HDR | Decision Economics

Winnipeg Transit

Cost-Benefit Analysis of Southwest Bus Rapid Transit Corridor Stage 2 Project

Final Report

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Executive Summary

The City of Winnipeg is currently working on a bus rapid transit (BRT) project, the Southwest Bus Rapid Transit (BRT) Corridor Stage 2 project that will extend southwest the existing transitway section.

Although the BRT are understood at a conceptual level, they have not been quantified in a systematic framework that would allow comparing them against the total costs. The purpose of this study is to provide a cost-benefit analysis assessment of the Southwest BRT Corridor Stage 2 project.

APPROACH

This cost-benefit analysis was conducted using industry accepted and common approaches and assumptions for this type of evaluations.

In particular, all costs and benefits were measured on an incremental basis, i.e. compared to the base case (or situation that would likely prevail in the absence of the project) specified here as the scenario in which the Southwest BRT Stage 2 is not constructed and transit services on Pembina Highway continue in their present form.

The key assumptions within which the analysis is framed are as follows:

- All monetary values are expressed in 2014 dollars.
- The period of analysis begins in 2016 and ends in 2039. It includes 4 years of project development and construction years (2016-2019) and 20 years of operations. Project operations are assumed to begin in 2020 and are evaluated until 2039.
- The benefits of the BRT are assumed to be fully realized starting from the first year of full operations in 2020.
- A constant 3 percent real discount rate is assumed throughout the period of analysis. This rate is consistent with the cost of borrowing by the City of Winnipeg and also a rate frequently used in cost-benefit analyses. The real discount rate of 8 percent is used for sensitivity analysis.
- The base year of the analysis is 2014, i.e. all costs and benefits are discounted to that year.

This analysis quantified the following benefits:

- State of good repair of transportation network:
  - Savings in pavement maintenance costs; and,
  - Residual value of the project.
- User benefits:
  - Travel time savings to auto users who continue to drive;
  - Out-of-pocket vehicle operating costs savings to auto users diverting to BRT;
  - Travel time impacts to auto users diverting to BRT (negative effect partially offsetting vehicle operating costs savings);
  - Travel time savings to existing/base case transit users; and,
  - Transportation benefits to new users/new travellers.
- Livability benefits;
- Environmental benefits (reduction in greenhouse gas emissions and air pollution);
- Improved road safety (reduction in auto collisions and related accident costs;)

- Incremental fare revenues of the transit agency; and,
- Helth benefits of increased physical activity related to transit use.

The costs against which the benefits are assessed include construction costs of structures and roadway, construction management and engineering, required utility relocations, purchase of land/right of way, equipment and vehicles, etc. In addition, incremental annual operating costs related to the BRT are also included as a cost element.

The assumptions adopted to populate this CBA and estimate individual benefits and costs are based on specific project information and projections, general practice for this type of evaluations, relevant literature on related issues, and economic data from Statistics Canada.

RESULTS

Summary Table 1 shows the summary results of the cost-benefit analysis for the main discount rate of 3% and the alternative rate of 8% for assessment of sensitivity of results. The table also shows all results in undiscounted dollar terms.

Overall, Summary Table 1 demonstrates that at the discount rate of 3% the expected NPV of the BRT Stage 2 project is larger than zero and of significant magnitude. At this discount rate, total project benefits amount to [redacted], project costs amount to [redacted], and NPV amounts to [redacted]. The benefit-cost ratio is 1.37; this means that for each $1 in costs the project generates benefits worth $1.37. The internal rate of return amounts to 5.9%, above the City of Winnipeg borrowing costs.

However, the table also shows that at a more conservative or stringent discount rate of 8% project NPV is negative at [redacted] and benefit-cost ratio amounts to just 0.81. The internal rate of return of 5.9% means that the project would generate NPV of at least $0 under a discount rate not higher than 5.9%.

Summary Table 1: Summary of Cost-Benefit Analysis Results

Financial Indicators	Discount Rate		
	3%	8%	Undiscounted
Total Costs, $M	[redacted]	[redacted]	[redacted]
Total Benefits, $M	[redacted]	[redacted]	[redacted]
NPV, $M	[redacted]	[redacted]	[redacted]
ROI, Percent	37%	-19%	97%
Benefit-Cost Ratio, Ratio	1.37	0.81	1.97
Internal Rate of Return (IRR), Percent	5.9%		
Payback Period (Years from Project Start)	21	24+	17

1. Introduction

The City of Winnipeg is currently working on a bus rapid transit (BRT) project, the Southwest Bus Rapid Transit (BRT) Corridor Stage 2 project that will extend the existing transitway southerly from Pembina & Jubilee to the University of Manitoba using land within Manitoba Hydro and CN Rail rights-of-way for most of its alignment. This alignment provides an opportunity to deliver rapid transit service directly to the University of Manitoba, downtown, and several neighborhoods in the southwestern and western parts of the city. The project also includes a widening of Pembina Highway as it underpasses the CN mainline near Jubilee at the northern limit of the Stage 2 transitway project.

The purpose of this study is to provide a cost-benefit analysis assessment of the Southwest BRT Corridor Stage 2 project. Although the benefits of this project are understood at a conceptual level, they have not been quantified in a systematic framework that would allow comparing them against the total costs. This study thus fills this gap conducting a formal cost-benefit evaluation and derives project evaluation metrics including net present value, benefit-cost ratio, and payback period.

This report is organized as follows. Section 2 provides a high level overview of the cost-benefit analysis as a project evaluation tool and lists the general key assumptions within which the analysis is framed. Section 3 outlines the methodology that was used to estimate project benefits and specifies input assumptions with their sources. Section 4 provides the costs that were used in this analysis. Section 5 reports the results.

2. Overview of Methodological Framework

This section provides a brief overview of the methodological principles entailed in the cost-benefit analysis and key assumptions of this evaluation.

2.1. Cost-Benefit Analysis as a Project Evaluation Approach

Cost-Benefit Analysis (CBA) is a conceptual framework that quantifies in monetary terms as many of the costs and benefits of a project as possible. Benefits are broadly defined and include a wide range of socio-economic benefits attributable to the project in the impact area and that would be experienced by various stakeholders. The benefits considered include thus categories such as travel time savings as well as improved road safety or improved environmental conditions (air pollution and greenhouse (GHG) emissions). Costs are also broadly defined and include all upfront capital construction costs, land costs, vehicle costs, etc. as well as incremental annual operations and management costs.

CBA is a forward-looking exercise, seeking to anticipate the benefits and costs of a project or proposal over its entire life-cycle, 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 on an incremental basis, i.e. compared to a situation that would likely prevail in the absence of the project. It should be emphasized that a properly defined base case could include the continuation of the *status quo* but also – if relevant – improvements to the *status quo* which would take place anyway as a substitute to the proposed build scenario.

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.

2.2. Build Scenario and Base Case

For this CBA, the base case is the scenario in which the Southwest BRT Stage 2 is not constructed and transit services on Pembina Highway continue in their present form. The alternative is the construction of the BRT in the intended location.

2.3. General Assumptions

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

The key assumptions are as follows:

- All monetary values are expressed in 2014 dollars. If the raw input data was initially valued in different terms, or comes from older sources, it is inflated to 2014 using a Consumer Price Index (CPI) from Statistics Canada (with data up to January 2014).
- The period of analysis begins in 2016 and ends in 2039. It includes 4 years of project development and construction years (2016-2019) and 20 years of operations. Project operations are assumed to begin in 2020 (although the planned opening of the BRT is in the fourth quarter of 2019), and are evaluated until 2039.
- The benefits of the BRT are assumed to be fully realized starting from the first year of full operations in 2020, i.e. no ramp-up to benefits realization is assumed (unless specified otherwise).
- A constant 3 percent real discount rate is assumed throughout the period of analysis. This rate is consistent with the cost of borrowing by the City of Winnipeg and also a rate frequently used in cost-benefit analyses. The real discount rate of 8 percent is used for sensitivity analysis.
- The base year of the analysis is 2014, 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, i.e. Southwest BRT Stage 2 constructed as planned.
- The annualization factor used to convert the daily auto traffic data to annual data is 260. This reflects the focus on the work day when most of the impacts related to auto users can be expected. The annualization factor for transit daily ridership data is 302.

3. Benefits Measurements, Data and Assumptions

Table 1 provides an overview of categories and types of benefits identified, quantified and monetized in this cost-benefit analysis. The sub-sections that follow provide a description of the methodology and assumptions that were used to estimate the various benefits. The last sub-section provides a discussion of other benefits which are recognized here in qualitative terms.

Table 1: Assumptions Used in the Estimation of State-of-Good-Repair Benefits

Category of Benefits	Benefit	Description
State of Good Repair	Pavement Maintenance Savings	Reduction in pavement maintenance costs due to changes in roadway usage/ reduction in VKT due to diversion of some auto trips to BRT and diversion of bus service to the dedicated BRT.
	Residual Value	Value of the Project after 20 years of use / at the end of analysis period.
User Benefits	Value of Travel Time Savings to Highway Users	Travel time savings to remaining roadway users.
	Net Out-of-Pocket Costs Avoided	Monetary cost savings to drivers diverting to transit (avoided vehicle operating costs net of transit fare payments).
	Value of Travel Time Impacts to Transit Riders who Diverted from Auto	Additional travel time cost to drivers diverting to transit. Travel time on transit offsets to some extent the out-of-pocket travel vehicle costs.
	Benefits to Existing Transit Users	Travel time savings to existing (Base Case) transit users due to faster speed and shorter wait times on BRT.
	Value of Transportation Benefits to Induced Riders	Consumer surplus or welfare benefit to induced or new riders who were not travelling before the Project.
Livability	Community Livability	Option value and amenity value of proposed facility; improvement in transportation options and access to amenities and public services.
Environmental	Reductions in Air Emissions	Reductions in pollutants and greenhouse gasses due to changes in private vehicle use relative to base case.
Safety	Accident Reduction	Reductions in property losses, injuries and deaths due to modal shifts.
Agency	Fare Revenues	Additional fare revenues of transit agency due to incremental ridership.
Health	Health Benefits of Increased Physical Activity	Transit transportation offers riders opportunities to increase their level of physical activity through daily walking. This may translate into reduction in incidence of health problems related to inactivity and reduction in mortality.

3.1. State of Good Repair

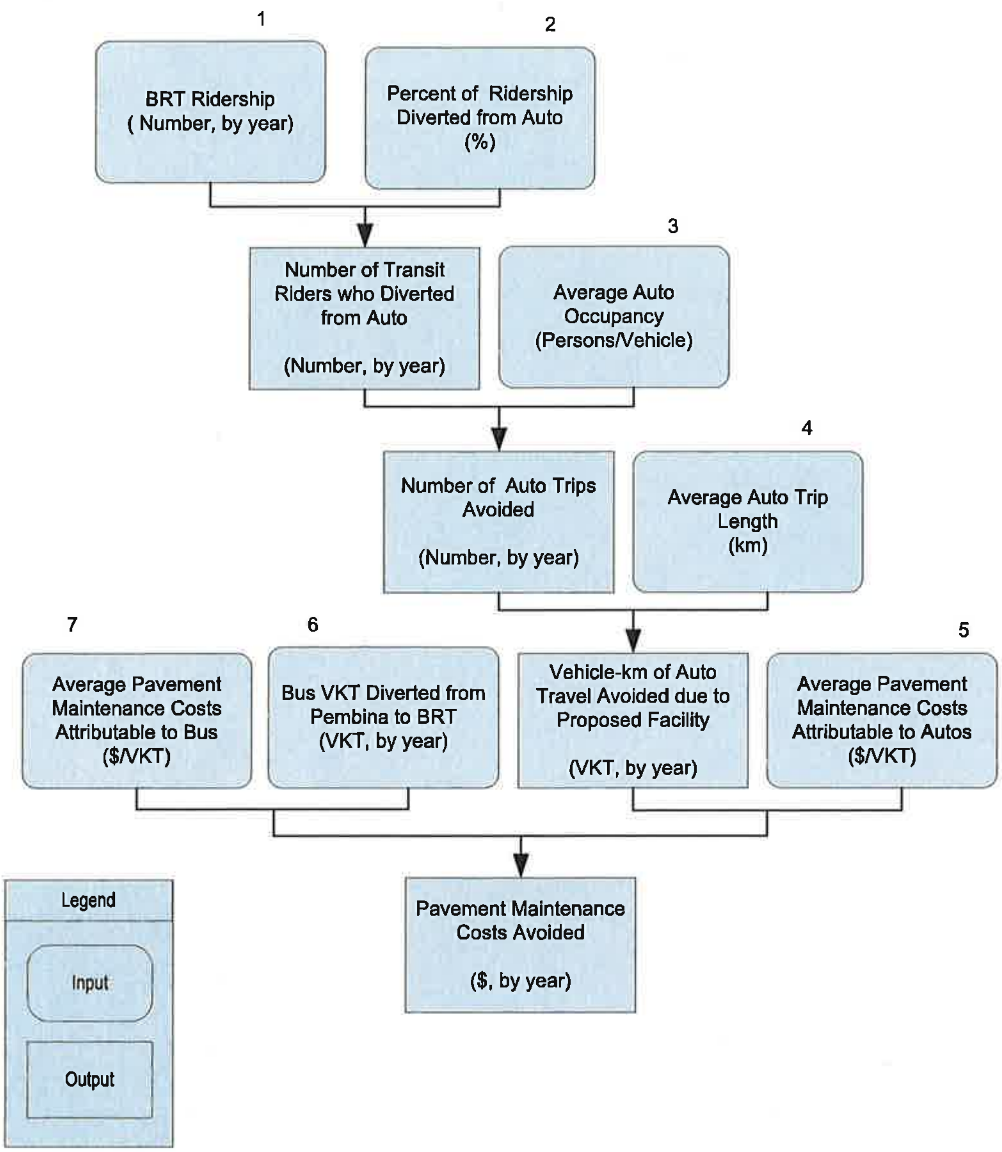
Approach

The reduction in vehicle kilometres travelled on Pembina Highway due to diversion of some auto trips to transit as well as diversion of transit buses to the dedicated BRT corridor will reduce wear and tear on the pavement and thus help improve the condition of the road network. To quantify this benefit, the impacts on the life-cycle pavement maintenance costs – or the costs savings in the annual pavement maintenance costs due to traffic diversion – were estimated.

This benefit in its essence is driven by the volume of vehicle kilometres (VKT) diverted and the average annual pavement maintenance costs per VKT. Auto VKT diverted were estimated based on assessed BRT ridership that would come from an auto. The number of auto trips that would be diverted to BRT is then multiplied by the average trip length in the corridor to give the total auto VKT avoided. Bus VKT avoided are assumed based on direct measures of bus VKT that would transfer services to the BRT. This methodology is shown in Figure 1.

The second benefit measured within the category of State of Good Repair is the residual value of the Project. The residual value of the Project is the sum of the residual values of the structure and right-of-way or land. This is calculated recognizing that the investment in the transit system has value beyond the 20-year analysis period within this CBA.

Figure 1: Estimation of Pavement Costs Avoided



Assumptions

The assumptions used in the estimation of State-of-Good-Repair benefits are summarized in the table below. To quantify the life-cycle benefits in pavement maintenance cost savings, the analysis applied a pavement maintenance cost of $0.09 per 100 auto VKT avoided and $0.03 per (one) bus VKT avoided to the estimated reduction in auto and bus VKT, respectively.

To quantify the residual value of the Project after 20 years, 60 percent of the original cost of the Project's construction costs of structures and 100 percent of its land costs are considered. All the land costs are considered at the full value at the end of this analysis as land typically does not depreciate. The costs of utility relocation, landscaping, engineering and administration were not assigned any residual value.

Based on the itemized costs of the BRT, costs of structures were estimated at [redacted] and land costs at [redacted]. The total estimated residual value of [redacted] is assigned to the end of the analysis period in 2039, and is discounted to 2014 using a discount rate.

Table 2: Assumptions Used in the Estimation of State-of-Good-Repair Benefits

Input #	Input Name	Units	Value	Source/Comment
1	Daily BRT Transit Ridership			Winnipeg Transit
	Ridership, initial estimates, 2016	Number, daily	15,400	Winnipeg Transit
	Average annual rate of growth in BRT transit ridership	percent	1.20%	Winnipeg Transit
2	Percentage of Ridership Diverted from Auto	percent	10.0%	Winnipeg Transit
3	Average Auto Occupancy	persons/ vehicle	1.20	Winnipeg Transit
4	Average Auto Trip Length	km	8.5	Winnipeg Transit. Note that transit and auto trip length are assumed equal.
5	Average Pavement Maintenance Cost, Auto	$/km	$0.0009	Addendum to the 1997 Federal Highway Cost Allocation Study Final Report (http://www.fhwa.dot.gov/policy/hcas/addendum.htm). Inflated to 2012 dollars.
6	Base Case Bus VKT Diverted			-
	Base Case Bus VKT	VKT, Annual	3,900,000	Winnipeg Transit
	Average Annual Rate of Growth	percent	0.90%	-
7	Average Pavement Maintenance Cost, Bus	$/km	$0.03	As for pavement maintenance for autos.
8	Residual Value of Structures			
	Construction Cost of Structures	$M	[redacted]	[redacted]
	Residual Value at End of Project Life	%	[redacted]	[redacted]
9	Residual Value of Land			
	Purchase Cost of Land	$M	[redacted]	[redacted]
	Residual Value at End of Project Life	%	[redacted]	[redacted]

3.2. User Benefits

The proposed BRT project would generate a range of mobility benefits and its related costs to people living in the impact area. In this analysis, the key measures of mobility improvements considered and quantified are:

- Travel-time savings;
- Out-of-pocket transportation cost savings; and,
- Benefits to induced riders (individuals who were not travelling before the project).

These benefits are often referred to as user benefits.

Travel time savings will be enjoyed by highway users who continue using an auto as well as by the existing transit users. The former enjoy travel time savings because of a reduction in VKT due to some auto VKT and bus VKT diversion which then results in an improvement in average speeds.

Out-of-pocket transportation cost savings will be enjoyed by auto users who divert to transit. These auto users would be saving cash expenses on parking, fuel and other vehicle operating expenses. 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. An estimate of the travel time differential is also included in this section to provide a full measure of impact.

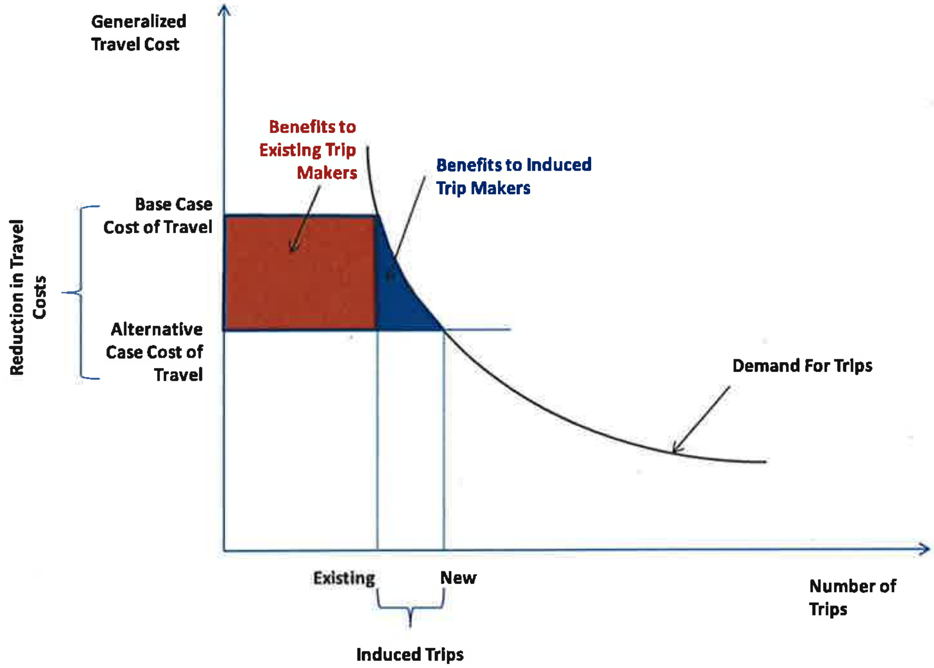
Induced riders will be enjoying the benefit of economic value that they receive from the transportation service that would be available to them and which they will decide to take advantage of after the project becomes operational.

The framework used in the estimation of user benefits is based on the theory of travel demand, and involves the estimation of changes in the cost of travel and consumer surplus. The demand for travel is an inverse relationship between the number of trips "demanded" and the generalized cost of travel, a cost measure which includes both out-of-pocket cash costs (such as vehicle operating and parking costs for auto users, or fare payments for transit riders) and travel time monetized using a value of time assumption. That relationship is depicted in Figure 2. The term "consumer surplus" refers to the area between the demand curve and the actual cost of travel at any point in time. It is a measure of welfare to the extent that people who are traveling at that cost are "paying" less than what they would be willing to pay. In other words the value the travelers are placing on a trip, as measured by their willingness-to-pay along the demand curve, is higher than what they are actually paying, and the difference is the consumer surplus.

As explained earlier, the project is expected to reduce the general cost of travel and result in benefits to both existing and new trip-makers. Benefits to existing trip-makers are represented by the red rectangle in Figure 2. They are estimated as the difference between the generalized cost of travel in the base case and the generalized cost of travel in the build scenario times the number of trips.

In addition, as the generalized cost of travel is being reduced, additional trips (beyond those diverted from other modes) are expected. These induced trip-makers represent a portion of all potential trip-makers who did not make a trip (or as many trips) in the no-build scenario, but are now "attracted" by the lower generalized cost allowed by the investment in the BRT.

Figure 2: Framework for the Estimation of User Benefits



User benefits resulting from new trips are depicted by the blue triangle in Figure 2. They are estimated using the "rule-of-a-half", which quantifies the change in the social welfare that results from induced trips, by linear approximation of the blue triangular area under the demand curve shown in Figure 2 and calculating the area as change in price multiplied by the number of induced trips and divided by two.

The methodology of estimation of each of the user benefits and data that was used are discussed in some detail below.

Auto Travel Time Savings

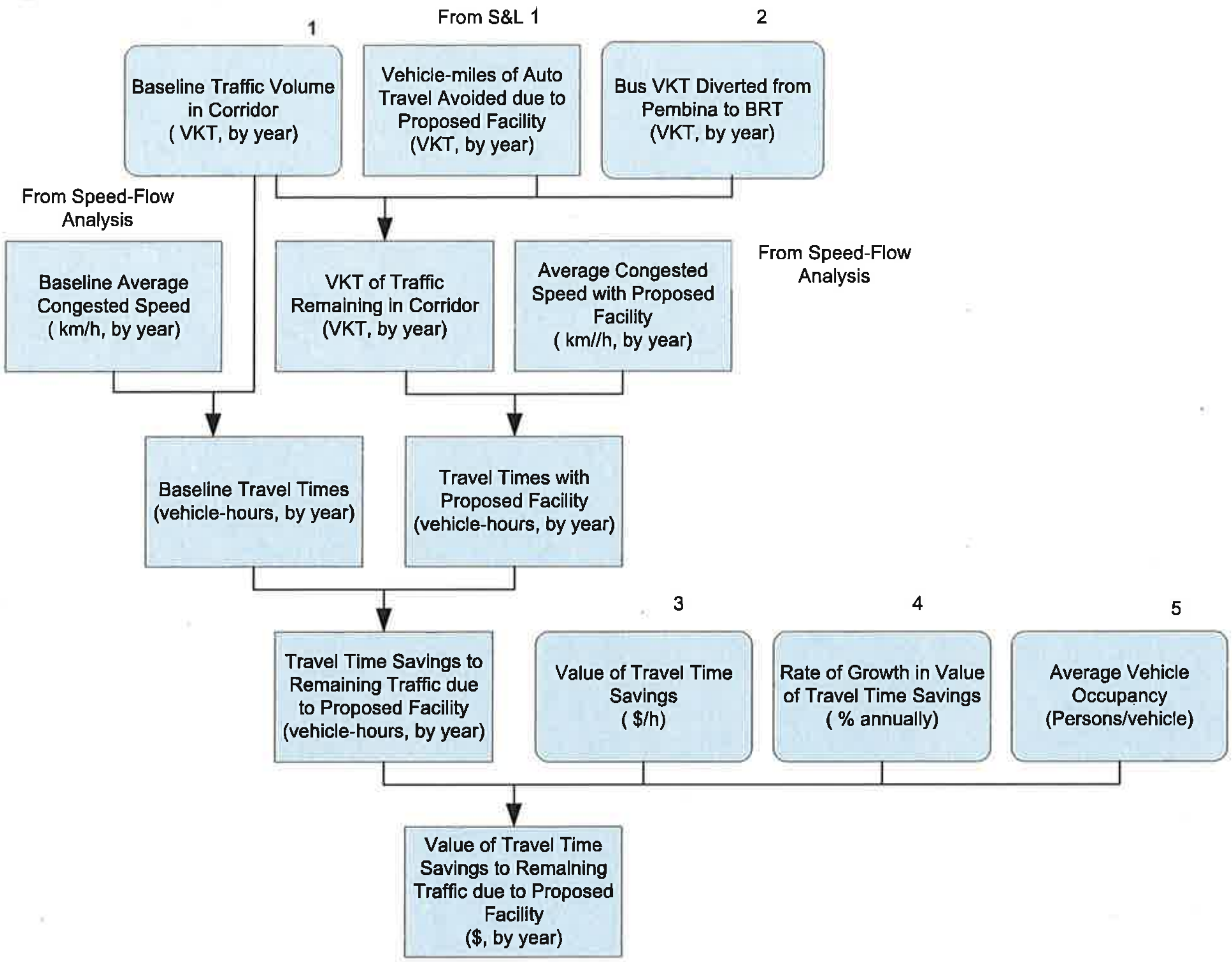
Approach

Figure 3 shows the estimation of travel time savings to auto users who continue driving in the existing travel corridor after the BRT opens. Although not shown explicitly in the figure, auto travel time savings are estimated separately for peak period (combined morning and evening) and off-peak. For simplification, the figure also omits the step in which the annual auto and bus VKT are estimated from a figure for 2016 and average annual rate of growth.

Both peak and off-peak travel time savings are estimated as the difference between the travel time under the no-build base case and under the build scenario which are then monetized using a value of travel time savings assumption. 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 and buses diverted to the dedicated BRT corridor. Speed-flow equations are used to predict the average speed under the base case and build scenario travel volumes and then travel time for a given volume of traffic. A Bureau of

Public Roads speed-flow relationship (BPR curve) is used for this purpose.[1] 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.

Figure 3: Estimation of Travel Time Savings to Remaining Auto Users



<u>Assumptions</u>

The assumptions used in the estimation of travel time savings to auto users who continue driving are summarized in the table below.

[1] A version of the curve with the coefficient equal to 0.15 and the exponent equal to 4 is used in this evaluation.

Table 3: Assumptions Used in the Estimation of Travel Time Savings to Remaining Auto Users

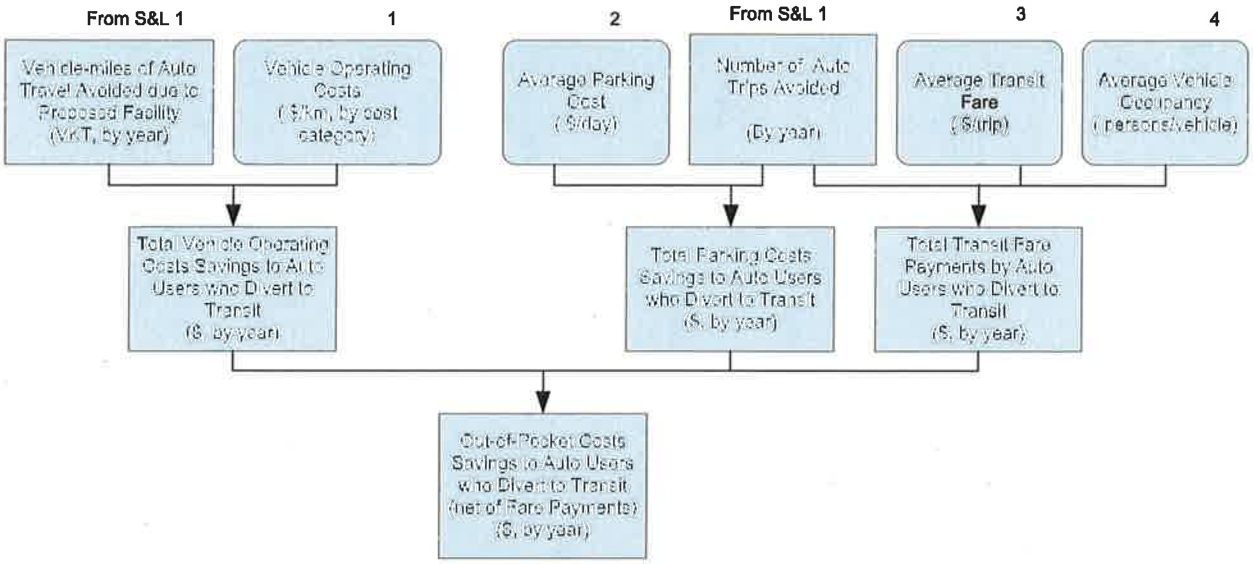
Input #	Input Name	Units	Value	Source/Comment
1	Baseline traffic volume in corridor			
	Traffic volume in Peak Period (AM and PM), 2016	Annual VKT	31,532,875	Calculated by HDR from ADT provided by Winnipeg Transit times corridor length.
	Traffic volume in Off-Peak Period, 2016	Annual VKT	77,632,625	Calculated by HDR from ADT provided by Winnipeg Transit times corridor length.
	Rate of growth	%		Winnipeg Transit. The same rate is assumed for peak and off-peak.
	2011-2016		0.76%	Winnipeg Transit
	2016-2021		0.91%	Winnipeg Transit
	2021-2026		0.95%	Winnipeg Transit
	2026-2031		0.74%	Winnipeg Transit
2	Base Case Bus VKT			
	Base Case Bus VKT, daily weekday, 2016	VKT, Daily	12,900	Winnipeg Transit
	Total Annual Bus VKT	Annual VKT	3,900,000	
	Average Annual Rate of Growth	percent	0.90%	Winnipeg Transit
	Percent of bus traffic in peak period	percent	57%	Assumed the same as percentage of trips (Winnipeg Transit).
3	Value of time	$/h, per person	$16.21	Calculated by HDR as 50% of median household wage in Winnipeg (median income divided by 1950).
4	Real Growth Rate in Value of Time (Growth Index)	%	1.023	Based on a 2.3% rate of growth in GDP for Winnipeg (Conference Board of Canada, "Long-Term Economic Forecast for Winnipeg's Census Metropolitan Area" August 2012).
5	Average Vehicle Occupancy	persons/ vehicle	1.2	Winnipeg Transit
	Percent of Diverted Ridership that is in Peak Hours	%	80%	Assumed the same as percentage of trips (Winnipeg Transit).

Out-Of-Pocket Cost Savings

Approach

Figure 4 shows the estimation of out-of-pocket cost savings to auto users switching to transit. Savings in vehicle operating costs are driven by the reduction in VKT which is then multiplied by a vehicle cost per km that includes fuel and other pertinent vehicle cost. This is then supplemented by savings in parking cost and reduced by transit fare payments. Note that for 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 transit 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 4: Estimation of Out-of-Pocket Costs Savings to Auto Users Diverting to Transit



<u>Assumptions</u>

Table 4 shows the assumptions used in the estimation of out-of-pocket travel cost savings. As explained earlier, vehicle operating cost savings are driven by the amount of VKT avoided which are monetized using a cost per VKT assumption and specifically fuel cost, maintenance cost, tire cost, and vehicle depreciation cost per VKT. Those costs are based on the 2013 edition of driving costs published annually by the Canadian Automobile Association (CAA), except for vehicle depreciation. The latter is based on a 2003 study for the Minnesota Department of Transportation. As argued in this study, the full vehicle depreciation cost calculated as total vehicle cost divided by total km driven by the vehicle over the time it is owned may be overestimating the depreciation cost intended for most cost-benefit analysis purposes. The full depreciation cost is related to the kilometres driven by the vehicle as well as its age. The Minnesota study developed an estimate related to "incremental" kilometres that captures the cost related to excessive or incremental driving of a vehicle.

Vehicle operating costs are assumed constant during the analysis period except for fuel which is assumed to increase in real terms. The rate of growth in fuel prices is based on forecasts by the US Energy Information Agency's Annual Energy Outlook (2013 Edition).

Table 4: Assumptions used in the Estimation of Out-of-Pocket Travel Cost Savings

Input #	Input Name	Units	Value	Source/Comment
1	Vehicle Operating costs	$/km	$0.255	Sum of the items below.
	Gas		$0.108	Driving Costs, CAA, 2013 Edition; Camry LE model (page 4).
	Maintenance		$0.037	Driving Costs, CAA, 2013 Edition; Camry LE model (page 4).
	Tires		$0.020	Driving Costs, CAA, 2013 Edition; Camry LE model (page 4).
	Vehicle depreciation		$0.09	The Per-Mile Costs of Operating Automobiles and Trucks, 2003, University of Minnesota, (converted to CAN$). Humphrey Institute of Public Affairs, for Minnesota Department of Transportation, 2003.
2	Average Parking Cost	$/day	$6.00	Reasoned assumption, by HDR. Based on a $120 monthly pass (based on current rates for parking posted at Winnipeg Parking Authority; reserved parking).
3	Average Transit Fare	$/trip	$1.52	Winnipeg Transit
4	Average Vehicle Occupancy	persons/ vehicle	1.2	Winnipeg Transit

Travel Time Impacts to Auto Users Diverting to Transit

Approach

Figure 5 shows the estimation of travel time impacts on auto users who divert to transit. Transit travel usually takes longer than auto travel and thus the monetized dis-benefit of travel time effects is included in this analysis for a more complete picture of user benefit effects. 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 (average sp0eed divided by trip length). Transit travel time includes time in vehicle and waiting times. Although not shown explicitly in the figure, auto travel time savings are estimated separately for peak period (combined morning and evening) and off-peak.

Highway travel time increases over time due to average speeds deteriorating over time while transit speed is assumed as approximately constant.

Figure 5: Estimation of Travel Time Impacts on Auto Users who Divert to Transit

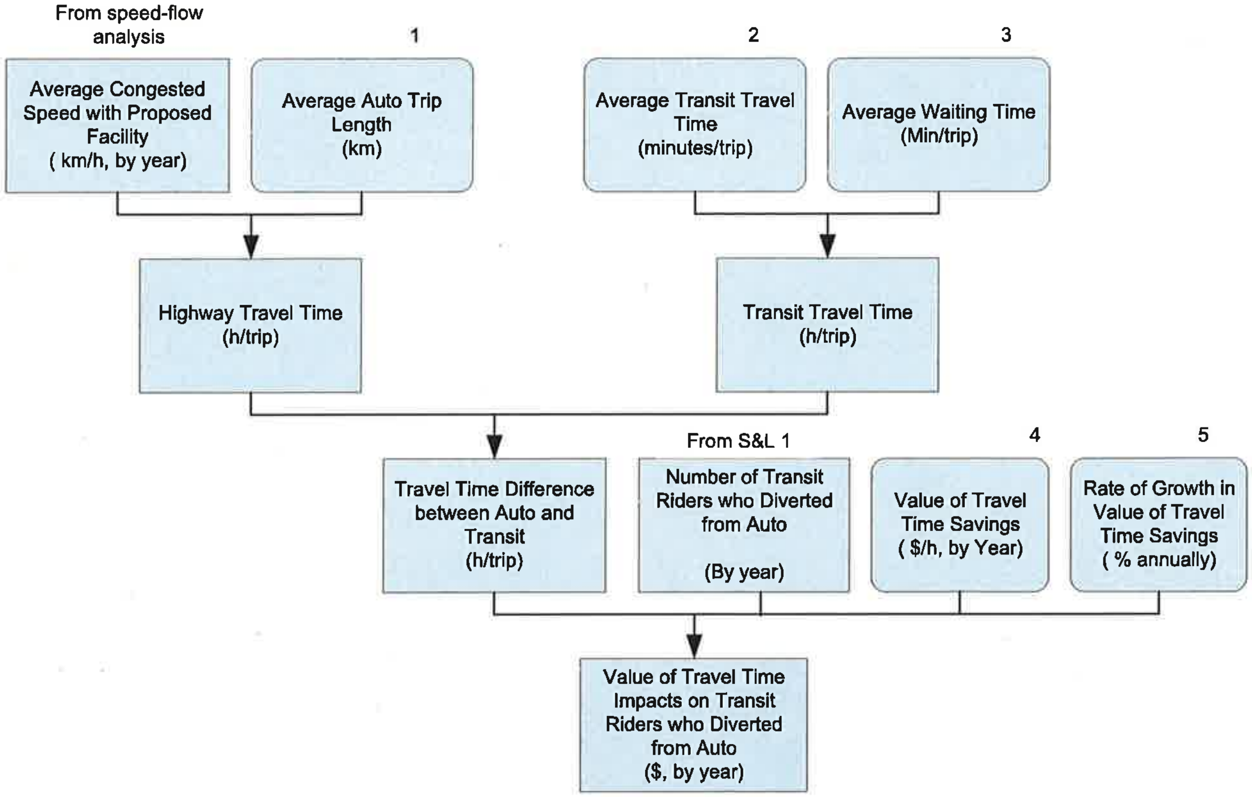


Table 5 shows assumptions used in the estimation of travel time impacts on auto users who divert to transit.

Table 5: Assumptions Used in the Estimation of Travel Time Impacts on Auto Users Diverting to Transit

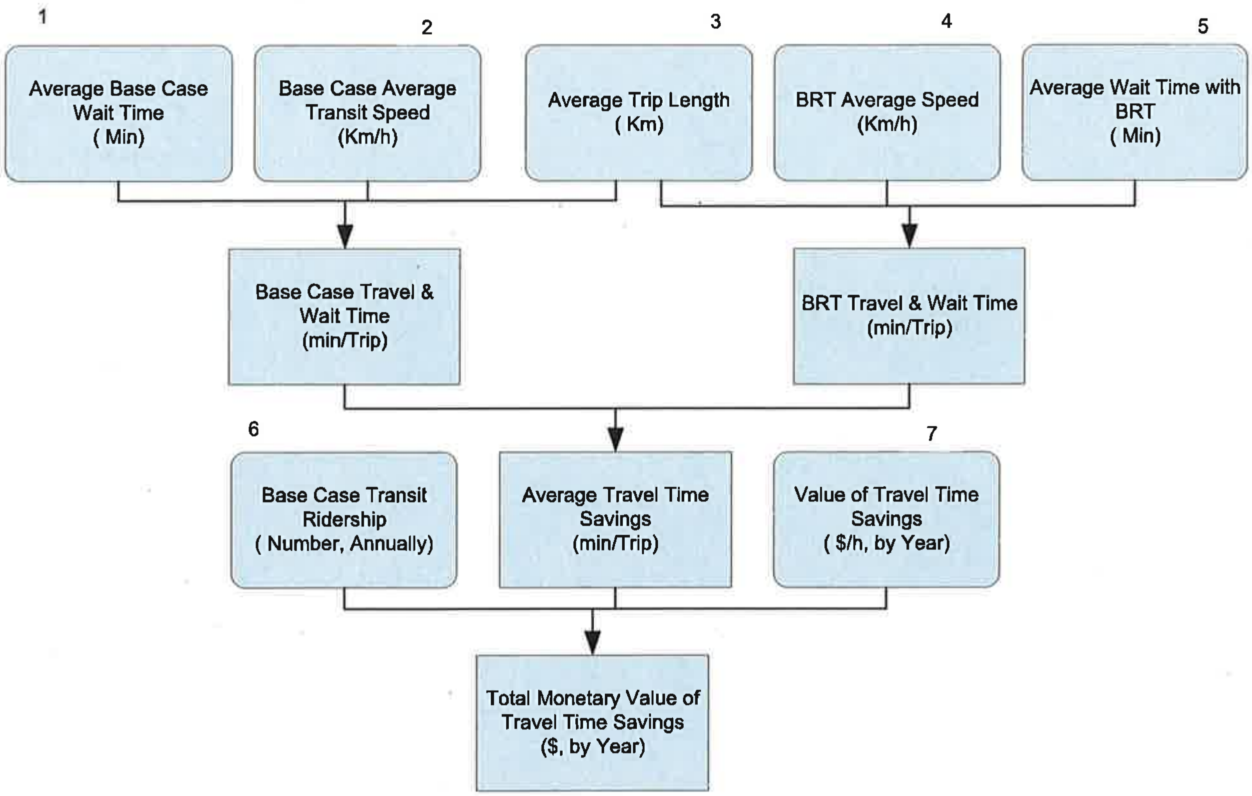
Input #	Input Name	Units	Value	Source/Comment
1	Average Auto Trip Length	km	8.5	Winnipeg Transit
2	Average Transit/BRT Travel Time, Minutes	minutes	18.2	Calculated from inputs provided by Winnipeg Transit (average speed divided by average trip length).
3	Average Transit Waiting Time	minutes	4	Winnipeg Transit
4	Value of Travel Time Savings	$/h	$16.21	Calculated by HDR as 50% of median household wage in Winnipeg (median income divided by 1950).
5	Real Growth Rate in Value of Time (Growth Index)	%	1.023	Based on a 2.3% rate of growth in GDP for Winnipeg (Conference Board).
	BRT speed, km/h	km/h	28.00	Winnipeg Transit. Note that speed assumed constant over study period.
	Percent of Diverted Ridership that is in Peak Hours		80%	Reasoned assumption. To be confirmed by Winnipeg Transit.

Travel Time Savings to Existing Transit Users

Approach

The fare for a bus and a BRT trip is the same. Therefore, the base case transit users (current and future users who will be taking transit in the corridor even in the absence of the BRT) benefit from the new service in the form of travel time savings due to higher average vehicle speed and shorter wait times. The difference in total travel time (in vehicle plus wait time) between the base case and BRT is multiplied by the value of travel time savings represents the value of these travel time savings per trip. Multiplying by total annual base case ridership gives the total monetary value of this benefit. This is illustrated in Figure 6 below.

Figure 6: Estimation of Travel Time Savings to Existing Transit Riders



Assumptions

The table below shows the assumptions used in the estimation of travel time savings to existing transit users. Transit operational information is used to calculate the travel time savings which are multiplied by the projected base case ridership. The value of travel time savings is based on the household income profile in Winnipeg.

Table 6: Assumptions Used in the Estimation of Travel Time Savings to Existing Transit Users

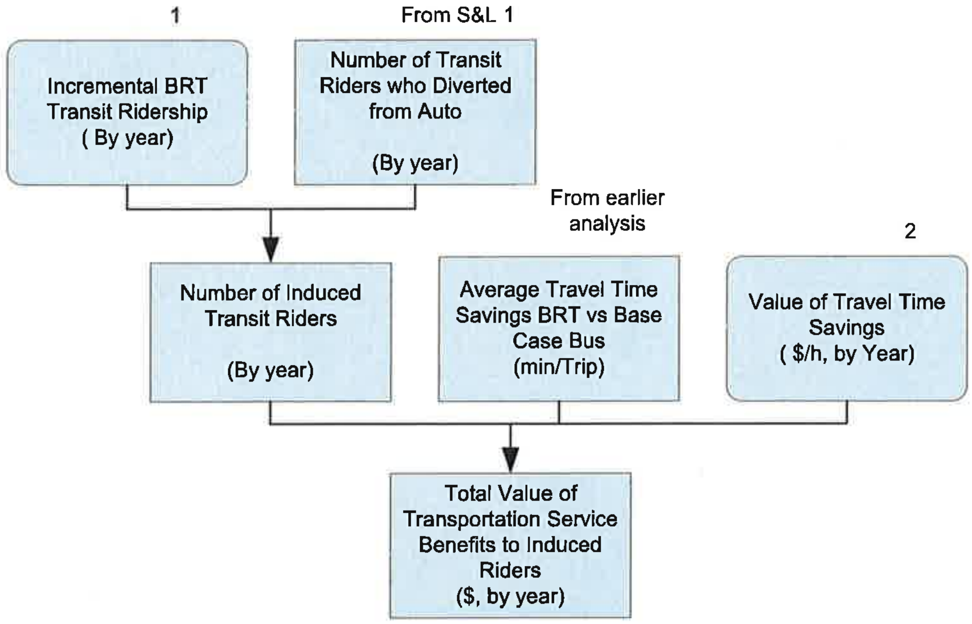
Input #	Input Name	Units	Value	Source/Comment
1	Base Case Average Waiting Time	min	6	Winnipeg Transit
2	Base Case average speed	km/h	19.7	Winnipeg Transit
3	Average Trip Length	km	8.5	Winnipeg Transit
4	BRT Average Speed	km/h	28	Winnipeg Transit
5	BRT Average Waiting Time	min	4	
6	Existing Transit Ridership			
	Ridership in opening year, 2016	Number, daily	13,400	Winnipeg Transit
	Average annual rate of growth in Base Case transit ridership	%	1.20%	Winnipeg Transit
7	Value of Travel Time Savings	$/h	$16.21	Calculated by HDR as 50% of median household wage in Winnipeg (median income divided by 1950).
	Real Growth Rate in Value of Time (Growth Index)	%	1.023	Based on a 2.3% rate of growth in GDP for Winnipeg (Conference Board of Canada, "Long-Term Economic Forecast for Winnipeg's Census Metropolitan Area" August 2012).

Benefits to Induced Riders

<u>Approach</u>

Figure 7 shows the estimation of economic benefits to induced riders. In the absence of 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 the BRT represents thus the transportation benefit to induced riders. Since the fare remains the same on the two systems (i.e. bus and BRT), this benefit is the same as the travel time savings to existing riders. 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 7: Estimation of Economic Benefit to Induced Riders



<u>Assumptions</u>

The value of time used to estimate this benefit is the same as for other benefits which are converted into monetary values using valuation of travel time savings. Number of induced trips is estimated as the difference between ridership under the BRT and the Base Case minus ridership that represents trips diverted from auto.

3.3. Livability Benefits

<u>Approach</u>

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, 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. However, 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:[2]

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[2] 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.

- 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%.

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.[3] 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.[4]

Property value impact of BRT could thus 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.

The data on the number of properties around each of the new BRT station was not available. Therefore, a more simplified "high-level" approach was adopted that uses the average density of residential dwellings across the entire City of Winnipeg, or number of properties per square kilometre (calculated as total number of residential dwellings divided by Winnipeg'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 estimated. Knowing the number of properties, their average value, and property premium, property value uplift can be calculated.

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 the livability 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 8 below provides a graphical illustration of the methodology.

The impact on commercial properties is not estimated here due to lack of data on commercial properties.

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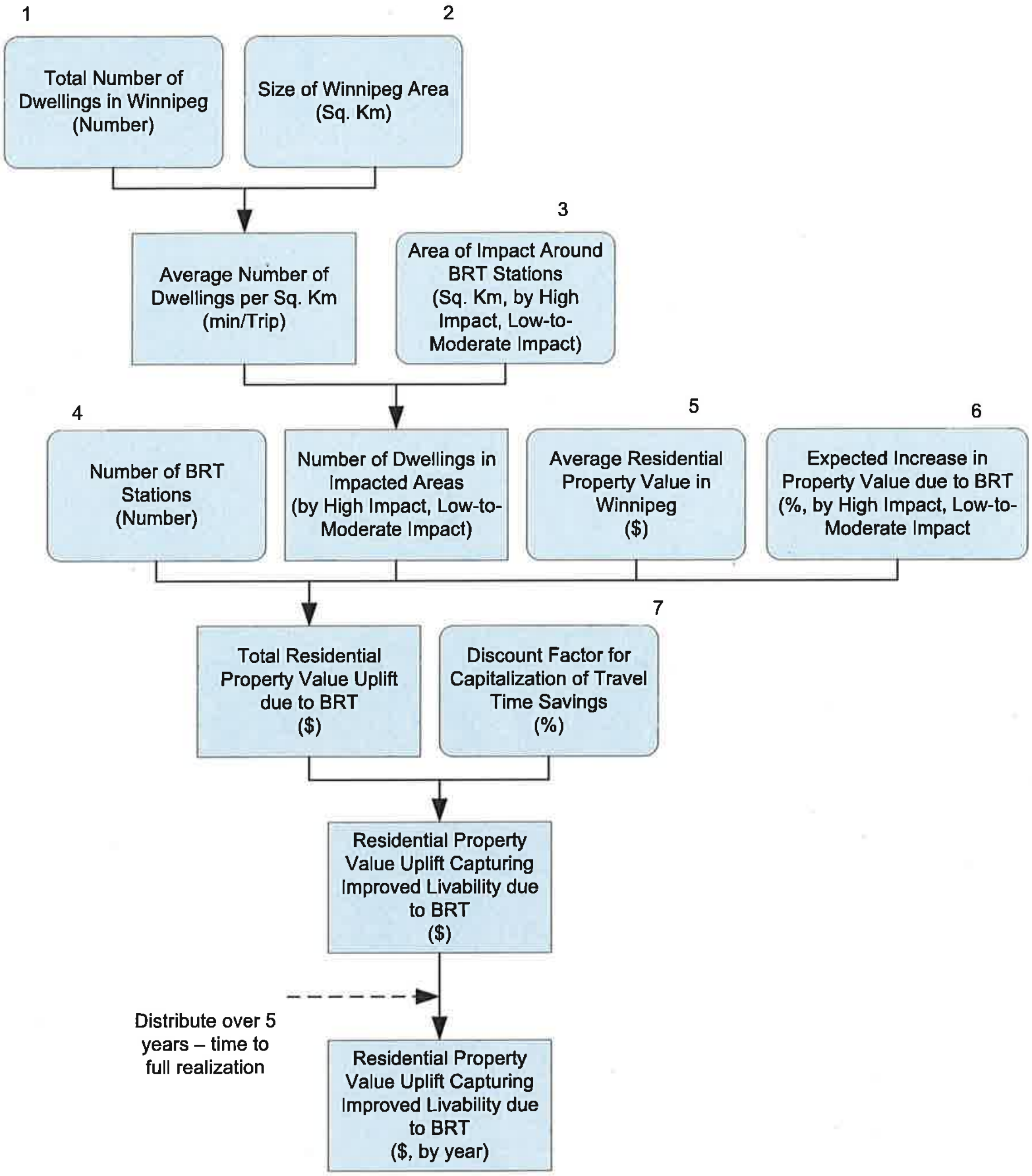
[3] Metrolinx, "Sheppard-Finch LRT Benefits Case", June 2009, Table 13, page 30.

[4] 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).

Figure 8: Estimation of Livability Benefits



Assumptions

Table 7 below provides a summary of all assumptions used in the estimation of livability improvements.

Livability Benefits

Table 7: Assumptions used in the Estimation of ~~Environmental Sustainability Benefits~~

Input #	Input Name	Units	Value	Source/Comment
1	Number of Dwellings in Winnipeg		268,785	Statistics Canada, 2011 Census
2	City Area, sq.km		464	Statistics Canada
3	[redacted]	sq. km		HDR reasoned assumption and industry practices.
	[redacted]		[redacted]	
	[redacted]		[redacted]	Excludes high impact area.
	[redacted]			Calculated based on average density of dwelling units in Winnipeg (units per sq. km).
	[redacted]	Number	[redacted]	
	[redacted]	Number	[redacted]	
4	Number of Stations	Number	10	Winnipeg Transit
5	Average residential property value in Winnipeg	$	$257,574	Statistics Canada, National Household Survey 2011.
6	Property value premium due to BRT	%		HDR reasoned assumptions based on literature.
	[redacted]	%	[redacted]	
	[redacted]	%	[redacted]	
7	Discount on property value uplift to account for possible double-counting	%	50.0%	Based on HDR project experience and research conducted for other projects.
8	Time to full realization of property value uplift	Years	5.00	HDR reasoned assumption.

Clarification:

Table 7 title is incorrect.

Correct title is *"Assumptions used in the Estimation of Livability Benefits"*.

3.4. Environmental Benefits

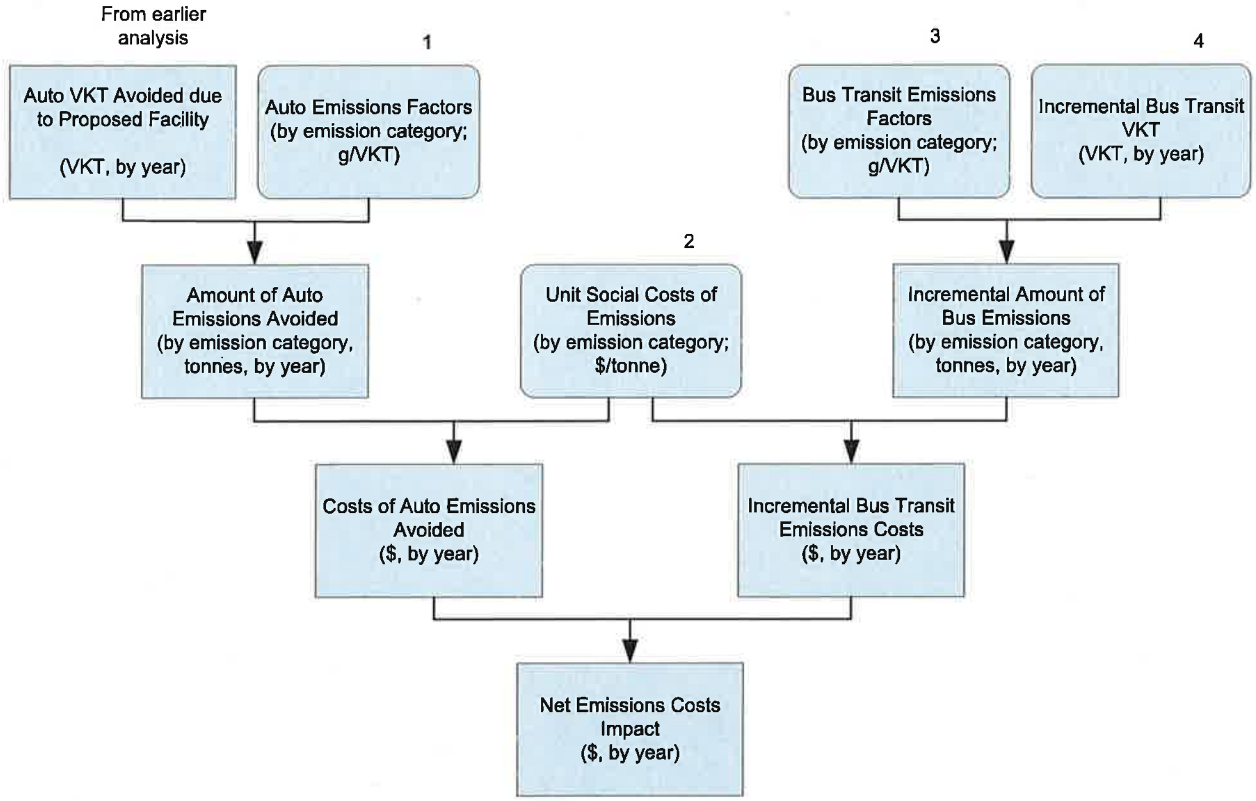
Approach

The Project generates positive environmental impacts in addition to the roadway impacts that have already been discussed earlier by reducing local and regional use of motorized vehicles and thus reducing fossil fuel consumption.

For the Project, two categories of environmental impacts are considered: reductions in greenhouse gas emissions and in air pollutant emissions. Greenhouse gas emissions are measured in carbon dioxide (CO_2) equivalent terms and air pollutants include carbon monoxide (CO), nitrogen oxides (NO_X), sulfur dioxide (SO_2), volatile organic compounds (VOC), and fine articulate matter (PM2.5).

Reduction in emissions depends upon the reduction in VKT resulting from diversion to transit by some auto users. Figure 9 below illustrates the general structure and logic of the estimation of emissions cost savings. Emission factors applied to VKT of travel are used to quantify the amount of emissions avoided or incremental emissions. These are then multiplied by unit social costs of emissions. Although shown in Figure 9, incremental transit bus emissions are assumed equal to zero as the bus diversion to BRT will result in no change in total bus VKT.

Figure 9: Estimation of Emission Impacts



Assumptions

The assumptions used in the estimation of sustainability benefits are summarized in the table below. The emission rates used in this CBA are obtained from Motor Vehicle Emission Simulator (MOVES). 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 costs are based on a range of literature on valuations of various pollutants reviewed by HDR and include a wide range of costs including human health and agricultural impacts. The specific value selected represents a mean or most commonly reported value encountered in the literature. All values were converted to Canadian dollars and inflated to 2014 dollars.

Table 8: Assumptions used in the Estimation of Environmental Sustainability Benefits

Input #	Variable Name	Unit	Value	Source
1	Auto Emissions Factors (Light Duty Gasoline Vehicles)	g/VKT	Varies by speed and air pollutant	For average congested speed on Pembina in BRT opening year (34 km/h or 21mph).
	SO_2		0.00422	
	PM 2.5		0.00310	
	VOC		0.02444	
	NO_X		0.16250	
	CO		1.77374	
	CO_2		280.5	
2	Unit Costs of Emissions	$/metric ton		
	SO_2		$35,799.13	
	PM 2.5		$334,895.13	
	VOC		$1,501.25	
	NO_X		$6,120.50	
	CO		negligible	
	CO_2/GHG		$42.24	Interagency Working Group on Social Cost of Carbon (Most Likely value at 3% discount rate). Cost varies by year. Value given here represents average 2015-2035.

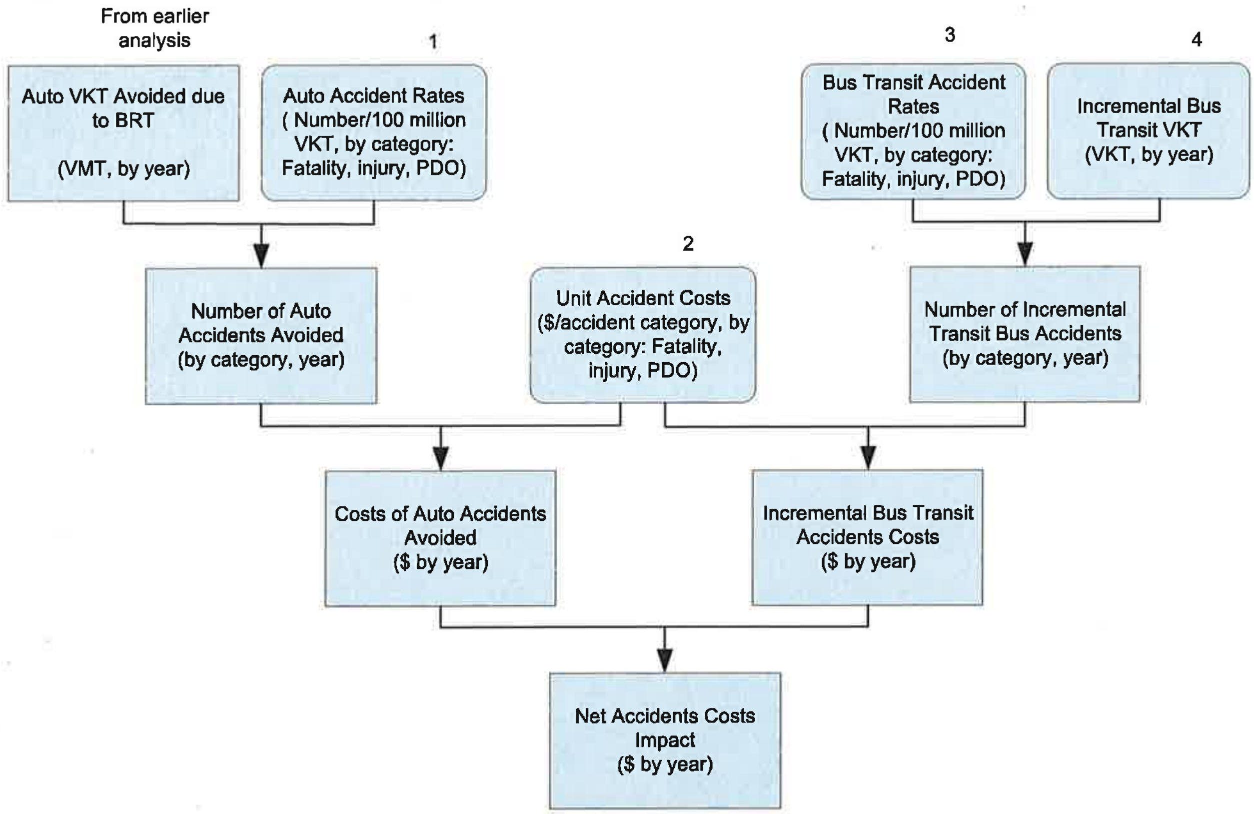
3.5. *Improved Safety Benefits*

Approach

The proposed BRT will contribute to road safety improvements in the corridor through a reduction in the total auto VKT which can be expected to decrease the total number of car accidents and thus accident-related societal costs.

The changes in the volume of VKT on the road 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 10. Although shown in Figure 10, incremental transit bus accidents are assumed equal to zero as the bus VKT will remain essentially unchanged.

Figure 10: Estimation of Safety Benefits



<u>Assumptions</u>

The assumptions used in the estimation of safety benefits are summarized in the table below. Accident rates are based on statistical data on the number of road accidents from the US Bureau of Transportation Statistics. Unit accident costs were derived from a 2010 study for Edmonton's Capital Region Intersection Safety Commission.

Table 9: Assumptions Used in the Estimation of Safety Benefits

Input #	Variable Name	Unit	Value	Source
1	Auto Accident Rates	Number/100 Million VKT		US Bureau of Transportation Statistics, National Transportation Statistics.
	Fatalities		0.69	
	Injuries		46.91	
	PDO		113.54	
2	Unit Accident Costs	$		Paul de Leur, "Collision Cost Study", prepared for Capital Region Intersection Safety Partnership, February 2010.
	Fatalities	$/Fatality	$3,813,652	
	Injuries	$/injury	$172,987	
	PDO	$/accident	$12,016	

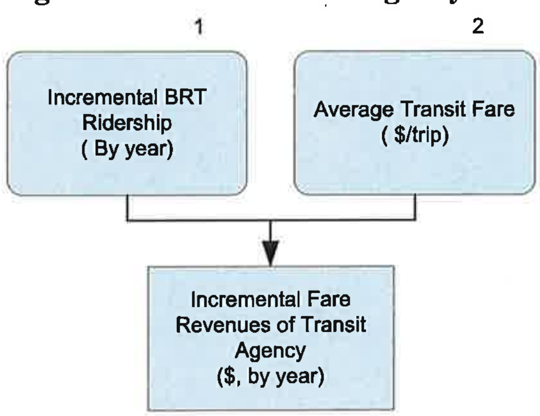
The collision costs estimated in the Edmonton 2010 study include a comprehensive range of costs including direct costs and indirect costs. Direct costs include property damage, emergency response, health services, legal costs, travel delay, and short-term productivity costs. Indirect costs include loss of productivity, pain and suffering, lost quality of life and loss of life. All costs were estimated using two general approaches: human capital costs and willingness to pay approaches. The latter approach usually produces much larger estimates for fatalities and serious injuries. For the purpose of this evaluation, the average of the two sets of estimates was used and inflated to 2014 dollars using a CPI index. Since the Edmonton study provided two estimates of injuries (for minor and serious injury), and the accident rates are available only for one general category of accidents, the unit cost used in this evaluation and shown in Table 9 was calculated as a weighted average of costs for serious and minor injury (with weights equal to 15% and 85%, respectively).

3.6. Agency Benefits (Incremental Revenues)

Approach

The incremental ridership on the new BRT section will provide Winnipeg Transit additional fare revenues. 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 were 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 11.

Figure 11: Estimation of Agency Benefits



Assumptions

The table below shows the assumptions used for the estimation of incremental transit revenues. The incremental BRT ridership was calculated as the difference between the BRT ridership and the base case ridership.

Table 10: Assumptions Used in the Estimation of Agency Benefits

Input #	Input Name	Units	Value	Source/Comment
1	Incremental BRT Transit Ridership			
	Incremental Ridership in 2016	Number	2,000	Calculated as difference between BRT and Base Case ridership.
	Average annual rate of growth	%	1.20%	Winnipeg Transit
2	Average Transit Fare	$/trip	$1.52	Winnipeg Transit

3.7. Health Benefits

Health benefits typically linked to the presence and use of public transportation include:[5]

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

The first two categories of impact are already accounted for under improved safety benefits and environmental benefits, respectively. Therefore, this benefit for the purpose of this evaluation 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.

Background and Approach in this Evaluation

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 day, 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.[6]

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.[7]

[5] As an example see: Toronto Public Health, "Road to Health: Improving Walking and Cycling in Toronto", a Healthy Toronto by Design Report, April 2012.
[6] "Canadian Health Measures Survey: Directly measured physical activity of Canadians, 2007 to 2011", Statistics Canada, The Daily, Thursday, May 30, 2013.
[7] 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.

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.[8] 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.[9] 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.[10] The median walk time to/from transit stops and stations amounts to as much as 19 minutes per day.[11]

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. Increase in physical activity would 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 populations 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) gives the monetary value of reduced mortality due to increased transit-related activity.[12]

A similar approach could be applied to transit projects. Although the specific activity profile of auto users in Winnipeg is not known, based on the data discussed above it can be assumed that walking to and from the transit stops or stations may be approximately sufficient to increase the level of physical activity of a new user to (or nearly to) the recommended level of physical activity.[13] This would then result in the avoidance of costs of physical inactivity for this population group. This methodology is

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[8] 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.

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

[10] 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.

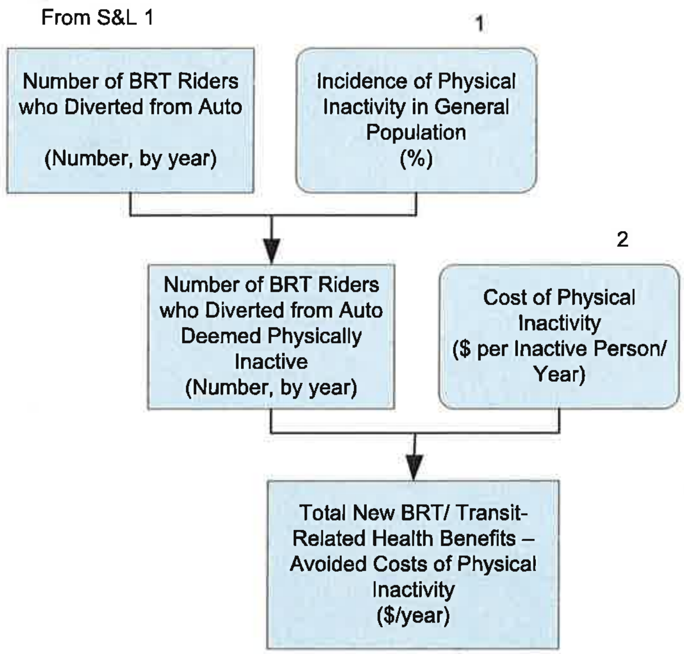
[11] See Besser and Dannenberg (2009). HDR's recent experience with a major Canadian transportation agency that collected data on walking time of transit passengers suggest an average walk time to/from transit station or stop of 9.45 minutes per transit trip-leg.

[12] 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

[13] Based on direct measurements of physical activity of Canadians (see "Canadian Health Measures Survey"), the average time spent in moderate to vigorous physical activity amounts to about 21 to 27 minutes per day (for women and men, respectively). Therefore, adding to this as an increment walking time to/from transit of about 10 to 15 minutes will result in achieving the recommended physical activity level of about 30 minutes per day.

illustrated in Figure 12 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 12: Estimation of Health Benefits of Increased Transit Use



Assumptions

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

A recent 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 form of lost output due to sickness).[14] 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 2014 using a Consumer Price Index gives an annual cost of inactivity of $307. This is interpreted as a benefit in the form of cost (largely) avoided for the group of auto users diverting to BRT.

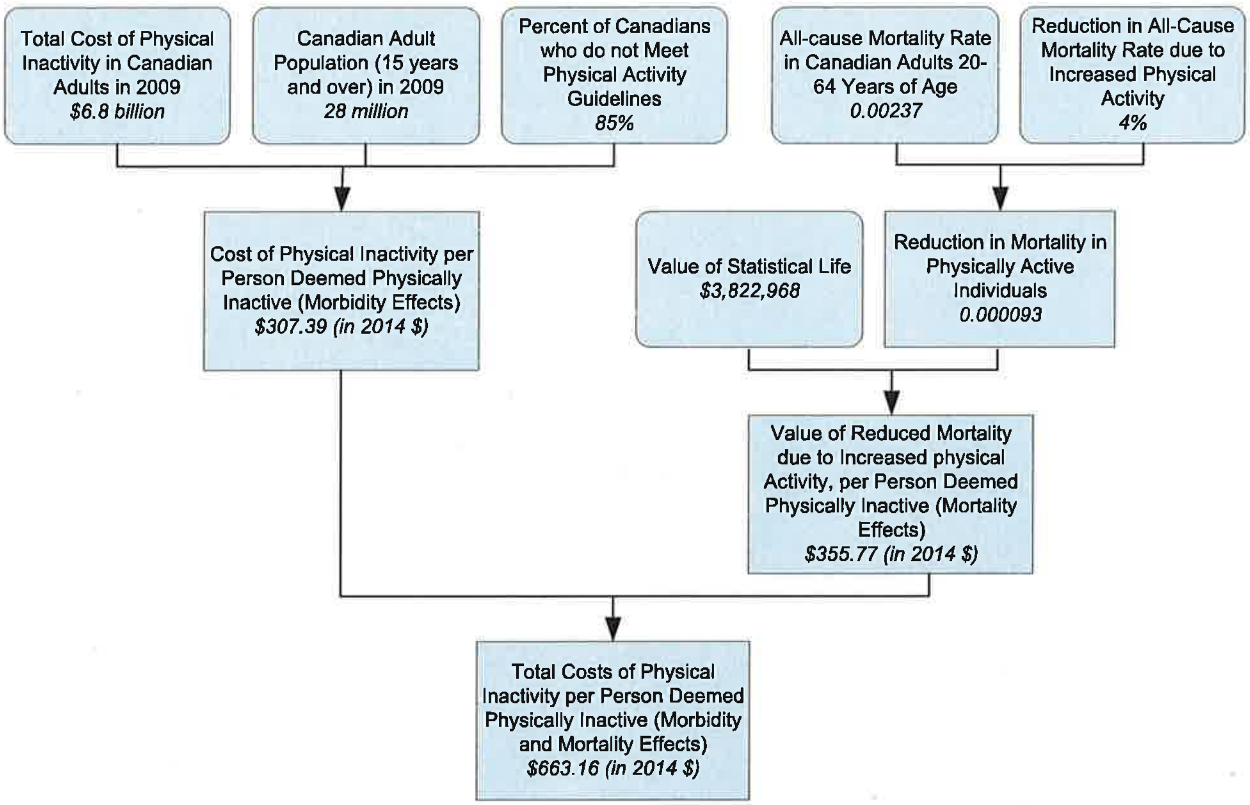
Reduction in mortality is based on a meta analysis of studies on the effects of physical activity on all-cause mortality. One such study by Samitz et.al (2011) concluded that an increase in light to moderate physical activity of one hour per week compared to no physical activity is associated with a 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 the new BRT line (adults 20 to 64 years old) gives a reduction in mortality of 0.0009306. Combining this with the value of statistical life of $3,822,968 (also used in this study for valuation of a

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

reduction in the number of fatalities due to a reduction in vehicle collisions) gives total value of a reduction in mortality of $355.70 per capita.

Combining the morbidity and mortality effects gives a total value of health benefit of $663.16 per capita per year. This derivation is illustrated in Figure 13. Table 11 that follows compiles all relevant assumptions.

Figure 13: Estimation of Valuation of Increased Physical Activity



Assumptions

The table below shows the key assumptions required to estimate the health benefits. The number of transit riders who diverted from auto is multiplied by the percentage of Canadians who do not meet the guidelines for physical activity. This gives the number of users deemed physically inactive (or insufficiently active) who could benefit from increased activity. This is then multiplied by the monetary value of increased activity derived in Figure 13.

Table 11: Assumptions Used in the Estimation of Health Benefits

Input #	Input Name	Units	Value	Source/Comment
1	Incidence of insufficient physical inactivity	percent	85%	Statistics Canada
2	Health Benefit Physical Activity			Derived by HDR based on various literature sources as shown in the figure above.
	Total Value of Health Benefits of Increased Physical Activity	$/inactive person	$663.16	

3.8. Other Benefits

The Southwest BRT Stage 2 may generate a range of other benefits for the City of Winnipeg. These benefits are more challenging to assess and may require detailed corridor specific economic data. Nevertheless, they are acknowledged and briefly discussed below in qualitative terms.

A topic of much interest in academia and government organizations in recent years have been so called "wider economic benefits" of transportation infrastructure.[15] This interest reflects a desire to improve the understanding of the role and impacts of such projects and to conduct more comprehensive assessments.[16]

The most potentially relevant benefits in the context of Winnipeg's Southwest BRT are market access benefits.[17] These effects capture the effect of expanding the range of destinations that a business can serve competitively from a given business location, or the range of areas from which it can reasonably acquire better production inputs and source better qualified workers. These effects are often represented as changes in the effective size or the effective density of the customer and labor market available to the firm. Expansion of the worker labor market can improve efficiency through better matching of specialized business needs and specialized worker skills, and can also enable more innovation through greater interaction of complementary firms and their employees. These effects are sometimes referred to as *agglomeration benefits.* They are likely significant in Winnipeg's case to the extent that the Southwest BRT will improve access to large and growing employment centres.

High capacity transit is also often seen as a catalyst, or potential catalyst, to development and re-development of areas around stations, attracting capital for commercial and residential development, and leading to revitalization of older commercial centres. While such developments are certainly desirable, in the context of a cost-benefit analysis proper attention has to be paid to the underlying drivers of such activities so as to avoid crediting the new transportation system with developments which represent a shift from other areas of the city (or which would take place anyway but somewhere else).

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[15] Refer to "Development of Tools for Assessing Wider Economic Benefits of Transportation:, SHRP 2 Strategic Highway Research Program Capacity, Transportation Research Board, July 2013, for a wide range of references reviewed during the course of that project and to populate spreadsheet models of impact.

[16] For example, the UK Department for Transport has issued specific guidance for conducting analysis and estimation of wider impacts of transportation projects. See: "The Wider Impacts Sub-Objective", TAG Unit 3.5.14, Department for Transport, Transport Analysis Guidance (TAG), September 2009, and "Wider Impacts and Regeneration" TAG Unit 2.8, Department for Transport, Transport Analysis Guidance (TAG), September 2009.

[17] Other frequently used categories of wider economic benefits are (1) Travel reliability benefits, and (2) Improved intermodal connectivity effects. See: "Development of Tools for Assessing Wider Economic Benefits of Transportation", SHRP 2 Strategic Highway Research Program Capacity, Transportation Research Board, July 2013. The discussion of market access effects in the main text is also based on this source.

During the construction period, Southwest BRT will also contribute to job creation or job opportunities in the construction and engineering industries and industries related to it through supply relationships. Although 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 opportunities supporting the community and offering valuable experience.

4. Project 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 and vehicles, etc. Total cumulative costs defined in this way are estimated at [redacted]. These costs are spread over the period of 4 years from 2016 to 2019 based on the cost schedule developed by Dillon. The costs of widening the Pembina Highway mentioned in the introductory section are excluded from this estimate as this is an add-on project not strictly required for the BRT.

~~The BRT is also expected to have an incremental annual operating cost of~~ [redacted] ~~related to the operations of one additional route.~~

~~Other operations and maintenance costs of structures and roadways (such as road maintenance, winter maintenance) are assumed to be included in the total capital cost estimate.~~

CLARIFICATION:

The above text is not correct. Correct text is:

"The Stage 2 BRT is expected to result in incremental annual operations and maintenance costs of [redacted] *over the 20 year analysis period. Infrastructure maintenance costs during the initial warranty period are assumed to be included in the total capital cost estimate."*

5. CBA Results

As mentioned earlier, the cost-benefit model was simulated over the period 2014 to 2039 with 2014 as the base year of the analysis to which all costs and benefits are discounted. Construction was assumed to begin in 2016, and 2020 was assumed to be the first year of full BRT operations. The model captures thus the construction period of 4 years from 2016 to 2019 and 20 years of project operations from 2020 to 2039. All quantifiable costs and benefits were estimated on an annual basis over that period. Discount rates of 3% and 8% were used to calculate the present value of costs, benefits, and net benefits.

Table 12 shows the summary results of the cost-benefit analysis for the main discount rate of 3% and the alternative rate of 8% for assessment of sensitivity of results. The table also shows all results in undiscounted dollar terms.

Overall, Table 12 demonstrates that at the discount rate of 3% the expected NPV of the BRT evaluated is larger than zero and of significant magnitude. At this rate, total project benefits amount to [redacted], project costs amount to [redacted], and NPV amounts to [redacted]. The benefit-cost ratio is 1.37; this means that for each $1 in costs the project generates benefits worth $1.37. The internal rate of return amounts to 5.9%, above the City of Winnipeg borrowing costs.

However, Table 12 also shows that at a more conservative or stringent discount rate of 8%, project NPV is negative at [redacted] and benefit-cost ratio of just 0.81. The internal rate of return of 5.9% means that the project would break even and generate NPV of at least $0 under a discount rate not higher than 5.9%.

Table 12: Summary of Cost-Benefit Analysis of Southwest BRT Corridor Stage 2 (2016-2039; 2014 Dollars)

Financial Indicators	Discount Rate		
	3%	8%	Undiscounted
Total Costs, $M	[redacted]	[redacted]	[redacted]
Total Benefits, $M	[redacted]	[redacted]	[redacted]
NPV, $M	[redacted]	[redacted]	[redacted]
ROI, Percent	37%	-19%	97%
Benefit-Cost Ratio, Ratio	1.37	0.81	1.97
Internal Rate of Return (IRR), Percent	5.9%		
Payback Period (Years from Project Start)	21	24+	17

Table 13 shows the detailed results of the cost-benefit analysis by category of benefits and costs for both discount rates considered. The last column in the table shows the distribution in percentage terms of costs and benefits for the discount rate of 3%.

Table 13: Detailed Breakdown of Benefits and Costs

Benefit Category	Values over Analysis Period by Discount Rate			Distribution at 3% Discount Rate
	3%	8%	Undiscounted	
BENEFITS				
State of Good Repair				
Pavement Maintenance Costs Avoided	[redacted]	[redacted]	[redacted]	0.3%
Residual Value	[redacted]	[redacted]	[redacted]	12.9%
User Benefits				
Value of Travel Time Savings to Remaining Auto Users	[redacted]	[redacted]	[redacted]	24.1%
Out-of-Pocket Cost Savings to Auto Users who Diverted to Transit	[redacted]	[redacted]	[redacted]	4.0%
Travel Time Impacts to Auto Users who Diverted to Transit	[redacted]	[redacted]	[redacted]	-2.6%
Benefit to Induced Riders	[redacted]	[redacted]	[redacted]	0.8%
Benefit to Existing Transit Users	[redacted]	[redacted]	[redacted]	47.1%
Economic Development Benefits				
Livability Benefits	[redacted]	[redacted]	[redacted]	6.1%
Safety Benefits				
Costs of Auto Accidents Avoided	[redacted]	[redacted]	[redacted]	1.3%
Environmental Benefits				
GHG Emissions Avoided	[redacted]	[redacted]	[redacted]	0.3%
Air Emissions Avoided	[redacted]	[redacted]	[redacted]	0.0%
Agency Benefits (Fare Revenues)	[redacted]	[redacted]	[redacted]	2.9%
Other Benefits				
Health Benefits of Higher Physical Activity	[redacted]	[redacted]	[redacted]	2.7%
Total Benefits	[redacted]	[redacted]	[redacted]	
COSTS				
Construction Costs	[redacted]	[redacted]	[redacted]	87.7%
Operations and Maintenance Costs	[redacted]	[redacted]	[redacted]	12.3%
Total Costs	[redacted]	[redacted]	[redacted]	
Net Benefit	[redacted]	[redacted]	[redacted]	

The last column in Table 13 demonstrates that user benefits account for over 70% of total project benefits. The largest benefit items are travel time savings to existing transit users (at over 47% of total benefits) followed by travel time savings to motorist who continue driving in the corridor (at 24% of total benefits). This is followed by the residual value of the project and livability benefits (at 12.9% and 6.1% of total benefits, respectively).

6. Concluding Remarks

This cost-benefit analysis finds that the net present value of Southwest BRT Stage 2 project is positive at the discount rate of 3%, a rate consistent with the City of Winnipeg's cost of borrowing and a rate frequently used in cost-benefit analyses. The project can thus be considered economically worthwhile from the City's perspective, and the benefit-cost ratio of 1.37 can be considered acceptable.

It should be pointed out that some key assumptions used in the analysis are rather conservative. In particular, the rate of growth in transit ridership (conventional and BRT) of 1.2% can be seen as conservative. In recent years, the growth in ridership for Winnipeg Transit has been higher than 1.2%; it has actually been closer to 3%. However, given the uncertainty regarding this figure, whether it would also apply to BRT and whether it is sustainable in the long run, a lower and more realistic growth figure was assumed.

In a test scenario, a constant rate of growth in transit ridership of 3% was assumed. This increased total benefits of the project to [redacted] at the 3% discount rate, the benefit-cost ratio to 1.57, and internal rate of return to 7.0%.[18]

[18] This scenario also assumed that total project costs remain constant, including vehicle and annual operating costs.