ATTACHMENT 2

Multiple Account Evaluation

Saskatoon BRT

City of Saskatoon

March 2018

Executive Summary

The City of Saskatoon is currently conducting planning and development studies of a Bus Rapid Transit (BRT) system for the City. The BRT system is expected to better accommodate the City's future growth and development objectives. In order to better understand how BRT may support these objectives and whether its benefits justify the costs, it is necessary to analyze the benefits, impacts, and costs of a BRT system in a structured evaluation framework.

Approach

The approach adopted for this study is the Multiple Account Evaluation (MAE), a type of socio-economic evaluation of investments that incorporates a wide range of user, financial, environmental, and broad socio-economic impacts that serve as evaluation criteria. The impacts include both quantitative and monetized impacts as well as qualitative impacts. The latter impacts are effects which can be considered important but which are difficult to quantify and monetize. The specific evaluation criteria were structured into categories, or accounts, as outlined below.

- **Transportation User Benefits Account.** This account includes travel time savings to highway users, vehicle cost savings, travel time impacts for BRT trips diverted from auto, travel time savings to transit users, transportation benefits to induced BRT users, safety improvements, transit reliability improvements, passenger comfort and trip attractiveness improvements.
- **Financial Account.** Includes factors such as incremental capital and operating costs but also fare revenue, pavement cost savings, and infrastructure adaptability and flexibility.
- **Environmental Account.** This account captures changes in greenhouse gas emissions and their monetary valuation of emissions avoided (or increased).
- **Economic Development Account.** This account captures the broad effects on the economy, or factors and issues that may affect the economic development in the project area, including community and land value uplift, land use shaping, employment, and network connectivity.
- **Social and Community Impacts Account.** This account presents the effects on the quality of life in the project area, including air emissions, health benefits, quality of life, and transportation equity.

The following are the key assumptions that frame the entire analysis:

- All monetary values are expressed in 2017 dollars.
- The period of analysis begins in 2019 and ends in 2041. It includes 3 years of project development and construction years (2019-2021) and 20 years of operations from 2022 to 2041.
- The benefits of BRT are assumed to be fully realized starting from the first year of full operations in 2022, i.e. no ramp-up to benefits realization is assumed.
- Quantified and monetized benefits and impacts are evaluated at a constant 3% real discount rate, and at an 8% discount rate.
- The base year of the analysis is 2018, i.e. all monetized benefits and impacts are discounted to that year.
- The quantified impacts shown in this document correspond to the effects of the build alternative at the mid-point of ridership estimates, at the level of 10,000 average daily trips.

The analysis quantified and monetized the following benefits and impacts (while the remaining benefits and impacts were considered in a qualitative manner):

- Transportation user benefits and impacts
    - Travel time savings to highway users remaining after BRT opening
    - Out-of pocket vehicle costs savings
    - Travel time impacts to BRT transit riders who diverted from auto
    - Travel time savings to existing transit users migrating to BRT
    - Transportation benefits to induced BRT riders
    - Safety and accident reduction benefits
- Financial impacts:
    - Fare revenue
    - Capital costs
    - Incremental operating costs
    - Pavement maintenance cost savings
- Environmental impacts
    - Reduction in greenhouse gas emissions
- Economic development impacts
    - Livability and property value uplift
- Socio-Community impacts
    - Reduction in air emissions
    - Health benefits.

The input assumptions adopted to estimate the quantified benefits, costs, and impacts are based on specific project information and projections (including project capital and operating costs, vehicle kilometers traveled in BRT corridors, ridership, and BRT operating characteristics), general practice for this type of evaluations, relevant literature on related issues, and economic data from Statistics Canada.

Results

Summary Table 1 presents the MAE outcomes. The table demonstrates that travel time savings to existing transit users represent the largest benefit. At the 3% discount rate, this benefit amounts to $145.4 million and at the 8% discount rate it amounts to $78.8 million. The second largest benefit is the land value uplift in the amount of $72 million at the 3% discount rate and $51.9 million at the 8% discount rate. This is followed by out-of-pocket costs savings to auto users diverting to transit, benefits to induced riders, and health benefits. Environmental impacts are relatively small at less than $1 million.

Infrastructure costs amount to $96.8 million and $87.8 million at the 3% and 8% discount rates, respectively. Incremental operating costs amount to $13.6 million and $7.8 million at the 3% and 8% discount rates, respectively. Incremental fare revenues due to induced ridership and ridership diverted from auto amount to $17.6 million and $9.8 million at the 3% and 8% discount rates, respectively, providing offset to incremental operating costs.

Comparing the magnitude of monetized impacts outlined above with costs, we can see that at the 3% discount rate travel time savings to BRT users alone are greater than the BRT costs. Although at the 8% discount rate travel time savings to transit users do not exceed costs, other benefits are also substantial, including transportation benefits to induced riders. The total value of transportation user benefits and impacts amounts to $185.6 million at the 3% discount rate and $100.6 million at the 8% discount rate. Therefore, the proposed BRT would pay for its costs in terms of transportation user benefits that it is expected to generate.

Summary Table 2 provides a specific account of quantified and monetized net benefits, costs, net present value and benefit-cost ratio. The table shows that the net present value of the proposed BRT amounts to $169.4 million at the 3% discount rate and $69.3 million at the 8% discount rate. The benefit-cost ratio amounts to 2.5 at the 3% discount rate and 1.7 at the 8% discount rate. These outcomes can be rated as very good project performance.

In addition, the proposed BRT project has a range of other benefits as compared to the traditional transit bus which are difficult to quantify. These benefits are considered and discussed in this report in in qualitative terms. The key of these benefits and impacts include:

- Improved reliability;
- Greater attractiveness and convenience;
- Improved transit network connectivity;
- Potential to be a catalyst for residential and commercial development around stations; and
- Improved public transportation options which contribute to higher quality of life, improved mobility and reduction in transportation access inequities across socio-economic groups.

In conclusion, the proposed BRT is expected to generate significant benefits to the City of Saskatoon that exceed total costs of the project even at the conservative discount rate of 8%. Qualitative benefits of the project, essentially improved quality of transportation, convenience, greater mobility for a wide range of population groups (including disadvantaged groups and those who do not drive), further strengthen the business case.

Summary Table 1: MAE Benefits and Impacts, by Category

Benefit or Impact Name	**Quantified and Monetized Impacts ($Millions)**		**Summary of Outcomes for Qualitative Factors**
	3% Discount Rate	**8% Discount Rate**	
Transportation User Benefits			
Travel Time Savings to Highway Users	$13.3	$7.1	
Out-of-Pocket Vehicle Costs Avoided	$26.0	$14.4	
Travel Time Impacts to Transit Users Diverted from Auto	-$24.8	-$13.6	
Travel Time Savings to Existing Transit Users	$145.4	$78.8	
Transportation Benefits to Induced Riders	$19.6	$10.6	
Safety, Accident Reduction	$6.0	$3.3	
Transit Reliability			Improved reliability due to greater frequency, design factors, and implementation of traffic management systems.
Passenger Comfort, Ride Quality and Attractiveness			More attractive and convenient to riders compared to traditional bus due to factors such as greater frequency, greater reliability, and higher speeds.
Financial and Infrastructure Impacts			
Fare Revenues	$17.6	$9.8	
New Infrastructure Capital Costs	$96.8	$87.8	

Benefit or Impact Name	**Quantified and Monetized Impacts ($Millions)**		**Summary of Outcomes for Qualitative Factors**
	3% Discount Rate	**8% Discount Rate**	
Incremental Operating Costs	$13.6	$7.8	
Operating Costs Savings			There will be changes in operations of regular buses but no net change in transit operating costs.
Pavement Maintenance Savings	$0.1	$0.0	The incremental effects on pavement maintenance costs are very small (although larger than $0).
Infrastructure Adaptability and Flexibility			Gives greater adaptability and flexibility than LRT solutions but no significant difference expected compared to regular bus (same vehicle technology).
Environmental			
Reduction in GHG Emissions	$0.4	$0.2	
Economic Development			
Community / Livability and Land Value Uplift	$72.0	$51.9	
Land Use Shaping and Improvement to the Urban Realm			Project may be a catalyst to high density residential and commercial development and redevelopment around transit stations. Some of this development may represent reallocation from elsewhere, or also be attributed to/ attracted by other street improvements.
Direct and Indirect Employment			Project will contribute to construction and engineering jobs during its development and construction phase.
Network Connectivity			This BRT project will also involve the entire system redesign, including routes and schedules of the regular (non-BRT) buses to improve connectivity to the BRT lines and the destinations served by it.
Socio-Community Impacts			
Reductions in Air Emissions	$0.10	$0.06	
Health Benefits	$4.1	$2.3	
Quality of Life, Mobility, and Accessibility Improvements			Improves transportation options to Saskatoon's residents by creating a new, affordable, high quality public transportation option, faster than the regular transit bus.
Transportation Equity			As above; new transportation option particularly valuable to disadvantaged populations who cannot afford a vehicle and/or cannot drive for various reasons. This will help reduce transportation access inequities.

Note: All monetary impacts are in terms of 2017 dollars, expressed in present value terms over the period 2019-2041 discounted to 2018.

Summary Table 2: Cost-Benefit Analysis Outcomes

Financial Indicators	3% Discount Rate	8% Discount Rate	Undiscounted
Total Costs, $M	$110.4	$95.6	$123.0
Total Benefits, $M	$279.8	$164.9	$404.0
NPV, $M	$169.4	$69.3	$281.0
Benefit-Cost Ratio, Ratio	**2.5**	**1.7**	**3.3**
Internal Rate of Return (IRR), Percent	16.9%		

Note: All monetary impacts are in terms of 2017 dollars, expressed in present value terms over the period 2019-2041 discounted to 2018.

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1. Introduction

The City of Saskatoon is currently conducting planning and development studies of a Bus Rapid Transit (BRT) system for the City. The BRT is expected to better accommodate the City's future growth and development objectives.

In order to better understand how BRT may support these objectives and whether its benefits and impacts justify the costs, it is necessary to analyze the benefits, impacts, and costs of a BRT system in a structured evaluation framework.

One of such frameworks frequently used for the public infrastructure project proposals is the Multiple Account Evaluation (MAE), a type of socio-economic evaluation of investments. The MAE framework incorporates a wide range of relevant evaluation criteria, both quantitative and monetized benefits and costs, as well as qualitative factors which are important but difficult to measure, and externalities. The evaluation criteria are structured into categories, or accounts, which typically include the following:[1]

- Customer Service, or User Benefits Account: analyzes direct and indirect benefits and impacts of the proposed project.
- Financial Account: analyzes the cost impacts of the project, in particular capital costs, operating costs, and other related costs and financial implications.
- Environmental Account: analyzes the effects on greenhouse gases.
- Economic Development Account: analyzes the broad effects on the economy, or factors and issues that may affect the economic development in the project area.
- Social and Community Impacts Account: analyzes the effects on the quality of life in the project area, social inclusiveness, and health.

MAE is, in its essence, an extension of the cost-benefit analysis in that it incorporates explicitly non-quantifiable factors important to consider in project evaluation to present them along with monetized benefits and costs and financial performance metrics such as net present value, or benefit-cost ratio. This is intended to provide a more comprehensive picture of the project, with its impacts and implications to a wide range of stakeholders.

The purpose of this study is to conduct a MAE of the proposed Saskatoon BRT project. In this report, Section 2 presents the MAE framework with its specific benefits, impacts, and costs, discusses their nature, the approach to quantification (for those benefits, impacts and costs which are possible to quantify), and the data used in this evaluation. Section 3 presents the results and in particular quantified benefits, costs, net present value, and benefit-cost ratio. Section 4 provides concluding observations.

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[1] Examples of agencies which practice a similar Multiple Account Evaluation framework include British Columbia Ministry of Transportation and Infrastructure (see BC Ministry of Transportation and Infrastructure, "Appendix 4, Option Evaluation Guidelines for MoTI Business Cases including Multiple Account Evaluation", updated December 2014; https://www.th.gov.bc.ca/publications/planning/Guidelines/Business%20Case%20Guidelines/4_Appendix_4-Option_Evaluation_MAE_2014-04-16.pdf)

2. Proposed MAE Framework, Data and Assumptions

The approach adopted for this study is the Multiple Account Evaluation (MAE), a type of socio-economic evaluation of investments that incorporates a wide range of user, financial, environmental, and broad socio-economic impacts that serve as evaluation criteria. The impacts include both quantitative and monetized impacts as well as qualitative impacts. The latter impacts are effects which can be considered important but which are difficult to quantify and monetize. **Table 3** provides an overview of the impact categories assessed in this engagement under the MAE framework.

Table 3: Benefits and Impacts of BRT (Relative to No-Build), by Account

Category / Account	Benefit or Impact Name	Description	Monetized or Qualitative Impact?
Transportation User Benefits	Travel Time Savings to Highway Users	Travel time savings to remaining roadway users.	Monetized
	Out-of-Pocket Vehicle Costs Avoided	Monetary cost savings to drivers diverting to BRT (avoided vehicle operating costs net of transit fare payments).	Monetized
	Travel Time Impacts to Transit Riders who Diverted from Auto	Additional travel time cost to drivers diverting to BRT. Travel time on transit offsets to some extent the out-of-pocket travel vehicle costs.	Monetized
	Travel Time Savings to Existing Transit Users	Travel time savings to existing (Base Case) transit users due to faster speed and shorter wait times on BRT.	Monetized
	Transportation Benefits to Induced Riders	Consumer surplus or welfare benefit to induced or new riders who were not travelling before the Project.	Monetized
	Safety, Accident Reduction	Reduction in property losses, injuries, and fatalities due to modal shift.	Monetized
	Transit Reliability	High-order and high-capacity transit systems like BRT are usually considered more reliable with better performance.	Qualitative; difficult to quantify without detailed data.
	Passenger Comfort, Ride Quality and Attractiveness	High-order and high-capacity transit systems like BRT are frequently considered more convenient and more attractive to riders.	Qualitative; partially accounted for under other user benefits.
Financial Impacts	Fare Revenues	Additional fare revenues of transit agency from incremental BRT ridership.	Monetized
	New Infrastructure Capital Costs	Capital costs of proposed BRT, including roadway, transit vehicles, equipment, and ROW.	Monetized
	Incremental Operating Costs	Additional related BRT operating costs (labour, supplies, services, etc.).	Monetized
	Operating Costs Savings	Operating cost savings elsewhere in the system, e.g. reduction in the costs of services which become redundant.	Monetized
	Pavement Maintenance Savings	Reduction in highway pavement maintenance costs due to reduction in auto/bus VKT.	Monetized
Financial Impacts (cont'd)	Infrastructure Adaptability and Flexibility	Ability to modify the system and structures to better fit to evolving needs.	Qualitative; difficult to monetize when future needs are not fully understood.

Category / Account	Benefit or Impact Name	Description	Monetized or Qualitative Impact?
Environmental	Reduction in GHG Emissions	Reduction in GHG emissions due to reduction in highway VKT.	Monetized
Economic Development	Community/Livability and Land/Property Value Uplift	Option, amenity, and/or use value of proposed BRT as manifested in the increase in property values.	Monetized
	Land Use Shaping and Improvement to the Urban Realm	High capacity transit is often seen as a potential catalyst to development and re-development of areas around stations.	Qualitative
	Direct and Indirect Employment	During construction, large scale transit projects contribute to job creation in the construction, engineering, and other industries related to it through supply relationships.	Qualitative
	Network Connectivity	A well designed system may improve connectivity between large employment centres and residential areas, a potential source of qualified labour force.	Qualitative
Socio-Community Impacts	Reductions in Air Emissions	Reduction in emissions of air pollutants (NOX, VOCs, PM, SOX) due to reduction in VKT.	Monetized
	Health Benefits of Increased Physical Activity	Transit transportation offers riders opportunities to increase their level of physical activity through daily walking and improve their health status.	Monetized
	Quality of Life Improvements/ Mobility and Accessibility Improvements	Improved transit services with greater network connectivity may also improve mobility of disadvantaged populations who don't have access to a private car.	Qualitative
	Transportation Equity	Better transit service may improve transportation options to disadvantaged population groups without access to a private car.	Qualitative

The monetized benefits and costs will be used to calculate the Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR) which are the key quantitative metrics used to determine the economic merits of an investment project and compare investment options that may be available.

The sections that follow provide a description of the specific proposed methodology and inputs that would be used to estimate the various quantitative monetized benefits and impacts, including capital costs and incremental operation and management costs, which would be included in the calculation of the benefit-cost ratio for the proposed BRT. A discussion of qualitative MAE benefits of BRT systems which cannot be easily quantified and monetized is also presented.

2.1 General Assumptions

All benefits and costs of the proposed investment are analyzed (and calculated in quantitative terms where possible) in relation to the no-build scenario. For the purpose of this evaluation, the no-build scenario is assumed as a business-as-usual situation without transformative investments and status-quo level of services.

NPV, BCR and IRR are metrics which require estimates of the benefits and costs over the entire life-cycle of the project evaluated, typically a period of 20 to 30 years. Therefore all inputs, or factors driving the magnitude of various costs and benefits have to be forecasted over that period, and all costs and benefits are estimated for each year of the analysis period.

Future benefits and costs are weighted against today's benefits and costs through discounting. This reflects society's general preference for the present as well as helps to compare costs and benefits that may be occurring at various points in time (such as upfront capital costs with benefits that may be taking place in a more distant future).

All costs and benefits are measured in (or converted to) monetary terms to the extent possible and using industry accepted valuation techniques, approaches, and input assumptions (such as the value of travel time savings). Attention is paid to inflationary influences and expressing all monetary values in dollars of the same year. Also, attention is paid to avoidance of double counting of effects which are essentially another manifestation of the same effects already accounted for elsewhere. The general principle is to avoid overestimation of benefits and underestimation of costs.

The input assumptions for estimation of the various benefits and costs are based on specific project information, general practice for this type of evaluations, relevant literature, and economic data from Statistics Canada. Detailed assumptions used to estimate various benefits and costs are specified in the methodology sections that follow. Below, we list key general assumptions that frame the entire analysis.

- All monetary values are expressed in 2017 dollars.
- The period of analysis begins in 2019 and ends in 2041. It includes 3 years of project development and construction years (2019-2021) and 20 years of operations from 2022 to 2041.
- The benefits of the BRT are assumed to be fully realized starting from the first year of full operations in 2022, i.e. no ramp-up to benefits realization is assumed.
- A constant 8 percent real discount rate is assumed throughout the period of analysis. The real discount rate of 3 percent is used for sensitivity analysis.
- The base year of the analysis is 2018, i.e. all costs and benefits are discounted to that year.
- The results shown in this document correspond to the effects of the build alternative.
- The annualization factor used to convert the daily ridership data to annual data is 286.

2.2 BRT Demand and Road Traffic in BRT Road Corridors

As of March 2018, and taking into account March 2018 conditions, demand for BRT is estimated in the range of between 8,600 and 12,500 average daily trips, and is expected to grow at an average annual rate of growth of 2.1%. This analysis is based on the mid-point of about 10,000 daily trips as the most likely demand.

It is expected that this ridership will be composed of the following sources: (1) trips diverted from auto, (2) induced trips by individuals who were not travelling before BRT, and (3) existing transit users who migrated to BRT for the trip leg serviced by the BRT. It is assumed that the latter group would account for 65% of ridership. This implies that the first two groups would account for a total of 35%. The shares of these groups were split equally at 17.5% each. It is noted that these shares are also consistent with the literature that documented the experience with BRT ridership in other cities.[2] Additional assumptions were also made regarding the distribution of the ridership between peak and off-peak hours. All assumptions are summarized in **Table 4** below.

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[2] Transit Cooperative Research Program (TCRP Report 118), "Bus Rapid Transit Practitioner's Guide", 2007, and Ingvardson, Jesper Blafoss and Otto Ankel Nielsen, "Effects of New Bus and Rail Rapid Transit Systems – An International Review", Journal of Transport Reviews, Vol. 38, 2018 (Issue 1), based on Dario Hidalgo, "Are Trains Better Than Rapid Transit Systems? A Look at the Evidence", The City Fix http://thecityfix.com/blog/are-trains-better-than-bus-rapid-transit-systems-a-look-at-the-evidence-dario-hidalgo/ (accessed January 2018).

Table 4: Key Ridership Input Statistics

Ridership Statistics and Inputs	Value
Percent ridership (total) that is in peak hours	50%
Percent ridership diverted from auto that is in peak hours	80%
Total daily ridership (2018 conditions)	10,000
Percentage of ridership diverted from auto	17.5%
Percentage of ridership that is induced	17.5%
Percentage of Existing Ridership	65%
Existing Transit Ridership in Corridor, Total	6,500
Induced Riders, Total	1,750
Ridership Diverted from Auto, Total	1,750
Ridership Diverted from Auto, Peak	1,400
Ridership Diverted from Auto, Off-Peak	350

Auto vehicle kilometres travelled (VKT) in the BRT corridors are estimated at 308,792,221 annually with about 30% of this traffic occurring during peak hours.[3] The average peak period speed along the corridors was estimated in September 2017 using a travel survey method.[4] Depending on the direction of travel and segment, the speed varied from about 25 km/h to about 40 km/h. The average amounted to 31.3 km/h.

2.3 Transportation User Benefits

The proposed BRT could generate a range of mobility benefits stemming from time and money costs of travel. In this analysis, the key measures of mobility improvements considered and quantified are:

- Travel-time savings to existing users of transit and highway corridor;
- Out-of-pocket transportation cost savings to existing users of transit and highway; and
- Mobility benefits to induced transit riders (individuals who were not travelling before the project).

These benefits are often referred to as transportation user benefits.

Travel time savings will be enjoyed by highway users who continue using auto as well as by the existing transit users. Auto users enjoy travel time savings because of a reduction in highway VKT and resulting increase in average speeds when some auto users switch to transit and some conventional bus services are diverted to the BRT corridor/or lanes. Transit users may experience travel time savings to the extent that the new BRT operates at a higher average speed, with higher frequencies, or offers better connections, or a more direct route.

Out-of-pocket transportation cost savings, including expenses on fuel and parking, will be enjoyed by auto users who divert to the new BRT. Since they have to pay a fare for the use of the transit system, fare payments are deducted from these savings. In addition, it can be argued that these users will be incurring a dis-benefit of longer travel time as for a given origin-destination pair transit travel usually takes more time than travel by private auto. The monetized value of this additional time should be deducted from the estimated vehicle costs savings.

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[3] This estimate is based on AADT traffic reports at the intersections along the proposed BRT routes. The number of vehicles was multiplied by the length of the relevant segment to obtain the segment VKTs. The sum of VKTs across all segments gave then total VTKs. It is noted that traffic volumes at different points along the BRT routes pertain to different years between 2007 and 2016. For the purpose of this evaluation, all traffic volumes were adjusted to 2016 assuming an average annual rate of growth of 1.8%.

[4] “Existing Conditions Report”, Bus Rapid and Conventional Transit Planning Services, November 2017.

Induced riders will be enjoying the benefit of economic value that they receive from the new BRT service. These benefits are estimated using the “rule-of-a-half”, which entails calculation of the change in price or travel cost with the BRT compared to the regular bus transit multiplied by the number of induced trips and divided by two.

The methodology of estimating various benefits and input data are discussed in some detail below.

Auto Travel Time Savings

Approach

Figure 1 shows the estimation of travel time savings to auto users who continue driving in the existing travel corridor after BRT opens.

Travel time savings are estimated as the difference between the travel time under the no-build case and under the build case for the remaining traffic which are then monetized using the value of time. Under the build scenario, travel times are expected to be lower as the volume of highway travel is lower with some auto users diverting to transit. The value of travel time savings is assumed to grow over time in real terms to account for expected growth in real incomes over time, and is multiplied by the average vehicle occupancy to capture the value of time for all vehicle occupants.

Auto traffic remaining under BRT is estimated separately as no-build traffic minus traffic diverted to BRT after its opening. Traffic diverted, in turn, is estimated as a percentage of initial BRT ridership that diverted from auto multiplied by average trip length and divided by average vehicle occupancy to account for situations when auto trips diverted have more than one vehicle occupant.

Speed-flow equations are used to predict the average future speed for the no-build and build scenario travel volumes based on the assumed initial no-build speed that is consistent with the actual road traffic situation in the affected corridors. A Bureau of Public Roads speed-flow relationship (the BPR curve) is used for this purpose.[5]

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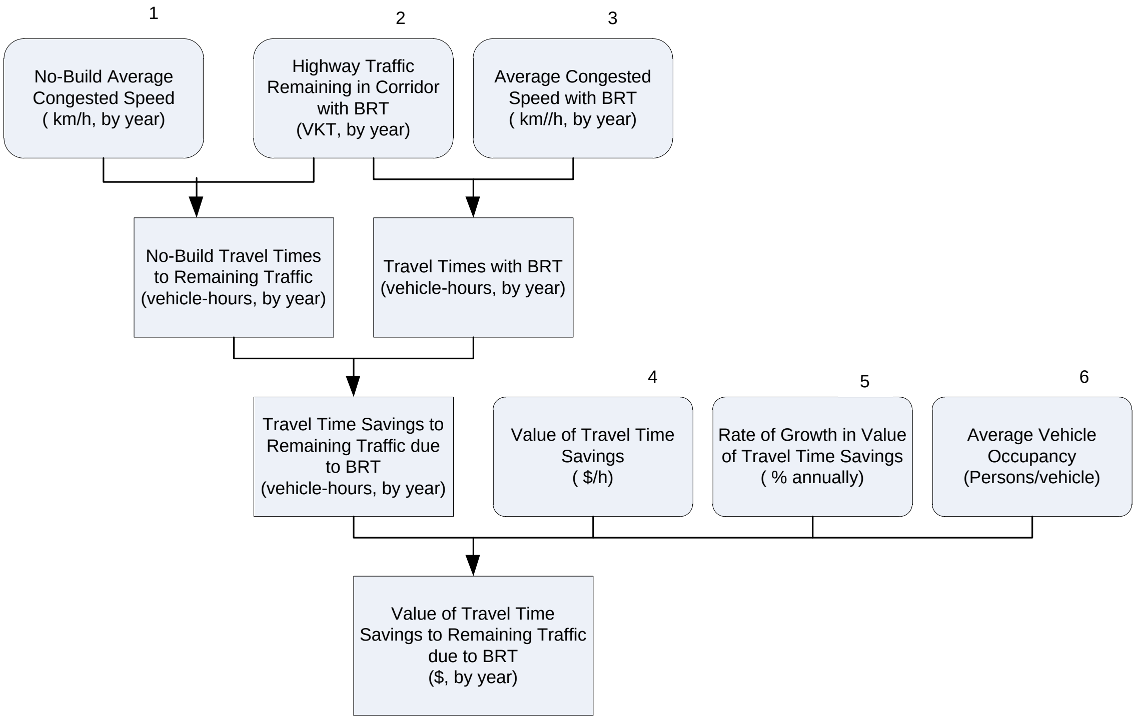
[5] The BPR the curve used in this analysis has the coefficient equal to 0.15. Since the standard BPR exponent of 4 results in rapid speed decline over time as traffic increases (to levels which may be considered very low), the exponent was calibrated to achieve the average speed at the end of the analysis period of about 27 km/h. Free-flow speed was assumed at 60 km/h.

Figure 1: Estimation of Travel Time Savings to Remaining Auto Users



Assumptions

The specific assumptions used in the estimation of travel time savings to auto users who continue driving are summarized in **Table 5** below. Note that travel time savings are considered only for peak period traffic. This is because data on travel speeds during off-peak hours was not readily available at the time of conducting this evaluation. It is noted, however, that auto diversion to BRT during off-peak period is expected to be minimal relatively to total traffic and thus unlikely to have any material impacts on travel times to the remaining off-peak auto traffic.

Table 5: Assumptions for Estimation of Travel Time Savings to Remaining Auto Users

Input #	Input Name	Value	Source/Comment
1	Initial No-build Speed, Peak Period, km/h	31.3	Existing Conditions Report, November 2017. Speeds for subsequent years are calculated with the BPR curve.
2	Highway Traffic Remaining in Corridor		
	No-Build Traffic Volume in Corridor, Peak Period, 2016	92,637,631	Developed by HDR team based on AADT reports.
	Rate of Growth, Average Annual %	1.80%	City of Saskatoon, ADT forecasts for streets within BRT corridors.
	Auto VKT Avoided		
	Daily BRT Transit Ridership	10,000	Developed by HDR team.
	Average Annual Rate of Growth in BRT Transit Ridership	2.1%	City of Saskatoon, Plan for Growth
	Percentage of Ridership Diverted from Auto	17.5%	Based on literature; experience in other cities with a BRT system, TCRP Report 118, Ingvardson and Nielsen (2018).
	Average Auto Occupancy	1.1	City of Saskatoon
	Average Auto Trip Length	6	City of Saskatoon.

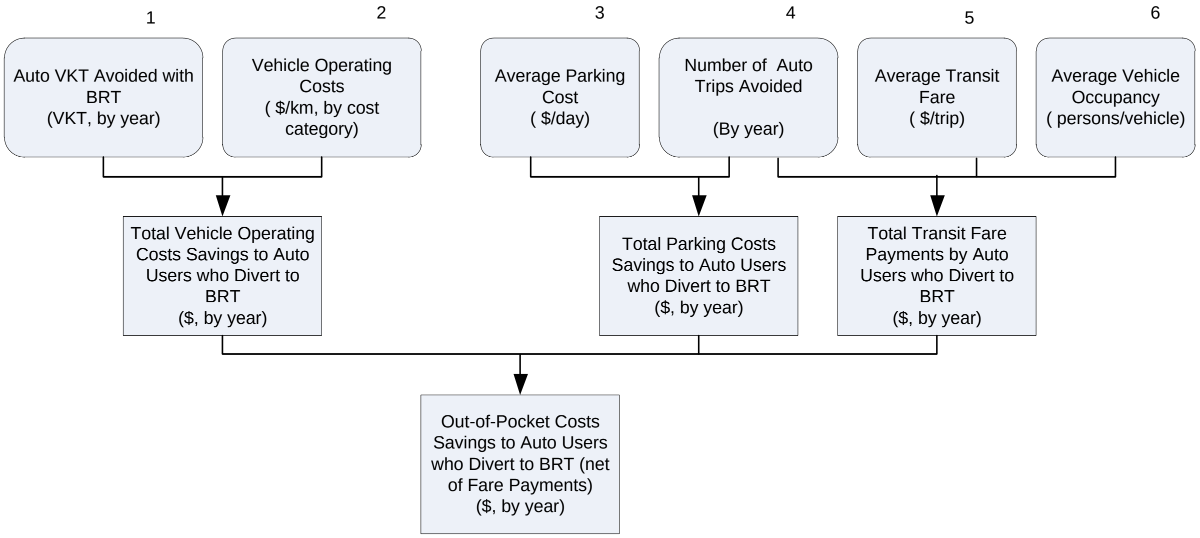
Input #	Input Name	Value	Source/Comment
	Percent of Diverted Ridership that is in Peak Hours	80%	Reasoned assumption, expect that most diversion would be for commuting trips.
3	Average Congested Speed after BRT	varies	Calculated in the model based on BPR curve.
4	Value of time, $/h	$19.62	Calculated by HDR as 50% of median household wage in Saskatoon (median income divided by 1950); 2016 Census, adjusted to 2017.
5	Real Growth Rate in Value of Time, % Annually	1.5%	Historical and current trends in real wage growth in Saskatoon and province.
6	Average Vehicle Occupancy	1.1	City of Saskatoon.

Out-Of-Pocket Cost Savings

Approach

Figure 2 shows the estimation of out-of-pocket cost savings to auto users switching to BRT. Savings in vehicle operating costs are driven by the reduction in VKT which is then multiplied by vehicle cost per km that includes fuel and other pertinent vehicle costs. This is then supplemented by savings in parking cost and reduced by transit fare payments. In the calculation of parking costs, number of auto trips avoided is divided by two as one daily parking fee covers two auto trips (to and from the trip destination). Average transit fare is multiplied by average auto occupancy to account for situations when auto trips diverted from highway to BRT have more than one vehicle occupant. Total fare payments are deducted from the sum of vehicle operating cost savings and parking cost savings to give the net savings in out-of-pocket costs of travel.

Figure 2: Estimation of Out-of-Pocket Costs Savings to Auto Users Diverting to BRT



Assumptions

Table 6 shows the assumptions used in the estimation of out-of-pocket travel cost savings. As explained earlier, vehicle operating cost savings depend on the amount of VKT avoided which are monetized using a cost per VKT assumption and the value of parking charge. Vehicle operating costs are assumed constant during the analysis period. This benefit is calculated only for the peak period.

Table 6: Assumptions for Estimation of Out-of-Pocket Costs Savings to Auto Users Diverting to BRT

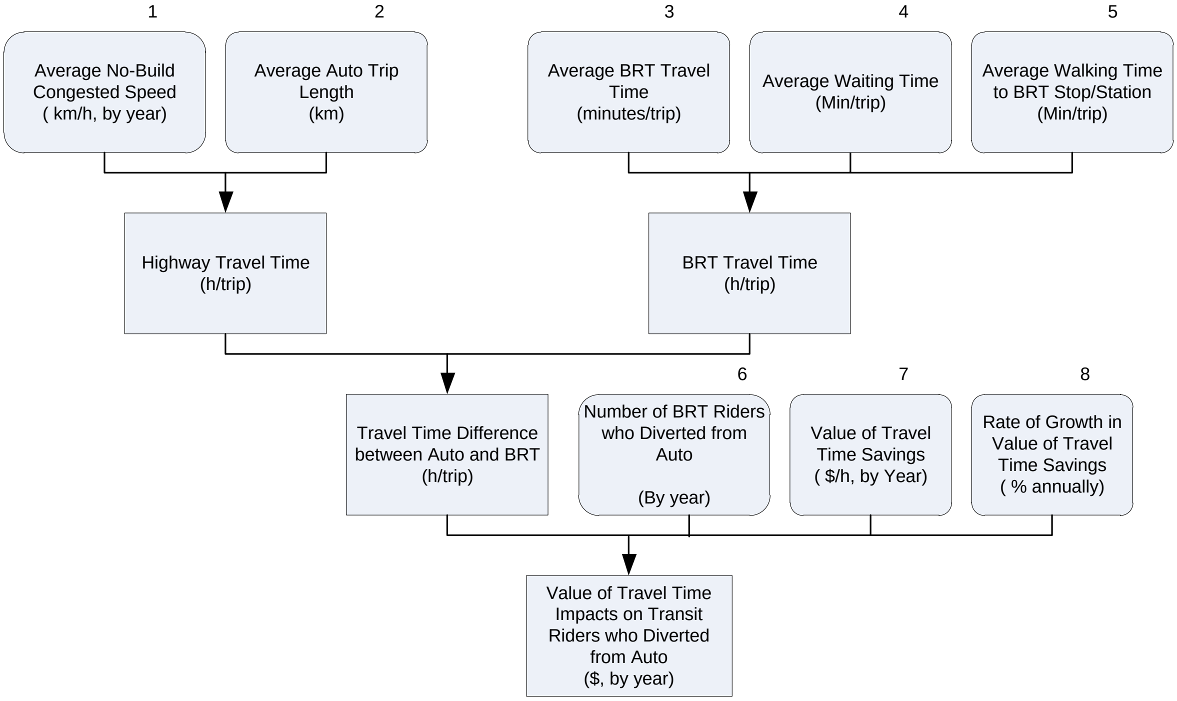
Input #	Input Name	Value	Source/Comment
1	Auto VKT Avoided, Annual VKT		Calculated as for travel time savings to remaining highway traffic.
2	Vehicle Operating Costs, $/km	$0.35	Sum of the items below.
	Gas	$0.13	Driving Costs Calculator, CAA, crossover vehicle type for Saskatchewan for 2017. Accessed March 2018.
	Vehicle Depreciation	$0.22	Driving Costs Calculator, CAA, crossover vehicle type for Saskatchewan for 2017. Accessed March 2018.
3	Average Parking Cost, $ per Day	$6.0	Based on monthly parking rate of $120, lower value of parking options in downtown (Impark Parking, accessed December 2017). Equivalent to $3.00 per trip.
4	Number of Auto Trips Avoided		Calculated using similar approach as VKT avoided.
	Daily BRT Transit Ridership	10,000	HDR team.
	Average Annual Rate of Growth in BRT Transit Ridership	2.1%	City of Saskatoon, Plan for Growth.
	Percentage of Ridership Diverted from Auto	17.5%	Based on literature, TCRP Report 118, Ingvardson and Nielsen (2018).
	Average Auto Occupancy	1.1	City of Saskatoon.
5	Average Transit Fare, $/trip	$0.99	City of Saskatoon based on transit statistics.
6	Average Vehicle Occupancy, Persons per Vehicle	1.1	City of Saskatoon.

Travel Time Impacts to Auto Users Diverting to BRT

Approach

Figure 3 shows the estimation of travel time impacts on auto users who divert to BRT. Transit travel usually takes longer than auto travel and thus the monetized longer travel time impact is included here for a more complete picture of user benefits. This impact is estimated as the difference in highway travel time and transit travel time multiplied by the value of travel time savings. Highway travel time is estimated on the basis of predicted highway speed (from the BPR curve) and the average trip distance in the corridor. Transit travel time includes time in vehicle, walk time to transit stop/ station, and waiting times. Travel time in transit vehicle is calculated based on the average trip length and transit speed. Highway travel time increases over time due to average speeds deteriorating over time while transit speed is assumed as approximately constant.

Figure 3: Estimation of Travel Time Impacts on Auto Users Diverting to Transit



Assumptions

Table 7 shows assumptions used in the estimation of travel time impacts on auto users who divert to transit. It is noted that, as with travel time savings to auto traffic remaining, this impact is calculated only for peak period traffic.

Table 7: Assumptions for Estimation of Travel Time Impacts on Auto Users Diverting to Transit

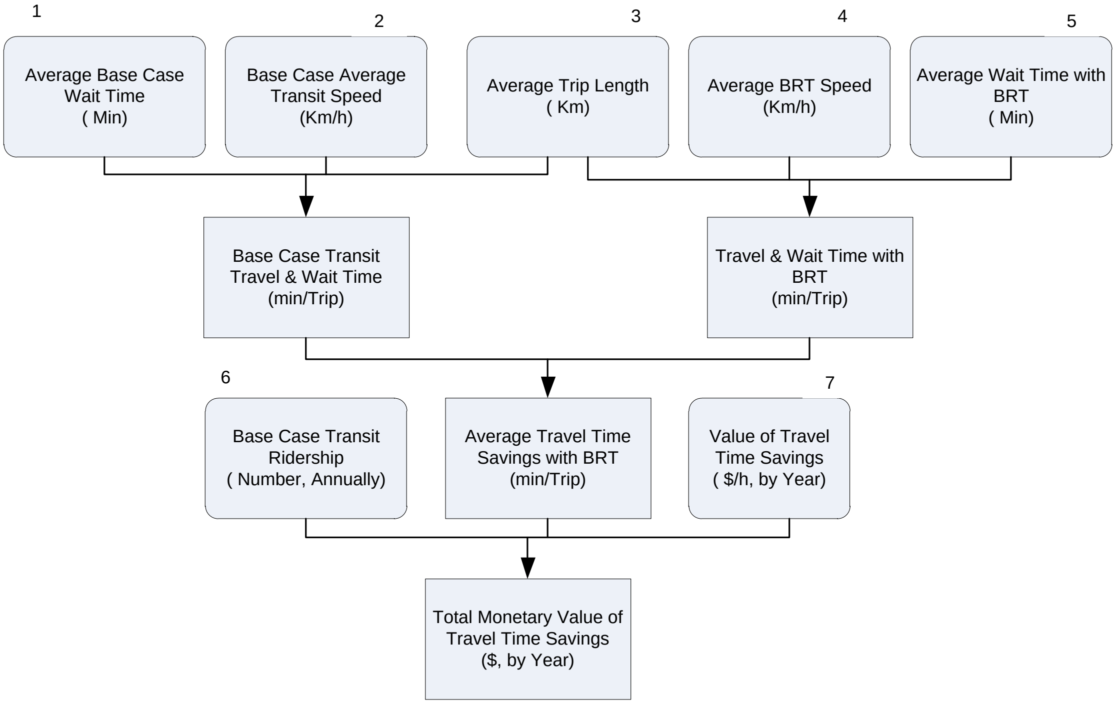
Input #	Input Name	Value	Source/Comment
1	Average No-build Speed, km/h		As in the calculation of highway travel time savings
2	Average Auto Trip Length, km	6	As in the calculation of highway travel time savings
3	Average Transit/BRT Travel Time (for Auto trips), Minutes	15.7	Calculated based on average trip length and average BRT speed
	BRT Speed, km/h	23.00	Estimated design speed; HDR team
4	Average Transit Waiting Time, Minutes	3	
5	Average Walking Time to Transit Stop, Minutes	2.6	
6	Number of BRT Riders who Diverted from Auto		As for calculation of travel time savings.
7	Value of Travel Time Savings, $/h	$19.62	Calculated as 50% of median household wage in Saskatoon (median income divided by 1950); 2016 Census, adjusted to 2017.
8	Real Growth Rate in Value of Time, Annual Average %	1.5%	Historical and current trends in real wage growth in Saskatoon and province.

Travel Time Savings to Existing Transit Users

Approach

The base case transit users (current and future users who will be taking transit in the corridor even in the absence of the proposed BRT) benefit from new services in the form of travel time savings that result from higher average speed and shorter wait times. The difference in total travel time (in vehicle plus wait time) between the base case bus transit and BRT is multiplied by the value of travel time savings to obtain the value of the travel time cost savings per trip. Multiplying this by total annual base case ridership that diverted to BRT gives the total monetary value of this benefit. This is illustrated in **Figure 4** below.

Figure 4: Estimation of Travel Time Savings to Existing Transit Riders



Assumptions

Table 8 shows assumptions used in the estimation of travel time savings to existing transit users who divert to BRT after its opening. It is noted that the travel time savings are calculated for the BRT leg of the trip; the connecting transit trips are assumed to have unchanged travel times.

Table 8: Assumptions for Estimation of Travel Time Savings to Existing Transit Riders

Input #	Input Name	Value	Source/Comment
1	Base Case Average Waiting Time, Minutes	10	HDR, BRT functional plan.
2	Base Case Average Transit Speed, km/h	19	HDR, BRT functional plan.
3	Average Trip Length, BRT Leg. km	7.0	HDR, BRT functional plan.
4	BRT Average Speed, km/h	23	HDR, BRT functional plan.
5	BRT Average Waiting Time, Minutes	3	HDR, BRT functional plan.
6	Existing Transit Ridership Diverted to BRT	6,500	Calculated at an assumed percentage rate of 65% of total BRT ridership.
	Average Annual Rate of Growth in Base Case Transit Ridership, %	2.1%	

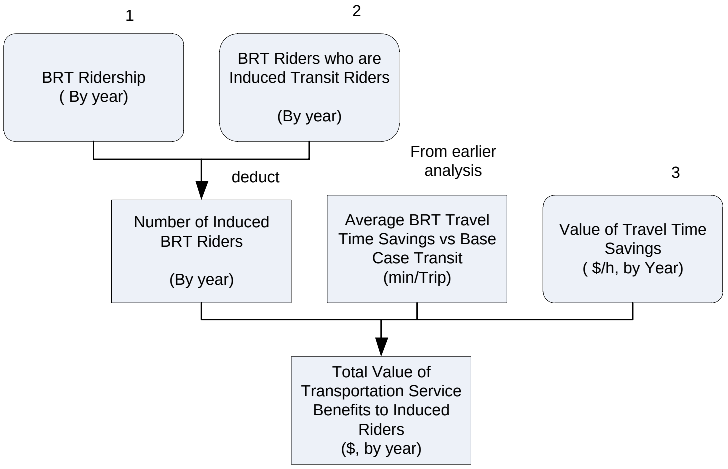
Input #	Input Name	Value	Source/Comment
7	Value of Travel Time Savings, $/h	$19.62	Calculated as 50% of median household wage in Saskatoon (median income divided by 1950); 2016 Census, adjusted to 2017.
	Real Growth Rate in Value of Time, Average Annual, %	1.5%	Historical and current trends in real wage growth in Saskatoon and province.

Benefits to Induced Riders

Approach

Figure 5 shows the estimation of economic benefits to induced riders. In the absence of the proposed BRT, the least-cost best travel alternative for potential travelers is bus transit. The difference between the time and money cost of conventional bus and the time and money cost of BRT represents thus the transportation benefit to induced riders. Assuming the same fare for BRT and conventional transit, the benefits to induced riders arise thus from travel time savings when using BRT. The travel time savings per trip are multiplied by the value of time and the number of induced users (and divided by two) to obtain the total value of this benefit.

Figure 5: Estimation of Economic Benefit to Induced Riders



Assumptions

Table 9 shows the assumptions for the estimation of benefits to induced riders. Average travel time savings with BRT are based on the calculations of travel time savings to existing transit users. Other inputs are based on the same assumptions as for other benefits.

Table 9: Assumptions for Estimation of Economic Benefit to Induced Riders

Input #	Input Name	Value	Source/Comment
1	Total Ridership (2018 conditions)	10,000	HDR team.
2	Percent of Ridership that is Induced	17.5%	Based on literature review, TCRP Report 118.
	Average Annual Rate of Growth in BRT Transit Ridership	2.1 %	City of Saskatoon, Plan for Growth.
3	Value of Travel Time Savings, $/h	$19.62	Calculated as 50% of median household wage in Saskatoon (median income divided by 1950); 2016 Census, adjusted to 201.7
	Real Growth Rate in Value of Time, Average Annual, %	1.5%	Historical and current trends in real wage growth in Saskatoon and province.

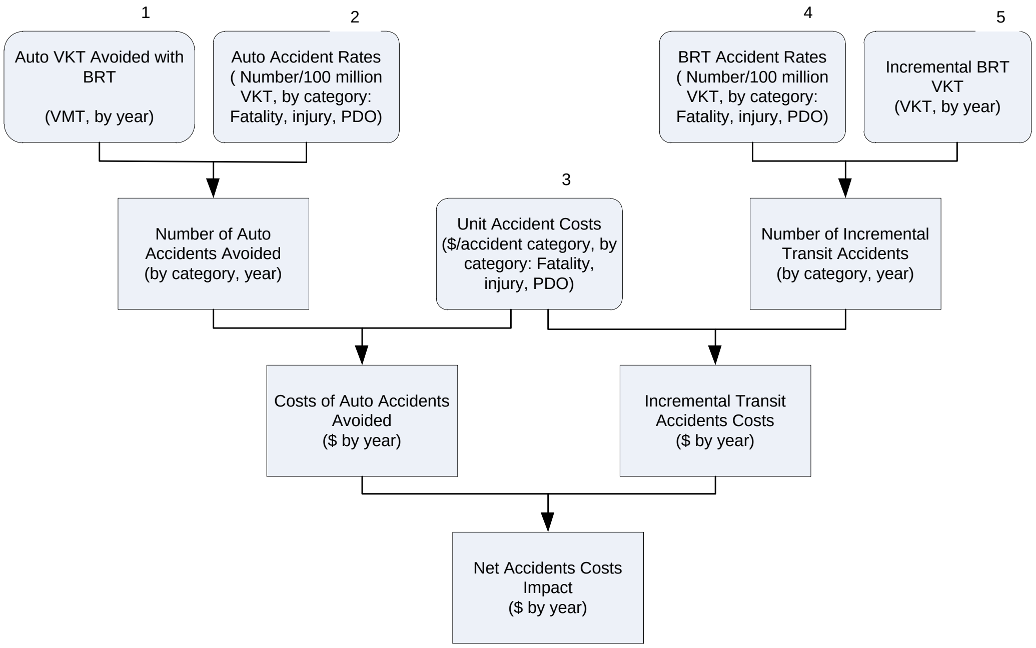
Safety Benefits

BRT will contribute to road safety improvements in the corridor through a reduction in the total auto VKT. Lower traffic translates into fewer car accidents and thus a reduction in accident-related societal costs. The specific methodology is described below.

Approach

The change in VKT in the corridor due to BRT are combined with accident rates for fatal, injury, property damage only (PDO) accidents (all measured in terms of accidents per million VKT) to estimate the change in the number of accidents. These are then multiplied by the unit social costs of accidents to obtain the total value of accident costs impacts. This general methodology is illustrated in **Figure 6** below.

Figure 6: Estimation of Safety Benefits



Assumptions

The key inputs in the estimation of safety benefits are auto accident rates. The incremental transit bus accidents are assumed equal to zero as bus VKTs are expected to remain unchanged. For the purpose of this analysis auto fatality and injury rates are based on Transport Canada annual publication “Canadian

Motor Vehicle Collision Statistics”. This publication provides the number of accidents and accident rates, by province. PDO accidents are not tracked in this publication. Therefore, for this analysis, the PDO accident rate was approximated from US accident data on the basis of rates of all crashes and injuries.

Unit accident costs were developed based on a review of Canadian sources on the issue and recommendations for cost-benefit applications. A summary of this review and the resulting input values (averages of the identified values) are presented in **Table 10**, and all input assumptions are then shown in **Table 11**.

Table 10: Unit Accident Costs in Canadian Sources

Source	Original Value, $	2017 Value, $
Value of Statistical Life (VSL), $ per Fatality		
Treasury Board, "Canadian Cost-Benefit Analysis Guide. Regulatory Proposals", 2007.	$6,110,000	$7,633,123
Apex Engineering, "Default Values for Benefit-Cost Analysis in British Columbia", prepared for BC MOTI, Dec 20, 2012.	$5,669,648	$6,093,590
Paul de Leur, “Collision Cost Study”, prepared for Capital Region Intersection Safety Partnership, February 2010	$3,618,000	$4,062,098
Average VSL		**$5,929,604**
Cost of Injury, $ per Injured Person		
Apex Engineering, "Default Values for Benefit-Cost Analysis in British Columbia", prepared for BC MOTI, Dec 20, 2012.	$90,385	$97,143
Paul de Leur, “Collision Cost Study”, prepared for Capital Region Intersection Safety Partnership, February 2010	$97,333	$109,280
Average Injury Cost,		**$103,212**
Property Damage Only Accident, $ per Crash		
Apex Engineering, "Default Values for Benefit-Cost Analysis in British Columbia", prepared for BC MOTI, Dec 20, 2012.	$11,367	$12,217
Paul de Leur, “Collision Cost Study”, prepared for Capital Region Intersection Safety Partnership, February 2010	$11,400	$12,799
Average PDO Accident Cost		**$12,508**

Table 11: Assumptions for Estimation of Safety Benefits

Input #	Input Name	Value	Source/Comment
1	Auto VKT Avoided, VKT		Calculated as for travel time savings
2	Auto Accident Rates		Transport Canada "Canadian Motor Vehicle Collision Statistics", 2015 (data for Saskatchewan), and US Bureau of Transportation Statistics.
	Fatalities, Fatalities/100 Million VKT	1.07	
	Injuries, Injured Persons/100 Million VKT	48.94	
	PDO, Number of Accidents/100 Million VKT	82.17	
3	Unit Accident Costs		As shown in **Table 10**.
	Fatalities, $ per Fatality	$5,929,604	
	Injuries, $ per Injured Person	$103,212	
	PDO (Auto), $ per Accident	$12,508	

Qualitative Benefits

Reliability

High-order and high-capacity transit systems operating in dedicated corridors or lanes will be unobstructed by the general traffic. This as well as other design factors and traffic management systems may allow the average travel speed to increase and reduce sensitivity to incidents and recurring delays. This will then translate into better on-time performance and greater reliability of the service.

Passenger Comfort, Ride Quality and Attractiveness

High-order and high-capacity transit systems like BRT and LRT are frequently considered as more convenient and more attractive to riders compared to the traditional bus.[6] This is due to a combination of factors including greater speeds, more frequent service, higher capacity of transit vehicles, greater visibility of the route, etc.

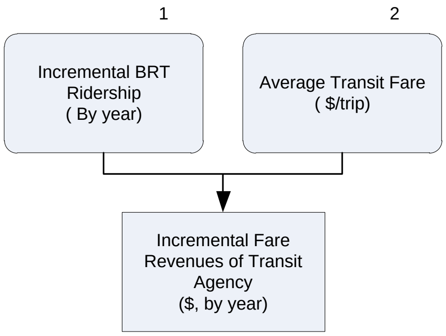
2.4 Financial Impacts

Incremental Fare Revenues (Agency Benefits)

Approach

The incremental ridership on the BRT route will provide additional fare revenues to the Saskatoon transit agency. These revenues were not recognized elsewhere (note that fare payments were deducted from out-of-pocket cost savings of auto users diverting to transit) and are not subtracted from the incremental operations and maintenance costs. Therefore, they can be seen as a “proper” benefit from the transit agency point of view. The incremental revenues for each year are estimated as a product of incremental ridership and average fare payment per trip as shown below in **Figure 7**.

Figure 7: Estimation of Agency Benefits



Assumptions

Incremental BRT ridership is the sum of induced ridership and ridership diverted from auto. The two components are calculated in the same way as for previous benefits using this input data. Average transit fare was assumed at $0.99, current average fare in Saskatoon, and assumed constant in real terms over the analysis period.

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[6] For a discussion of arguments see: Scherer, Milena, “Is Light Rail More Attractive to users Than Bus Transit?” Transportation research record: Journal of the Transportation research Board, vol. 2144, 2010.

Capital Costs

Project costs in a cost-benefit analysis are also accounted for comprehensively and include construction costs of structures and roadway, construction management and engineering, required utility relocations, purchase of land/right of way, equipment, vehicles, etc.

As of March 2018, total cumulative costs defined in this way are estimated at $103 million (with a range of +30% and -20%). The construction would be carried out over a period of 3 years with expenditure shares amounting for 25%, 40%, and 35% over those years.[7] For the purpose of this CBA evaluation, it was assumed that construction would take place over the years from 2019 to 2021. 2022 is then the year of project opening and first full year of operations. As mentioned earlier, the benefits of BRT are assumed to be fully realized starting from that first year of operations.

Incremental Operating Costs

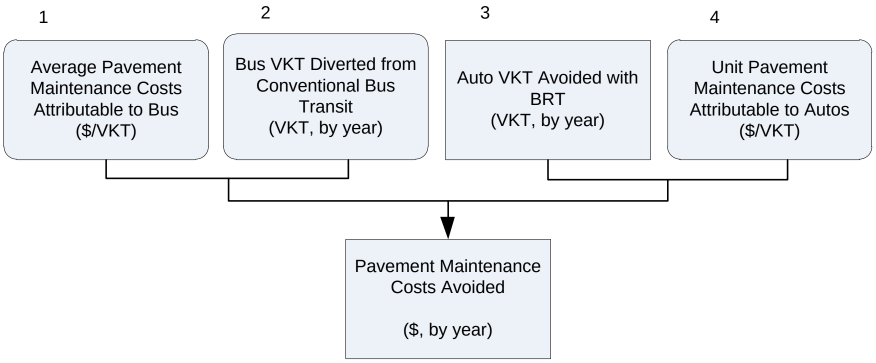
In addition to the capital costs, business case also considers the additional, or incremental, costs of operating and maintaining the new systems after it is opened to the public. These costs would entail primarily labour costs but should also include any other additional related costs of operations such as goods and services, supplies, etc. These costs may be fairly constant over the years (in real terms) or change by year reflecting – as an example – forecasted changes in the extent of maintenance that will be required. As of March 2018, City of Saskatoon estimates this cost at about $1 million annually.

Pavement Maintenance Costs Savings

Approach

The reduction in VKTs on BRT road corridors due to diversion of some auto trips to transit is expected to reduce wear and tear on the highway pavement and thus help improve the condition of the road network. This benefit is quantified as a reduction in the annual pavement maintenance costs. The unit incremental cost of pavement maintenance is multiplied by highway VKTs avoided to obtain total value of this benefit. This is illustrated in **Figure 8**.

Figure 8: Estimation of Pavement Costs Avoided



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[7] City of Saskatoon, "Plan for Growth", Attachment 1: Saskatoon Bus Rapid Transit – Preferred Configuration; Future Bus Rapid Transit Plans, October 2017.

Assumptions

Table 12 shows the assumptions for calculations of pavement costs impacts. Bus VKTs and auto VKTs avoided are calculated as for previous benefits. Unit pavement maintenance costs represent marginal cost for this cost category and are based on the literature on the incremental socio-economic costs of various vehicle types (how they contribute to total highway costs). Note that bus VKT remains unchanged and thus the corresponding input is omitted.

Table 12: Assumptions for Estimation of Pavement Costs Avoided

Input #	Input Name	Value	Source/Comment
1	Average Pavement Maintenance Cost, Bus, $/km	$0.03	As for pavement maintenance for autos.
2	Auto VKT Avoided, VKT		Calculated as for previous benefits.
4	Average Pavement Maintenance Cost Auto, $/km	$0.0011	Addendum to the 1997 Federal Highway Cost Allocation Study Final Report (http://www.fhwa.dot.gov/policy/hcas/addendum.htm). Inflated to 2017 dollars.

Qualitative Impacts

Adaptability and Flexibility

Adaptability and flexibility essentially reduces capital and operating costs in case when changes and modifications to some aspects of service or structures are required. Therefore more flexible solutions are more desirable and will score better in the evaluation.

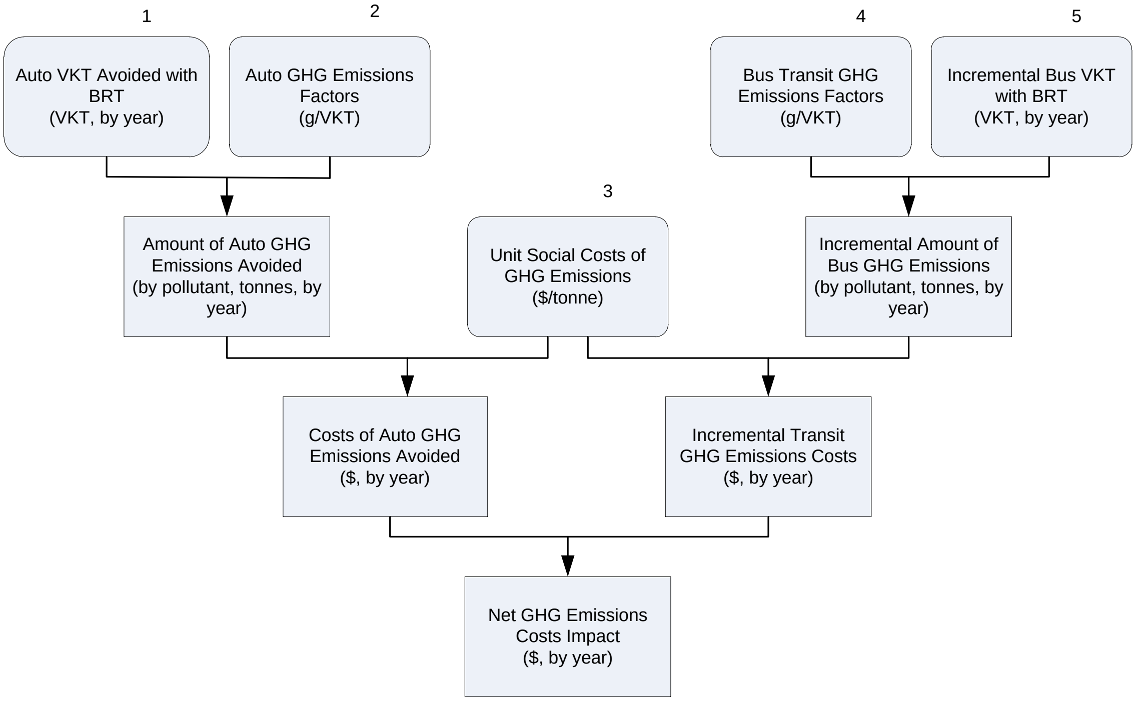
2.5 Environmental Benefits

Transit projects generate positive environmental impacts by reducing local and regional use of motorized vehicles and thus reducing fossil fuel consumption and the resulting exhaust emissions of greenhouse gases (GHG).

Approach

Reduction in emissions depends upon the reduction in auto and bus VKT after the BRT opens**. Figure 9** below illustrates the general structure and logic of the estimation of emissions cost savings. GHG emission factors in terms of grams per VKT are multiplied by VKT reduced to give the amount of emissions avoided. These are then multiplied by unit social costs of GHG to give the monetary value of this benefit. Any incremental transit emissions are accounted for in a similar logic.

Figure 9: Estimation of Emission Impacts



Assumptions

The assumptions used in the estimation of GHG emissions are summarized in **Table 13** below. The emission rates used in this analysis are adopted from California's Department of Transportation Cal-B/C Cost-Benefit Analysis Modeling Tool, a widely recognized tool for analysis of transportation infrastructure projects. The emission rates for this tool are based on California EMFAC 2014 data. As the table indicates, the emission factors vary by speed. The original metric of the emission factors, grams per mile, was converted to grams per kilometer. Per-unit emission social cost was assumed on the basis of carbon tax currently in place in British Columbia.

Table 13: Assumptions for Estimation of Emission Impacts

Input #	Input Name	Value	Source/Comment
1	Auto VKT Avoided with BRT, VKT	Varies	Calculated as for travel time savings
2	Auto GHG Emissions Factors, grams/VKT	Varies by speed	Cal-B/C Cost-Benefit Analysis Modeling Tool (based on California EMFAC 2014), California Department of Transportation.
3	Unit Costs of GHG Emissions, $/tonne	$30	Based on carbon tax in place in Alberta as of January 2018. This value is assumed constant over the analysis period.[8]

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[8] HDR recognizes that social cost of GHG emissions and carbon pricing are matters of public debate. Some provincial governments, including Alberta and British Columbia, have announced plans to increase carbon tax above $30/tonne. The federal government also plans to introduce a carbon tax scheme. GHG emissions impacts in a CBA are intended to measure the social impact of changes in emissions, rather, than track changes in carbon tax revenue (which would be a transfer from consumers to government and thus cancel itself out in a CBA). The current carbon tax rate in Alberta is intended as an approximate valuation of the social impacts.

2.6 Economic Development

Community Livability and Land/Property Value Uplift

Research indicates that commercial and residential properties located close to a transit station have on average higher property values than other properties of similar size and quality. For commercial properties, the increased property value captures the monetary value of increased sales potential, better access to production inputs, or skilled workforce. For residential properties, the increased property value captures the general preference and willingness to pay to live in neighbourhoods which are more “walkable”, have greater transportation options (due to the presence of a good transit system), or are more “livable”.

These benefits are particularly pronounced for the light rail and commuter rail systems with ample literature documenting the before and after impacts and estimating the property premiums. There is also emerging literature documenting similar benefits for BRT systems although smaller (and more variable) in magnitude and for a more limited area of impact. A study on socio-economic effects of BRT systems refers to the following examples:[9]

- In Brisbane, South East Busway increased residential property values near stations 20% compared to similar areas beyond walking distance of stations.
- In Seoul, residences within 300 meters of the BRT stations experienced land price premiums of 5 to 10%.
- In Boston, residential properties around the stations (with the area of impact unspecified) had values higher by 7.6%.

Approach

Property value impact could be estimated based on the number of properties within a certain radius/area of impact from a station, average property value and the property price premium forecasted based on experience in other jurisdictions.

For the purpose of this evaluation, HDR adopted fairly conservative property uplift forecasting assumptions of 2% to 4% based on a literature review documented in a study of new transit options benefits conducted for Metrolinx.[10] The higher value was assumed for properties within 400 metres from a station and a lower effect was assumed for properties located further away but within 800 metres from a station.[11]

To determine the number of properties that would be affected, a simplified “high-level” approach is adopted that is based on readily available housing data and an assumed number of stations deemed to experience benefits. Specifically, the approach uses the average density of residential dwellings in Saskatoon, or number of properties per square kilometre (calculated as total number of residential dwellings divided by Saskatoon’s area in square kilometres). Using the average density, the number of properties in an area of a certain size – such as area 400m and 800m around a station – can be calculated. Knowing the number of properties, their average value, and property premium, property value uplift can then be calculated as well.

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[9] See: World Resources Institute, “Social, Environmental, and Economic Impacts of BRT Systems. Bus Rapid Transit Case Studies from Around the World”, Table 7, page 41.

[10] Metrolinx, “Sheppard-Finch LRT Benefits Case”, June 2009, Table 13, page 30.

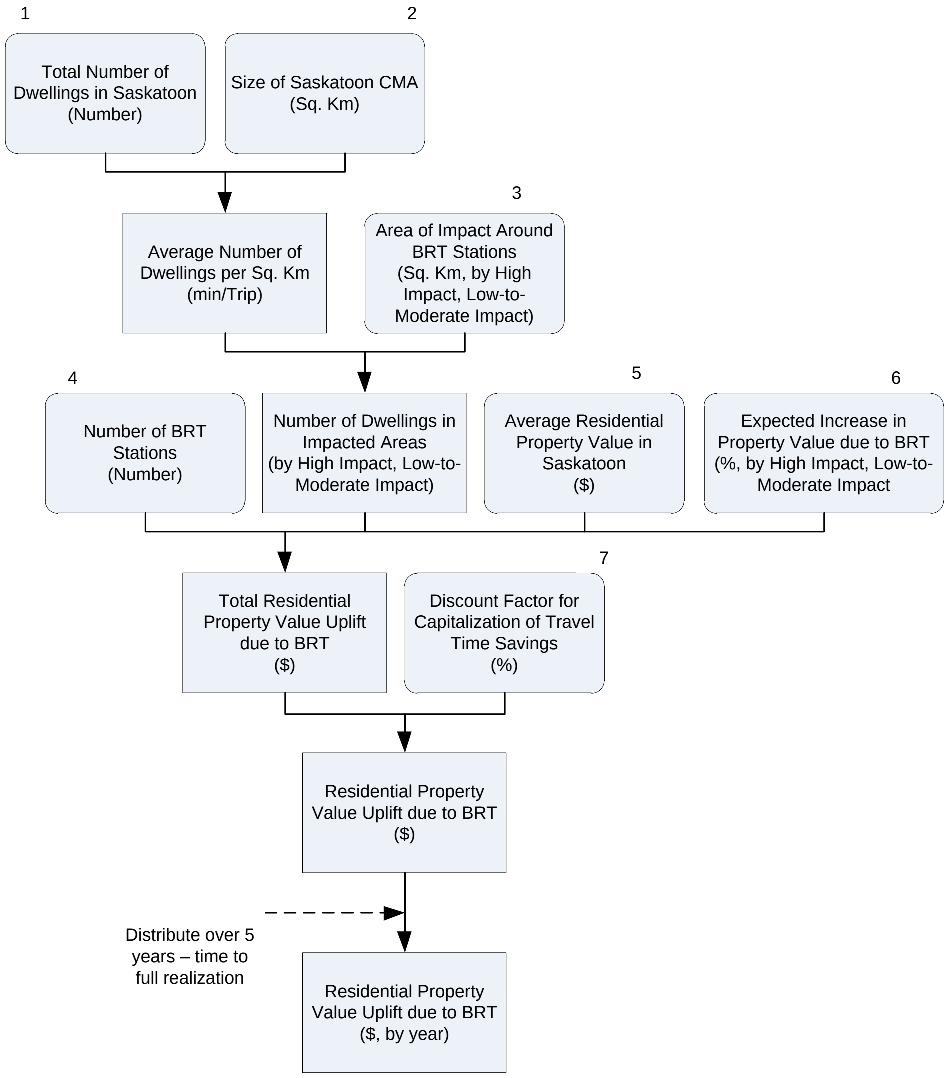
[11] Although the area of BRT impact differs across studies, in general there seems to be acknowledgement of impact within an “easy walking distance” such as 10 to 15 minutes. Assuming a leisure walk speed of 3.2 km/h, a distance of 800 m could be easily reached within 15 minutes. Therefore, the maximum area of impact is assumed here at 800 m from a station. This is a larger area of impact than that indicated in the Metrolinx Sheppard-Finch study (at 400 m from a station).

The property value uplift is spread over a period of 5 years after construction is finished to express the idea that it will take time for full adjustment to take place.

In addition, for the purpose of estimating this benefit, only half of the property value uplift is taken. This captures the idea that the increase in property values may also be a manifestation (or capitalization) of travel time savings that a specific location offers to users and potential users. Travel time savings were already accounted for elsewhere in this analysis. Therefore, discounting property value uplift in this way in the context of cost-benefit analysis helps avoid the problem of double counting of the same benefits.

Figure 10 below provides a graphical illustration of the methodology in the context of residential properties. The impacts on commercial properties could be estimated in a similar manner with similar data. Such data, however, was not available at the time of writing this report.

Figure 10: Estimation of Livability/Land Value Uplift Benefits



Assumptions

The **Table 14** below provides a summary of assumptions. The number of stations that will experience the property value benefits is assumed at 21.

Table 14: Assumptions for Estimation of Livability/Land Value Uplift Benefits

Input #	Input Name	Value	Source/Comment
1	Number of Dwellings in Saskatoon	98,565	Statistics Canada, 2016 Census
2	City Area, sq.km	228	Statistics Canada
3	Area of Impact around BRT Stations, sq.km		
	High Impact Area (400 m from station)	0.51	HDR calculation, radius area around a station.
	Medium to Low Impact area (800 m from station)	2.03	HDR calculation, radius area around a station. Excludes high impact area.
	Average Number of Residential Properties Impacted around each Station		Based on average density of dwelling units in Saskatoon.
	High Impact Area	220	
	Medium to Low Impact Area	659	
4	Number of Stations	21	
5	Average Residential Property Value in Saskatoon	$383,406	Statistics Canada, 2016 Census
6	Property Value Premium due to BRT		HDR reasoned assumptions based on literature
	High Impact Area	4%	
	Medium to Low Impact Area	2%	
7	Discount on Property Value Uplift	50.0%	Based on HDR project experience and research conducted for other projects.
8	Time to Full Realization	5.00	HDR reasoned assumption

Qualitative Benefits

Land Use Shaping and Improvements in Urban Realm

Because of the benefits discussed above, high capacity transit is often seen as a potential catalyst to development and re-development of areas around stations that may attract capital for commercial and high density residential development, and lead to the revitalization of older commercial centres and/or the development of mixed use neighbourhoods on empty and underutilized parcels. However, attention has to be paid to the nature of this development to distinguish between truly facilitated incremental development and development relocated from elsewhere in the region. Development that would likely take place anyway should not be credited as a benefit of the new transit system.

The street infrastructure improvements that frequently accompany large new transit projects such as upgraded street lighting, upgraded cycling lanes, trees, sidewalks, improved signage and street furniture also in general improve the appearance of urban streets and enhance their environment (the urban realm).

Direct and Indirect Employment

During the construction period, large scale transit projects contribute to job creation in the construction and engineering industries, as well as other industries related to it through supply relationships. Although these jobs represent another manifestation of costs and thus typically are not included as a benefit in a cost-benefit analysis, they can be seen as an element of a continuous stream of job opportunities supporting the community, offering employment income and valuable worker experience.

Network Connectivity

A well designed transit system that improves connectivity, in particular connectivity between large employment centres and residential areas, effectively expands the range of origins from where a business can source a well-qualified labour force. This may then improve business operating efficiency and facilitate growth and is considered an example of "wider economic benefits" of transportation infrastructure improvements.

Recent research finds significant links between transit service and employment density or agglomeration, and from agglomeration to average wages and GDP per capita.[12] On balance, a 10% increase in bus and rail seat density (i.e. per 1000 population) is found to increase wages by 0.23% and GDP per capita by nearly 1%. This effect is over and above any direct effect of transit in the form of a reduction in commuting costs for labour and transportation costs for freight.

Agglomeration also allows firms located in close proximity to each other to save on certain costs by sharing external factors, resources and services, or having better access to these resources and services, including accounting, advertising, legal advice, management consulting, and IT.[13]

This BRT project will also involve the entire system redesign, including routes and schedules of the regular (non-BRT) buses to improve connectivity to the BRT lines and the destinations served by it.

2.7 Socio-Community Impacts

Reduction in Air Emissions/Pollution

As discussed earlier, transit projects generate positive environmental impacts by reducing local and regional use of motorized vehicles and thus reducing fossil fuel consumption and the resulting exhaust emissions of common air pollutants such as nitrogen oxides (NO_X), sulfur dioxide (SO_2), volatile organic compounds (VOC), and fine particulate matter (PM2.5). The specific approach is described below.

Approach

The methodology of estimation of these benefits follows the same logic as estimation of the environmental benefits discussed earlier. Reduction in emissions depends upon the reduction in auto and bus VKTs with the new BRT. Emission factors for each pollutant in terms of grams per VKT are multiplied by VKT reduced to give the amount of emissions avoided. These are then multiplied by unit social costs of emissions (for each pollutant) to give the monetary value of this benefit.

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[12] Chatman, Daniel and Robert Nolan (2013), “Transit Service, Physical Agglomeration and Productivity in US Metropolitan Areas”, Urban Studies 2013, pages 1-21. The reported transit-wage rate elasticity amounts to 0.00234 and the reported transit-GDP elasticity amounts to 0.097.

[13] Kennedy, Christopher. The Evolution of Great World Cities: Urban Wealth and Economic Growth. University of Toronto Press, 2011.

Assumptions

As for GHG emissions, the emission rates used here are adopted from California's Department of Transportation Cal-B/C Cost-Benefit Analysis Modeling Tool, a widely recognized tool for analysis of transportation infrastructure projects. The emission rates for this tool are based on California EMFAC 2014 data. The emission factors vary by speed. The original metric of the emission factors, grams per mile, was converted to grams per kilometer.

The per-unit emission social costs are based on recommendations from US Department of Transportation for benefit-cost analysis. These recommendations were, in turn, based on literature on valuations of various pollutants to identify a wide range of costs including human health and agricultural impacts.

Table 15: Assumptions for Calculations of Environmental Benefits

Input #	Input Name	Value	Source/Comment
1	Auto VKT Avoided with BRT, VKT		Calculated as for travel time savings.
2	Auto Emissions Factors, grams/VKT	varies by speed and air pollutant	Cal-B/C Cost-Benefit Analysis Modeling Tool (based on California EMFAC 2014), California Department of Transportation.
3	Unit Costs of Emissions, $/tonne		US Department of Transportation, "Benefit-Cost Analysis Guidance for TIGER and INFRA Applications", July 2017. Converted to Canadian dollars.
	SO2	$61,115	
	PM 2.5	$473,025	
	VOC	$2,624	
	NOx	$10,341	
	CO	$0	
	CO2	$30	Source: Based on carbon tax currently in place in BC and new schedule in Alberta effective January 1, 2018.

Health Benefits

Health benefits typically linked to the presence and use of public transportation include:[14]

- Reduction in the number of accidents and resulting injuries and fatalities (through a reduction in auto VKT);
- Improved public health due to reduced air pollution (also through a reduction in auto VKT); and,
- Increased physical activity and reduction in costs of physical inactivity.

The first two categories of impacts are already accounted for under improved safety benefits and environmental benefits, respectively. Therefore, for the purpose of this evaluation this benefit is focused on the third effect, i.e. the effects of increased physical activity due to the increased use of transit. Below, the existing evidence on the impacts of physical inactivity and links between transit use and physical activity are discussed in some detail as they provide the basis for the specific methodology and assumptions.

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[14] As an example see: Toronto Public Health, "Road to Health: Improving Walking and Cycling in Toronto", a Healthy Toronto by Design Report, April 2012.

The key element of the methodology is a premise that a transit project will attract a certain number of auto users, many of them physically inactive individuals. It is then assumed that using transit by these individuals will involve walking to and from bus stops and stations that will increase their level of physical activity. This will then create some health benefits in the form of a reduction in the risk of death or illness. The magnitude of these benefits will be proportional to the benefits to be enjoyed by an individual classified as "physically active". This proposed approach is a simplified version of a methodology practiced by the United Kingdom Department for Transportation in their benefit-cost analysis guidance as well as World Health Organization in their Health Economic Assessment Tool (HEAT).[15]

Approach

Physical inactivity contributes to a variety of serious health problems including heart disease, certain cancers, and Type 2 diabetes, creating a range of social costs such as increased health care costs and reduced productivity. There is a fair amount of literature that links physical inactivity to the risk of developing these conditions, their medical treatment costs, and other cost impacts as well as premature mortality. Health agencies recommend for healthy adults moderate to vigorous physical activity of at least 150 minutes per week, or 30 minutes per day 5 days per week, to help reduce the risk of these diseases. However, 85% of Canadians do not meet these guidelines.[16]

Human-powered transportation such as walking and cycling, or active transportation, provides an opportunity for individuals to incorporate moderate physical activities into their daily routines and increase their overall level of physical activity. This has been shown to be more sustainable in the long-term than structured activity programs (e.g., running or going to the gym), yet with similar health benefits.[17]

Typically, health benefits of active transportation are discussed in the context of dedicated facilities such as walk and bike paths, walkable bridges, or bike lanes. However, there is an emerging trend of recognizing this benefit for transit projects that would result in a significant increase in walking and cycling of their riders.[18] This arises from the observation that every transit trip begins and/or ends with walking and thus offers the same type of opportunities.

Research suggests that people who regularly use public transportation tend to be physically more active than auto users. According to one study, transit users take 30% more steps per day and spend 8.3 more minutes walking per day than people who rely on cars.[19] Another study points out that 29% of transit users are physically active for 30 minutes or more each day (thus satisfying the guidelines on physical activity for health solely by walking to and from public transit stops) and the median walk time to/from transit stops and stations amounts to as much as 19 minutes per day.[20]

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[15] See: Department for Transport, "TAG Unit 4.1. Social Impact Appraisal", November 2014, Transport Analysis Guidance (TAG), and World Health Organization, Health Economic Assessment Tools (HEAT) for Walking and Cycling, "Economic Assessment of Transport Infrastructure and Policies", Methods and User Guide, 2014 Update. The simplification of the approach used in this study entails assumptions that the benefit is uniform across all projects or its components (here transit stations) and the same for all new users.

[16] "Canadian Health Measures Survey: Directly measured physical activity of Canadians, 2007 to 2011", Statistics Canada, The Daily, Thursday, May 30, 2013.

[17] Referenced from Conor C.O. Reynolds, Meghan Winters, Francis J. Riesa, Brian Gouge (2010), "Active Transportation in Urban Areas: Exploring Health Benefits and Risks", National Collaborating Centre for Environmental Health", June 2010, http://www.ncceh.ca/sites/default/files/Active_Transportation_in_Urban_Areas_June_2010.pdf.

[18] See for example: Todd Litman, *"Evaluating Public Transportation Health Benefits"*, Victoria Transport Policy Institute, a study for the American Public Transportation Association, 14 June 2010.

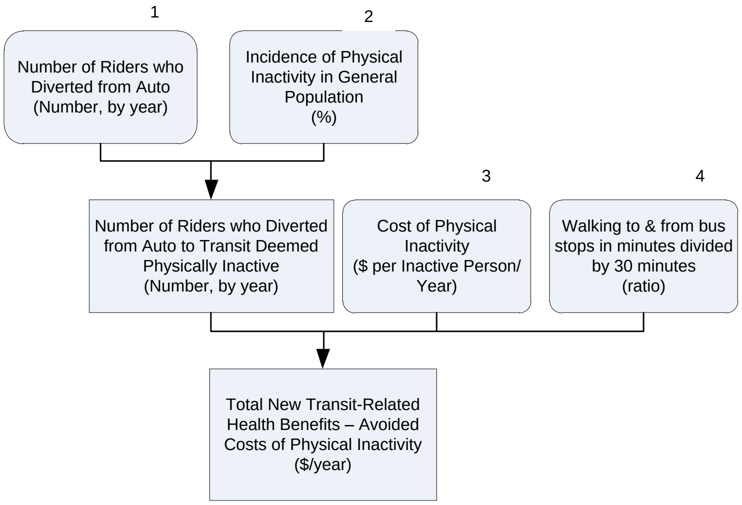
[19] Quoted from: Active Living Research, "Active Transportation: Making the Link from Transportation to Physical Activity and Obesity" Research Brief, Summer 2009.

[20] Besser Lilah M. and Andrew L. Dannenberg, "Walking to Public Transit Steps to Help Meet Physical Activity Recommendations", American Journal of Preventive Medicine, 2005, 29 (4), pages 274-280.

Monetary valuation of the health benefits of projects involving walking or bicycling rests on the assumption that they would help engage new previously inactive users and thus help reduce the incidence of physical inactivity in the general population. Increases in physical activity would then reduce the costs related to physical inactivity. The emerging practice of valuation of these benefits uses thus the literature on the economic costs of inactivity. The total costs of inactivity in a country or region are converted into a cost per capita and interpreted as a cost saving per new user of an active transportation project. The total monetary effect of reduced mortality is based on the literature on the impact of physical activity on all-cause mortality. The reduction in mortality for the population that can be considered physically active as compared to those which are not physically active multiplied by the value of statistical life (such as that for valuation of the reduction in fatalities due to road accidents) provides the monetary value of reduced mortality due to increased transit-related activity.[21]

A similar approach could be applied to transit projects. Although the specific activity profile of auto users in Saskatoon is not known, based on the data discussed above it can be assumed that walking to and from the transit stops or stations will increase the level of physical activity and generate benefits that could be extrapolated from the benefits of full physical activity (defined earlier as moderate to vigorous activity of 150 minutes per week). This methodology is illustrated in **Figure 11** below. Note that this benefit is recognized only for the new riders who diverted from auto as the existing transit riders already experience this benefit.

Figure 11: Estimation of Health Benefits of Increased Transit Use



Assumptions

The monetary valuation of the costs of physical inactivity is briefly discussed here and illustrated in the figure that follows.

A 2012 paper on the cost of physical inactivity in Canadian adults estimated these costs for 2009 at $6.8 billion (including $2.4 billion in direct health care costs and $4.3 billion in indirect costs, or costs in the

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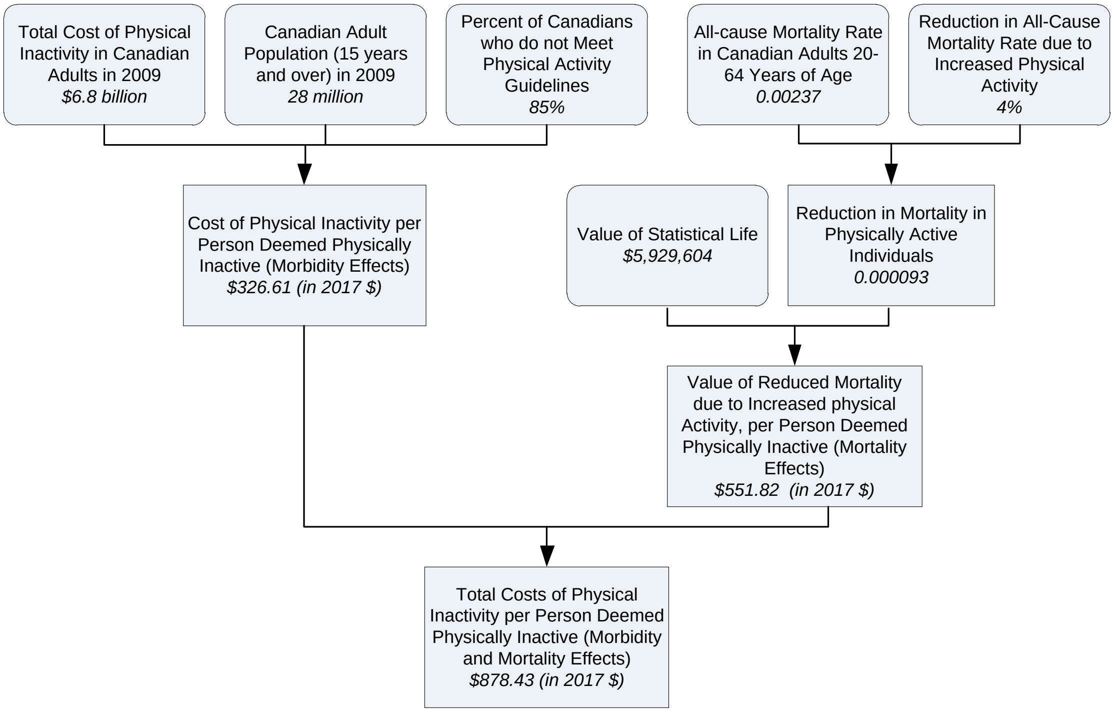
[21] As a reference for possible approaches and developed recommendations see: (1) Department for Transport (United Kingdom), *Guidance on the Appraisal of Walking and Cycling Schemes*, TAG Unit 3.14.1, January 2010, (2) Kevin J. Krizek, Gary Barnes, Gavin Poindexter, Paul Mogush, David Levinson, Nebiyou Tilahun, David Loutzenheiser, Don Kidston, William Hunter, Dwayne Tharpe, Zoe Gillenwater, Richard Killingsworth,2006) "*Guidelines for Analysis of Investments in Bicycle Facilities*", National Cooperative Highway Research Program (NCHRPP), Report 552, and (3) New Zealand Transport Agency, "Economic Evaluation Manual", Volume 2 (EEM2), effective from January 2010

form of lost output due to sickness).[22] Given the population of adults (15 years of age or older) in Canada of 28 million this translates into an annual per-capita cost of inactivity of $243, or cost per inactive adult of $286 (based on the assumption that 85% of adults are inactive). Inflating this figure to 2017 using the Consumer Price Index gives an annual cost of inactivity of $326.

Reduction in mortality is based on a meta-analysis of studies on the effects of physical activity on all-cause mortality. One such study by Samitz et.al (2011) concluded that an increase in light to moderate physical activity of one hour per week compared to no physical activity is associated with a reduction in all-cause mortality of 4%. Applying this to the all-cause mortality rate of adults that are most likely to be affected by a new transit alternative (adults 20 to 64 years old) gives a reduction in mortality rate of 0.0009306. Combining this with the value of statistical life of $5,929,604 (based on a range of values identified in Canadian sources[23]) gives total value of a reduction in mortality of $551 per capita.

Combining the morbidity and mortality effects gives a total value of health benefit of $878 per capita per year. This derivation is illustrated in **Figure 12**.

Figure 12: Estimation of Valuation of Increased Physical Activity



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[22] Ian Janssen, “Health care costs of physical inactivity in Canadian adults”, Applied Physiology, Nutrition and Metabolism, Vol. 37, 2012.

[23] The sources considered include: (1) Treasury Board, "Canadian Cost-Benefit Analysis Guide. Regulatory Proposals", 2007, (2) Apex Engineering, "Default Values for Benefit-Cost Analysis in British Columbia", prepared for BC MOTI, Dec 20, 2012, and (3) Paul de Leur, “Collision Cost Study”, prepared for Capital Region Intersection Safety Partnership, February 2010. All values were adjusted to 2017 dollars and averaged.

Table 16 provides a summary of assumptions.

Table 16: Assumptions for Estimation of Health Benefits

Input #	Input Name	Value	Source/Comment
1	Ridership Diverted from Auto		
	Total Ridership (2018 conditions)	10,000	HDR team.
	Average Annual Rate of Growth in BRT Transit Ridership	2.1%	City of Saskatoon, Plan for Growth
	Percentage of Ridership Diverted from Auto	17.5%	Based on literature; experience in other cities with a BRT system, TCRP Report 118, Ingvardson and Nielsen (2018).
2	Incidence of Insufficient Physical Activity	85%	Statistics Canada.
3	Health Benefit Physical Activity and Health Benefit from BRT	$878.4	
4	Walking to/from Bus Stop as % of 30 min (activity level required to be considered physically active)	30.0%	Based on distance to & from bus stops of 300 m and walking speed of 4 km/h.

Qualitative Impacts

Quality of Life Improvements, Mobility and Accessibility Improvements, and Transportation Equity

Better transit services may improve transportation options to disadvantaged population groups without access to a private car.

About 12% of Saskatoon's residents live in low-income households.[24] Access to affordable transportation is particularly important for these individuals and may be essential for their livelihood and to access amenities, services, employment, and educational opportunities. Transit is also important to other disadvantaged groups such as individuals with disabilities, elderly, and others who do not drive for various reasons.[25] Transit facilitates mobility and independence of these individuals and thus may contribute to their successful social functioning and reduction in social inequalities.

However, new major transit projects may also create their own equity issues and impacts, for example if low-income and disadvantaged population groups have disproportionately more difficult access to the new system than the better-off population groups. Therefore, the distribution of the new transit stations across the regions should be analyzed in the context of the profile of the neighbourhoods where they are located.

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[24] Source: 2016 Census, Statistics Canada, profile of Saskatoon Census Metropolitan Area; prevalence of low-income based on low-income measure (LIM-AT).

[25] The data on these social groups is not readily available. Although the prevalence of these groups in Saskatoon is not necessarily higher than in the rest of Canada, in total they likely represent a large number.

3. Results

This section outlines the results of the evaluation. The first subsection reports all MAE benefits and impacts in their structured format. It provides the monetary estimates of the quantifiable benefits and impacts and provides a summary of impacts which are more difficult to quantify and which are considered in a qualitative manner. The following subsection focuses on the quantifiable benefits and impacts to derive project performance metrics (based on quantifiable benefits and impacts only), including net present value and benefit-cost ratio, so as to provide a high-level presentation of the value for money that the proposed BRT project would generate.

3.1 MAE Benefits and Impacts

Table 17 presents the results of this analysis. As stated earlier, all benefits and impacts were estimated over the analysis period from 2019 to 2041 with 2019-2021 being the construction period and 2022 the first year of operations. The table also provides a brief summary of the benefits and impacts considered in a qualitative manner only.

The table demonstrates that travel time savings to existing transit users represent the largest benefit. At the 3% discount rate, this benefit amounts to $145.4 million and at the 8% discount rate it amounts to $78.8 million. The second largest benefit is the land value uplift in the amount of $72 million at the 3% discount rate and $51.9 million at the 8% discount rate. This is followed by out-of-pocket costs savings to auto users diverting to transit, benefits to induced riders, and health benefits. Environmental impacts are relatively small at less than $1 million.

Infrastructure costs amount to $96.8 million and $87.8 million at the 3% and 8% discount rates, respectively. Incremental operating costs amount to $13.6 million and $7.8 million, at the 3% and 8% discount rates, respectively. Incremental fare revenues due to induced ridership and ridership diverted from auto amount to $17.6 million and $9.8 million at the 3% and 8% discount rates, respectively, providing offset to incremental operating costs.

Comparing the magnitude of monetized impacts outlined above with costs, we can see that at the 3% discount rate, travel time savings to BRT users alone are greater than the BRT costs. Although at the 8% discount rate travel time savings to transit users do not exceed costs, other benefits are also substantial, including transportation benefits to induced riders. The total value of transportation user benefits and impacts amounts to $185.6 million at the 3% discount rate and $100.6 million at the 8% discount rate. Therefore, the proposed BRT would pay for its costs in terms of transportation user benefits that it is expected to generate. **Table 18** in the next section provides a specific account of all quantified and monetized net benefits, costs, net present value, and benefit-cost ratio.

The key qualitative benefits and impacts of the BRT as compared to the traditional bus transit include:

- Improved reliability;
- Greater attractiveness and convenience;
- Improved transit network connectivity;
- Potential to be a catalyst for residential and commercial development around stations, and
- Improved public transportation options which contribute to higher quality of life, improved mobility and reduction in transportation access inequities across socio-economic groups.

Table 17: MAE Benefits and Impacts, by Category

Benefit or Impact Name	3% Discount Rate ($M)	8% Discount Rate ($M)	Comments and Summary of Outcomes for Qualitative Factors
Transportation User Benefits			
Travel Time Savings to Highway Users	$13.3	$7.1	
Out-of-Pocket Vehicle Costs Avoided	$26.0	$14.4	
Travel Time Impacts to Transit Users Diverted from Auto	-$24.8	-$13.6	
Travel Time Savings to Existing Transit Users	$145.4	$78.8	
Transportation Benefits to Induced Riders	$19.6	$10.6	
Safety, Accident Reduction	$6.0	$3.3	
Transit Reliability			Improved reliability due to greater frequency, design factors, and implementation of traffic management systems.
Passenger Comfort, Ride Quality and Attractiveness			More attractive and convenient to riders compared to traditional bus due to factors such as greater frequency, greater reliability, and higher speeds.
Financial and Infrastructure Impacts			
Fare Revenues	$17.6	$9.8	
New Infrastructure Capital Costs	$96.8	$87.8	
Incremental Operating Costs	$13.6	$7.8	
Operating Costs Savings			There will be changes in operations of regular buses but no net change in transit operating costs.
Pavement Maintenance Savings	$0.1	$0.0	The incremental effects on pavement maintenance costs are very small (although larger than $0).
Infrastructure Adaptability and Flexibility			Gives greater adaptability and flexibility than LRT solutions but no significant difference expected compared to regular bus (same vehicle technology).
Environmental			
Reduction in GHG Emissions	$0.4	$0.2	
Economic Development			
Community / Livability and Land Value Uplift	$72.0	$51.9	
Land Use Shaping and Improvement to the Urban Realm			Project may be a catalyst to high density residential and commercial development and redevelopment around transit stations. Some of this development may represent reallocation from elsewhere, or be attracted by other street improvements.
Direct and Indirect Employment			Project will contribute to construction and engineering jobs during its development and construction phase.
Network Connectivity			This BRT project will also involve the entire system redesign, including routes and schedules of the regular (non-BRT) buses to improve connectivity to the BRT lines and the destinations served by it.

Benefit or Impact Name	**3% Discount Rate ($M)**	**8% Discount Rate ($M)**	**Comments and Summary of Outcomes for Qualitative Factors**
Socio-Community Impacts			
Reductions in Air Emissions	$0.10	$0.06	
Health Benefits	$4.1	$2.3	
Quality of Life, Mobility, and Accessibility Improvements			Improves transportation options to Saskatoon's residents by creating a new, affordable, high quality public transportation option, faster than the regular transit bus.
Transportation Equity			As above; new transportation option particularly valuable to disadvantaged populations who cannot afford a vehicle and/or cannot drive for various reasons. This will help reduce transportation access inequities.

Note: All monetary impacts are in terms of 2017 dollars, expressed in present value terms over the period 2019-2041 discounted to 2018.

3.2 Cost-Benefit Analysis Results

Table 18 summarizes the analysis of the quantified and monetized benefits, impacts, and costs of the proposed BRT, and presents the cost-benefit analysis outcomes. The table shows that the net present value of the proposed BRT amounts to $169.4 million at the 3% discount rate and $69.3 million at the 8% discount rate. The benefit-cost ratio amounts to 2.5 at the 3% discount rate and 1.7 at the 8% discount rate.

Table 18: Cost-Benefit Analysis Outcomes, by Scenario

Financial Indicators	**3% Discount Rate**	**8% Discount Rate**	**Undiscounted**
Total Costs, $M	$110.4	$95.6	$123.0
Total Quantified Net Benefits, $M	$279.8	$164.9	$404.0
NPV, $M	$169.4	$69.3	$281.0
Benefit-Cost Ratio, Ratio	**2.5**	**1.7**	**3.3**
Internal Rate of Return (IRR), Percent	16.9%		

Note: All monetary impacts are in terms of 2017 dollars, expressed in present value terms over the period 2019-2041 discounted to 2018.

4. Concluding Observations

This cost-benefit analysis finds that the proposed BRT is expected to generate significant benefits to the City of Saskatoon that exceed total costs of the project at the discount rate of 3% and even at the conservative discount rate of 8%. The project can thus be considered economically worthwhile from the City's perspective. The benefit-cost ratio of 2.5 at the 3% discount rate and 1.7 at the 8% discount rate and can be considered as very good outcomes.

Qualitative benefits of the project, essentially improved quality of transportation, convenience, greater mobility for a wide range of population groups (including disadvantaged groups and those who do not drive), further strengthen the business case.