance facility. While the precise location of such a facility will be studied as part of the more detailed project definition phase, it is assumed that the facility will be located close to the LRT corridor so as to minimize the costs to connect the facility with the mainline. As part of the detailed analysis, it is also assumed that operating costs and deadheading requirements, balanced by neighbourhood impacts, will be considered as part of the site selection process.

Option 3 – Phased LRT

Under this option the implementation of the eastern section of the full LRT alignment is delayed until such time that the capital investment required to expand LRT eastward is warranted to support and encourage complementary re-development activities along the corridor. In doing so, this option examines the implications of deferring some of the costs and benefits attributable to the full LRT to provide an opportunity for the eastern section of the corridor to mature to a point

[7] Travel speeds vary along the length of the corridor with operating conditions. The average speed in the downtown section is shown as 33 kph however travel speeds in the downtown core are assumed to be somewhat slower in the range of 25 kph.

where such an extension could generate greater benefits and re-development up-lift from the LRT investment. For the purpose of this assessment, the downtown and western sections are assumed to be in service in 2015 while the implementation of the eastern section is postponed until 2030.

The interim eastern terminus of the LRT line will be at the intersection of King Street East and Ottawa Street. This eastern terminus was chosen because of the established Business Improvement Area (BIA) for the area's textile and home décor district. As with Option 2, this option will ultimately include 17 station locations as shown in Table 1 above. Of these, 5 stations including Eastgate Square, Nash Road, Parkdale Road, Queenston Traffic Circle and Kenilworth, are deferred until 2030. Again, as with the other options, traffic operations on King Street and Main Street are assumed to operate as two-way streets with the LRT operating along the median of King Street alongside the vehicle traffic lanes.

Similar to the other options, the physical location and configuration of each station will vary depending upon the specific characteristics and constraints at each station location.

The estimated travel time from end to end of the first phase of the LRT line between McMaster University and the eastern terminus is 17 minutes assuming 10 stations, and an overall average speed of 33 kph and appropriate signal priorities. The average speeds and travel times for each section are provided in the following table:

TABLE 5 OPTION 3 – PHASED LRT AVERAGE SPEEDS AND TRAVEL TIMES

	Distance	Average Speed[8]	Station Spacing	Travel Time
East Section – BRT-Lite Eastgate to Ottawa Street	4.9 km	25 kph	≈980 m	12 min
Downtown Ottawa Street to Logwood Road South	7.2 km	33 kph	≈800 m	13 min
West Section Longwood Road South to University	2.1 km	35 kph	≈1,150 m	4 min
TOTAL ROUTE	**14.2 km**			**30[9] min**

Under this option, a passenger traveling between McMaster University and Eastgate Square will be required to transfer between the new LRT line and an improved BRT-lite service at Ottawa Street. Including the transfer time, the travel time from McMaster University to Eastgate Square

[8] See footnote 7

[9] A one minute transfer is assumed at Ottawa Street bringing the total time for the route to 30 minutes

is estimated to be approximately 30 minutes. The vehicle capacity and proposed operating frequencies for this first phase on the LRT line are assumed to be the same as proposed for the Full LRT scenario. Given the reduced length of the alignment however, the number of vehicles required to provide this level of service is lower than under Option 2.

With the phased introduction of LRT as proposed under this option, it is assumed that the existing B-Line service will continue to serve the Queenston Road corridor between the easternmost LRT station near Ottawa Street and Eastgate Square. It is expected that the current B-Line service will be extended beyond Eastgate Square to a future proposed transit hub at Fifty Road with connections to GO Transit and as such, Eastgate Square will no longer function as the terminus point. It is also assumed that the local buses currently connecting to the existing BRT-Lite service at Eastgate Square will be rerouted as appropriate to a new connection at the Ottawa Street LRT station. As a result of these changes, the level of service along the eastern segment of the ultimate B-Line LRT corridor is expected to improve relative to today's level as the number of new buses and interlined routes operating along the corridor will result in a dramatic increase in the frequency of bus service.

As with Option 2, Option 3 will require the construction of a new operations and maintenance facility. Although the location of this facility will be the subject of a more detailed study in the future, it is assumed that the facility will be near to the LRT corridor and will accommodate operational issues. Given the truncated LRT line proposed for this option, locations for the operations and maintenance facility are constrained to be within the reasonable limits of the line. Although the immediate fleet requirements under this option are less than that required under Option 2, the size of the facility is assumed to be the same as that envisioned for Option 2 in order accommodate the fleet expansion at some point in the future.

In 2030, the second phase of the B-Line LRT would be introduced to extend LRT eastward to Eastgate Square as described in Option 2. At that time the fleet would be expanded to 30 vehicles in order to continue to provide 4 minute headways along the extended route.

Summary of Options

The options to be examined are summarized in the table below.

TABLE 6 SUMMARY OF OPTIONS

	Option 1	Option 2	Option 3
Opening Year	2015	2015	2015/2030
Headway	2.5 min	4 min	4 min
Capacity (phpd)[10]	2200	1950/ 3900	1950 /3900
LRT Vehicles	n/a	30	20 /30
BRT Vehicles	36	n/a	n/a
Travel time (end-to-end)	34	26	30[11]

[10] Per Peak Hour Peak Direction capacities for LRT are shown for both one-car and two-car trains.

[11] Approximately 17 minute travel time from McMaster University to Ottawa Street on phase I LRT segment.

Part C Assessment

Evaluation Framework

The comparative analysis uses a Multiple Account Evaluation (MAE) methodology. The MAE is a framework that provides a systematic identification and analysis of broader implications and criteria of an option. It systematically compares the impacts on costs, users, environment, economy and community and shows the trade-offs among the often conflicting criteria.

The MAE framework includes a number of evaluation accounts that together address the most significant project performance and policy considerations for a specific project. The criteria and the accounts can be tailored for a project. The relevant accounts for the analysis of the Hamilton Rapid Transit project are:

- Transportation User Benefits
- Financial Impacts
- Environmental Impacts
- Economic Impacts
- Socio-Community Impacts

It is important to note that the options defined in this report have only been developed to a level of technical detail sufficient to enable a comparative analysis for the purpose of selecting a preferred option. Project scope, costs and service plans need to be developed in more detail for funding and implementation.

The assessment is done by comparing each option to the Base Case and identifying any incremental costs or benefits that are generated by each option. Hence, the results should not be interpreted as "total" values, but as the incremental impact compared to the Base Case.

The analysis is done over a 30-year period (2009-2038). Where possible the impacts are monetized and quantified. In order to compare the options on a "like-to-like" basis and to reflect time value of money the monetized values are discounted to today's value at a real discount rate of 5%. These values, and other input variables used in this analysis are shown in Appendix A.

Transportation User Benefits

This account considers the incremental benefits to the transportation users as a result of the investment in the Hamilton Rapid Transit project. The monetized benefits are measured in travel time savings for both transit users and road users; automobile operating cost savings achieved by individuals as their trip times or overall automobile usage declines; and reduction in accidents as a result of declining automobile usage.

In addition to the monetized benefits, there are qualitative user impacts which may include passenger comfort, accessibility and reliability. In most instances they are captured in the ridership and travel time savings, but in some instances they can be isolated and identified separately if significantly different among the options.

All transportation user benefits described below are incremental to the Base Case.

Travel Time Savings

Travel time savings are included for both transit and non-transit users. With the improvement of transit services along the Main Street / King Street corridor in Hamilton, the analysis shows that the investment will generate significant time savings for existing transit users (those that currently travel on buses), new transit users and auto users. The value of time is estimated at an average of $13 per hour[12] and is expected to grow, in real terms, by 1.6% per year over the period.

The present value of travel time savings for both transit and auto users over the evaluation period (2009-2038) is largest for Option 2 and estimated at $647 million and approximately 15 percent greater than the travel time savings generated by Option 3 at $553 million. Option 1, the Full BRT option, generated the lowest travel time savings of the three options resulting in a present value savings of $269 million.

Under all three options, the majority of the benefits result from the travel time savings which reflect the proposed operating speeds and consequent competitive travel times offered by transit. The higher transportation benefits for Option 2, for example, are a combination of higher transit ridership resulting from the relatively competitive travel times and the continuity of the LRT line along the entire corridor, as well as greater automobile user time savings resulting from reduced congestion along the realigned Main Street / King Street corridor. These travel time benefits however are dependent upon the ability of the new rapid transit system to achieve the proposed operating speeds which in turn is dependent upon the implementation of the necessary transit priorities.

Option 3 has the second highest transit user benefits of the three options with higher transit and automobile user savings than Option 1. The higher transit user benefits are associated with the faster travel times for the LRT versus the BRT. Option 1 has the lowest travel time savings of the three options.

[12] See Appendix A for details.

Automobile Operating Cost Savings

Automobile operating costs savings are derived from a reduction in auto kilometres as a result of the transit investment. The analysis shows that the Hamilton Rapid Transit project will result in reduced auto usage and that the degree of the decline is related to the rapid transit technology. It is estimated that the reduction in auto kilometres by 2021 ranges from a low of close to 5 million vehicle kilometres for Option 1 to more than 17 million kilometres for Option 2. By 2031, the annual reduction in auto use grows to more that 7.5 million kilometres for Option 1 and more than 42 million kilometres annually for both Options 2 and 3, which are the same by that date.

Translating these savings into monetary terms, the present value of the automobile operating cost savings over the period are $40 million, $187 million and $178 million for Options 1, 2 and 3 respectively. The estimates for all options are shown in Table 7.

The automobile operating cost savings are greatest for the LRT options reflecting the ability for LRT to draw a greater number of auto users to transit than BRT for at least a portion of their journey or an occasional trip.

Safety Benefits

The reduction in collisions is based on fewer vehicle kilometres driven. The monetary savings resulting from a reduction in collisions is calculated based on an assumed value of 7 cents per kilometre in reduced road travel (see Appendix A). The present value of safety benefits over the period ranges between $4 million for Option 1 up to $18 million for Option 2. The estimates for all options are shown in Table 7.

Qualitative Transportation Benefits

The major differences among the Hamilton Rapid Transit options from a user's perspective are travel time, reliability, need for transfer and passenger comfort. Travel time and transfer requirements are largely captured in the travel time savings estimates. Therefore, from a user's perspective, the options are differentiated by the degree to which service and schedule reliability are achieved and by passenger comfort.

Under all three of the Hamilton Rapid Transit options, the operating assumptions include significant signal priority / pre-emption at intersections along the corridor. Despite these priority measures, the at-grade alignments proposed for both BRT and LRT will create challenges for both technologies. While transit only lanes will enhance the reliability of all three options, both technologies will likely experience some variability in travel time depending on traffic congestion and cross-traffic at intersections as well as accidents.

The comparatively strong benefits generated by LRT are in large part driven by the higher average travel speeds, and consequently lower travel times, relative to BRT. For the purpose of this comparative assessment, average speeds for LRT were assumed to be between 33 and 35 kph as compared to 25 kph for BRT. While these average speeds are achievable, as demonstrated in other jurisdictions, the LRT will likely require signal pre-emption along much of the corridor as opposed to the less specific signal priority in order to ensure that these average speeds can be maintained. As indicated earlier, the majority of the benefits are related to travel time savings which in turn is related to the operating speeds and travel time.

The regional ridership model does not capture the difference in reliability among modes. While empirical evidence suggests that transit users put a high value on reliability, to the extent that all three options are subject to similar reliability constraints, none of the Hamilton Rapid Transit options will provide a significant reliability benefit relative to one another. However, to the extent that BRT will have more flexibility versus LRT to divert from its alignment in the event of a significant congestion delay, BRT may be considered to have a very slight advantage. On the other hand, the proposed 2.5 minute headway for the BRT as compared to 4 minutes for LRT options may present operational challenges as the short headway required to deliver the required capacity limits the operational flexibility for the BRT.

Options 1 and 2 both serve the entire rapid transit corridor as described for the purpose of this analysis. The phased LRT alignment proposed for Option 3 will force a transfer for passengers travelling along the eastern segment of the corridor in the short and medium term. Therefore Options 1 and 2 are more desirable from a user's perspective. In addition to the convenience of not having to transfer, the LRT is also likely to be perceived as a more comfortable technology. Option 2 therefore is likely to be the most preferred from a transit user's perspective.

Summary

Table 7 summarizes the incremental transportation user benefits associated with the Hamilton Rapid Transit project.

TABLE 7 INCREMENTAL TRANSPORTATION USER BENEFITS

All Values in NPV $m	Option 1	Option 2	Option 3
Travel Time Savings	269	647	553
Automobile Cost Savings	40	187	178
Accident / Collision Reductions	4	18	17
Transportation User Benefits	**313**	**852**	**748**

Financial Account

This account includes the assessment of the direct incremental "cash" items, primarily costs and revenues from the owner's perspective, for each option over the assessment period. Costs include the incremental capital and operating costs incurred by each option compared to the Base Case. Incremental revenues may also include fare revenues, advertising, and proceeds from disposal of assets. Any savings resulting from the implementation of the options are also included in this account.

Ridership and Revenues

Annual ridership and fare revenues have been projected using Greater Golden Horseshoe Travel Forecasting Model[13]. The ridership estimates indicate that Option 2 generates the highest demand with an AM peak hour demand of 1946 passengers in 2021 in the westbound direction. Option 1 generates the second highest ridership at 1560 passengers while Option 3 carried an estimated 1496 passengers during the AM peak hour. These passenger flows increase to almost 2100 passengers by 2031 (for Options 2 and 3) while Option 1 shows over 1700 passengers.

Based on these ridership estimates, the analysis shows that in 2021 (from a system-wide perspective) Option 2 would generate incremental annual fare revenues of close to $600,000 million versus $200,000 and $100,000 for Options 1 and 3 respectively. In net present value terms over the period of the analysis, incremental revenues are $5.7 million, $15.6 million and $12.5 million for Options 1, 2 and 3 respectively.

13 This model has been used for the development of the Regional Transportation Plan (RTP) and ensures consistency with that work. The model is strategic in nature and the effect of small projects can be minimal. However the main purpose of the benefits case work is of a comparative nature and we consider the model adequate for this purpose.

Capital and Operating Costs

The capital costs include all costs associated with the construction and acquisition of the infrastructure, revenue collection, vehicles, and maintenance centre. The estimates also include, design, management & administration, insurance, environmental permitting, property, and contingencies. Costs also include a preliminary estimate to make the King Street/Highway 403 bridge crossing compatible with LRT. Interest during construction is not included.

The construction period is assumed to be the same for all three options with start in 2011 and completion by 2014 for opening of service in 2015. Predictably, Option 1 has the lowest capital cost of the three options with an estimated cost of $218 million. The full LRT proposed under Option 2 is estimated to cost $829 million while the estimated capital cost for the truncated LRT alignment, as proposed under Option 3, is $605 million for the initial phase with the balance of $223 million being deferred until 2030.

Table 8 shows the capital costs and operating costs for each option. All values are expressed in 2008 dollars.

TABLE 8 CAPITAL AND OPERATING COSTS

All Values in 2008 $m	Option 1	Option 2	Option 3
Capital Costs	218	829	605
Annual incremental operating costs 2031	4.8	12.5	12.5

The operating costs used for this comparative assessment are considered conservative as they do not take into account any potential bus operating cost savings that may be realized with the introduction of the new rapid transit line. Savings could be anticipated from replacing the current BRT-Lite service with the new service as well as from other potential operating efficiencies that could be achieved by removing or rerouting buses to leverage the new rapid transit line. Furthermore, the operating costs used for this assessment are based on experience in other jurisdictions[14]. If operating costs in Hamilton could be reduced relative to these other jurisdictions, the on-going cost of the new rapid transit service would decrease.

[14] LRT operating costs based on TTC operating costs and BRT costs from York Region.

Summary

Table 9 shows the capital costs, operating costs and incremental fare revenues expressed in present value for the period 2009-2038.

A comparison of capital costs in present value terms shows that Option 2 has the highest cost of $655 million followed by the truncated LRT option, Option 3, with a cost of $563 million expressed in present value terms. Option 1, the full BRT option, has lowest present value cost estimated at $171 million.

Over the period of the analysis, none of the options generate sufficient incremental fare revenues to cover the incremental operating costs associated with the introduction of the new rapid transit line. However, as indicated earlier, the operating costs used in this comparative analysis are considered to be conservative. Furthermore, the relatively low incremental fare revenues likely indicate that much of the travel times savings described earlier are associated with improved travel times for existing riders which does not contribute to additional fare revenue for the operator.

TABLE 9 INCREMENTAL COSTS AND REVENUES

All Values in NPV $m	Option 1	Option 2	Option 3
Capital Costs	171	655	563
Operating Costs	49	129	92
Total Incremental Costs	**220**	**784**	**655**
Incremental Fare Revenues	5.7	15.6	12.5

Comparing Benefits and Costs

Table 10 compares the results from the Transportation User Benefits and Financial accounts. As illustrated in the table, all of the proposed rapid transit options generate positive net benefits resulting in a benefit cost-ratio that is greater than 1. Option 1 is the lowest cost option and generates the highest benefit-cost ratio of 1.4. Both LRT options are more costly than the BRT option but also generate greater benefits than the BRT option. The benefit-cost ratio for Options 2 and 3 are 1.1.

TABLE 10 COMPARISON BENEFITS AND COSTS

All Values in NPV $m	Option 1	Option 2	Option 3
Transportation User Benefits	313	852	748
Incremental Costs	(220)	(784)	(655)
Net Benefit (Cost)	**93**	**69**	**93**
Benefit-Cost Ratio	1.4	1.1	1.1

Environmental Impacts

This account examines the environmental impacts of the Hamilton Rapid Transit options. The major environmental impact with respect to urban transit projects is the ability of the project to reduce greenhouse gas emissions from reduced automobile usage.

Greenhouse Gas Emissions

As mentioned in the Transportation User Benefits section, all three options lead to an annual decline in automobile usage. By 2021, it is estimated that the number of kilometres travelled by automobile will decline by almost 4.8 million kilometres annually under Option 1. The annual reduction anticipated under Options 2 and 3 are approximately 17 million and 15 million kilometres respectively in 2021. As shown in Table 11, this translates into an annual reduction of CO_2 emissions of approximately 970 tonnes, 3,450 tonnes and 3,000 tonnes in 2021 respectively for Options 1, 2 and 3. These annual reductions increase by 2031 to more than 1,470 tonnes for Option 1 and more than 8,500 tonnes for Options 2 and 3.

The present value of the reduction in CO_2 emissions over the period 2009-2038, based on an average value of $0.01 per kilometre (see Appendix A), is estimated at $0.6 million for Option 1, $2.6 million for Option 2 and $2.5 million for Option 3. The value of a tonne of CO_2 is currently a subject of debate. These figures, regardless of the value assigned per tonne of CO_2, are still very useful for comparison purposes among the options.

TABLE 11 REDUCTION IN CO_2 EMISSIONS

	Option 1	Option 2	Option 3
2021 Reduction in CO_2 tonnes	970	3,449	3,003
2031 Reduction in CO_2 tonnes	1,471	8,532	8,532
NPV Value ($ m)	0.6	2.6	2.5

Economic Development Impacts

This account measures the economic impacts for each scenario relative to the Base Case, including impacts from construction and economic impacts incurred from implementation of project options. These impacts are reported in terms of GDP, the change in jobs and the change in the associated labour income, and are stated in 2008 dollars. Results reflect how the implementation of the Hamilton Rapid Transit Project will directly affect both households and businesses in the regional economy, and total provincial economic impacts that are derived by applying Ontario specific multipliers to derive indirect affect of employment, wages and GDP generated by the direct impacts of construction and improvements to the transportation network.

This account also includes an assessment of the incremental impacts the options will have on land values and development in the corridor.

Temporary Economic Impacts During Construction

The implementation of the Hamilton Rapid Transit Project will generate both direct and indirect economic benefits that are temporary in nature and span the schedule of construction. As shown in Table 12, the construction is estimated to create between 990 and 3,729 person-years of employment and between 847 and 2,064 person-years of employment indirectly as a result of increased economic activity for suppliers[15]. The impact on employment, wages and GDP is driven by the capital cost required to build each option. Option 2, which has the highest capital cost of the three options, also has the largest employment and income impacts.

15 Based on Province of Ontario Multipliers, 2004.

TABLE 12 EMPLOYMENT AND INCOME IMPACTS DURING CONSTRUCTION

	Direct Impacts			Regional (Indirect) Impacts		
	Employment (person years)	Wages ($m)	GDP ($m)	Employment (person years)	Wages ($m)	GDP ($m)
Option 1	990	34.4	83.3	847	19.0	46.1
Option 2	3,729	129.6	313.8	2,064	71.7	173.7
Option 3	2,773	96.4	233.4	1,535	53.3	129.1

Long-term Economic Impacts

In the long-term there will be ongoing economic benefits as a result of the Hamilton Rapid Transit Project. These benefits reflect both households' freed up vehicle operating expenditures and transportation cost savings to area businesses. The former effect is simply a redirected consumption demand by households away from purchases of gas, parking, automotive parts and services and into other consumer goods/services.

The latter reflects improved regional competitiveness for Hamilton businesses that now have lower costs of doing business, including access to a larger labour market and encountering less congestion on roadways because people are choosing to use the transit system instead of driving. The impact of the Hamilton Rapid Transit project will be different for each business.

Implementation of the Hamilton Rapid Transit project will also generate social benefits that can be monetized, including valuing time savings and emission benefits. These have already been captured above under transportation user benefits.

As shown in Table 13, the Hamilton Rapid Transit project is also expected to have an on-going and positive impact on jobs, wages and the GDP once it is in operation. The impacts for each option are driven by transit and auto travel time savings provided by each option. Option 2 has the greatest employment and income impact with an estimated 81 direct jobs and 35 indirect jobs created in 2021. By 2031 the operating scenarios for Options 2 and 3 are similar with the eastward extension of the LRT line proposed under Option 3 in place. Therefore the impacts are the same for both options with 132 direct and 35 indirect jobs being created.

TABLE 13 EMPLOYMENT AND INCOME IMPACTS

	Direct Annual Impacts			Indirect Annual Impacts		
	Employm. (Jobs)	Wages ($m)	GDP ($m)	Employm. (Jobs)	Wages ($m)	GDP ($m)
2021						
Option 1	32	1.1	2.7	14	0.5	1.2
Option 2	81	2.8	6.9	35	1.2	2.9
Option 3	61	2.1	5.1	25	0.9	2.2
2031						
Option 1	34	1.2	2.9	14	0.5	1.2
Option 2	132	4.6	11.2	55	1.9	4.6
Option 3	132	4.6	11.2	55	1.9	4.6

Land Value Changes

There is evidence from a number of different jurisdictions around the world that investment in rapid transit can have a positive impact on property values in the general area of a new rapid transit line and particularly within close proximity to station areas.[16] This evidence also suggests that the specific rapid transit technology is also a determining factor in the degree to which property values may be influenced. For example, a more permanent, rail-based, higher capacity technology such as LRT will typically capture a larger area of property within their area of influence than lower capacity bus-based transit facilities. As shown in Table 14, the catchment area around at-grade LRT is typically 500 metres as compared to the slightly smaller catchment area around a BRT station estimated to be 400 metres.

As indicated in the table, the introduction of rapid transit will provide a modest lift in percentage terms to land values within the applicable area of station impact. Based upon the ranges shown, BRT has significant modest influence on vacant residential properties within the station catchment areas with an estimated property price premium of between 1 and 7 percent versus a

[16] The estimates are based on a 2002 comprehensive review of land value and public transport literature that references approximately 150 studies. The studies show that the premium placed on property values fluctuates widely for different transit projects with the same technology. The estimates included above represent the mid-range of the premiums found in the reference material.

range of between 4 and 6 percent for LRT. With respect to the potential impacts on commercial property, BRT provides a potential lift of between 2 and 6 percent, significantly lower than the potential uplift to vacant commercial properties within the station catchment area for LRTestimated to be within 8 to 14 percent.

TABLE 14 PROPERTY VALUE UPLIFT FACTORS

Technology		BRT	LRT
Station impact Area (m)		400	500
Premium %			
Vacant Residential	Low	1	4
	High	7	6
Vacant Commercial	Low	2	8
	High	6	14
Residential	Low	1	2
	High	2	4
Commercial	Low	2	2
	High	4	4
Industrial	Low	0	0
	High	0	0
Institutional	Low	0	0
	High	0	0

While it is possible for property values within the catchment area of new rapid transit lines to experience much greater increases than those shown in the table, it is not necessarily possible to directly attribute the increase to any one factor. For example, in addition to the introduction of rapid transit, local planning policies, density and land-use intensification objectives, and other zoning changes will also influence property values and are important to the overall success of the rapid transit project.

The ranges presented in the table represent only the estimated property value uplift that can be specifically attributed to the introduction of a new rapid transit line based upon experiences elsewhere. Hence do not take into account the potential property value uplift that may arise from the City of Hamilton's current support for a mix of higher density uses along arterial roads, including retail, residential, employment, entertainment and institutional uses. It is arguable that the introduction of a new rapid transit line along the Main Street-King Street corridor will better enable the planned density resulting in greater property values. However, for the purpose of this comparative assessment, this potential benefit has not been specifically included. Nonetheless, an investment in rapid transit, made in conjunction with supportive planning and other initiatives, is a key component to the realization of land use intensification plans and property value uplift.

For the purpose of this analysis, land value uplift in the mid-ranges of those shown in the table is used for existing residential and commercial uses. For vacant lands under residential and commercial uses it is estimated that higher uplift may be potentially possible.

For the purpose of land value estimation, an analysis of the Hamilton Official Plan (OP) was undertaken to determine the breakdown of land use by high-level type within each of the three segments of the corridor; namely, the eastern, downtown and western segments. The uplift in property value under each option was determined based on the total assessment of lands within the station catchment area and the estimated increase in values based on experiences in other jurisdictions. The value estimates for each option are as follows:

Option 1

Based upon a station catchment area of 400 metres, it is estimated that the implementation of BRT will result in an average uplift of between *1.2% and 2.3%*. It is estimated that the potential uplift in assessment value as a result of this BRT option could result in *approximately $38 million to $77 million*.

Option 2

Based upon a station impact area of 500 metres, the full LRT option will create a larger overall impact area than the BRT option and therefore implies that more land value uplift benefits will accrue to the project. Within the area impacted under this option, the average uplift is between *1.5% and 3.2%* It is estimated that the potential uplift in assessment value as a result of this Option may result in between *$50 million to $144 million*.

Option 3

Option 3 defers the opening of five of the 17 stations until 2030. Within the area impacted for the stations to be implemented as part of the first phase of this LRT proposal, the average uplift is estimated in the range of *1.1% and 3.2%*. It is estimated that the potential uplift in assessment value as a result of this Option may result in *almost $38 million to $106 million*.

Although the number of stations is reduced in Option 3 as compared to Options 1 and 2, the impact area for LRT is expected to be larger than that for BRT hence offering an increased uplift as compared to Option 1. However, when compared to Option 2, the smaller number of stations and hence lower total impact area is estimated and result in less land/property being subject to uplift effect. Overall, the average uplift in Option 2 is estimated to be the highest among the options primarily due to a larger area of the uplift impact and a higher percentage uplift factors using LRT. Although the station impact area is 500 metres for both Option 2 and 3, the lower number of stations contemplated for the first phase of Option 3 is expected to result in a smaller impact area and hence a lower potential uplift as compared to Option 2.

Summary

Table 15 summarizes the economic development impacts including direct and indirect impacts along with the land value uplift for each option.

TABLE 15 ECONOMIC DEVELOPMENT IMPACTS

	Option 1	Option 2	Option 3
Total Impacts During Construction Period:			
Employment (Person-years)	1,837	5,793	4,308
GDP ($m)	129.4	487.5	362.5
Income ($m)	53.4	201.3	149.7
Impacts in 2031[17]:			
Employment (jobs)	48	187	187
GDP ($m)	4.1	15.8	15.8
Income ($m)	1.7	6.5	6.5
Land Value Increase ($m)			
Low Estimate	38	50	38
High Estimate	77	144	106

Social Community Impacts

This account examines each option from the community perspective with specific consideration given to the ability of each option to enhance the quality of life within a local community. This may result from land use changes or developments that can occur in response to the introduction of a new rapid transit line, as well as the improvements brought about by the enhanced accessibility, both locally and regionally, offered by the new transit alternative. This account also considers the ability of each option to positively affect the overall health of the local community and its residents through reduced auto congestion on local streets as well as the ability of transit to support a more balanced lifestyle for local residents and enhance personal safety. Visual impacts and noise are also assessed as part of this account.

Land Use Shaping

Experience in other jurisdictions demonstrates that when combined with complementary local planning initiatives the implementation of transit can positively support and influence development, particularly around rapid transit stations, and promotes more compact, mixed use

[17] Option 2 extended to replicate Option 3 in 2031 and therefore options are effectively the same

communities. The type and magnitude of the development is dependent upon a number of factors including the general nature of the transit corridor and the surrounding neighbourhoods.

As shown in the land value uplift section above, the Main Street / King Street corridor in Hamilton is a well establish corridor within the city consisting of a mix of residential, commercial, retail, industrial, recreational (parks) and institutional uses. Densities also vary along the corridor with more concentrated development occurring closer to the city centre and within the downtown section of the proposed rapid transit alignment.

For the purpose of this analysis, it is assumed that, consistent with the land value uplift estimates presented earlier in this report, all three transit options are capable of promoting land use changes to support the local planning initiatives and changes to the local zoning. While it is difficult to quantify, it is generally accepted that investments in rail rapid transit initiatives are more likely to attract complementary land development investments compared to bus-based transit initiatives, provided that the transit investment is undertaken in concert with other complementary planning initiatives. With this in mind, the investment associated with the fixed rail infrastructure proposed under Options 2 and 3 is more likely to result in the redevelopment of the corridor and therefore achieve the city's objective to revitalize the city's core and create a more densely developed, less car-dependent urban environment.

Road Network

As proposed, the new rapid transit line will impact the local road network in two significant ways. Firstly, based on the average transit speeds proposed for the corridor, particularly LRT which is proposed to operate at an average speed of between 33 and 35 kph, a significant level of signal pre-emption will be required to support the transit operation. Depending on the extent of signal pre-emption required, there is the potential to negatively impact north-south traffic at intersections where they are likely to experience longer delays while priority is given to the east-west traffic. While the average travel speeds are lower for BRT than LRT, the frequency of the BRT service along the corridor will also require some signal priority / pre-emption which would also negatively affect north-south traffic.

The proposal to implement rapid transit along the Main Street / King Street corridor is also based on the assumption that the City of Hamilton will convert the current one-way operation of King Street and Main Street through the downtown segment with two-way traffic. The implications of this two-way conversion are included in the sensitivity analysis section; conversion is considered a positive move from a city-building perspective that will create a more pedestrian and transit-friendly environment.

Construction

All three options will involve a certain degree of disruption to traffic, neighbouring commercial, retail and residential properties during construction as King Street is realigned to accommodate a dedicated two-lane rapid transit right-of-way. While the specific construction impacts associated with the implementation of each option cannot be determined until the project is defined in more detail, it is assumed that the LRT construction will be more disruptive than the BRT option. Given that the length of the alignment proposed for Option 2 is greater than initial alignment proposed under Option 3, it is assumed that the construction impacts for Option 2 will be greater. However, under the current proposal, the alignment defined as Option 3 is to be extended eastward in 2030 to a terminal station at Eastgate Square. Therefore, the disruption required to construct Option 3 is similar to that anticipated under Option 2 but is split into two construction phases. Under any scenario, it is also assumed that careful planning and appropriate construction methods will mitigate some of this potential disruption.

Sensitivity Analysis

Direct Connection to Hunter Street GO Station

A sensitivity analysis was conducted as part of this comparative analysis to determine whether a deviation of the LRT alignment proposed under Option 2 to create a direct connection with the Hunter Street GO Transit Station would provide greater transportation benefits than the King Street alignment through the downtown area.

The results show that providing a direct connection to the Hunter Street GO Transit Station would generate slightly higher peak point ridership but that the increased travel time associated with this deviation would result in fewer transportation user benefits as compared to the more direct King Street alignment. Specifically, the GO Transit deviation results in substantially lower travel time savings of only $367 million. This represents a decline of $280 million from the travel time savings estimated for the King Street alignment. Similarly, as shown in Table 16 below, the deviation also results in a lower automobile operating cost savings and safety benefit. Given these findings, an alignment that deviates from King Street to more directly serve the Hunter Street GO Station is less preferred.

Notwithstanding this result, it is likely that the importance of a convenient transit connection to the GO rail network will increase over time as the GO service continues to be enhanced and bi-directional travel within the region increases. Additional work that would improve the connectivity of the GO rail network and the Hamilton Rapid Transit project therefore should be undertaken as it will likely be beneficial to the regional transit network, the community of Hamilton, and the broader region.

TABLE 16 DETOUR EFFECTS OF DIRECT CONNECTION TO HAMILTON HUNTER STREET STATION

All Values PV $m	Option 2	Option 2a	Difference
Travel Time Savings	647	367	-280
Automobile Operating Cost Savings	187	156	-31
Safety Benefits	18	5	-3
Total Transportation User Benefits	**852**	**538**	**-314**

One-Way Base Case

For the purpose of the comparative analysis presented in this report it was assumed that Main Street and King Street in downtown Hamilton were converted from one-way to two-way streets prior to the implementation of the proposed rapid transit system. As a consequence, the results presented in this report only reflect the incremental transportation benefits generated by the introduction of the new rapid transit line into the two-way street environment. The results do not capture any transportation benefits that may have resulted from the two-way conversion itself.

To better understand the potential implication of the two-way conversion, a sensitivity analysis was undertaken as part of the comparative assessment to measure the transportation benefits associated with the combined two-way conversion along with the introduction of a new rapid transit line.

As shown in Table 17, this comparison of the changes to traffic and transit ridership relative to the current conditions reveals significantly higher transportation benefits than those estimated assuming the two-way streets were in place in the Base Case. Under the two-way street system, existing traffic patterns change significantly as the current one-way streets tend to encourage longer cross-town trips while the two-way streets tend to support short trips. The lower incremental benefits associated with the introduction of transit under the two-way configuration indicates that there are likely transportation benefits to be gained from the two-way conversion itself. The introduction of a time-competitive rapid transit system following the conversion to two-way streets provides additional incremental benefits.

TABLE 17 TWO-WAY VERSUS ONE-WAY STREETS

All values in NPV $m	Travel Time Savings	Auto Operating Cost Savings	Safety Benefits	Total Transportation Benefits
		Option 1		
2-way Base	269	40	4	313
1-way Base	315	361	34	710
Difference	**(46)**	**(321)**	**(30)**	**(397)**
		Option 2		
2-way Base	647	187	18	852
1-way Base	828	500	48	1,376
Difference	**(181)**	**(313)**	**(30)**	**(524)**
		Option 3		
2-way Base	553	178	17	748
1-way Base	703	482	46	1,057
Difference	**(150)**	**(304)**	**(29)**	**(309)**

Discount Rate

Since the analysis is based on discounted cash flow and subject to changes as the discount rate changes, the robustness of the ranking of the options with respect to the benefit-cost ratio was tested under two alternative discount rates – 3% and 7%. As shown in Table 18, with a discount rate of 3%, all three options continue to provide a positive net present value and benefit-cost ratios greater than 1.0. The ranking is also unaltered by the lower discount rate as the timing of the cash flow is assumed to be the same among the options. When subjected to a higher discount rate of 7% however the relative ranking remains unchanged but the net benefits of Options 2 and 3 become negative with benefit-cost ratios of 0.9. The benefit-cost ratio for Option 1 drops to 1.2 for the 7% discount rate scenario with net benefits remaining positive but declining to $38 million.

TABLE 18 DISCOUNT RATE SENSITIVITY ANALYSIS

Discount Rate	3%		5%		7%	
	NPV ($m)	BCR	NPV ($m)	BCR	NPV ($m)	BCR
Option 1	181	1.7	93	1.4	38	1.2
Option 2	338	1.4	69	1.1	(91)	0.9
Option 3	325	1.4	93	1.1	(44)	0.9

Summary of Results

The analysis of the Hamilton rapid transit options reveals that the highest cost option (the full LRT along the Main Street-King Street corridor), with estimated capital and operating costs of $784 million in net present value terms, also generates the highest Transportation User Benefits. These are estimated at more than $850 million resulting in a benefit-cost ratio of 1.1. By comparison, Option 1 (the full BRT option), generates an estimated $313 million in Transportation User Benefits less than one-half of that generated by of Option 2. However the estimated cost of $220 million for Option 1 in net present value terms is also much lower than either LRT option, resulting in a strong benefit-cost ratio of 1.4. By deferring a portion of the capital investment, the net present value of Option 3 is reduced by almost $130 million from the cost of the full LRT option. The Transportation User Benefits of this option are also lower than the full LRT option resulting in the same benefit-cost ratio (1.1).

For each option, the majority of benefits are derived from the travel time savings thus highlighting the importance of the operating speed of the rapid transit system to the success of the project. Given the supportive transit signal priority/pre-emption measures proposed under each of the options, the City of Hamilton has an opportunity to establish a new performance standard for the region to fully realize the benefits from the rapid transit investment.

None of the options generate sufficient incremental fare revenues to cover the incremental operating cost associated with the introduction of the new rapid transit line. The greatest incremental fare revenues are generated by Option 2 which is also the most costly to operate on an annual basis. However, the operating costs used in this comparative analysis are considered to be conservative and estimated at the higher end of the range. Lowering these costs would result in better revenue to cost ratios for all three options. The relatively low incremental fare revenues however indicate that much of the travel time savings are associated with improved travel times for existing riders, which does not contribute to additional fare revenue for the operator.

All of the options are somewhat effective in attracting people out of their cars and reducing automobile usage. Option 2, which has the largest effect, will result in a reduction of greenhouse gas emissions by approximately 3,449 tonnes annually by 2021 increasing to 8,532 tonnes by 2031. In net present value terms, this equates to $2.6 million for Option 2 compared to $0.6 million and 2.5 million for Options 1 and 3 respectively.

As expected the options with the highest capital costs generated the most significant economic development effects. Option 2, which has the highest capital cost will have the largest impact on employment, income and GDP during construction and is estimated to generate approximately 5,793 person-years of employment[18]. Option 3 defers some of the capital and on-going operating costs but still generates relatively strong employment, income and construction GDP effects. By contrast, the lower cost BRT option produces the lowest overall economic development and employment benefits during construction as well as during the on-going operations.

All of the options support the City of Hamilton's land use and economic development objectives to revitalize the corridor by enhancing and supporting complementary planning and densification initiatives. LRT demonstrates a greater ability to attract investment and redevelopment than the BRT alternative and consequently provides higher property value uplift. At the upper end of the range of estimated uplift, Option 2 produces double the uplift of Option 1 at $144 million versus $77 million. At the lower end of the range, the difference is less dramatic with Option 1 producing an estimated $38 million in property value uplift versus $50 million for Option 2. Option 3 by comparison defers the implementation of a portion of the line and postpones potential development opportunities in the vicinity of up to five of the proposed LRT stations. As a consequence the potential uplift is constrained and is estimated to be in the range of between $38 million and $106 million.

Overall, the results indicate that an investment in LRT in Hamilton will generate significant benefits and support the City's broader objectives to revitalize, redevelop and reshape its most significant east-west corridor. While the lowest cost option, Option 1, produces the highest benefit-cost ratio of 1.4, both LRT options generated benefit-cost ratios that are greater than 1.0. The highest cost option, Option 2, also produced the greatest benefits in all accounts, all of which make an important contribution towards achieving the objectives and goals of both the City and the Province.

Finally, the results of the comparative analysis presented in this report are based on the assumption that the current one-way street system through the downtown core is converted to a two-way traffic system where both Main Street and King Street are converted to two-way streets. In the absence of this conversion, the incremental benefits generated by the introduction of a rapid transit are greater than those presented in this report, reflecting the different trip

[18] Includes both direct and indirect impacts.

characteristics under each scenario. The one-way system typically supports longer cross town trips rather than the shorter trips encouraged by the two-way streets. As a consequence, the travel time savings resulting from the introduction of rapid transit under a two-way street scenario are less significant than under a one-way scenario as individual trip patterns already reflect the shorter trip distances. However, as the results show, the introduction of rapid transit under the two-way scenario does present positive travel savings as rapid transit is able to offer faster and more competitive travel times for the shorter trips. Furthermore, the two-way street system is more supportive of the City's objective to create a healthy, more pedestrian-friendly downtown.

In addition to the merits of the two-way conversion, the ability of the rapid transit system to compete with the auto and generate strong travel time benefits is directly related to the operating speed of the rapid transit system. For each option assessed in this study, the majority of the benefits are derived from the travel time savings. If the City of Hamilton provides the supportive transit signal priority/pre-emption measures proposed under each of the options, the results indicate that the city can leverage the benefits from a rapid transit investment while establishing a new performance standard for rapid transit in the region.

The table below summarizes the results from the MAE.

TABLE 19 MAE SUMMARY

	Option 1	Option 2	Option 3
Transportation User Account			
Transportation User Benefits (PV $m)	313	**852**	748
Qualitative User Benefits	✓	✓✓✓	✓✓
Financial Account			
Costs (PV $m)	**(220)**	(784)	(655)
Benefits Less Costs (PV $m)	93	**69**	93
Benefit-Cost Ratio	**1.4**	1.1	1.1
Environmental Account			
GHG Emissions (PV $m)	0.6	**2.6**	2.5
Economic Development Account			
Economic Impacts During Construction			
Employment (person-years)	1,837	5,793	4,308
GDP ($m)	129.4	487.5	362.5
Income ($m)	53.4	201.3	149.7
Long-term Economic Impacts			
Employment (person-years)	48	187	187
GDP ($m)	4.1	15.8	15.8
Income ($m)	1.7	6.5	6.5
Development Potential ($m)	38 - 77	50 - 144	38 - 106
Social Community Account			
Land Use Shaping	✓	✓✓✓	✓✓
Road Network	✓✓✓	✓	✓✓
Construction Implications	✓✓✓	✓✓	✓

APPENDIX

A

INPUT VARIABLES AND ASSUMPTIONS

Factor	Value	Source
Discount Rate Sensitivity Analysis	5% (real terms) 3% and 7%	Province of Ontario
Value of Time Business Other Weighted Average	 $35.16 (2008$) $10.82 $13.02	Transport Canada, Greater Golden Horseshoe Model
Value of Time Growth	1.6% per annum	Based on GDP per capita increases, GDP/ Population estimates from www.greatertoronto.org
Average Accident Cost	$0.07 per km	Collision Statistics: 2004 Canadian Motor Vehicle Traffic Collision Statistics, TP3322. Vehicle Kilometers: Statistics Canada, Catalogue No. 53-223-XIE, "Canadian Vehicle Survey"
Greenhouse Gas Emissions 2006 2021 2031	 2.39 kg /l or 0.23 kg per km 2.35 kg /l or 0.21 kg per km 2.35 kg /l or 0.20 kg per km	Urban Transportation Emissions Calculator, Transport Canada, Greater Golden Horseshoe Model
Average Cost of CO_2	$0.01 per km $40/tonne (median cost)	Several literature sources, Transport and Environment Canada, Greater Golden Horseshoe Model and http://envirovaluation.org/index.php/2007/09/06/university_of_hamburg_forschungsstelle_n_1
Auto Operating Costs	In 2008$ + 2.0% p.a. increase 2007 - $0.50/km 2021 - $0.65/km 2031 - $0.79/km	Data in 2007 based on CAA calculation of average driving costs and includes operating and ownership costs (long-term costs). Increase based on Greater Golden Horseshoe Model
Annualisation Factors: Metro / LRT Road	Peak-daily/Daily-Annual 3 / 300 10 / 300	Greater Golden Horseshoe Model