



Hamilton
Public Works

HAMILTON B-LINE LRT EVALUATION OF PHASING SCENARIOS

TECHNICAL REPORT



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1 INTRODUCTION

1.1 Background

In 2008, the Metrolinx Board approved and adopted *The Big Move*, a Regional Transportation Plan (RTP) for the Greater Toronto and Hamilton Area (GTHA). Rapid transit in Downtown Hamilton between McMaster University and Eastgate Square was identified as a top 15 transit priority project for early implementation. Subsequently, Metrolinx prepared the *Hamilton King-Main Benefits Case* which undertook a comparative analysis of the feasible options for rapid transit within Downtown Hamilton. The options that were reviewed included a full BRT, a full LRT and a phased LRT. Each of these options was assessed using a Benefits Case Evaluation (BCE) methodology that took into consideration project performance and policy implications associated with transportation user benefits, financial impacts, environmental impacts, economic impacts and socio-community impacts. Results of the BCE analysis indicated that the full LRT should be carried forward for further review as it generally provided the greatest benefits in all the accounts and supported the City of Hamilton's broader objectives to revitalize, redevelop and reshape the B-Line corridor.

Following the recommendation of the *Hamilton King-Main Benefits Case* report, the City of Hamilton undertook and completed the Hamilton Rapid Transit Preliminary Design and Engineering Study, which included the preparation of an Environmental Project Report (EPR) following the Transit Projects Assessment Process (TPAP). The EPR was filed in October 2011 and a Statement of Completion was issued in December 2011. B-Line features as presented in the EPR included the recommendation of a LRT function, 14 km of dual track guideway, two terminal points (McMaster University and Eastgate Square), 16 on-street stops between the two termini and the identification of track location, whether curbside or along the median.

While the EPR has recommended a full LRT along the B-Line corridor between McMaster University and Eastgate Square, Metrolinx requested an evaluation of possible LRT phasing scenarios to compare associated benefits and costs and to aid in the determination of funding contribution. It was recommended that the assessment of phased LRT scenarios be undertaken using the Multiple Account Evaluation (MAE) process that performs a comparative analysis of financial, policy and community implications for each phasing scenario.

1.2 Purpose of Study

In order to meet funding contribution specifications per Metrolinx directive, the City of Hamilton initiated the Hamilton B-Line LRT Phasing Study in April 2012. The purpose of this study was to determine the most effective / phasing implementation plan for the B-Line LRT that took into consideration costs and revenue, transportation user benefits, environmental impacts, economic and growth opportunities, community benefits and urban development opportunities. The evaluation of each of the phasing scenarios was based on information provided in the LRT studies previously undertaken by the City of Hamilton. In particular, the completed reports were reviewed to obtain service requirements, capital costs, operating costs, land use data and ridership data.

1.3 Report Structure

This report provides a summary of the study process and findings for the Hamilton B-Line LRT Phasing Study. The main components of the report are briefly described below with further details included in each of the sub-sections.

- Section 2:** This section provides a description of the B-Line LRT phasing scenarios identified for the multiple accounts evaluation.
- Section 3:** This section provides an overview of the Multiple Accounts Evaluation procedure developed for the City of Hamilton and applied to the evaluation of the phasing scenarios for the B-Line LRT.
- Section 4:** This section describes the evaluation of each phasing scenario according to the identified measures for each account.
- Section 5:** This section presents a summary of the Multiple Accounts Evaluation and identifies the phasing scenario that has the most potential / benefit.

2 PHASING SCENARIOS

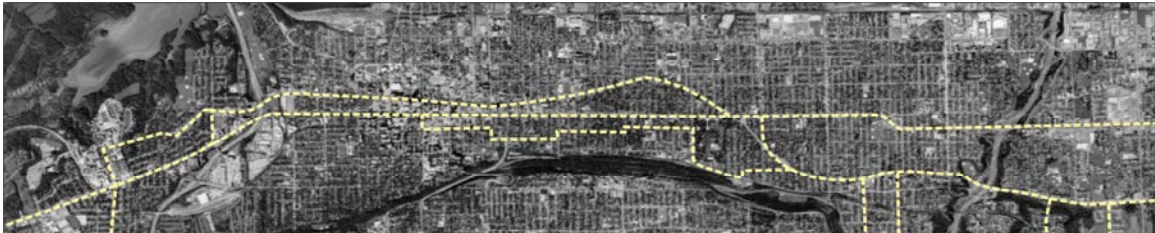
The B-Line LRT corridor as defined in the Hamilton Rapid Transit Preliminary Design and Feasibility Study extends from McMaster University in the west to Eastgate Square in the east. As noted in the previous section, Metrolinx requires that phasing scenarios be considered and evaluated for the purposes of identifying funding contributions. As a result, five (5) phasing scenarios were identified for evaluation in this study through discussions with the City.

One of the key factors in determining each phasing scenario was the feasibility of the start / end station to be developed as a major terminal. In addition, the development of the phasing scenarios also considered the potential location of a Maintenance Storage Facility (MSF) at 330 Wentworth Street North. While a phasing scenario from McMaster University to Downtown Hamilton (MacNab Street) was identified, it was not carried forward for further evaluation as the LRT tracks would need to extend beyond the Downtown to access the Maintenance Storage Facility. The following sections provide a brief overview of each of the phasing scenarios and a description of their main features.

2.1 Scenario A: Business as Usual

When developing a benefits case analysis, it is typical that a *Do Nothing* scenario be included as part of the assessment to show the comparative benefits of the recommended option. In this study, Scenario A (Business as Usual) is comparable to the *Do Nothing* scenario as it is comprised of the existing HSR bus routes that operate along the identified B-Line LRT alignment corridor and assumes that the LRT is not implemented. The bus routes that are included in this scenario include: 1, 1A, 5 group, 10, 10A, 51, 52, 55, 55A and 58. **FIGURE 1** displays the bus routing that currently supports the B-Line LRT alignment corridor.

FIGURE 1: Phasing Scenario A: Business as Usual



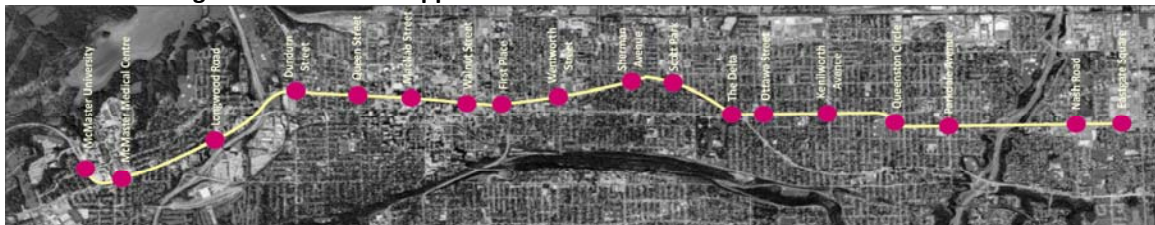
While Scenario A is comparable to a *Do Nothing* scenario, it is not assessed in this study's comparative evaluation. In the February 2010 *Hamilton King-Main Benefits Case* report, the *Do Nothing* scenario was already included in the evaluation. Recommendations from that particular report noted that the full LRT should be carried forward for further review. As a result, Scenario A, as described above, is only being included in this report for reference purposes rather than evaluation purposes.

2.2 Scenario B: TPAP Approved B-Line

The *Hamilton Rapid Transit Preliminary Design and Feasibility Study* was completed in 2011, with the Statement of Completion for the Environmental Project Report (EPR) issued in December 2011. This study was undertaken following the Transit Project Assessment Process (TPAP) and recommended that a full LRT be implemented between McMaster University and Eastgate Square along the King-Main-Queenston corridor for a total of 14km. The full LRT would consist of 18 stops, two of which would function as main terminals (McMaster University and Eastgate Square), and run along the median and curbside at different sections of the route.

FIGURE 2 displays the routing and stops associated with the full LRT, also referred to as the B-Line LRT.

FIGURE 2: Phasing Scenario B: TPAP Approved B-Line

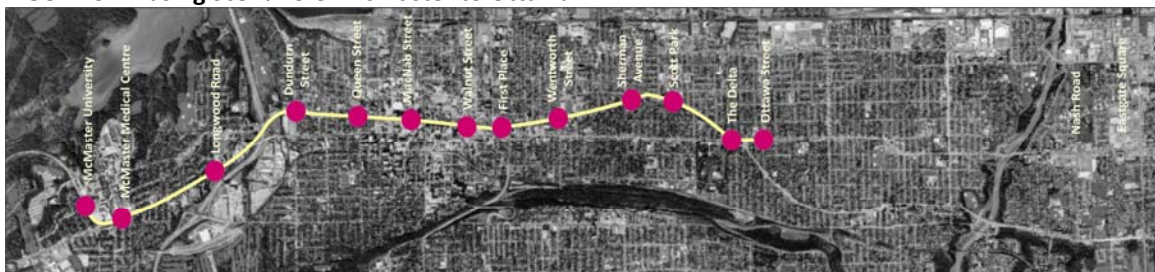


McMaster University would serve as the west anchor for this phasing scenario. McMaster University not only functions as an educational institution but is also a major employment and service area due to the hospital located on site. The market for the west anchor is driven by students, teaching staff, medical staff and hospital users. Eastgate Square would serve as the east anchor for the phasing scenario. It has been identified as a planned Sub-Regional node that includes a major commercial centre and higher density residential land uses. The market for the east anchor is driven by consumers and employees.

2.3 Scenario C: McMaster to Ottawa

Scenario C looked at the implementation of the LRT between McMaster University and Ottawa Street. The length of this phase would be approximately 9.1km with a total of 13 stops, two of which would function as main terminals (McMaster University and Ottawa Street), and run along the median and curbside at different sections of the route. **FIGURE 3** displays the routing and stops associated with the Scenario C LRT alignment.

FIGURE 3: Phasing Scenario C: McMaster to Ottawa

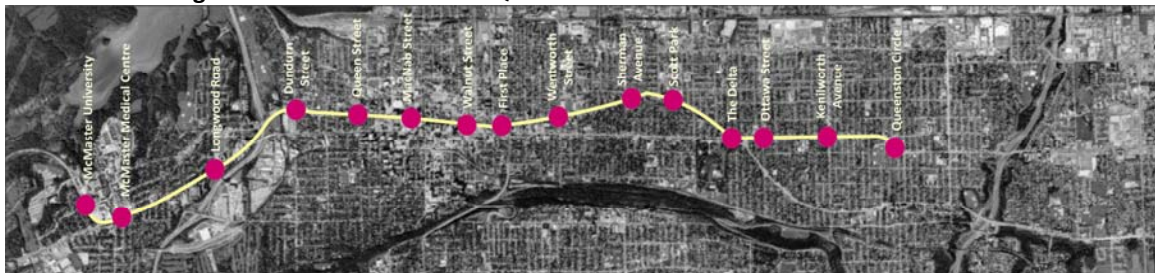


McMaster University would serve as the west anchor for this phasing scenario. McMaster University not only functions as an educational institution but is also a major employment and service area due to the hospital located on site. The market for the west anchor is driven by students, teaching staff, medical staff and hospital users. Ottawa Street would serve as the east anchor for the phasing scenario. The Ottawa Street area is an established Business Improvement Area (BIA) for textiles and home décor. As a result, the market for the east anchor is driven by consumers and employees.

2.4 Scenario D: McMaster to Queenston Circle

Scenario D looked at the implementation of the LRT between McMaster University and Queenston Circle. The length of this phase would be approximately 10.8km with a total of 15 stops, two of which would function as main terminals (McMaster University and Queenston Circle), and run along the median and curbside at different sections of the route. **FIGURE 4** displays the routing and stops associated with the Scenario D LRT alignment.

FIGURE 4: Phasing Scenario B: McMaster to Queenston Circle

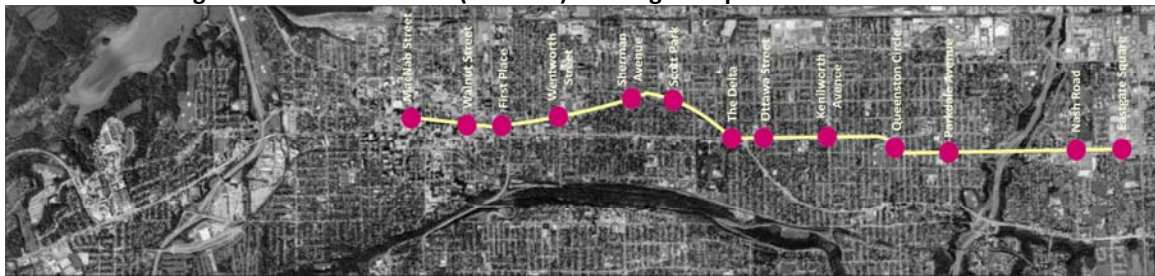


McMaster University would serve as the west anchor for this phasing scenario. McMaster University not only functions as an educational institution but is also a major employment and service area due to the hospital located on site. The market for the west anchor is driven by students, teaching staff, medical staff and hospital users. Queenston Circle would serve as the east anchor for the phasing scenario. The Queenston Circle area is a major residential area with some commercial developments. As a result, the market for the east anchor is driven by consumers, employees and residents.

2.5 Scenario E: Downtown (MacNab) to Eastgate Square

Scenario E looked at the implementation of the LRT between Downtown Hamilton (MacNab Street) and Eastgate Square. The length of this phase would be approximately 9.2km with a total of 13 stops, two of which would function as main terminals (MacNab Street and Eastgate Square), and run along the median and curbside at different sections of the route. **FIGURE 5** displays the routing and stops associated with the Scenario D LRT alignment.

FIGURE 5: Phasing Scenario E: McMaster (MacNab) to Eastgate Square



Downtown Hamilton (MacNab Street) would serve as the west anchor for this phasing scenario. Downtown Hamilton not only functions as a major employment node but it also provides commercial, civic and entertainment services. As a result, the market for the west anchor is driven by employers and consumers. Eastgate Square would serve as the east anchor for the phasing scenario. It has been identified as a planned Sub-Regional node that includes a major commercial centre and higher density residential land uses. The market for the east anchor is driven by consumers and employees.

3 MULTIPLE ACCOUNTS EVALUATION

Historically, phasing scenarios were assessed purely on benefit / cost analysis (dollar value assessment). However, recent Metrolinx direction has been to undertake a comparative evaluation of phasing scenarios from both a quantitative and qualitative perspective, also known as the Multiple Account Evaluation (MAE) methodology. A brief description of the purpose of the MAE methodology and typical accounts and measures required to undertake the evaluation for the B-Line LRT corridor is provided below.

3.1 Purpose of Evaluation

A Multiple Accounts Evaluation (MAE) includes the clear identification of advantages, disadvantages and trade-offs involved with each phasing alternative under consideration. This detailed evaluation can then be used to inform and assist in the decision-making process utilizing quantitative and qualitative assessments for defined evaluation criteria. The MAE methodology digresses from the typical comparison of alternatives based on dollar benefits and instead, provides an understanding of the overall benefits of the alternative to the system as a whole, both from a fiscal perspective and from a community perspective.

3.2 Identified Accounts and Measures

Traditionally, five evaluation accounts have been identified to cover major concerns and objectives of the proponent. Within each of these accounts, measures specific and applicable to the project under assessment are defined and used as part of the evaluation of alternatives. A review of evaluation processes noted that not all accounts are applicable to an evaluation. Each “project” needs to be individually assessed to determine the relevance / need for a criterion and analysts who collect data and conduct evaluations should not use a pre-determined formal weighting scheme. It is up to the decision-makers to decide the relative importance of each account.

The five typical evaluation accounts include: the financial account, the user benefit account, the environmental account, the economic growth and development account and the social account. For the Hamilton B-Line LRT Phasing Scenario evaluation, an additional account was included in the evaluation process, the urban development account, in order to better understand the benefits of each LRT phasing option to the community services and community development along the B-Line LRT alignment corridor. The definition of each account is provided below with the measures specific to this study.

- **Financial account:** The identification of the revenue and expenditure

implications of each alternative, which includes the cost to the infrastructure provider. The costs are usually presented as a net present value cost inclusive of capital, rehabilitation and maintenance costs. Measures that were evaluated include:

- Effectiveness of capital cost investment
 - Effectiveness of operating cost investment
 - Cost effectiveness of B-Line service
- **User benefit account:** The identification of the benefit or value the customers or users derive from the LRT phasing alternative from a qualitative and quantitative perspective. The measure that was evaluated is noted below:
 - B-Line travel time costs
- **Environmental account:** The identification of community / social environment benefits / impacts of the phasing scenario. The measure that was evaluated is noted below:
 - Air quality (GHG)
- **Economic development account:** The identification of the nature, magnitude and significance to increased tax revenue and employment opportunities along the B-Line corridor. Measures that were evaluated include:
 - Accessibility to employment areas
 - Increased DC revenues
- **Social account:** The identification of benefits / impacts to the social fabric and community adjacent to the B-Line corridor. Measures that were evaluated include:
 - Community accessibility and connectivity
 - LRT construction mitigation
- **Urban development account:** The identification of benefits / impacts to development opportunities along the corridor. Measures that were evaluated include:
 - Reurbanization potential
 - Regional transit connectivity

Each of these measures and the method by which the comparative analysis was undertaken will be discussed further in Section 4 of this report.

4 EVALUATION OF ACCOUNTS

To determine the B-Line LRT Phasing Scenario that would provide the greatest overall benefit to all stakeholders, whether the City, Metrolinx, HSR operators or the adjacent community, a detailed evaluation of each of the accounts was undertaken. The following sections highlight the specific measures evaluated under each account, the inputs and assumptions and how each phasing scenario compares with each other.

4.1 Financial Account

Three measures were identified for the evaluation of the Financial Account. In order to fairly assess the financial implications of each of the phasing scenarios, this account did not evaluate capital or operating costs as standalone measures. Instead, the measures introduced as part of the Financial Account evaluation were the effectiveness of the capital cost investment, the effectiveness of the operating cost investment and the overall cost effectiveness of the B-Line service. Each of these measures is described in further detail below.

4.1.1 Effectiveness of Capital Cost Investment

The effectiveness of the capital cost investment was a measure of the capital cost in relation to the annual passenger kilometres (km). Capital costs were defined as the costs required to implement the phasing scenario inclusive of infrastructure (vehicles and maintenance centre), construction, design, management and administration, insurance, property and contingencies in 2011 dollars. Annual (2031) passenger kilometers were defined as the total LRT passenger kilometres for each phasing scenario based on the total number of passengers on the LRT between each stop and the distances between each stop.

Specific inputs required for the evaluation of this measure included the following:

- B-Line LRT capital cost estimates for each phasing scenario;
- EMME model AM peak period LRT station boardings and alightings, inclusive of transfers;
- Annual ridership (boardings) for each phasing scenario; and,
- LRT distances between stops in kilometres to determine total phasing scenario LRT kilometres.

The capital costs for Scenario B were obtained from the *Hamilton Rapid Transit Preliminary Design and Feasibility Study Cost Estimate Report* (February 2012) for the B-Line. The capital costs for the remaining phasing scenarios (C, D and E), were then estimated from the Scenario B costs. The majority of the capital cost items were pro-rated according to the length of the phasing scenario with the exception of three

specific line items. The cost for the guideway was adjusted to include or exclude costs associated with a Highway 403 structure and a Red Hill Valley Structure, depending on the phasing scenario. The cost for trackwork and stations was adjusted based on the number of stations within the phasing scenario and assuming two terminal stations. The maintenance facility cost was kept constant for each of the phasing scenarios as it would be required in all cases. **TABLE 1** provides a summary of the capital costs associated with each of the phasing scenarios.

TABLE 1: Capital Cost Estimates

Capital Cost Items	SCENARIO B TPAP	SCENARIO C McMaster to Ottawa Street	SCENARIO D McMaster to Queenston Circle	SCENARIO E Downtown to Eastgate Square
Length of LRT Service (km)	13.8	9.1	10.8	9.2
Preparatory works	\$95,578,021	\$63,026,086	\$74,800,190	\$63,718,681
Guideway	\$79,811,694	\$50,329,450	\$60,161,326	\$41,107,796
Trackwork and stations	\$115,586,465	\$84,590,225	\$96,988,721	\$84,590,225
Systems	\$90,750,250	\$57,842,556	\$71,021,935	\$60,500,167
Maintenance facility	\$48,480,143	\$48,480,143	\$48,480,143	\$48,480,143
Vehicles	\$110,000,000	\$72,536,232	\$86,086,957	\$73,333,333
Total Construction Cost (2011 \$)	\$540,206,573	\$376,804,692	\$437,539,271	\$371,730,344
Design and management (.22)	\$120,431,493	\$82,897,032	\$96,258,640	\$81,780,676
Property allowance (.06)	\$34,557,000	\$22,608,282	\$21,876,964	\$22,303,821
Total Estimate Before Contingencies (2011 \$)	\$695,195,066	\$482,310,006	\$555,674,874	\$475,814,841
Contingencies (17%)	\$116,190,893	\$81,992,701	\$94,464,729	\$80,888,523
Total Estimate With Contingencies (2011 \$)	\$811,385,959	\$564,302,707	\$650,139,603	\$556,703,364

The 2031 EMME database that was prepared for the City as part of the TPAP provided the base LRT ridership estimates for each of the phasing scenarios. As the EMME model only provided AM peak period LRT boardings, these numbers were adjusted to obtain annual ridership estimates. The AM peak period boardings were adjusted by an annual factor of 909, which normalized weekend travel and reduced public holiday services. The AM peak period LRT boardings and the annual factor provided a base annual ridership estimate.

As noted in the report *Hamilton Rapid Transit: Making the Case Transportation Case Review* (August 2011), several other uptake factors should also be applied to the base annual ridership to account for changes in policy and benefits associated with the implementation of the LRT. The LRT ridership uptake factors that were used to determine annual ridership included: a bus network update factor of 16%; a vehicle operating costs factor of 4%; a parking charges factor of 16%; a LRT quality benefits factor of 37%; and, a revised growth opportunities factor of 47%. These factors resulted in a total uplift factor of 1.2 for Scenario B and total uplift factors pro-rated by LRT length for the remaining phasing scenarios, with the exception of the bus network update factor which was maintained for all phasing scenarios.

One final adjustment was applied to the 2031 annual LRT ridership estimate to ensure consistency with approved City ridership numbers. Based on an approved 2031 annual LRT ridership of 18.9 M, each of the 2031 annual LRT ridership numbers were adjusted by a calibration factor of 0.93. Details of the 2031 LRT annual ridership estimates for each of the phasing scenarios is provided in **TABLE 2**.

TABLE 2: 2031 LRT Annual Ridership Estimates

Annual Ridership	SCENARIO B	SCENARIO C	SCENARIO D	SCENARIO E
	TPAP	McMaster to Ottawa Street	McMaster to Queenston Circle	Downtown to Eastgate Square
Peak Period Boardings	10,154	6,947	8,122	7,588
Base annual ridership (peak period *909)	9,229,986	6,314,823	7,382,898	6,897,492
Base Annual Ridership (M)	9.2	6.3	7.4	6.9
Bus network update	0.16	0.16	0.16	0.16
Vehicle operating costs	0.04	0.03	0.03	0.03
Parking charges	0.16	0.11	0.08	0.06
LRT quality benefits	0.37	0.24	0.29	0.25
Revised growth	0.47	0.31	0.37	0.31
Total Uplift Factor	1.20	0.85	0.93	0.80
2031 annual forecast ridership (M)	20,305,969	11,655,882	14,258,344	12,427,307
Adjusted 2031 annual forecast ridership (0.93)	18,884,551	10,839,970	13,260,260	11,557,396
2031 Annual Ridership (M) - boardings	18.9	10.8	13.3	11.6

Subsequent to estimating the 2031 LRT annual ridership associated with each of the phasing scenarios, it was necessary to determine the 2031 annual LRT passenger kilometres to assist in evaluating the effectiveness of the capital cost measure. The passenger kilometres were estimated from the 2031 EMME model transit assignments by finding the product of the number of passengers between two LRT stops and the distance between the same stops. The AM peak period passenger kilometre estimate for each phasing scenario was then adjusted by the annual and uplift factors noted above to obtain 2031 LRT passenger kilometres. **TABLE 3** provides a summary of Financial Account Measure #1: LRT Capital Costs (2011 \$) / 2031 Annual Passenger KM.

TABLE 3: LRT Capital Costs (2011\$) / 2031 Annual Passenger KM

	SCENARIO B	SCENARIO C	SCENARIO D	SCENARIO E
	TPAP	McMaster to Ottawa Street	McMaster to Queenston Circle	Downtown to Eastgate Square
Capital costs (2011 \$) / 2031 Annual passenger km	\$8.39	\$9.43	\$8.76	\$10.49
% Change in relation to TPAP		12%	4%	25%
Capital costs	\$811,385,959	\$564,302,707	\$650,139,603	\$556,703,364
Annual LRT passenger km	96,736,325	59,812,927	74,229,149	53,071,783
Annual LRT passengers (boardings)	18,900,000	10,800,000	13,300,000	11,600,000

Comparison results indicate that Scenario B has the lowest capital cost per annual passenger kilometre with Scenario D following closely behind.

4.1.2 Effectiveness of Operating Cost Investment

The effectiveness of the operating cost investment was a measure of the LRT and bus operating costs in relation to the annual passenger kilometres (km). Operating costs were defined as the costs required to operate the phasing scenario. Annual (2031) passenger kilometers were defined in Section 4.1.1.

Specific inputs required for the evaluation of this measure included the following:

- Annual 2031 LRT operating costs;
- Annual 2031 bus operating costs;
- LRT scenario passenger kilometres that included transfers; and,
- Bus scenario passenger kilometres.

The LRT operating cost for Scenario B was obtained from the *Hamilton Rapid Transit Preliminary Design and Feasibility Study Cost Estimate Report* (February 2012) for the B-Line with detailed line item estimates provided in the *Hamilton Rapid Transit Preliminary Design and Feasibility Study Preliminary Operations & Maintenance Plan* (November 2011) for the B-Line. The LRT operating costs for the remaining phasing scenarios (C, D and E), were then estimated from the Scenario B costs. The majority of the operating cost items were pro-rated according to the length of the phasing scenario with the exception of two specific line items. The office supply costs and the insurance costs were kept constant for each of the phasing scenarios as it would be required in all cases. It is of note that the LRT operating costs were provided in 2011 \$ and as a result, a compounded growth rate of 2% per annum was applied to the 2011 LRT operating cost to obtain a 2031 LRT operating cost.

The bus operating costs were obtained by estimating the 2031 bus passengers, inclusive of transfers, and multiplying it by a gross operating cost per boarding passenger of \$2.93, which is representative of a 2012 B-Line service specific operating cost. Similar to the LRT operating cost, a compounded growth rate of 2% per annum was applied to the 2012 bus operating cost to obtain a 2031 bus operating cost. 2031 bus passengers were representative of bus riders boarding at bus stops between McMaster University and Eastgate Square along the B-Line LRT alignment. These bus riders were assumed to be comprised of the riders who chose the bus over the LRT along the same alignment as the B-Line or the riders who would be required to take a bus to the LRT terminal station in the phased scenarios C, D and E.

TABLE 4 provides a summary of the LRT and bus operating costs associated with each of the phasing scenarios.

TABLE 4: 2031 Operating Cost Estimates

2031 Operating Cost Item per Annum	SCENARIO B	SCENARIO C	SCENARIO D	SCENARIO E
	TPAP	McMaster to Ottawa Street	McMaster to Queenston Circle	Downtown to Eastgate Square
Labour costs (admin, operations, maintenance)	\$17,905,963	\$10,238,955	\$12,607,426	\$10,995,889
Vehicle maintenance costs	\$587,454	\$335,917	\$413,621	\$360,750
Track maintenance / rail replacement	\$125,206	\$82,563	\$97,987	\$83,471
Power costs	\$726,480	\$479,055	\$568,549	\$484,320
Cost for parts for maintenance of catenary and TPSS	\$89,157	\$58,792	\$69,775	\$59,438
Cost for parts for maintenance of communication and fare collection equipment	\$44,578	\$25,491	\$31,387	\$27,375
Office supplies	\$53,970	\$53,970	\$53,970	\$53,970
10% insurance, rates, property taxes, etc.	\$1,953,281	\$1,953,281	\$1,953,281	\$1,953,281
2031 LRT Operating Costs	\$21,486,089	\$13,228,024	\$15,795,996	\$14,018,494
Bus Operating Costs	\$5,975,839	\$24,330,203	\$17,073,827	\$29,879,197
Total 2031 LRT and Bus Operating Costs	\$27,461,928	\$37,558,228	\$32,869,823	\$43,897,691

Using the methodology described in Section 4.1.1 of the report, the LRT and bus passenger kilometres were estimated. **TABLE 5** provides a summary of Financial Account Measure #2: 2031 B-Line LRT + Bus Operating Cost / Passenger KM. Scenario B has the lowest LRT and bus operating cost per annual passenger kilometre followed by Scenario D.

TABLE 5: 2031 B-Line LRT + Bus Operating Cost / Passenger KM

	SCENARIO B	SCENARIO C	SCENARIO D	SCENARIO E
	TPAP	McMaster to Ottawa Street	McMaster to Queenston Circle	Downtown to Eastgate Square
Annual 2031 LRT operating costs	\$21,486,089	\$13,228,024	\$15,795,996	\$14,018,494
Annual 2031 bus operating costs	\$5,975,839	\$24,330,203	\$17,073,827	\$29,879,197
Total (LRT + bus) operating costs	\$27,461,928	\$37,558,228	\$32,869,823	\$43,897,691
Annual LRT passenger km	96,736,325	59,812,927	74,229,149	53,071,783
Annual bus passenger km	4,110,729	17,957,365	10,254,486	30,332,104
Total (LRT + bus) passenger km	100,847,054	77,770,292	84,483,635	83,403,887
2031 LRT + bus operating costs / Annual passenger km	\$0.27	\$0.48	\$0.39	\$0.53

4.1.3 Cost Effectiveness of B-Line Service

The cost effectiveness of the B-Line Service is defined as a measure of the annual passenger revenue in relation to the annual operating cost. Annual passenger revenue was defined as the forecast revenue for the 2031 horizon year based on forecast ridership. Annual (2031) operating costs were defined in Section 4.1.2.

Specific inputs required for the evaluation of this measure included the following:

- 2031 B-Line Corridor LRT and bus annual ridership (including transfers);

- 2031 B-Line Corridor LRT and bus annual operating costs; and,
- Average ridership fare.

Details for the operating costs estimates are provided in Section 4.1.2. The annual forecast revenue was estimated based on a \$2.05 average fare per boarding. As the 2031 annual ridership estimates were based on total boardings, the 2031 ridership estimates were adjusted to account for transferring passengers, who would not be paying a second fare to board the LRT. Current Hamilton Street Railway (HSR) statistics indicate that approximately 77% of the total boarders would be paying passengers. The 2031 annual LRT passengers were then adjusted accordingly.

TABLE 6 provides a summary of Financial Account Measure #3: 2031 LRT and Bus Revenue / Operating Cost. Scenario B has the highest LRT and bus revenue per operating cost and Scenario D has the second highest value.

TABLE 6: Cost Effectiveness of B-Line Service

B-Line Corridor	SCENARIO B TPAP	SCENARIO C McMaster to Ottawa Street	SCENARIO D McMaster to Queenston Circle	SCENARIO E Downtown to Eastgate Square
Annual LRT passengers (boardings)	18,900,000	10,800,000	13,300,000	11,600,000
Annual LRT passengers less transfers (77% total boardings)	14,553,000	8,316,000	10,241,000	8,932,000
Annual bus passengers (stops on B-Line LRT alignment)	1,400,000	5,700,000	4,000,000	7,000,000
2031 total passengers (less transfers)	15,953,000	14,016,000	14,241,000	15,932,000
Average fare	\$2.05	\$2.05	\$2.05	\$2.05
LRT and bus annual revenue	\$32,703,650	\$28,732,800	\$29,194,050	\$32,660,600
Annual 2031 LRT and bus operating costs	\$27,461,928	\$37,558,228	\$32,869,823	\$43,897,691
2031 LRT and bus revenue / operating costs ratio	1.19	0.77	0.89	0.74

4.1.4 Financial Account Summary

The LRT phasing scenarios were ranked based on the ability of each LRT phasing scenario to best meet the measure identified in the Financial Account, as shown in **TABLE 7**.

TABLE 7: Financial Account Summary

Financial Account Summary	SCENARIO B TPAP	SCENARIO C McMaster to Ottawa Street	SCENARIO D McMaster to Queenston Circle	SCENARIO E Downtown to Eastgate Square
LRT capital cost (2011 \$) / 2031 Annual passenger km	\$8.39	\$9.43	\$8.76	\$10.49
Measure #1 Ranking	1	3	2	4
2031 LRT + bus operating cost / Annual passenger km	\$0.27	\$0.48	\$0.39	\$0.53
Measure #2 Ranking	1	3	2	4
2031 LRT + bus revenue / Annual operating costs	1.19	0.77	0.89	0.74
Measure #3 Ranking	1	3	2	4
Total Measure Ranking	3	9	6	12

By summing the rank provided for each measure, a total measure ranking was obtained. Scenario B, which had the lowest total measure ranking, was identified as the LRT phasing scenario most beneficial for implementation from the financial perspective. Scenario D followed closely behind Scenario B, making it a feasible option in the event that Metrolinx or the City requires a staged implementation program.

4.2 Community / User Benefit Account

The purpose of the Community / User Benefit account is to identify the benefit or value customers or users derive from each LRT phasing scenario. The measure introduced as part of this account was the comparison of the travel time cost of the user on the B-Line LRT corridor alignment. Details of this evaluation are as follows.

4.2.1 B-Line Travel Time Cost

The B-Line travel time cost is a measure of the transit user travel time represented in terms of a dollar value. Evaluation of this measure involves the comparison of travel times along the entire B-Line LRT corridor alignment, from McMaster University to Eastgate Square, stated in passenger value of time (VOT) numbers. In the phasing scenarios where the LRT either terminates prior to Eastgate Square or begins east of McMaster University, the bus travel times associated with accessing the LRT at the terminal station, inclusive of transfer wait times, is included in the evaluation of the travel time cost in order for the measure to be reasonably compared.

Specific inputs required for the evaluation of this measure included the following:

- Transit travel time on the bus; and,
- Transit travel time on the LRT.

The transit travel times were obtained from the EMME model transit network for both the bus and the LRT services. The LRT travel times were estimated by adding each of the travel times between respective stops. The bus travel times were estimated from a 2031 EMME model whose transit network did not include the LRT. Thus, for phasing scenarios C, D and E, the transit travel time was comprised of travel time on the LRT and travel time on a bus. A three (3) minute transfer wait time was included into the overall transit travel time estimate when both the LRT and the bus were used. The value of time was obtained from a 2008 dollar value estimate provided in the *Hamilton Rapid Transit: Making the Case Transportation Case Review* (August 2011) of \$13.02 increased to represent a 2012 dollar value of \$13.87. The travel time cost comparison is summarized in **TABLE 8**.

TABLE 8: Travel Time Cost Comparison

PHASING SCENARIO	INPUTS			MEASURE
	Transit travel time on LRT (min)	Transit travel time on bus (min)	Transfer wait time (min)	Travel time cost (\$/person)
Scenario B: McMaster to Eastgate	31	0	0	\$7.17
Scenario C: McMaster to Ottawa	22.99	13.25	3	\$9.07
Scenario D: McMaster to Queenston	25.3	9.21	3	\$8.67
Scenario E: Downtown to Eastgate	26.32	15.07	3	\$10.26

Scenario B, which is the full LRT from McMaster University to Eastgate Square, provides the lowest travel time cost per transit user. Scenario D has the second lowest travel time cost.

4.3 Community / Environmental Account

The purpose of the Environmental Account is to compare the impacts of the LRT phasing scenarios to the community / social environment. The decrease in level of CO₂ tonnes as a result of LRT implementation was used as the evaluation measure. Further details are provided below.

4.3.1 Air Quality (Greenhouse Gas)

With the implementation of the LRT, there is a potential for existing auto drivers to transfer their primary mode to transit services and become transit users. Fewer auto drivers on the road would lead to a decrease in the amount of CO₂ emissions. The Air Quality measure can therefore be defined as an assessment of the decrease in greenhouse gas (GHG) emissions resulting from LRT phasing scenarios (in CO₂ tonnes).

Specific inputs required for the evaluation of this measure included the following:

- LRT and Bus Passenger kilometres.

In order to determine the reduction in the emission of CO₂ as a result of LRT implementation, the total LRT and bus passenger kilometres travel measures were utilized. The process by which the passenger kilometres were estimated is described in Section 4.1.2. The passenger kilometres were then converted to equivalent auto kilometres assuming an auto occupancy rate of 1.2. The report prepared by Metrolinx titled *Hamilton King-Main Rapid Transit Benefits Case* (February 2010) noted that the greenhouse gases were emitted at a rate of 0.2 kg/km. Based on this emission rate, a maximum reduction in CO₂ emitted was estimated. However, as a detailed emissions model was not prepared for this comparative analysis, this measure was summarized

with an index. A lower index was indicative of a greater decrease in CO₂ emissions. **TABLE 9** provides a summary of reduction in air quality comparison.

TABLE 9: Reduction in Air Quality Comparison

PHASING SCENARIO	INPUTS			MEASURE
	LRT and bus passenger km	Equivalent auto km	Auto CO ₂ (kg)	Decrease in Level of CO ₂ Index
Scenario B: McMaster to Eastgate	100,847,054	84,039,212	16,807,842	1
Scenario C: McMaster to Ottawa	77,770,292	64,808,577	12,961,715	4
Scenario D: McMaster to Queenston	84,483,635	70,403,029	14,080,606	2
Scenario E: Downtown to Eastgate	83,403,888	69,503,240	13,900,648	3

The Air Quality Measure indicates that Scenario B will potentially result in the lowest greenhouse gas emissions with Scenario D producing the second lowest emission level.

4.4 Community / Economic Development and Growth Account

Two measures were identified for the Economic Development and Growth Account. This Account evaluates the potential for increased tax revenue and increased employment opportunities along the corridor. Thus, the measures developed to address both these requirements included accessibility to employment areas and Development Charges (DC) revenues associated with LRT implementation. Further details are provided below.

4.4.1 Accessibility to Employment Areas

The implementation of the LRT would likely improve accessibility to the employment areas in the corridor adjacent to the LRT. In order to capture the influences of LRT phasing scenarios on accessibility to employment areas, the measure is defined as the percentage of employment opportunities adjacent to the B-Line for which improved accessibility is provided. As the entire evaluation is for comparative purposes only, the results of the comparison are provided as an index, specifically the employment accessibility index.

Specific inputs required for the evaluation of this measure included the following:

- GRIDS future employment estimates within 400m of the B-Line LRT alignment;
- New corridor intensification employment opportunities within 400m of LRT; and,
- Annual LRT ridership.

In the City of Hamilton’s Official Plan, future population and employment estimates were based on GRIDS, the City’s Growth Related Integrated Development Strategy. Subsequent to the filing of the Official Plan document, the City of Hamilton received direction from Metrolinx to undertake specific studies with respect to a LRT in advance

of funding contribution opportunities to provide a framework and support for its implementation. The City completed a preliminary design and feasibility study alongside a TPAP for the LRT and has also undertaken corridor studies to identify development and growth opportunities and strategies. In particular, the *Main-King-Queenston Corridor Strategy Study* was completed by the Planning Department that identified higher potential for intensification along the B-Line LRT Corridor alignment as a result of the implementation of the LRT. The employment estimates used to evaluate this measure are therefore based on the sum of the GRIDS employment numbers within 400m of the LRT and the employment intensification identified by the Corridor Strategy Study, which are in addition to any estimates from GRIDS. The Employment Accessibility Index was then calculated by comparing the forecast total employment with the forecast annual ridership. The inputs and resulting measure are presented in **TABLE 10**.

TABLE 10: Comparison of Accessibility to Employment Areas

PHASING SCENARIO	INPUTS			MEASURE	
	2031 GRIDS employment	2031 Corridor employment	B-Line Alignment Ridership (M)	Total employment	Employment Accessibility Index
Scenario B: McMaster to Eastgate	59,932	1,598	20.3	61,530	3.0
Scenario C: McMaster to Ottawa	53,014	757	16.5	53,771	3.3
Scenario D: McMaster to Queenston	54,013	800	17.3	54,813	3.2
Scenario E: Downtown to Eastgate	41,533	958	18.6	42,491	2.3

For this measure, Scenarios B, C and D have very similar index values with Scenario C being slightly higher and thus providing slightly better accessibility.

4.4.2 Increased DC Revenue

The implementation of the LRT could result in an increase in tax revenue due to new residential or commercial developments. To determine each phasing scenario’s impact on economic development, the level of increase in DC revenue is evaluated based on identified new residential and employment developments within 400m of the LRT alignment.

Specific inputs required for the evaluation of this measure included the following:

- Number of new residential units; and,
- Increase in commercial square feet.

The number of new residential units and increase in commercial square footage was provided by the City and reflective of higher intensification along the B-Line LRT corridor alignment as noted in their Corridor Strategy Study. Development Charge (DC) rates for the residential unit and commercial square footage were obtained from a DC Pamphlet issued by the City in the summer of July 2012. The DC rates for an apartment unit and

commercial square footage were noted to be \$15,250 / unit and \$16.03 / square footage. A summary of the evaluation for the increased DC revenues measure is provided in **TABLE 11**.

TABLE 11: Comparison of DC Revenues

PHASING SCENARIO	INPUTS		MEASURE
	# of new residential units	Increase in commercial square feet	Increased DC revenue
Scenario B: McMaster to Eastgate	18106	1,278,082	\$296,604,154
Scenario C: McMaster to Ottawa	12424	605,685	\$199,175,131
Scenario D: McMaster to Queenston	12979	639,854	\$208,186,610
Scenario E: Downtown to Eastgate	13986	766,301	\$225,570,305

Scenario B shows the highest increase in DC revenue. The remaining three phasing scenarios (C, D and E) result in increased DC revenue; however, the revenue increases are much lower than Scenario B. Scenario E has the highest increase in DC revenue of Scenarios C, D and E.

4.5 Community / Social Account

Two measures were identified for the Social Account. This Account evaluates the benefits / impacts that each LRT phasing scenario has on the social fabric as a whole and to the adjacent community. To evaluate the Social Account, community accessibility and connectivity and LRT construction mitigation were identified as appropriate measures. Further details are provided below.

4.5.1 Community Accessibility and Connectivity

Community accessibility and connectivity is a measure that determines that degree of walkability and accessibility to cultural, educational and community facilities. The benefits to the community will be in the phasing scenario's ability to provide accessibility / connectivity within an acceptable environment. More importantly, the LRT phasing scenario should facilitate access to these facilities. The results of this measure are provided as a community exposure index.

Specific inputs required for the evaluation of this measure included the following:

- Number of schools within 400m of the LRT alignment;
- Number of churches within 400m of the LRT alignment;
- Number of libraries within 400m of the LRT alignment;
- Number of community / recreation centres within 400m of the LRT alignment;
- Number of cultural centres within 400m of the LRT alignment; and,
- Future population with 400m of the LRT alignment.

Each of the community facilities was identified from online mapping tools. It was assumed that community / recreational centres included parks whereas cultural centres included points of interest. Future population within 400m of the LRT alignment was based on the sum of GRIDS population estimates and the population intensification potential identified by the Corridor Strategy Study, as described in Section 4.4.1. The Community Exposure Index was calculated by comparing the forecast population with the summation of all the facilities to which accessibility / connectivity was provided. Details of the evaluation are provided in **TABLE 12** below.

TABLE 12: Comparison of Community Accessibility and Connectivity

PHASING SCENARIO	INPUTS					MEASURE	
	# of schools	# of churches	# of libraries	# of com / rec centres	# of cultural centres	2031 Population	Community Exposure Index
Scenario B: McMaster to Eastgate	39	96	5	38	11	100,764	0.53
Scenario C: McMaster to Ottawa	23	75	3	32	11	75,328	0.52
Scenario D: McMaster to Queenston	28	83	4	33	11	82,328	0.52
Scenario E: Downtown to Eastgate	28	73	4	28	8	75,725	0.54

Due to fluctuations in forecast population for each of the phasing scenarios and a similar distribution of community facilities, the LRT phasing scenarios reflect minor variances in the calculated community exposure index. Scenario E provides the highest Community Exposure Index and thus best meets the objectives of this Account.

4.5.2 LRT Construction Mitigation

LRT construction mitigation is an important measure in evaluating the impacts that the construction of the LRT would have on the adjacent community / neighbourhoods and also for the City as a whole. The measure was defined as a comparison of opportunities for reducing LRT construction impacts to autos and buses travelling along the LRT corridor alignment. The results of this measure are provided as the construction mitigation index.

Specific inputs required for the evaluation of this measure included the following:

- Number of segments;
- Segment lengths; and,
- Existing population and employment within 400m of the proposed LRT alignment.

One of the first input requirements was the identification of implementation segments covered by each LRT phasing scenario. The implementation segments were obtained by evaluating the existing road network running parallel to the proposed B-Line LRT corridor alignment, mainly between McMaster University and Eastgate Square. Each

segment was strategically chosen based on the number of alternate routes that would be available during LRT construction. Once the segments were identified, each was provided with a rating of poor (1), medium (2) and good (3). A poor rating indicated that there were a limited number of alternate routes available. A good rating indicated that there were multiple alternate routes available. The rating for each segment was multiplied with the corresponding segment length and the summation of these products was used to provide section ratings for each phasing scenario. The section rating was then compared with the sum total of existing population and employment to obtain the construction mitigation index. A summary of the evaluation findings is provided on

TABLE 13.

TABLE 13: Comparison of LRT Construction Mitigation

PHASING SCENARIO	INPUTS					MEASURE
	# of segments	total rating	section rating (m)	existing population	existing employment	Construction Mitigation Index
Scenario B: McMaster to Eastgate	6	14	28,945	68,278	46,898	0.25
Scenario C: McMaster to Ottawa	4	9	17,885	52,722	42,403	0.19
Scenario D: McMaster to Queenston	5	12	22,985	59,016	43,363	0.22
Scenario E: Downtown to Eastgate	5	13	25,145	52,097	34,005	0.29

Scenario E shows the highest construction mitigation index, which indicates that it has the most alternate routing options available during LRT construction. Scenario B has the second most options for re-routing.

4.6 Community / Urban Development Account

Two measures were identified for the Urban Development Account. As this Account evaluates the benefits / impacts to development opportunities, reurbanization potential and Regional transit connectivity measures were identified for this account. Further details are provided below.

4.6.1 Reurbanization Potential

Reurbanization potential reflects how a phasing scenario supports and influences reurbanization / land use integration, especially in the vicinity of the LRT stations that will promote more compact, mixed use communities. The measure evaluates node development potential along the corridor and community access benefits. The results of this measure are provided as the reurbanization index.

Specific inputs required for the evaluation of this measure included the following:

- Number of focus areas by type;
- Reurbanization potential value;

- Population forecasts within 400m of the LRT alignment; and,
- Employment forecasts within 400m of the proposed LRT alignment.

In the *Main King Queenston Corridor Strategy Study*, a detailed analysis of each of the proposed LRT stations was undertaken to obtain a better understanding of existing land uses and demographics. In the report, each station was evaluated for its potential in becoming a focus area. The number of focus areas within each phasing scenario was then tabulated. The study also rated the development potential of the surrounding station area as either low, medium or high. For the purposes of this evaluation, a numeric value of 1, 2 or 3 representing the low, medium or high rating, respectively, was assigned for each station. The reurbanization potential value was obtained by summing the development potential ratings along each LRT phasing scenario. Future population and employment forecasts were obtained as discussed in Sections 4.4.1 and 4.5.1. The product of the number of focus areas and the reurbanization potential value was then compared with the sum total of future population and employment to obtain the reurbanization index. A summary of the evaluation findings is provided on **TABLE 14**.

TABLE 14: Comparison of Reurbanization Potential

PHASING SCENARIO	INPUTS				MEASURE
	# of focus area by type	Reurbanization potential	Population forecasts	Employment forecasts	Reurbanization Index
Scenario B: McMaster to Eastgate	12	29.5	100,764	61,530	2.181
Scenario C: McMaster to Ottawa	7	19.5	75,328	53,771	1.057
Scenario D: McMaster to Queenston	9	23	82,328	54,813	1.509
Scenario E: Downtown to Eastgate	9	20.5	75,725	42,491	1.561

Scenario B has the highest reurbanization index which demonstrates that it has the best potential to support or influence reurbanization / land use integration. Scenarios D and E have the next highest potentials with Scenario E being slightly higher than Scenario D.

4.6.2 Regional Transit Connectivity

Regional transit connectivity allows for ease of accessibility and transfer to Regional GO and Intercity Bus Transit Services and GO Train services as well as connections to Regional Facilities (e.g., hospitals, universities, colleges, courts, etc.). To evaluate Regional transit connectivity, the measure reviews the accessibility to intercity transit services and Regional facilities. The results of this measure are provided as an accessibility index.

Specific inputs required for the evaluation of this measure included the following:

- Number of Regional facilities within 400m of the LRT alignment;

- GO and Intercity transit terminals within walking distance of LRT service; and,
- Population and employment within 400m of the LRT alignment.

With the aid of online interactive mapping tools, the number of Regional facilities, inclusive of hospitals, universities, colleges and courts, and GO and intercity transit terminals tabulated. The sum total of the facilities and terminals for each LRT phasing scenario was then compared to future population and employment forecasts to obtain the accessibility index. A summary of the findings are provided in **TABLE 15**.

TABLE 15: Comparison of Regional Transit Connectivity

PHASING SCENARIO	INPUTS				MEASURE
	# of Regional facilities	GO and intercity transit terminals	Population forecasts	Employment forecasts	Accessibility Index
Scenario B: McMaster to Eastgate	19	5	100,764	61,530	6.8
Scenario C: McMaster to Ottawa	18	4	75,328	53,771	5.9
Scenario D: McMaster to Queenston	18	4	82,328	54,813	6.2
Scenario E: Downtown to Eastgate	16	2	75,725	42,491	6.6

Scenarios B and E show the highest accessibility index, which indicates that these two LRT phasing scenarios provide the greatest accessibility to intercity transit services and Regional facilities.

5 Summary of Evaluation

The MAE procedure is designed such that the performance of each of the LRT phasing scenarios can be easily summarized through a comparison table. The evaluation summary identifies the implications and advantages / disadvantages of the alternatives, in comparison with each other. One method by which this can be accomplished is through a five (5) point scale for each criterion and then providing a summary point scale for the overall account for each alternative. Another method is to utilize a comparative weighting system (e.g., worse, better, best or 1, 2, 3 check-marks, or open, half and full circles) for the criterion being evaluated from a qualitative perspective.

For the purposes of the Hamilton B-Line LRT Phasing Study, the comparative weighting system was utilized. Each LRT phasing scenario was assigned a rating of 1, 2, 3 or 4, with a “1” being assigned to the phasing scenario that best met the criteria being evaluated and a “4” being assigned to the phasing scenario that was the poorest in meeting the criteria being evaluated. Each measure was assigned a rating and in the instances where there was more than one measure in the account, a sum total of the rating for each measure was obtained to determine an overall weight for the account.

As funding availability plays an important role in the implementation of the LRT, the Financial Account was summarized on its own, as presented in **TABLE 16**. The results of the MAE indicate that the full LRT from McMaster University to Eastgate Square best meets the criteria identified for all three measures under the Financial Account. Scenario D, with the LRT extending from McMaster University to Queenston Circle, follows closely behind as the second best phasing scenario from a financial perspective.

TABLE 16: Financial Account Summary

Phasing Scenario	Capital Measure	Operating Measure	Cost Effectiveness Measure	Overall Financial Account
Scenario B: McMaster to Eastgate Square	1	1	1	1
Scenario C: McMaster to Ottawa Street	3	3	3	3
Scenario D: McMaster to Queenston Circle	2	2	2	2
Scenario E: Downtown to Eastgate Square	4	4	4	4

While Scenario B best met the criteria from the financial perspective, it was also necessary to determine the phasing scenario that would best meet the criteria of the community, whether it be the City of Hamilton as a whole or the community adjacent to the B-Line LRT Corridor. The remaining five Community Accounts, namely the User Benefit Account, the Environmental Account, the Economic Development Account, the

Social Account and the Urban Development Account, evaluated the overall quality of life or improvements / benefits to the community. The ability of each LRT phasing scenario to meet the criteria in each of the accounts was then summarized, as shown in **TABLE 17**, using the same rating system as the Financial Account. The Community Account Summary indicates that Scenario B, the full LRT between McMaster University and Eastgate Square, best meets the criteria for four out of the five Community Accounts, with Scenario D as the second best LRT phasing scenario.

TABLE 17: Community Account Summary

Phasing Scenario	User Benefit Account	Environmental Account	Economic Development Account	Social Account	Urban Development Account	Overall Community Account
Scenario B: McMaster to Eastgate Square	1	1	1	2	1	1
Scenario C: McMaster to Ottawa Street	3	4	2	4	4	4
Scenario D: McMaster to Queenston Circle	2	2	2	3	3	2
Scenario E: Downtown to Eastgate Square	4	3	3	1	2	3

Based on the comparative analysis undertaken for each of the financial and community accounts, Scenario B represents the LRT phasing scenario that best meets the financial as well as the community criteria. A summary of the overall phasing evaluation is shown in **TABLE 18** with the best ranked phasing scenario shown in **FIGURE 6**.

TABLE 18: Summary of Phasing Evaluation

Phasing Scenario	Financial Account	Community Account	Overall MAE Ranking
Scenario B: McMaster to Eastgate Square	1	1	1
Scenario C: McMaster to Ottawa Street	3	4	3
Scenario D: McMaster to Queenston Circle	2	2	2
Scenario E: Downtown to Eastgate Square	4	3	3

FIGURE 6: Scenario B – McMaster University to Eastgate Square



APPENDICES