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GO LAKESHORE EXPRESS RAIL BENEFITS CASE ANALYSIS – CONTEXT

Background

On November 28, 2008, the Metrolinx Board approved the regional transportation plan, entitled The Big Move, which identified GO Lakeshore Express Rail as a Top 15 priority project. The Board also required a Benefits Case Analysis (BCA) be completed for the Lakeshore Corridor and the other priority projects.

The BCA examines the proposed improvement apart from other network improvements in order to isolate its specific benefits. The Lakeshore Express Rail BCA will need to be set within the broader context of the GO rail network, and as such, this report will provide one of the many inputs to the GO Transit System Electrification Study, expected to be completed in 2010.

KEY IMPLEMENTATION ISSUES

Project Costs and Timelines

The potential phasing of the electrification of the Lakeshore Corridor relative to the rest of the GO rail system in the Greater Toronto and Hamilton Area (GTHA) will be analysed as part of the broader GO Transit System Electrification Study.

The Lakeshore Express Rail project is currently unfunded. Due to the unique characteristics of the corridor (ownership, traffic, physical constraints and ridership demand) the estimates developed for this corridor are not necessarily transferable to other projects. In addition, project costs and timelines presented in this report are rough order of magnitude estimates for the purposes of evaluating the relative costs and benefits of each option. Costs and timelines would need to be refined as part of any future planning, design and engineering project development phases.

Union Station Capacity

Capacity limitations at Union Station will need to be addressed to accommodate the service increases contemplated in *The Big Move*. Future Union Station capacity needs are driven by projected ridership growth for the entire GO Rail network, as well as VIA Rail, and are not exclusively attributable to Lakeshore Corridor.

Two studies are currently underway related to this issue. The first is focused on determining the demands on Union Station platform and track capacity and the Union Station Rail Corridor (USRC) rail and signal capacity, and quantifying the growth in platform space required and developing a staging plan for the next five to 25 years. The second is a broader and related study to examine GTHA system-wide options beyond Union Station for meeting the additional 2031 demand and capacity needs. These studies will be coordinated with the broader GO Transit System Electrification Study.

Corridor Ownership

As a result of the fragmented ownership of the Lakeshore Corridor, electrification would have to be approved by Canadian National Railways (CN) and, to a lesser extent, Canadian Pacific Railway (CP). The majority of the Corridor is owned by CN, with the exception of the Metrolinx-owned Union Station Rail Corridor between Bathurst Street and the Don Valley and the GO Subdivision between Durham Junction and Oshawa. CP owns the section between Hamilton Junction and the Hamilton Hunter Street Station.

Vehicle Technology

For the purposes of this study, the use of electric locomotives pulling/pushing the existing bi-level rail cars was assumed. Smaller, lightweight Electric Multiple Units (EMUs) may offer operating performance and cost advantages and could also be considered in the design for long-term service needs. Pending future project approvals, this issue could be more fully explored as part of future planning, design and engineering project development phases.

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GO TRANSIT LAKESHORE EXPRESS RAIL BENEFITS CASE

June 2009

INTERIM REPORT

GO Transit Lakeshore Express Rail

Benefits Case

Interim Report

June 11, 2009

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Building on the Province's $11.5 billion MoveOntario 2020 funding commitment for rapid transit expansion in the GTHA, Metrolinx developed the Regional Transportation Plan (RTP) to improve mobility throughout the GTHA Region. The final RTP, entitled The Big Move, was unanimously approved by the Metrolinx Board of Directors in November 2008.

As the rapid transit projects contemplated in the RTP move 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.

This report is focused on improvements to GO Transit's service in the Lakeshore East and West Corridors between Oshawa and Hamilton. Two options were identified in consultation with Metrolinx and GO Transit:

- Option 1: Diesel operations with fleet and infrastructure improvements through 2015; and
- Option 2: Electrified operations with fleet and infrastructure improvements as follows:
  - Phase One – Fleet and infrastructure improvements through 2015; and:
  - Phase Two – Fleet and infrastructure improvements through 2031.

It should be noted that meeting the forecast 2031 RTP ridership demands through expanded diesel operations was deemed not to be a feasible option for comparison purposes, and thus only the electrification scenario has been carried forward in Phase 2 of this analysis.

TABLE 1 SUMMARY OF OPTIONS

	Base Case	Option 1	Option 2	
			Phase 1	Phase 2
Power Source	Diesel	Diesel	Electric	Electric
Coach-type	Bi-level	Bi-level	Bi-level	Bi-level
Train Length	10 Coaches	10 Coaches	10 Coaches	10 Coaches
Number of Trains	17 (2015)	24 (2015)	24 (2015)	44 (2031)
Maximum Number of Peak Hour Trains (eastbound)	8	10	10	14
Maximum Number of Peak Hour Trains (westbound)	6	9	9	12
Peak Hour Capacity – 2031 eastbound	12,320	15,400	15,400	21,560
Peak Hour Capacity – 2031 westbound	9,240	13,860	13,860	18,480
Minimum Travel Time – Eastbound Express (Hamilton to Union)	66 min	61 min	52 min	46 min
Minimum Travel Time – Eastbound Local (Hamilton to Union)	N/A	75 min	63 min	63 min
Minimum Travel Time – Westbound Express (Oshawa to Union)	44 min	39 min	35 min	33 min
Minimum Travel Time – Westbound Local (Oshawa to Union)	60 min	58 min	47 min	47 min
Capital Costs ($billions)[1]	N/A	0.86	1.89	5.97[2]
Annual Incremental Operating Cost in 2031 ($million)	N/A	215	117	141

[1] The capital costs presented in this report should be considered indicative and represent point in time estimates for the purpose of project evaluation and option selection. The costs will be refined as the project moves into design, procurement and implementation, and are therefore not intended for budgeting purposes.

[2] Note: Option 2 Phase 2 capital costs include Phase 1 capital costs ($1.89B) plus $4.09B in additional capital costs to 2031.

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; and
- Socio-Community Impacts.

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 form the MAE.

TABLE 2 MULTIPLE ACCOUNT EVALUATION SUMMARY

	Option 1	Option 2	
		Phase 1	Phase 2
Transportation User Account			
Transportation User Benefits (PV $m)	3,611	4,567	**5,849**
Qualitative User Benefits	✓	✓✓	✓✓✓
Financial Account			
Costs (PV $m)	2,568	2,507	**4,660**
Benefits Less Costs (PV $m)	1,043	**2,060**	1,188
Benefit-Cost Ratio	1.4	**1.8**	1.3
Environmental Account			
GHG Emissions (PV $m)	28	31	**40**
Qualitative Environmental Impacts	✓	✓✓	✓✓
Economic Development Account			
Economic Impacts During Construction ($m)	554.8	1,516	**4,879**
Long-term Economic Impacts ($m)	232.5	250.6	**271.6**
Development Potential ($b)	3.87	3.87	**9.28**
Social Community Account			
Land Use Shaping	✓	✓✓	✓✓✓
Health	✓	✓✓	✓✓✓
Accessibility	✓	✓✓	✓✓✓

The analysis shows that electrifying the GO Lakeshore corridor to include the infrastructure and service enhancements defined under Option 2 Phase 2 provides greater user benefits than either the Phase 1 diesel or electric options but that it is also the most costly option. When considering both costs and benefits together, Option 2 Phase 1 results in the highest benefit to cost ratio of

1.8 versus 1.4 and 1.3 for the Phase 1 diesel and Phase 2 electric options, respectively, indicating that there are significant benefits associated with the improved levels of service and travel times resulting from the electrification of the corridor. It should be noted that when including both operating and capital costs, Option 2 Phase 1 was found to be slightly less expensive overall relative to Option 1. The additional infrastructure and service enhancements required to implement the second phase of the electric option, which cannot be done without first making the Phase 1 investment, also provides additional benefits that exceed the cost of implementation. However, the incremental benefits associated with the second phase of the electric option are lower relative to those resulting from the initial investment in electrification and therefore result in a lower overall benefit to cost ratio for the second phase.

Both options are very effective in attracting people out of their cars and reducing automobile usage. The enhanced levels of service and travel times provided by Option 2 Phase 2 have the greatest impact on automobile use and consequently result in a reduction of greenhouse gas emissions of more than 170,000 tonnes annually by 2031. By comparison, Option 1 Phase 1 results in an annual reduction of greenhouse gas emissions of approximately 118,000 tonnes while Option 2 Phase 1 results in an annual decrease of almost 132,000 tonnes.

There are positive economic development benefits generated by the capital expenditures under both options. Both phases of the electrification option generate more direct and regional employment than the diesel option. Option 2 Phase 2 is significantly higher, providing an estimated 33,000 and 18,000 person-years of direct and indirect employment, respectively, during construction, approximately three times more than are expected to be generated by Option 2 Phase 1 and almost ten times more than the diesel option. Option 2 Phase, due to its faster travel time, also has the highest on-going economic development and productivity impacts resulting in 2031 in 2,098 additional jobs, $78.8 million in wages and $198.4 million in increased GDP.

The residential land development potential for both options is significant at more than $3 billion for Phase 1 of both the diesel and electric options. The faster and more frequent service proposed under Option 2 Phase 2 results in a dramatic increase in the land development potential, increasing the value by more than $9 billion by 2031.

Improvements proposed under either option will improve regional connectivity between six Urban Growth Centres (UGCs) identified in the Greater Golden Horseshoe Growth Plan, including Downtown Hamilton, Downtown Burlington and Midtown Oakville, Downtown Toronto, Downtown Pickering and Downtown Oshawa, from west to east. The level of service enhancements made possible with the electrification of the corridor, and particularly when coupled with the improvements proposed under Option 2 Phase 2, will significantly shape and transform the GO Lakeshore corridor from a Downtown Toronto-oriented commuter rail line to one providing frequent bi-directional service among a series of major employment and residential nodes. The improved connectivity and accessibility made possible by the proposed improvements under

Option 2 will enhance live and work opportunities in all of the six UGCs noted above, as well as other intermediate station areas along the line. This again is particularly true for the second phase of the electrification option which leverages the initial investment to improve the frequency, reliability and speed of the GO Transit service.

Overall, the investment required to electrify the GO Lakeshore corridor will return significant benefits, improving the viability of the GO Transit system as an alternative to the automobile and providing the support and stimulus necessary to improve the connectivity and accessibility between UGCs to help manage growth and shape land development patterns.

Part A Project Rationale

Introduction

Purpose of Report

In 2006 the Province of Ontario created the Greater Toronto Transportation Authority, later renamed to 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.

Building on the Province's $11.5 billion MoveOntario 2020 (MO 2020) commitment to rapid transit expansion in the GTHA, Metrolinx has developed a Regional Transportation Plan (RTP) to improve mobility throughout the GTHA Region. The final RTP, entitled The Big Move, was approved by the Metrolinx Board of Directors in November 2008.

As the rapid transit projects contemplated in the RTP move closer to implementation, a Benefits Case will be prepared for each project. The Benefits Case will describe a range of feasible options including the business-as-usual scenario 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 GO Transit – Lakeshore Express Rail project is one of the transit projects contemplated in *MoveOntario 2020* and in the RTP. The project involves expanding the people moving capacity by widening the network of tracks and introducing electric power through an overhead catenary system along the entire length of the rail corridor between Hamilton and Oshawa. This will enable a switch from the current diesel locomotive operations to a more efficient, faster electric train operation.

To better understand the potential benefits and technical feasibility of an electrified corridor, in 2008, GO Transit and Metrolinx undertook a technical assessment of the Lakeshore Corridor to examine potential electric operations. This review of technology options for the Lakeshore Corridor – diesel and electric - enabled a comparative assessment. The operational feasibility and implementation requirements of each technology are compared based on a proposed phasing of infrastructure investment:

- Phase I - infrastructure upgrades to allow for an enhanced level of service by 2015; and
- Phase II - infrastructure upgrades and level of service improvements to meet the demand anticipated in the RTP for 2031.

This document presents the comparison of these options against the Base Case and the relative strengths and weaknesses of each option with regard to people, the economy, and the environment vis-à-vis 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 Lakeshore 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; and
- Part C – Project Assessment: This section describes the evaluation methodology, the analysis and the summary results.

Project Rationale

Context and Need

GO Transit is one of North America's most successful regional public transportation providers, carrying over 50 million passengers a year in an 8,000 square kilometre service area. The combined Lakeshore East and West Corridor between Hamilton and Oshawa, illustrated in Figure 1 below, is the single most significant corridor in the entire GO Transit service area from a ridership perspective, carrying almost 60 percent of all passengers on the GO Transit rail network.[3]

The population along the Lakeshore Corridor is expected to increase significantly between now and 2031, and significant capacity improvements will need to be completed in order to address a growing demand for the commuter rail service. In an effort to improve service and respond to a growing demand, GO Transit initiated the GO Rail Improvement Program (GO TRIP) in 2003. This more than $1 billion initiative is being funded under the Canada Strategic Infrastructure Fund (CSIF), with matching federal and provincial funds in the amount of $385 million each, and contributions of up to $235 million from municipalities within the Greater Toronto and Hamilton Area.[4]

[3] GO Transit 2007-08 Annual Report – The Year in Review.

[4] A more detailed description of GO Transit's GO TRIP and Union Station renewal initiatives is available on the GO Transit website at www.gotransit.com/gotrip

FIGURE 1 GO TRANSIT SYSTEM MAP

In total, GO TRIP is comprised of 12 construction projects across the GO Transit network involving the addition of several kilometres of new track along with a number of new and/or improved grade separations aimed at reducing the potential for conflicts between GO Transit and freight rail services. The GO TRIP initiatives include three projects along the Lakeshore Corridor including the addition of new tracks between Port Credit and Kerr Street (Oakville) and Burlington Junction and Bayview Junction along the Lakeshore West Corridor, and between Union Station and Eglinton along the Lakeshore East Corridor. In addition to the new third track, these projects also include a number of bridge enhancements and station improvements all aimed at improving the service for GO Transit customers. GO TRIP investments specifically allocated to the GO Lakeshore corridor total approximately $230 million.

In addition to GO TRIP, GO Transit has also initiated the Union Station renewal program to double the station capacity by 2014 to more than 80 million passengers per year, improve train operations and reliability and reduce train operating costs.

In recent years, rising fuel costs, growing climate change concerns and capacity challenges related to growing ridership levels have brought renewed interest in the potential benefits of electrification. The electrification of the Lakeshore Corridor was identified in the Ontario Government's *MoveOntario 2020* plan to expand rapid transit in the Greater Toronto and Hamilton Area. The MoveOntario 2020 vision was further refined through the development of the Regional Transportation Plan (RTP), unanimously approved by the Metrolinx Board in November 2008. The RTP identified electrified express rail service on the Lakeshore Corridor from Hamilton to Oshawa as one of 15 top priority projects (GO Lakeshore Express Rail).

Given the operational changes that were introduced along the Lakeshore Corridor since 2001 and the changing market circumstances between 2001 and 2008, and in particular, the relative change in electricity and diesel fuel costs, GO Transit and Metrolinx initiated a further assessment of electrification in the Corridor in 2008.[5]

The 2031 ridership forecasts developed for the RTP projected a significant increase in demand along the Lakeshore Corridor to 86.6 million passengers per year on the Lakeshore West section (Hamilton – Union Station) and 56.4 million passengers per year on the Lakeshore East section (Oshawa – Union Station)[6]. This represents a substantial increase from the 2007 annual ridership figures of 14.1 million and 11.4 million passengers on the Lakeshore West and Lakeshore East lines, respectively[7]. Among the many recommendations to improve and expand the region's transit network was a recommendation to introduce an Express Rail service along the Lakeshore rail corridor between Hamilton and Oshawa.

With this in mind, GO Transit and Metrolinx increased the scope of their technical assessment to include passenger projections to 2031 and outline the requirements for an electrified GO Lakeshore Corridor that would approximate the level of service and capacity required to meet the 2031 RTP ridership forecasts.

Project Objectives

The GO Lakeshore project supports the following key objectives:

- Offer higher order transit to promote usage of transit and increase transit modal share in the Corridor;
- Reduce greenhouse gas emissions by replacing the current diesel train operations with electrically powered trains and by increasing transit modal share;
- Stimulate land development and support intensification in the six Urban Growth Centres along the Lakeshore Corridor; and
- Improve access and connectivity to inter-regional transportation links.

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[5] This technical information referred to in this Benefits Case Assessment is primarily drawn from two reports prepared for GO Transit by Hatch Mott McDonald, namely; GO Transit Corridor Electrification, Update of 2001 Addendum to 1992 Study, April 17, 2008 and GO Lakeshore Corridor 2031, Addendum to '08 Lakeshore Corridor Electrification Update, October 20, 2008. These reports are hereafter referred to as the GO Transit and Metrolinx 2008 technical assessment of GO Lakeshore corridor.

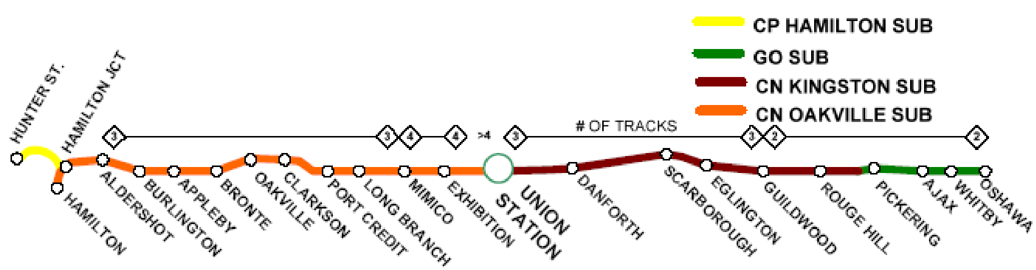
[6] These annual ridership estimates are based on an operating scenario that assumes 5 minutes headways with operating speeds of 80 kilometres per hour.

[7] GO Transit 2007-08 Annual Report – The Year in Review

Project Overview

As illustrated in Figure 2 below, the Lakeshore Corridor is approximately 115 kilometres in length and runs from its western terminus in Hamilton via Union Station in downtown Toronto to an eastern terminus in Oshawa, serving a total of 21 stations. The majority of the trips are peak direction trips inbound to Union Station in downtown Toronto in the am peak period and outbound from Union Station in the pm peak period. The Lakeshore Corridor currently carries a total of approximately 100,000 passengers each weekday.

FIGURE 2 GO TRANSIT LAKESHORE CORRIDOR



At the present time the majority of GO Transit passengers travel in the peak direction to Union Station, where connections are available with Toronto's subway system. The current service cannot be significantly expanded without further infrastructure improvements. Given the mixed-use nature of the Corridor, including freight, VIA, and GO Transit operations, current operational constraints include limited track capacity at key points along the Corridor and at Union Station, and limitations on train frequencies due to the current signalling system. In order to meet the expected demand through to 2031, additional track capacity, expanded passenger handling facilities and an enhanced signalling system that will enhance capacity in the Corridor are required.

It is envisioned that the required system enhancements would be implemented in two broad phases. Phase 1 includes upgrades between now and 2015 and a second phase would involve additional upgrades between 2015 and 2031. Subject to operational feasibility and necessary project approvals, the longer term Phase 2 improvements could be broken into a series of smaller implementation phases between 2015 and 2031. The proposed improvements by 2015 include:

- Upgrading the current signalling system to handle more frequent train operations;
- Fleet expansion from the current 17 train sets to 24 trains sets in the Lakeshore Corridor to allow expanded peak period and off-peak services;
- New and expanded maintenance and storage facilities; and
- Expansion of the Hunter Street Tunnel to allow more frequent service to Hamilton.

In addition to these upgrades, electrification by 2015 would further enhance service on the Lakeshore Corridor. The superior acceleration capabilities of an electrically powered train as compared to a diesel train would permit faster travel times along the Corridor. In addition to the infrastructure improvements described above, which apply to both the diesel and electric scenario, electrifying the Lakeshore Corridor would provide a means of further increasing capacity and meeting broader environmental objectives such as reducing greenhouse gas emissions in the region. In addition to the upgrades listed above, the 2015 electrification scenario would also require the following infrastructure improvements:

- Installation of an overhead catenary system along the entire length of the Corridor;
- New electrified maintenance and storage facilities;
- Modifications to a number of the existing underpasses and overpasses along the Corridor to accommodate the larger operating envelop of the electric train and overhead catenary system; and
- Replacement of the current diesel locomotives with new electric locomotives in the Corridor (with diesel locomotives redeployed to other GO Transit corridors).

The proposed infrastructure upgrades between 2015 and 2031 would support a significantly increased frequency of service in line with the Express Rail vision and associated ridership forecasts for the Corridor outlined in the RTP. Infrastructure requirements include expanding track capacity along the entire Corridor, particularly where more frequent service may be constrained by interactions with VIA and freight train operations, grade separation of all remaining at-grade road crossings, as well as continued signalling upgrades to permit tighter spacing of train operations in the Corridor.

For the purposes of this analysis, it was assumed that the Lakeshore Corridor would need to be electrified to support the level of service required to meet the 2031 ridership levels forecasted in the RTP. The use of diesel-powered trains to achieve required 2031 service levels has not been examined in sufficient detail to allow for adequate comparisons with the electrified option in Phase 2. However, an equivalent diesel-powered Phase 2 option would likely require significantly more track capacity, primarily due to slower train acceleration rates relative to electric operations. This would likely entail substantial property acquisition requirements to expand the existing right-of-way, with potentially prohibitive costs given the physical constraints along the Corridor. As a result, the use of a diesel alternative to meet 2031 service requirements was deemed to be infeasible, and only an electrified option has been carried forward for assessment in Phase 2.

An important implication of this finding is that of the two options examined in this analysis, only the electric option is capable of providing sufficient capacity to meet the 2031 RTP ridership projections. In other words, at some point the initial investments to transition the Lakeshore

Corridor from a diesel to an electric operation will be required if the long-term RTP Express Rail vision for this Corridor is to be achieved.

Issues and Assumptions

Operations

In addition to the increased capacity, the proposal to electrify the Corridor may provide an opportunity for greater operational efficiencies compared to diesel trains. Electric trains can accelerate and decelerate much faster than diesel trains, leading to shorter headways and more capacity along the Corridor with the same number of vehicles. Replacing the current diesel powered fleet with electrically powered trains would also contribute to a reduction in greenhouse gas emissions, depending on the source of electricity. Current plans in Ontario to replace the use of coal with cleaner alternatives to generate electricity imply that there will be a significant reduction in greenhouse gas emissions associated with the electrification of the Corridor.[8]

GO Transit currently owns the Union Station Rail Corridor and the GO Subdivision between Durham Junction and Oshawa. The remainder of the Lakeshore Corridor is owned by CN, with the exception of the segment between Hamilton Junction and the Hunter Street Terminal, which is owned by CP. It is recognized that any effort to electrify the Corridor will require the approval of both CN and CP.

Should the project proceed, Metrolinx and GO Transit would also need to work closely with the Ontario Power Authority, and other relevant parties, to determine the power supply implications and other potential electricity system impacts related to the electrification of the Lakeshore Corridor.

Union Station

The capacity improvements envisioned as part of the Lakeshore Express Rail are intended to serve a growing demand, but will also put additional stress on station facilities, particularly at Union Station where the majority of GO passengers disembark and board during the morning and evening peaks, respectively. Significant upgrades will be required at Union Station, beyond those currently underway, to accommodate projected 2031 ridership volumes. The need for increased Union Station capacity will be driven by ridership growth and associated service increases on all GO Transit rail corridors, and are thus beyond the scope of this analysis. A separate, dedicated study of future capacity needs both at Union Station itself and within the Union Station Rail Corridor will be required to determine the most appropriate options for accommodating projected long-term growth at Union Station as a result of passenger growth on all of GO Transit's rail corridors, in addition to other services using Union Station.

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[8] Ministry of Energy and Infrastructure, 2008-09 Results-based Plan (available at http://www.mei.gov.on.ca/english/about/?page=plan0809-energy).

Technology

The number of options, including technology and operating scenarios, presented and assessed in this report is limited to those scenarios for which there has been a sufficient level of technical analysis undertaken to date to enable a reasonable comparison. While this report provides sufficient information to broadly identify the preferred technology and operating scenario amongst the options presented, further refinements could be examined should the project proceed through the planning/design/engineering phases. For example, as illustrated in Appendix B, the use of Electric Multiple Units (EMUs) could potentially offer greater travel time savings and operational benefits compared with the electric locomotive-hauled train configuration considered in this assessment.[9]

[9] See Appendix for additional information on the potential advantages of EMUs and obstacles to implementation in the Lakeshore Corridor.

Part B Options

Project Options

As discussed in the preceding sections of this report, the physical constraints within the Lakeshore Corridor place limitations on the number of feasible options to meet long-term capacity requirements. In light of this challenge, two options have been identified as possible candidates to address the current capacity constraints along the Lakeshore Corridor and improve service levels to meet the anticipated passenger demand in the near term. Option 1 (Diesel) includes infrastructure upgrades that will improve the Lakeshore service by 2015, but will not provide sufficient improvements to enable GO Transit to meet the anticipated passenger demand in 2031. The second option (electrification) would ultimately provide for sufficient service enhancements to meet the projected ridership in the RTP for 2031. To facilitate a comparison of these options, the second option is defined as two distinct implementation phases involving different degrees of infrastructure improvements and investments through 2015 and 2031, respectively. For comparative purposes, both of the options are compared against a Base Case. The options and phases are outlined below and are summarized in the following sections.

- Base Case: Business as usual including currently planned infrastructure upgrades along Corridor (GO TRIP);
- Option 1: Diesel operations with fleet and infrastructure improvements through 2015; and
- Option 2: Electrified operations with fleet and infrastructure improvements as follows:
  - Phase One – Fleet and infrastructure improvements through 2015; and:
  - Phase Two – Fleet and infrastructure improvements through 2031.

Base Case

The Base Case is defined as the current network with the completion of the GO TRIP projects on the Lakeshore East and West Corridors representing an investment of approximately $230 million. It is also assumed that GO Transit will continue to operate its existing fleet of 17 train sets in the Lakeshore Corridor utilizing diesel MP-40 locomotives to haul bi-level coaches. It is assumed that today's level of service will be maintained through to 2031.

Under this scenario, on the Lakeshore West Line it assumed that eight 10-car trains will operate inbound to Union Station during the peak hour providing capacity for 12,320 passengers. On the Lakeshore East line, six 10-car trains will operate in-bound to Union Station in the peak hour providing capacity for 9,240 passengers. Up to two coaches may be added to each train over time if the additional capacity is warranted subject to there being sufficient storage capacity at the GO Transit's yards and maintenance facilities. However, for the Base Case it is assumed that significant new peak hour capacity cannot be added due to track capacity constraints and the limitations of the existing signalling system.

The number of stations along the Corridor is assumed to remain as illustrated in Figure 2 above.

The Base Case as proposed includes no additional capital expansion investments over and above what has been invested through the GO TRIP program. Capital costs for each of the proposed options below are over and above the GO TRIP investment.

Option 1 – Enhanced Diesel Operations

This option includes improvements to the existing diesel service to provide sufficient capacity for the 2015 peak demand per hour per direction. Specifically the improvements include:

- Expansion of the existing Hunter Street Tunnel[10]; and
- Train control and signals upgrades.
- 7 additional train sets.

This option assumes that 24 diesel-powered 10-car train sets would be in service by 2015 to meet forecast demand[11]. The capacity of each bi-level coach is 154 people resulting in a total of 1,540 passengers per train. In the peak hour, it is assumed that 10 and 9 trains will operate along the Lakeshore West and Lakeshore East lines, respectively.

[10] For the purposes of this report, capital and operating costs were developed based on the assumption that the Lakeshore West Corridor would continue to terminate at the Hunter Street Terminal in Hamilton. GO Transit is in the planning stages for a second Hamilton station at James Street North on CN's Grimsby Subdivision, which could provide an alternative western terminus for expanded operations.

[11] GO Transit and Metrolinx 2008 technical assessment of GO Lakeshore corridor.

For the purpose of this assessment it is assumed that GO Transit will continue to provide Local and Express Train service in the Lakeshore Corridor. Express Trains have limited stops during peak hours and cater to longer-haul, regional length trips. Local Trains, on the other hand, stop at each of the stations along the Corridor. An Intermediate Local service identified as part of the technical assessment is also assumed where trains stop at all of the stations along their route but that do not travel the entire length of the Corridor[12]. Prototype schedules for peak period, peak direction and counter peak trips under Option 1 are included in Table 3 below. Off-peak trips would operate on a half-hourly frequency, serving all stations.

TABLE 3 OPTION 1 - AM PEAK PERIOD SCHEDULES FOR 2015 DIESEL SERVICE

LAKESHORE EAST - PEAK DIRECTION

Westbound	LSE Local	Pickering Local	Osh-Pick Express	Total # of Trains
Headway (Peak/Shoulder)	60min/30min	20min/120min	12min/60min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	1/4	3/1	5/2	9/7
Oshawa	0.00		0.00	6/6
Whitby	5.00		4.00	6/6
Ajax	12.00		11.00	6/6
Pickering	18.00	0.00	17.00	9/7
Rouge Hill	24.00	6.00		4/5
Guildwood	31.00	13.00		4/5
Eglinton	36.00	18.00		4/5
Scarborough	41.00	23.00		4/5
Danforth	46.00	28.00		4/5
Union Station	58.00	38.00	39.00	9/7

LAKESHORE EAST - COUNTER PEAK DIRECTION

Eastbound	LSE Local	Total # of Trains
Headway (Peak/Shoulder)	30min/30min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	2/4	2/4
Union Station	0.00	2/4
Danforth	10.00	2/4
Scarborough	16.00	2/4
Eglinton	21.00	2/4
Guildwood	25.00	2/4
Rouge Hill	31.00	2/4
Pickering	38.00	2/4
Ajax	44.00	2/4
Whitby	51.00	2/4
Oshawa	58.00	2/4

LAKESHORE WEST - PEAK DIRECTION

Eastbound	LSW Local	Oakville Local	Oakville Express	Ham-Oak Express	Total # of Trains
Headway (Peak/Shoulder)	60min/30min	20min/120min	30min/-	15min/40min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	1/4	3/1	2/-	4/3	10/8
Hamilton Hunter	0.00			0.00	5/7
Aldershot	15.00			15.00	5/7
Burlington	20.00			20.00	5/7
Appleby	26.00			26.00	5/7
Bronte	32.00			32.00	5/7
Oakville	38.00	0.00	0.00	38.00	10/8
Clarkson	45.00	6.00			4/5
Port Credit	51.00	13.00			4/5
Long Branch	57.00	18.00			4/5
Mimico	62.00	24.00			4/5
Exhibition	69.00	30.00			4/5
Union Station	75.00	36.00	22.00	61.00	10/8

LAKESHORE WEST - COUNTER PEAK DIRECTION

Westbound	LSW Local	Total # of Trains
Headway (Peak/Shoulder)	30min/30min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	2/4	2/4
Union Station	0.00	2/4
Exhibition	4.00	2/4
Mimico	11.00	2/4
Long Branch	16.00	2/4
Port Credit	22.00	2/4
Clarkson	28.00	2/4
Oakville	36.00	2/4
Bronte	41.00	2/4
Appleby	47.00	2/4
Burlington	53.00	2/4
Aldershot	58.00	2/4
Hamilton Hunter	76.00	2/4

Peak hour is 7:30am to 8:29am ; Shoulder includes 6:30am-7:29am and 830:am to 9:29am

This option also includes the construction of a new maintenance and storage facility along Lakeshore East line to accommodate the larger fleet and facilitate more efficient staging. The incremental capital cost of the upgrades and rolling stock compared to the Base Case is estimated at $858 million.

Incremental annual operating costs compared to Base Case to 2031 are estimated at $1,888 million. All costs are expressed in 2008 dollars.

[12] GO Transit and Metrolinx 2008 technical assessment of GO Lakeshore corridor.

As discussed previously in this report, taking into consideration the physical constraints in the Lakeshore Corridor, meeting the forecast 2031 RTP ridership demands through expanded diesel operations was deemed not to be a feasible option for comparison purposes, and thus has not been carried forward in this analysis.

Option 2 – Incremental Electrified Express Rail Implementation

Phase 1 – Improvements through 2015

This option contemplates electrification of the entire Lakeshore Corridor by 2015 in addition to the signalling, fleet and infrastructure upgrades included in Option 1. The specific improvements were developed as part of the technical assessments of the Lakeshore Corridor undertaken by GO Transit and Metrolinx in 2008 and include:

- Construction of an Overhead Catenary System along the length of the Corridor;
- Modifications to existing structures to allow sufficient clearance for electrification;
- Expansion of existing Hunter Street Tunnel in Hamilton[13];
- New electrified maintenance and storage facilities; and
- 24 electric locomotives.

The technical assessments assumed that 24 10-car electric train sets would be in operation by 2015. The electric locomotives (Bombardier's ALP-46 locomotive was used for performance modelling purposes) will haul conventional bi-level coaches with the same passenger capacity, 1,540 passengers per train, as in Option 1.

As with Option 1, in the peak hour it is assumed that 10 and 9 trains will operate along the Lakeshore West and Lakeshore East lines, respectively. The increase in peak hour peak direction service relative to the Base Case is due to the additional vehicles, enhancements to the maintenance facility and the proposed signal upgrades.

While the mixture of local and express trains is the same as for Option 1 the travel times associated with the electric trains are shorter than under the diesel option due to enhanced acceleration capabilities. Prototype schedules for peak period, peak direction and counter peak trips under Option 2, Phase 1 are included in Table 4 below. Off-peak trips would operate on a half-hourly frequency, serving all stations.

Based on cost information prepared as part of the technical assessment, assuming a fleet of 24 10-car trains, the estimated incremental capital cost of this phase through 2015, over and above

[13] For the purposes of this report, capital and operating costs were developed based on the assumption that the Lakeshore West Corridor would continue to terminate at the Hunter Street Terminal in Hamilton. GO Transit is in the planning stages for a second Hamilton station at James Street North on CN's Grimsby Subdivision, which could provide an alternative western terminus for expanded operations.

those expenditures required for the Base Case, is approximately $1.89 billion. The annual operating costs for this option to 2031 are estimated to be $1.02 billion higher than the Base Case. Again, all numbers are in 2008 dollars.

TABLE 4 OPTION 2: PHASE 1 - AM PEAK PERIOD SCHEDULES FOR 2015 ELECTRIC SERVICE

LAKESHORE EAST - PEAK DIRECTION				
Westbound	LSE Local	Pickering Local	Osh-Pick Express	Total # of Trains
Headway (Peak/Shoulder)	60min/30min	20min/120min	12min/60min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	1/4	3/1	5/2	9/7
Oshawa	0.00		0.00	6/6
Whitby	4.00		4.00	6/6
Ajax	10.00		10.00	6/6
Pickering	15.00	0.00	15.00	9/7
Rouge Hill	20.00	5.00		4/5
Guildwood	26.00	11.00		4/5
Eglinton	30.00	15.00		4/5
Scarborough	34.00	19.00		4/5
Danforth	38.00	23.00		4/5
Union Station	47.00	31.00	35.00	9/7

LAKESHORE EAST - COUNTER PEAK DIRECTION		
Eastbound	LSE Local	Total # of Trains
Headway (Peak/Shoulder)	30min/30min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	2/4	2/4
Union Station	0.00	2/4
Danforth	7.00	2/4
Scarborough	12.00	2/4
Eglinton	16.00	2/4
Guildwood	19.00	2/4
Rouge Hill	24.00	2/4
Pickering	30.00	2/4
Ajax	35.00	2/4
Whitby	41.00	2/4
Oshawa	47.00	2/4

LAKESHORE WEST - PEAK DIRECTION					
Eastbound	LSW Local	Oakville Local	Oakville Express	Ham-Oak Express	Total # of Trains
Headway (Peak/Shoulder)	60min/30min	20min/120min	30min/-	15min/40min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	1/4	3/1	2/-	4/3	10/8
Hamilton Hunter	0.00			0.00	5/7
Aldershot	13.00			13.00	5/7
Burlington	17.00			17.00	5/7
Appleby	22.00			22.00	5/7
Bronte	27.00			27.00	5/7
Oakville	32.00	0.00	0.00	32.00	10/8
Clarkson	38.00	5.00			4/5
Port Credit	43.00	11.00			4/5
Long Branch	48.00	15.00			4/5
Mimico	52.00	20.00			4/5
Exhibition	58.00	25.00			4/5
Union Station	63.00	30.00	19.00	52.00	10/8

LAKESHORE WEST - COUNTER PEAK DIRECTION		
Westbound	LSW Local	Total # of Trains
Headway (Peak/Shoulder)	30min/30min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	2/4	2/4
Union Station	0.00	2/4
Exhibition	3.00	2/4
Mimico	9.00	2/4
Long Branch	13.00	2/4
Port Credit	18.00	2/4
Clarkson	23.00	2/4
Oakville	30.00	2/4
Bronte	34.00	2/4
Appleby	39.00	2/4
Burlington	44.00	2/4
Aldershot	48.00	2/4
Hamilton Hunter	64.00	2/4

Peak hour is 7:30am to 8:29am ; Shoulder includes 6:30am-7:29am and 830:am to 9:29am

Phase 2 – Improvements from 2015 to 2031

Phase 2 of Option 2 includes a significant service expansion to meet the RTP 2031 ridership forecast. Based on the technical assessment, 44 electrically-powered 10-car trains are required to provide sufficient capacity to meet this demand level.

The following infrastructure improvements, which are in addition to those included in Phase 1 of this electrified scenario, would be undertaken incrementally between 2015 and 2031[14]:

- Grade separation of all at-grade road/rail crossings along the entire Corridor;
- Track capacity expansion along the entire Corridor;
- Train Control and Signalling upgrades to provide Positive Train Control (CAB Signalling) to minimize required train headways; and

[14] GO Transit and Metrolinx technical assessment of the GO Lakeshore corridor, 2008.

- 20 additional electric locomotives and 200 bi-level coaches.

As with Phase 1 of this option, the infrastructure improvements envisioned under this phase are in addition to those improvements undertaken as part of the GO TRIP initiative (the Base Case).

Based on the proposed fleet requirements, it is assumed that an ultimate fleet requirement of 44 10-car train sets will be in place by 2031 with a phased increase from 24 train sets in 2015 to 38 train sets in 2025. Although Phase 2 travel times are similar to those in Phase 1, the expanded track capacity and signalling system upgrades allow for significantly enhanced service levels both in the peak and off-peak periods. Peak hour, peak direction frequency will increase to 14 in-bound peak hour trains along Lakeshore West, and to 15 inbound peak hour trains along the Lakeshore East line. As well, services in the off-peak periods and during the peak hour in the counter-peak direction would operate at headways of no greater than every 15 minutes. At this level of service, the Lakeshore Corridor would essentially achieve the Express Rail vision outlined in the RTP. Customers would no longer be required to consult a schedule when planning trips as the longest potential wait between trains would be less than 8 minutes for off-peak and counter peak trips, and potentially less than five minutes for peak period, peak direction trips at certain stations.

Prototype schedules for peak period, peak direction and counter peak trips under Option 2, Phase 2 are included in Table 5 below. Off-peak trips would operate on a frequency of every 15 minutes, serving all stations.

Based on cost information prepared as part of the GO Transit and Metrolinx technical assessment, assuming a fleet of 44 10-car trains by 2031, the estimated incremental capital cost of this option compared to the Base Case is approximately $5.97 billion. It should be noted that this cost also incorporates the $1.89 billion for the infrastructure and fleet expansion capital costs included in Phase 1, as these must be in place before Phase 2 can be undertaken. The estimated incremental capital costs for Phase 2 alone are approximately $4.09 billion. The annual incremental operating costs for this option to 2031 are estimated at $1.24 billion. All numbers are in 2008 dollars.

TABLE 5 OPTION 2: PHASE 2 - AM PEAK PERIOD SCHEDULES FOR 2031 ELECTRIC SERVICE

LAKESHORE EAST - PEAK DIRECTION						
Westbound	LSE Local	Pickering Local	Osh-Ajax Express	Osh-Pick Express	Osh-Eglin Express	Total # of Trains
Headway (Peak/Shoulder)	15min/30min	15min/30min	60min/-	60min/30min	30min/-	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	4/4	4/4	1/-	1/4	2/	12/12
Oshawa	0.00		0.00	0.00	0.00	8/8
Whitby	4.00		4.00	4.00	4.00	8/8
Ajax	10.00		10.00	10.00	10.00	8/8
Pickering	15.00	0.00	↓	15.00	15.00	11/12
Rouge Hill	20.00	5.00	↓	↓	20.00	10/8
Guildwood	26.00	11.00	↓	↓	26.00	10/8
Eglinton	30.00	15.00	↓	↓	30.00	10/8
Scarborough	34.00	19.00	↓	↓	↓	8/8
Danforth	38.00	23.00	↓	↓	↓	8/8
Union Station	47.00	31.00	33.00	35.00	43.00	12/12

LAKESHORE EAST - COUNTER PEAK DIRECTION		
Eastbound	LSE Local	Total # of Trains
Headway (Peak/Shoulder)	15min/11min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	4/11	4/11
Union Station	0.00	4/11
Danforth	7.00	4/11
Scarborough	12.00	4/11
Eglinton	16.00	4/11
Guildwood	19.00	4/11
Rouge Hill	24.00	4/11
Pickering	30.00	4/11
Ajax	35.00	4/11
Whitby	41.00	4/11
Oshawa	47.00	4/11

LAKESHORE WEST - PEAK DIRECTION					
Eastbound	LSW Local	Oakville Local	Ham-Oak Express	Ham-Bur Express	Total # of Trains
Headway (Peak/Shoulder)	20min/30min	15min/30min	12min/30min	30min/-	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	3/4	4/4	5/4	2/-	14/12
Hamilton Hunter	0.00		0.00	0.00	10/8
Aldershot	13.00		13.00	13.00	10/8
Burlington	17.00		17.00	17.00	10/8
Appleby	22.00		22.00	↓	8/8
Bronte	27.00		27.00	↓	8/8
Oakville	32.00	0.00	32.00	↓	12/12
Clarkson	38.00	5.00	↓	↓	7/8
Port Credit	43.00	11.00	↓	↓	7/8
Long Branch	48.00	15.00	↓	↓	7/8
Mimico	52.00	20.00	↓	↓	7/8
Exhibition	58.00	25.00	↓	↓	7/8
Union Station	63.00	30.00	52.00	46.00	14/12

LAKESHORE WEST - COUNTER PEAK DIRECTION		
Westbound	LSW Local	Total # of Trains
Headway (Peak/Shoulder)	15min/11min	(Peak/Shoulder)
Total # of Trains (Peak/Shoulder)	4/11	4/11
Union Station	0.00	4/11
Exhibition	3.00	4/11
Mimico	9.00	4/11
Long Branch	13.00	4/11
Port Credit	18.00	4/11
Clarkson	23.00	4/11
Oakville	30.00	4/11
Bronte	34.00	4/11
Appleby	39.00	4/11
Burlington	44.00	4/11
Aldershot	48.00	4/11
Hamilton Hunter	64.00	4/11

Peak hour is 7:30am to 8:29am ; Shoulder includes 6:30am-7:29am and 830:am to 9:29am

Summary of Options

The options described above are summarized in Table 6 as follows.

TABLE 6 SUMMARY OF OPTIONS

	Base Case	Option 1	Option 2	
			Phase 1	Phase 2
Power Source	Diesel	Diesel	Electric	Electric
Coach-type	Bi-level	Bi-level	Bi-level	Bi-level
Train Length	10 Coaches	10 Coaches	10 Coaches	10 Coaches
Number of Trains	17 (2015)	24 (2015)	24 (2015)	44 (2031)
Maximum Number of Peak Hour Trains (eastbound)	8	10	10	14
Maximum Number of Peak Hour Trains (westbound)	6	9	9	12
Peak Hour Capacity – 2031 eastbound	12,320	15,400	15,400	21,560
Peak Hour Capacity – 2031 westbound	9,240	13,860	13,860	18,480
Minimum Travel Time – Eastbound Express (Hamilton to Union)	66 min	61 min	52 min	46 min
Minimum Travel Time – Eastbound Local (Hamilton to Union)	N/A	75 min	63 min	63 min
Minimum Travel Time – Westbound Express (Oshawa to Union)	44 min	39 min	35 min	33 min
Minimum Travel Time – Westbound Local (Oshawa to Union)	60 min	58 min	47 min	47 min
Capital Cost ($billion)	N/A	0.86	1.89	5.97
Annual Incremental Operating Cost in 2031 ($million)	N/A	215	117	141

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 GO Lakeshore Corridor project are:

- Transportation User Benefits;
- Financial Impacts;
- Environmental Impacts;
- Economic Impacts; and
- 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 improvements in GO Transit's Lakeshore Corridor. 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 that are not easily quantified. In most instances they are captured in the ridership and travel time savings, but in some instances they can be isolated and identified separately, especially where there are large differences among the options. Those considerations include passenger comfort, accessibility and reliability.

All transportation user benefits are incremental to the Base Case.

Travel Time Savings

The travel time savings were estimated using the Greater Golden Horseshoe Model, which was the basis of the RTP ridership forecasts. It is a regional network model that functions best in measuring the impacts from large changes in the network. It is less reliable in measuring small changes, such as the reduction of one station, as these small changes typically have only minor impacts on ridership decisions and are therefore lost in the overall network effect. For the purpose of the GO Lakeshore comparison however, the model provides a useful comparison of the impacts associated with different operating scenarios.

For the purposes of modelling, all options were treated as Regional Rail services in 2015. The transition of GO Lakeshore service from Regional Rail to the Express Rail vision described in *The Big Move* is expected to require the implementation of Phase 2 (in addition to other improvements, such as integration of the GO rail system with regional and local transit services). Consequently, only Option 2 Phase 2 was modelled as an Express Rail service in 2031.

The average value of time is estimated at $13.02 per hour increasing by 1.6% per year in real terms. Based on the hours saved provided by the Greater Golden Horseshoe Model, the net present value of travel time savings for transit users and automobile drivers is estimated at $980 million for Option 1 for the period 2015 to 2038. In comparison, the net present value of travel time savings for transit users and automobile drivers under the electric option are estimated to be $1.7 billion for the Phase 1 and $2.1 billion for Phase 2 of Option 2.

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 automobile kilometres travelled decrease under both options.

The present value of the automobile operating cost savings over the period, assuming a cost saving of $0.50 per kilometre, is estimated at $2.4 billion for Option 1 and $2.6 billion and $3.5 billion for phases one and two of Option 2 respectively.

Safety Benefits

The reduction in accidents follows from the fewer kilometres driven. The average saving of an accident is assumed to be 7 cents per kilometre. The present value of safety benefits in Option 1 over the analysis period is estimated at $231 million. For Option 2 the estimated safety benefits are $258 million and $333 million for phases one and two respectively.

Qualitative Transportation User Benefits

Compared to the Base Case both of the diesel and electric options provide improved service for the transit users and other transportation through more frequent service, faster travel times and greater reliability. Relative to one another the electric options provide more benefits with faster travel times and greater reliability from a schedule perspective.

Summary

Table 7 summarizes the incremental transportation user benefits associated with the GO Lakeshore Express Rail project. As shown in the table the net present value of the incremental user benefits ranges from a low of $3.6 billion for Phase 1 of Option 1 to a high of $5.9 billion for Option 2 Phase 2.

TABLE 7 INCREMENTAL TRANSPORTATION USER BENEFITS

	Option 1	Option 2	
All Values in NPV $m		**Phase 1**	**Phase 2**
Travel Time Savings	$981	$1,672	$2,062
Automobile Cost Savings	$2,399	$2,637	$3,454
Accident Reductions	$231	$258	$333
Transportation User Benefits	**$3,611**	**$4,567**	**$5,849**

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, such as fare revenues, advertising, and proceeds from disposal of assets are also shown in this account. Any savings resulting from the implementation of the options are also included.

Fare Revenues

Annual ridership and fare revenues have been projected using Greater Golden Horseshoe Travel Forecasting Model[15]. Over the period of operations through 2038, the results indicate that both options generate more ridership than the base case and generate additional incremental fare revenues. For Option 1, the model estimates a net present value of $120 million in incremental fare revenue for the diesel option. The estimated incremental fare revenues results generated for the electric options are higher than the diesel option with an estimated net present value of $190 million and $230 million for Phase 1 and Phase 2 of Option 2, respectively.

Capital and Operating Costs

The capital costs include all costs associated with the required infrastructure upgrades under each option including the installation of signals, additional track and new vehicles[16]. Additional costs associated with the electric options include the costs to electrify the Corridor and modify underpasses where necessary to accommodate the overhead catenary system. Operating costs under both the diesel and electric scenarios include fuel and / or electricity costs as well as maintenance to the rolling stock and the infrastructure.

For the purpose of this assessment all of the necessary infrastructure improvements and additional rolling stock are assumed to be in place to begin Phase 1 operations in 2015.

[15] 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 comparative in nature and the model is considered adequate for this purpose.

[16] Capital and operating costs for the options were based on information drawn from the GO Transit and Metrolinx 2008 technical assessment of GO Lakeshore corridor. Operating costs for the diesel option were estimated using the ratio of electric and diesel operating costs determined as part of the technical assessment.

The estimated capital and operating costs are presented in Table 8 and expressed in 2008 dollars. As shown in the table, the capital cost associated with the diesel option is $858 million versus $1.886 billion for the first phase of the electric option. The cost of Phase 2 of the electric option as shown in the table is $5.986 billion and involves much greater investment in infrastructure improvements and facilitates improved levels of service. It should be noted however that the $5.986 billion is an additional incremental cost relative to the Base Case and includes all of the incremental capital expenditures required to implement the first phase of the electric option. The true incremental cost of expanding the electric service to include the Phase 2 infrastructure improvements is approximately $4.086 billion.[17]. Therefore the investment to implement Option 2 Phase 2 implies the implementation of Option 2 Phase 1.

TABLE 8 CAPITAL AND OPERATING COSTS

All Values in 2008 $m	Option 1	Option 2	
		Phase 1	Phase 2
Incremental Capital Costs	858	1,887	5,973
Annual incremental operating costs in 2031	215	117	141

Summary

Table 9 shows the present value of capital costs, operating costs and incremental fare revenues for both phases with each option. The net present value of the costs for Option 1 is $2.6 billion. By comparison, the net present values of the costs of Option 2 are $2.5 billion for Phase 1 and $4.7 billion for Phase 2.

The present value of incremental ridership revenues range from $120 million for Option 1 to $230 million for Phase 2 of Option 2.

[17] Incremental capital costs referred to in Table 8 represent a comparison to the Base Case. The capital costs for Option 2 Phase 2 as shown in Table 8 include the Option 2 Phase 1 costs. The increased capital costs requirements of the Option 2 Phase 2 proposal is approximately $4.086 billion.

TABLE 9 INCREMENTAL COSTS AND REVENUES

All Values in NPV $m	Option 1	Option 2 Phase 1	Option 2 Phase 2
Capital Costs	680	1,486	3,420
Operating Costs	1,888	1,020	1,240
Total Incremental Costs	2,568	2,507	4,660

Comparing Benefits and Costs

A comparison of the results from the Transportation User Benefits and Financial accounts show that both options generate benefits that are greater in value than their costs. The analysis of the options reveals that Phase 1 of the electric option provides the greatest benefits relative to the costs with a benefit cost ratio of 1.8. The benefit cost ratio for Option 2 Phase 2 is lower at 1.3 indicating that, despite the very significant user benefits, the costs to expand the infrastructure beyond 2015 are relatively high. Nonetheless, both phases of the electric option provide a positive benefit cost ratio suggesting that the benefits from the investment outweigh the costs.

Similarly, the diesel option provides a benefit cost ratio of 1.4 indicating that the investment in signals, coupled with a slightly expanded fleet and an improved service results in reasonable benefits relative to the cost. This positive result is somewhat misleading however as the investment between 2015 and 2031 aimed at expanding the fleet and dramatically improving the service frequency to achieve the required level of service is not feasible. As a result, while the short term investment in the diesel option may generate positive benefits from the Phase 1 operating scenario, the diesel option will ultimately restrict GO Transit from being able to expand in the future to meet the 2031 RTP ridership projections. This limitation is not reflected in the benefit cost ratio.

TABLE 10 COMPARISON BENEFITS AND COSTS

	Option 1	Option 2	
All Values in NPV $m		Phase 1	Phase 2
Transportation User Benefits	3,611	4,567	5,849
Incremental Costs	(1,888)	(2,507)	(4,660)
Net Benefit (Cost)	**1,043**	**2,060**	**1,188**
Benefit-Cost Ratio	1.4	1.8	1.3

Environmental Impacts

This account examines the environmental impacts of the GO Lakeshore project 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, the projected reduction in automobile usage drives the decrease in GHG emissions. Table 11 shows annual reductions in GHG emissions.

The present value of the reduction in CO_2 emissions over the period 2015 through 2038, based on an average value of $0.01 per kilometre, is estimated at $28 million for Option 1. The benefits associated with the electric options are higher than the diesel scenario resulting net present values of $75 million for Phase 1 Option 2 and $101 million for Phase 2 Option 2. It can be argued that the relative low value society currently puts on CO_2 emissions[18] does not fully reflect taking emissions reduction seriously, and hence the net present value should be higher.

TABLE 11 REDUCTIONS IN CO2 EMISSIONS

	Option 1	Option 2	
		Phase 1	Phase 2
2021 Reduction in CO_2 tonnes	31,904	45,905	45,905
2031 Reduction in CO_2 tonnes	118,091	131,701	170,067
NPV Value ($ m)	$28	$31	$40

Other Environmental Issues

The upgrades proposed under both options are largely restricted to the existing rail corridor and therefore are unlikely to create significant environmental issues particularly in areas where the Corridor is adjacent to residential developments. The construction related activities required for the physical works will likely create additional noise and emissions that will have to be assessed and mitigated as necessary as part of a more detailed environmental review.

Similarly, the frequency of service proposed for the GO Express Rail project will result in more activity along the Corridor throughout the day. The electrified options will reduce the emissions associated with these operations, however, to the extent that the Corridor will continue to be used by diesel services operated by VIA and the CN Rail, the positive environmental implications for adjacent properties will require a more detailed assessment.

[18] There are numerous sources on what the value of CO_2 emissions should be. The values range from $10 to $100 per tonne of CO_2. For the purpose of this analysis a median value of $40 per tonne was used.

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 GO Lakeshore Project will (a) directly affect households and businesses in the regional economy, and (b) total provincial economic impacts that are derived by applying Ontario specific multipliers to derive indirect affects 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 GO Lakeshore 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 associated with Option 1 is estimated to create more than 3,787 person-years of employment and generate another 2,096 years of employment indirectly as a result of increased economic activity for suppliers[19]. Similarly, the first phase of the electric option will generate 10,354 and 5,729 person-years of direct and indirect employment, respectively. Expanding the scope to include Phase 2 of Option 2 is expected to generate the higher employment with 33,310 and 18,165 person-years of direct and indirect employment respectively.

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	3,787	141.9	357.1	2,096	78.5	197.7
Option 2 Ph 1	10,354	387.9	976.4	5,729	214.6	540.4
Option 2 Ph 2	33,310	1,247.8	3,141.3	18,165	690.6	1,738.5

19 Based on Province of Ontario Multipliers, 2004.

Long-term Economic Impacts

In the long-term there will be ongoing economic benefits as a result of the GO Lakeshore project. These benefits reflect both households' reduced 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 transportation cost savings to area businesses reflects improved regional competitiveness for GTHA businesses that now have lower costs of doing businesses, 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 GO Lakeshore Express rail project will be different for each affected business.

Implementation of the GO Lakeshore project will also generate social benefits that can be monetized, including valuing time savings and emission benefits. These have already been captured as part of the transportation user benefits account.

As shown in Table 13, the GO Lakeshore project is expected to have a significant impact on jobs, wages and the GDP once in operation. The impacts for each option are driven by the travel time provided by each option.

TABLE 13 LONG-TERM EMPLOYMENT AND INCOME IMPACTS

	Direct Annual Impacts in 2031			Direct and Indirect Annual Impacts in 2031		
	Employment (Jobs)	Wages ($m)	GDP ($m)	Employment (Jobs)	Wages ($m)	GDP ($m)
Option 1	1,803	67.7	170.5	655	24.6	62.0
Option 2 Phase 2	1,936	72.7	183.1	714	26.8	67.5
Option 2 Phase 2	2,098	78.8	198.4	774	29.0	73.2

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 and particularly within close proximity to station areas. The area considered to be within a rapid transit stations' range of influence varies depending on the type of rapid transit technology. More permanent, rail-based, higher capacity technologies typically capture a larger area of property within their area of influence than lower capacity bus-based transit facilities.

The potential for any of the proposed options for GO Lakeshore Express Rail to affect land values is somewhat difficult to quantify, since both options utilize the existing corridor and neither of the options includes additional new stations. However, it is anticipated that the faster, more reliable and frequent service provided by the enhanced GO Lakeshore services examined in this report, particularly the ultimate Phase 2 electrification option, will greatly improve the connections between the six Urban Growth Centres and other sub-centres along the Lakeshore corridor and ultimately transforming the functionality and accessibility of the communities along the corridor to the similar extent that would be expected with the introduction of a new freeway.

Both options will increase ridership at each existing station locations and correspondingly result in substantial increased capacity within the Lakeshore corridor. This increased traffic flow can be expected to create potential for redevelopment and intensification of existing uses along the existing station areas. The increased passenger demand brought about by the enhanced service levels and improved travel times coupled with the corresponding development intensification will likely create redevelopment opportunities at existing park and ride facilities as travel patterns shift and more passengers elect to walk or cycle to a nearby station.

One way to assess the rough quantum of land value uplift would be to assume that the increased transportation capacity in the corridor will translate directly into increased development. This assumption, while simplistic, reflects the built-up nature of the Lakeshore corridor and the fact that the provision of additional transportation capacity on road networks in the corridor is very difficult, particularly in the six urban growth centres linked by the Lakeshore line. Assuming transportation capacity is the only limiting factor on growth, and that the increased capacity translates directly into residential development, the options would enable development with the following approximate value:

TABLE 14 POTENTIAL RESIDENTIAL DEVELOPMENT ENABLED BY INCREASED CAPACITY

	Option 1	Option 2	
All Values in 2009 $bn		Phase 1[20]	Phase 2
Eastbound	$1.55	$1.55	$4.64
Westbound	$2.32	$2.32	$4.64
TOTAL	$3.87	$3.87	$9.28

[20] Due to lack of existing research/evidence on the difference in impacts attributable to technologies, it is not possible to attribute a difference in land value to the change from diesel to electric technology. However, it is very likely that some benefit would result from the reduction in noise and emissions, and potentially, from the reduced travel times associated with electrification. As such, the method used may underestimate the land value benefit associated with Option 2 Phase 1.

Service improvements planned for the second phase of the electrification option would enable all day operations with 15 minute headways in both directions, and the equivalent of six minute headways in the peak period. The improved connectivity would provide for much higher service frequencies than those offered by commuter rail service today. The proposed improvement of frequencies in the Lakeshore Corridor every six minutes in the peak and 15 minutes in the off-peak will enable more frequent, reliable and faster access to employment for commuters, as well as enable transit accessibility and use for other trip purposes including leisure activities during the day and weekends. Thus the traffic at station locations is expected to increase substantively.

While many studies exist of the impact of rail transit on land values, few or none have successfully isolated the land value impacts of increased service frequencies. A study[21] of the Hudson Bergen Light Rail Transit System and the City of Evanston's Transit-Oriented Redevelopment reviewed Transit Oriented Development in three US cities found that the amount of high-density development that has occurred in three suburban cities - Jersey City and neighbouring Hoboken in New Jersey, and Evanston, Illinois was directly attributable to improved transit systems and according to the study authors "*densification could never have occurred this quickly if these cities did not have rich transit networks providing very high-quality connections to jobs, culture and destinations in their big city neighbours*". The authors note that the three cities are emerging as vital, resource-rich, more sustainable places because of the presence of so much development so close to transit. The case studies of New Jersey and Evanston illustrate that transit-oriented density and development has enhanced the surrounding neighbourhoods and that this was enabled through improved service frequencies. In these cases, the transit agencies extended their hours of service by 30 minutes at the beginning and end of the day and eliminated the mid-day gap in service thus enabling additional users of the system e.g. school student travel. Similarly in New Jersey, investment in the Hudson Bergen Light Rail Line has helped stimulate private investment and has enabled to catalyze sustainable growth.

Another Study[22] comparing the land value impact of transit systems that provide high ridership and frequent service as compared to those serving more limited markets indicates that the former generate significant positive premiums, whereas latter may have insignificant impacts. The findings indicate that high frequency service, such as BART and the San Diego Light Rail generated significant positive premiums of up to $2.72 per metre to the nearest station.

Impact of Electrification on Land Values

Electrifying the corridor will result in faster travel times and higher ridership. Given that these travel time savings are a clear benefit to passengers, it is likely that the relative time difference between the diesel and electric options would increase the attractiveness of GO travel and therefore could translate into increased property values particularly near the end stations where the travel time improvements are most significant.

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[21] *Gloria Ohland and Cali Gorewitz*, Communicating the Benefits of Transit Oriented Development

The Hudson Bergen Light Rail Transit System and the City of Evanston's Transit-Oriented Redevelopment

[22] Landis el al (1994)

It is also possible that the cleaner electric options could be more attractive to residents adjacent to the Corridor and result in higher land values, as studies have found that externalities such as air and noise pollution and the stigma associated with being close to heavy rail lines lowers property values. However, despite the fact that GO Transit operations along the Corridor represent a significant proportion of train activity, GO Transit will continue to share the Corridor with other non-electric trains. Both options will also result in an increased number of trains in the corridor on a daily basis. Given this, it is difficult to gauge whether the improvements to the GO Transit operations will be enough to positively influence property prices based on air quality improvements and/or noise reductions associated with electrification.

Summary

The GO Lakeshore project is expected to have a substantial effect on employment and the wider economy, particularly during construction. Over the period of the analysis, the economic benefits of the on-going electric operation are slightly higher than the diesel scenario. The second phase of the electric option incrementally improves on these benefits however, as the numbers indicate, the majority of the operational benefits are achieved in the first phase.

In terms of land use, the enabling effect of the transformation of GO Service will have a positive impact on land values. The impact is considerably greater for Option 2, Phase 2, than for Option 1 or Option 2, Phase 1; however, it is difficult to quantify the impact beyond an assessment of the increased amount of development enabled by increased transportation capacity in the corridor.

TABLE 15 ECONOMIC DEVELOPMENT IMPACTS

	Option 1	Option 2	
		Phase 1	Phase 2
Total Impacts During Construction Period:			
Employment (Person-years)	5,883	16,083	51,475
GDP ($m)	554.8	1,516.8	4,879.8
Income ($m)	220.4	602.5	1,938.4
Long-term Impacts in 2031:			
Employment (Person-years)	2,458	2,650	2,872
GDP ($m)	232.5	250.6	271.6
Income ($m)	92.3	99.5	107.8
Residential Development Enabled ($b)	3.87	3.87	9.28

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 Changes

The GO Express rail service will utilize the existing Lakeshore Corridor and stations. Land use impacts will occur at both a local and a regional scale.

Localized Development Opportunities

As noted above, the project will, through increased service frequency, provide a stimulus to development in station areas, although the scale of the impact is difficult to quantify. All-day, frequent service will create a much stronger degree of transit accessibility in Lakeshore line station areas, which will likely influence encourage the decisions of residents, businesses, and property owners alike to locate within a short distance of a GO station.

Many (in fact nearly all) GO stations on the Lakeshore line have substantial surface parking areas in the area around stations; many outside of Toronto exceed 2,000 parking spaces. One of the most dramatic potential land use impacts is the potential for redevelopment of some of these surface parking areas through construction/co-development of structured parking. The increased capacity associated with the transformation of GO to an all-day Express Rail service under Option 2 Phase 2 may impact the economics in areas around GO stations to the point where this type of development becomes feasible. This type of impact could be transformative in terms of built form within GO station areas.

As one example, a GO station with 2,000 surface parking spaces occupies in the order of 5.6 hectares. Replacing the surface parking with a 5-storey structure, and allowing for shared structured parking for both a new development and for GO parking, would still allow a 2-3 hectare parcel to be developed. This scale of site could house multiple high-rise towers (office or residential); development capacity would essentially be limited only by the modal split of residents or workers to the area and any other infrastructure or planning considerations.

Regional Development Impacts

On a regional level, the project will improve regional connectivity between six Urban Growth Centres identified in the Greater Golden Horseshoe Growth Plan, including Downtown Hamilton, Downtown Burlington, Midtown Oakville, Dowtown Toronto, Downtown Pickering and Downtown Oshawa, from west to east. Significantly, the project will help the Lakeshore line transform from a one-way, Toronto-centric line to one providing frequent service among a series of major employment and residential nodes. It will increasingly be possible to live and work in any one of the six centres (or other intermediate station areas along the line) and conveniently travel to work by GO transit. This transit investment should result in a mutually reinforcing benefit for nodes along the line.

An additional impact may result from travel times becoming competitive with auto travel. The economics of personal choices to live close to a GO Station within this corridor will shift from being entirely oriented to commuters to the Toronto CBD, to being a broadly-based service that enables a transit-oriented lifestyle for a wide demographic. The effect of the project could then have wide-ranging implications, as a much broader portion of the population would be able to choose to live in the Lakeshore corridor without the need to own a car (or, more commonly, to own multiple vehicles).

Health

The extent to which the GO Express Rail project can influence and encourage greater densities along the Corridor, particularly near the ends of the line where the travel time benefits are greatest, the greater the potential to reduce auto dependency and promote more liveable communities. This is turn will increase walking generally; including walking to access the GO stations, consequently supporting improved health. Furthermore, the extent to which the improved GO Transit service can address traffic congestion within the GO communities and along the Corridor, the greater the health benefit to that community in terms of reduced environmental impacts of car pollution. As well, the electric trains themselves will reduce the emissions attributable to GO Transit operations which could improve the health benefits for those immediately adjacent to the Corridor.

Accessibility

The increased travel speeds and consequent improvements in travel times, particularly associated with the electrified options, will greatly improve the connectivity and accessibility of between the Urban Growth Centres and other sub-centres along the Lakeshore corridor. Residents from Hamilton and Oshawa travelling to downtown Toronto and points in between will have access to more frequent and reliable transportation options to numerous destinations along the corridor. Similarly, with the more frequent off-peak directional service proposed under the GO Express Rail initiative, the accessibility of destinations to the east and west of downtown Toronto will be greatly enhanced creating greater opportunities and alternatives for commuters and travellers at all points along the corridor. To the extent that other transit services connect with the GO Transit stations throughout the day, transit passengers will also experience improved access to the entire region.

Summary

All of the options provide improved travel times and levels of service relative to the Base Case and consequently have the potential to positively affect land use, health and accessibility. To the extent that the electric service provides faster relative speeds and better travel times, the positive influences in these areas is more likely. This is particularly relevant for Phase 2 of the electric option which dramatically increases the frequency of service in both directions throughout the day and provides service as often as every six minutes in the peak hour.

Sensitivity Analysis

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 16, the relative ranking among the options does not change and more importantly, even with a 7% discount rate, the options all have a benefit-cost ratio greater than one.

TABLE 16 DISCOUNT RATE SENSITIVITY ANALYSIS

Discount Rate	3%		5%		7%	
	NPV ($m)	BCR	NPV ($m)	BCR	NPV ($m)	BCR
Option 1 Ph 1	1,952	1.6	**1,043**	1.4	496	1.2
Option 2 Ph 1	3,614	2.2	**2,060**	1.8	1,094	1.5
Option 2 Ph 2	2,720	1.5	**1,188**	1.3	304	1.1

Summary Results

TABLE 17 MAE SUMMARY

	Option 1	Option 2	
		Phase 1	Phase 2
Transportation User Account			
Transportation User Benefits (PV $m)	3,611	4,567	5,849
Qualitative User Benefits	✓	✓✓	✓✓✓
Financial Account			
Costs (PV $m)	2,568	2,507	4,660
Benefits Less Costs (PV $m)	1,043	2,060	1,188
Benefit-Cost Ratio	1.4	**1.8**	1.3
Environmental Account			
GHG Emissions (PV $m)	28	**31**	40
Qualitative Environmental Impacts	✓	✓✓	✓✓
Economic Development Account			
Economic Impacts During Construction ($m)	554.8	1,516	4,879
Long-term Economic Impacts ($m)	232.5	250.6	271.6
Development Potential ($b)	3.87	3.87	9.28
Social Community Account			
Land Use Shaping	✓	✓✓	✓✓✓
Health	✓	✓✓	✓✓✓
Accessibility	✓	✓✓	✓✓✓

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	1.64% 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 - $0.60/km 2021 - $0.78/km 2031 - $0.95/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

APPENDIX

B

ELECTRIC MULTIPLE UNITS OVERVIEW

Electric Multiple Units (EMUs)

Due to time constraints and resource limitations, costing and performance assumptions for both the diesel and electric options in the Lakeshore Benefits Case Analysis were developed based on the premise that conventional locomotive-hauled trains would continue to be used in the Corridor. However, it is acknowledged that, particularly over the longer term, the potential use of alternative train technologies could be considered to further improve train operations and reduce travel times. One potential option that could be explored in more detail is the use of Electric Multiple Units (EMUs), which are electrically-powered trains consisting of several powered cars that are controlled by one driver.

The following provides an overview of the potential performance advantages of using EMU technology compared with conventional locomotive-hauled train sets.

Acceleration

A consist of EMUs has a greater number of powered axles relative to a locomotive-hauled train. As a result, a key advantage of EMUs is the higher achievable acceleration rate. Acceleration rates of 0.7m/s^2 are common with EMUs, compared with 0.4 m/s^2 by locomotive-hauled train sets such as those currently used by GO Transit. The major benefit higher acceleration levels is increased average operating speeds, particularly on local trains with frequent station stops, and reduced overall travel time. To illustrate, Table 1 below provides a comparative summary of the simulated travel times for a local (all-stops) train from Union Station to Hamilton with a locomotive-hauled electric train versus an EMU train. It should be noted that the comparative advantage of EMUs would not be as evident on Express schedules with fewer station stops.

TABLE 1: LAKESHORE WEST COMPARATIVE TRAIN SCHEDULES

Westbound	**Electric Locomotive-hauled Train[23]**	**EMU Train[24]**
Union Station	0.00	0.00
Exhibition	3.00	3.00
Mimico	9.00	8.00
Long Branch	13.00	12.00
Port Credit	18.00	16.00
Clarkson	23.00	21.00
Oakville	30.00	26.00
Bronte	34.00	30.00
Appleby	39.00	34.00
Burlington	44.00	39.00
Aldershot	48.00	42.00
Hamilton Hunter	64.00	55.00

Train Capacity

Locomotive trains generally have fixed train capacity because they are fairly difficult to split apart and join together making them less flexible to adjust to demand levels throughout the day. In general, the same train configurations used for peak period services are used for off-peak and counter-peak services leaving much of the train capacity unused. EMU's address this issue by using auto-couplers to join and split trains making them much easier to reconfigure for varying times of the day, which could potentially reduce operating costs and energy use.

Reliability

EMU technology tends to be more reliable than locomotive-hauled trains because of the added redundancy in its vehicle design. While the failure of a locomotive would disable an entire train, service disruptions due to mechanical difficulties can potentially be avoided with EMUs as more than one vehicle is powered. At the very least, EMUs would generally have the ability to make it

[23] Bombardier ALP-46 locomotive assumed for performance modeling purposes.

[24] Alstom Coradia Double-deck EMU assumed for performance modeling purposes.

back to the maintenance facility if equipment fails without the need for a recovery vehicle, except in the rare case of a complete equipment failure.

Higher operating speeds, increased flexibility of train capacity and better reliability are beneficial to both the operator and passengers. Such benefits, mainly shorter travel times and improved reliability can increase attractiveness of rail and improve ridership.

Potential Cost Implications and Obstacles to the Use of EMUs

While time did not permit an extensive evaluation of the associated costs and benefits comparisons between EMUs and locomotive-hauled trains, it was noted that EMU vehicles would likely require a higher initial capital cost over traditional bi-level cars, as each EMU vehicle would have its own propulsion system. In addition, maintenance costs are expected to be higher relative to bi-level cars due to this additional traction equipment.

Perhaps the largest current obstacle to the use of EMUs in a mixed-use freight and passenger rail corridor such as the Lakeshore line is the requirement that vehicles meet North American safety and crash worthiness standards (enforced by Transport Canada in Canada and the Federal Railroad Administration in the United States). These standards differ significantly from those in Europe, where EMUs are already used extensively in many countries. As a result, the current options for “off-the-shelf” EMU vehicles that would meet Transport Canada’s crash worthiness standards are limited. The additional cost and risks associated with developing new compliant vehicles could prove to be a significant obstacle to implementation in the short term, and modifying European vehicles to meet North American standards could reduce the performance and associated benefits of EMUs discussed previously. In the longer term, it is possible that a future convergence of North American and European safety standards could provide opportunities for the use of EMUs on the Lakeshore Corridor and other GO Transit rail lines.