Appendix D: Benefit Cost Analysis

North Avenue Rising

Benefit-Cost Analysis

Economic Analysis Supplementary Documentation

Prepared for Maryland Transit Administration (MTA)

2016 TIGER Discretionary Grant Program

April 28, 2016

EXECUTIVE SUMMARY

A benefit-cost analysis (BCA) was conducted for the North Avenue Rising Complete Streets project for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the TIGER 2016 program. The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the 2016 TIGER Benefit-Cost Analysis Guidance.[1] The period of analysis corresponds to 34 years and includes 4 years of construction and 30 years of benefits after operations begin in 2021.

Sponsored by the Maryland Transit Administration (MTA) and City of Baltimore, the North Avenue Rising project is a unique suite of proposed transportation investments intended to improve corridor and regional mobility and leverage these transportation improvements with other State, City and private development initiatives to revitalize the surrounding area. Over the past several decades, North Avenue and the communities that surround it have suffered from economic disinvestment. Today the corridor is characterized by a mixture of vacant residential and commercial property and deteriorating sidewalk and roadway infrastructure, but it is also home to long-standing institutions like Coppin State University and an emerging arts district which includes the Maryland Institute College of Art. The corridor has a rich cultural history which should be celebrated, and just beneath the surface of its disrepair it is brimming with potential. The City of Baltimore and the surrounding residential communities have come together with a common goal to revitalize the corridor to its full potential.

North Avenue plays a vital role in Baltimore as a corridor that connects neighborhoods and institutions across the City. One of the few east-west roadways that span the Jones Falls Expressway, North Avenue is an important route for multiple users. North Avenue connects to both the Maryland Transit Administration (MTA)'s Metro Subway and Light Rail lines, and is traversed by Baltimore's second busiest bus line, carrying nearly 4 million passengers annually – a figure that is expected to grow as the MTA implements its new *BaltimoreLink* bus network. North Avenue is also a designated truck route and serves as US Route 1 through Baltimore City.

North Avenue Rising includes dedicated bus lanes, transit signal priority (TSP) for buses, enhanced bus stops, accessibility improvements to the critical Penn/North Metro station, improved crosswalks, bike lanes, and needed intersection improvements and roadway repaving throughout the corridor.

Costs

The capital cost for this project is expected to be $27,330,000 in undiscounted 2015 dollars through 2020. At a 7 percent real discount rate, these costs are $21.7 million; at a 3 percent discount rate, these costs are $24.7 million. As a result of the project, operations and maintenance costs along the corridor are projected to be reduced by $104,000 per year in the long term. Over the entire 34-year analysis period the total costs of the project accumulate to $24.2 million in undiscounted 2015 dollars, $20.7 million when discounted at 7 percent, and $22.9 million when discounted at 3 percent.

[1] U.S. Department of Transportation. Benefit-Cost Analysis Guidance for TIGER Applicants. 2016.

The project is expected to be financed by Federal, State, local and private funds according to the allocation shown in Table ES-1.

TABLE ES-1: Project Costs by Funding Source, in Undiscounted Millions of 2015 Dollars

Funding Source	Capital Costs	Percent by Source
TIGER (Requested)	$14,730,000	53.9%
FHWA Surface Transportation Block Grant Program	$1,600,000	5.9%
MTA	$10,000,000	36.6%
City of Baltimore	$1,000,000	3.6%
Total	**$27,330,000**	**100%**

Benefits

In 2015 dollars, the project is expected to generate $23.9 million in discounted benefits using a 7 percent discount rate, and $49.8 million using a 3 percent discount rate. These benefits result from travel time savings for bus users along the corridor, which are partially offset by corresponding delays for auto users along the corridor. This leads to an overall project Net Present Value of $3.2 million and a Benefit Cost Ratio (BCR) of 1.16 at a 7 percent discount rate.At a 3 percent discount rate, the Net Present Value is $26.9 million and the BCR is 2.17. The overall project benefit matrix can be seen in Table ES-2.

Table ES-2: Project Impacts and Benefits Summary, Monetary Values in Millions of 2015 Dollars

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impact	Population Affected by Impact	Economic Benefit	Summary of Results (at 7% discount rate)	Summary of Results (at 3% discount rate)
Congestion along the North Avenue Corridor	Dedicated Bus Lanes	Reduced congestion for buses; decreased travel times	MTA bus riders	Passenger Time Savings	$31.6 million	$64.8 million
Congestion along the North Avenue Corridor	Dedicated Bus Lanes	Increased travel time for auto users during weekday peak-hour trips	Auto Users along North Avenue	Passenger Delay	-$7.6 million	-$15.0 million
Excessive O&M Costs	Installation of new energy-efficient LED lighting	Reduced O&M costs	MTA/City of Baltimore	O&M Cost Savings	$0.9 million	$1.8 million

Source: WSP|Parsons Brinckerhoff, 2016

The overall project impacts can be seen in Table ES-3, which shows the magnitude of change and direction of the various impact categories.

Table ES-3: Project Impacts, Cumulative 2021-2050

Category	Unit	Quantity	Direction
Bus Passenger Time	PHT	6,961,256	▼
Auto User Time	PHT	1,582,856	▲
O&M Costs	$ (undisc.)	$3,120,000	▼

Source: WSP|WSP|Parsons Brinckerhoff, 2016

In addition to the monetized benefits presented in Table ES-2, the project would create the following qualitative benefits:

Quality of Life

- The project will revitalize North Avenue, which was identified as a key corridor in MTA's *BaltimoreLink* Plan. The goal of *BaltimoreLink* is to create an interconnected transit system that allows users to board transit anywhere on the high-frequency network and reach their destinations with only a single transfer. The project will implement several of the key elements of BaltimoreLink that are necessary to create an improved system.
- The project will introduce bicycle facilities both on and parallel to North Avenue in order to continue the development of the citywide bicycle network.
- The project will increase the speed and reliability of transportation for the residents of various affordable housing options being constructed along North Avenue, further reducing the overall housing and transportation costs for the neighborhood's low-income population.
- The project will enrich the streetscape surrounding local cultural assets and institutions, including the National Great Blacks in Wax Museum, the Station North Arts and Entertainment District, and the Centre Theatre.

Economic Competitiveness

- The project will enrich the character of North Avenue while improving transit travel time and reliability, thus providing more mobility choices for corridor residents.
- The project will address goals outlined by the City's Leveraging Investments in Neighborhood Corridors (LINCS) program, which is intended to improve the aesthetics and vitality of crucial transportation corridors.
- The project will facilitate better connections between bus routes and the Penn North Metro Subway station, providing neighborhood residents with improved access to employment opportunities across the region.
- The project will leverage prior and future investments by anchor institutions located along the corridor, including Coppin State University and the Maryland Institute College of Art (MICA), as well as institutions located near the corridor, including the University of Baltimore and Johns Hopkins University.

Safety

- The project will contribute to the City's ongoing efforts to reduce crime in the neighborhoods along the North Avenue corridor. The project will incorporate CPTED principles, including the installation of pedestrian-scale lighting along the corridor and CCTV at key locations, in order to make the corridor more secure and provide transit passengers with a safer and more secure waiting environment.
- The project will reduce transit and auto accidents along the North Avenue corridor with a variety of interventions, including: repainting crosswalks to a standard of high visibility; adding pedestrian-scale lighting; installing pedestrian curb bump outs; and applying "pedestrian lead" programming at intersections which helps to separate pedestrians from turning vehicles.
- The project will upgrade sidewalks along the corridor to ADA standards.

State of Good Repair

- The project will rehabilitate escalators at the Penn North Metro station, reducing unscheduled downtime, which has averaged 11 percent over the last six months.
- The project will rehabilitate or replace several North Avenue roadway segments identified as "mediocre" or "poor" by the Baltimore City DOT's (BCDOT) Pavement Management Survey.
- The project will install colored asphalt to demarcate dedicated bus lanes, reducing lifecycle maintenance costs and service disruptions relative to the epoxy coatings currently used by BCDOT.

Environmental Sustainability

- The project will improve the quality of, and encourage the use of, mass transit, pedestrian, and bicycle infrastructure, thus reducing neighborhood residents' dependence on automobiles
- According to the Baltimore City Health Department (BCHD), many of the proposed features of the streetscape plan could bring health improvements to the corridor population. Additional pedestrian-scale street lighting may help to reduce the incidence of crime and increase pedestrians' perceptions of safety, while repairing and improving sidewalks along North Avenue may facilitate walking for transportation and recreation. The addition of bike lanes is expected to encourage more active transportation in the corridor.
- Buses on North Avenue will operate with fewer traffic-induced stops and starts, reducing idling and associated fuel consumption. New sidewalk and Metro station lighting will be more modern and energy efficient.

While these benefits are not easily quantifiable, they do provide real advantages and improvements that will be experienced by individuals and businesses in the region.

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1 INTRODUCTION

A benefit-cost analysis (BCA) was conducted for the North Avenue Rising Project for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the TIGER 2016 program. The following section describes the BCA framework, evaluation metrics, and report contents.

1.1 BCA FRAMEWORK

A BCA is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative. Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a BCA is to assess whether the expected benefits of a project justify the costs from a national perspective. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off as a result of the proposed project.

The BCA framework involves defining a Base Case or "No Build" Case, which is compared to the "Build" Case, where the grant request is awarded and the project is built as proposed. The BCA assesses the incremental difference between the Base Case and the Build Case, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life-cycle. The importance of future welfare changes are determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the 2016 TIGER Benefit-Cost Analysis Guidance.[2] This methodology includes the following analytical assumptions:

- Assessing benefits with respect to each of the five long-term outcomes defined by the U.S. DOT;
- Defining existing and future conditions under a No Build base case as well as under the Build Case
- Estimating benefits and costs during project construction and operation, including at least 20 years of operations beyond the Project completion when benefits accrue;
- Using U.S. DOT recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2015 dollars. In instances where cost estimates and benefits valuations are expressed in historical dollar years, using an appropriate Consumer Price Index (CPI) to adjust the values;
- Discounting future benefits and costs with real discount rates of 7 percent and 3 percent (sensitivity analysis) consistent with U.S. DOT guidance;

[2] U.S. Department of Transportation. Benefit-Cost Analysis Guidance for TIGER Applicants. 2016.

1.2 PRISM

This benefit cost analysis was done using PRISM™, a benefit cost analysis tool that uses a methodology consistent with the most recent guidelines developed by USDOT. The tool determined benefits according to the following five categories: Quality of Life; Economic Competitiveness; Safety; State of Good Repair; and Environmental Sustainability.

2 PROJECT OVERVIEW

2.1 DESCRIPTION

North Avenue plays a vital role in Baltimore as a corridor that connects neighborhoods and institutions across the City. One of the few east-west roadways that span the Jones Falls Expressway, North Avenue is an important route for multiple users. North Avenue connects to both the Maryland Transit Administration (MTA)'s Metro Subway and Light Rail lines, and is traversed by Baltimore's second busiest bus line, carrying nearly 4 million passengers annually – a figure that is expected to grow as the MTA implements its new *BaltimoreLink* bus network. North Avenue is also a designated truck route and serves as US Route 1 through Baltimore City.

Over the past several decades, North Avenue and the communities that surround it have suffered from economic disinvestment. Today, the corridor is characterized by a mixture of vacant residential and commercial property and deteriorating sidewalk and roadway infrastructure, but it is also home to long-standing institutions like Coppin State University and an emerging arts district which includes the Maryland Institute College of Art. The corridor has a rich cultural history which should be celebrated, and just beneath the surface of its disrepair it is brimming with potential. The City of Baltimore and the surrounding residential communities have come together with a common goal to revitalize the corridor to its full potential.

Sponsored by the MTA and City of Baltimore, the *North Avenue Rising* project is a unique suite of proposed transportation investments intended to improve corridor and regional mobility and leverage these transportation improvements with other State, City and private development initiatives to revitalize the surrounding area. As shown in Figure I below, *North Avenue Rising* includes dedicated bus lanes, enhanced bus stops, accessibility improvements to the critical Penn/North Metro station, improved crosswalks, bike lanes, and needed intersection improvements and roadway repaving throughout the corridor.

More specifically, *North Avenue Rising* features the following transportation improvements:

- Dedicated bus lanes to improve transit reliability and increase bus speeds
- Needed roadway repaving to maintain a state of good repair
- Transit signal priority (TSP) installed at key intersections in order to reduce delay for buses at intersections and improve on time performance
- Enhanced bus stops at key transfer points, featuring improved shelters, landscaping, and improved signage to assist wayfinding and direct transit, bikes, and cars
- Sidewalk improvements, ADA compliant curb ramps, and pedestrian signals at key intersections
- Pedestrian scale sidewalk lighting

- Bikeshare stations, bike lanes and shared bus/bike lanes where feasible along North Avenue and parallel roadways
- Landscaping, trash receptacles, and public art
- Access, lighting, and safety improvements to MTA's Penn/North Metro Station
- Reconstruction of the Pennsylvania Avenue/North Avenue intersection

North Avenue is already a heavily transit dependent corridor, with fewer than 47 percent of corridor households having reliable access to an automobile. Moreover, MTA's Route 13, which serves North Avenue communities, is MTA's 2nd busiest line in its system, carrying over 12,000 riders each weekday. The goal of *North Avenue Rising* is to support economic revitalization along the corridor through increased mobility, and to broaden access for residents of the corridor to economic opportunities throughout Baltimore. In fact, North Avenue has already been identified as a key transit corridor in MTA's $135 million re-visioning of the citywide transit network.

MTA's *BaltimoreLink* plan will result in an interconnected transit system featuring a re-design of the entire local and express bus systems throughout the City and the addition of 12 new high-frequency, branded, and color-coded bus routes that improve connections to jobs and other transit modes, known as *CityLink*. In fact, new *CityLink* service – as well as other local bus routes - will operate on the dedicated bus lanes - and be enhanced by Transit Signal Priority and passenger amenity investments - being implemented as part of the *North Avenue Rising* project. Meanwhile, the City of Baltimore has also been engaged in a number of community and economic development initiatives on North Avenue. Following a streetscape planning effort for the east side of North Avenue – which is currently under construction - the Baltimore City Department of Transportation (BCDOT) partnered with the Neighborhood Design Center to develop a Streetscape Master Plan for West North Avenue. The planning process included extensive public engagement to ensure that the community's vision was captured, resulting in a Master Plan which recommends many of the transit, bicycle, and pedestrian improvements which make up the *North Avenue Rising* project scope.

Earlier this year, BCDOT also completed an assessment of priority opportunities for infrastructure investment in neighborhoods along the corridor. The plans identified general maintenance needs, improvements related to Safe Routes to School, and programmed bicycle facilities. BCDOT further participated in an Urban Land Institute Technical Assistance Panel for Pennsylvania and North Avenues which identified economic development opportunities and transportation investments aimed at maximizing economic potential

2.2 General Assumptions

2.2.1 Discount Rates and Base Year

For project investments, dollar figures in this analysis are expressed in constant 2015 dollars. In instances where certain cost estimates or benefit valuations were expressed in dollar values in other

(historical) years, the U.S. Bureau of Labor Statistics' Consumer Price Index for Urban Consumers (CPI-U) was used to adjust them.[3]

The real discount rates used for this analysis were 3.0 and 7.0 percent, consistent with U.S. DOT guidance for TIGER 2016 grants[4] and OMB Circular A-4.[5].

2.2.2 Evaluation Period

For the North Avenue Rising project, the evaluation period includes the relevant (post-design) construction period during which capital expenditures are undertaken, plus 30 years of operations beyond the Project completion within which to accrue benefits.

For the purposes of this study, it has been assumed that construction of the project begins as early as 2017 and continues through 2020; it is assumed that the project would be fully complete and operational starting in 2021. The analysis period, therefore, begins with the first expenditures in 2017 and continues through 30 years of operations, or through 2050.

All benefits and costs are assumed to occur at the end of each year, and benefits begin in the calendar year immediately following the final construction year.

2.2.3 Ridership Estimates and Projection Sources

Bus ridership projections for the North Avenue corridor were developed using MTA's Automatic Passenger Count (APC) data for current ridership on existing bus routes along the North Avenue corridor. For purposes of conservative analysis, future projections are based on current ridership for existing bus routes along North Avenue, and do not include any assumptions for induced ridership growth resulting from the project.

The methodology for estimating travel time savings and delays is described in greater detail in Section 3.

2.2.4 Annualizing Factor Assumptions

Ridership models produce outputs on a daily or sub-daily basis. An annualization factor is thus necessary to convert the outputs into to yearly values. For bus ridership (and associated travel time savings for bus passengers), an annualization factor of 300 was applied. Auto user delays associated with the proposed interventions would occur only during peak-hour trips on weekdays; as a result, auto user projections were annualized using a factor of 260.

2.2.5 Benefit-Cost Evaluation Measures

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following two common benefit-cost evaluation measures are included in this BCA.

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[3] U.S. Bureau of Labor Statistics. Consumer Price Index, All Urban Consumers, U.S. City Average, Series CUSR0000SA0. 1982-1984=100

[4]TIGER 2016 NOFA: Benefit-Cost Analysis Guidance, Updated March 1, 2016; http://www.dot.gov/tiger/guidance

[5] White House Office of Management and Budget, Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (October 29, 1992). (http://www.whitehouse.gov/omb/circulars_a094).

Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.

- **Benefit Cost (B/C) Ratio:** The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The B/C ratio expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of their associated costs.

2.3 Base Case and Build Case

For the purposes of this BCA, existing conditions along the North Avenue corridor are assumed to remain in the baseline condition, or "base case." The proposed project represents the build case.

2.4 Project Costs

2.4.1 Capital Costs

The proposed project would result in the implementation of a suite of multimodal transportation improvements. The capital costs for the proposed project, $27,330,000, comprise installation of the following elements:

- Dedicated bus lanes to improve transit reliability and increase bus speeds
- Needed roadway repaving to maintain a state of good repair
- Transit signal priority (TSP) installed at key intersections in order to reduce delay for buses at intersections and improve on time performance
- Enhanced Bus stops at key transfer points, featuring improved shelters, landscaping, and improved signage to assist wayfinding and direct transit, bikes, and cars
- Sidewalk improvements, ADA compliant curb ramps, and pedestrian signals at key intersections
- Pedestrian scale sidewalk lighting
- Bikeshare stations, bike lanes and shared bus/bike lanes where feasible along North Avenue and parallel roadways
- Landscaping, trash receptacles, and public art
- Access, lighting, and safety improvements to MTA's Penn/North Metro Station
- Reconstruction of the Pennsylvania Avenue/North Avenue intersection

Table 1: Project Elements and Costs, 2015 Dollars

Project Element	Cost (2015 $)
Dedicated Bus Lanes	$3,300,000
Traffic Signal Priority	$1,960,000
Repaving	$3,380,000
Penn North Intersection Improvements	$2,000,000
Enhanced Bus Stops	$2,210,000
Penn North Station Improvements	$4,915,000
Bike Lanes	$425,000
Bikeshare Equipment	$240,000
Streetscaping	$8,900,000
Total	$27,330,000

Table 2: Project Schedule

Design and Construction Start	2017
Construction End	2020
Construction Duration	4 Years
Project Opening	2021

2.4.2 Operations and Maintenance Costs

The installation of new energy-efficient LED lighting at the North Avenue Metro Subway station is expected to yield $104,000 in annual operating savings. That cost savings represents the only difference in O&M costs between the base case and build condition; as a result, it is the only portion of O&M costs evaluated in this BCA.

2.4.3 Residual Value

The project is assumed to have a 30-year lifecycle, which coincides with the end of this BCA; therefore, this analysis assumes the residual value, or remaining capital value, to be zero using a straight line depreciation method.

2.5 Project Benefits

The proposed project would result in a variety of benefits that would accrue to Baltimore residents, particularly those who live or work in the neighborhoods surrounding the North Avenue corridor. These benefits include improvements related to economic competitiveness, quality of life, safety, state of good repair, and environmental sustainability. These benefits are expected to last throughout the duration of the project's lifecycle.

For the purposes of this BCA, two types of benefits have been quantified: travel time savings and O&M cost reductions. The proposed project would introduce enhanced bus service to the North Avenue corridor, reducing travel times for bus users, but increasing trip times for some auto users during certain portions of the day. The installation of LED lighting along the corridor, as well as the Penn North Metro station, would reduce energy costs for MTA and the City of Baltimore. These benefits were selected for quantification and monetization because they are predictable and readily monetized using widely-

accepted economic methodology. Details of the methodology and assumptions used to analyze these benefits are provided in Section 3.

The project would result in several benefits that are not readily quantifiable or monetizable, but are substantially likely to provide real advantages and improvements that will be experienced by individuals and businesses in the region. These benefits are identified and described briefly below.

Quality of Life

- The project will revitalize North Avenue, which was identified as a key corridor in MTA's *BaltimoreLink* Plan. The goal of *BaltimoreLink* is to create an interconnected transit system that allows users to board transit anywhere on the high-frequency network and reach their destinations with only a single transfer. The project will implement several of the key elements of BaltimoreLink that are necessary to create an improved system.
- The project will introduce bicycle facilities both on and parallel to North Avenue in order to continue the development of the citywide bicycle network.
- The project will increase the speed and reliability of transportation for residents of the various affordable housing options being constructed along North Avenue, further reducing the overall housing and transportation costs for the neighborhood's low-income populations.
- The project will enrich the streetscape surrounding local cultural assets and institutions, including the National Great Blacks in Wax Museum, the Station North Arts and Entertainment District, and the Centre Theatre.

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- The project will address goals outlined by the City's Leveraging Investments in Neighborhood Corridors (LINCS) program, which is intended to improve the aesthetics and vitality of crucial transportation corridors.
- The project will facilitate better connections between bus routes and the Penn North Metro Subway station, providing neighborhood residents with improved access to employment opportunities across the region.
- The project will leverage prior and future investments by anchor institutions located along the corridor, including Coppin State University and the Maryland Institute College of Art (MICA), as well as institutions located near the corridor, including the University of Baltimore and Johns Hopkins University.

Safety

- The project will contribute to the City's ongoing efforts to reduce crime in the neighborhoods along the North Avenue corridor. The project will incorporate CPTED principles, including the installation of pedestrian-scale lighting along the corridor and CCTV at key locations, in order to make the corridor more secure and provide transit passengers with a safer and more secure waiting environment.
- The project will reduce transit and auto accidents along the North Avenue corridor with a variety of interventions, including: repainting crosswalks to a standard of high visibility; adding

pedestrian-scale lighting; installing pedestrian curb bump outs; and applying "pedestrian lead" programming at intersections which helps to separate pedestrians from turning vehicles.
- The project will upgrade sidewalks along the corridor to ADA standards.

State of Good Repair

- The project will rehabilitate escalators at the Penn North Metro station, reducing unscheduled downtime, which has averaged 11 percent over the last six months.
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- Buses on North Avenue will operate with fewer traffic-induced stops and starts, reducing idling and associated fuel consumption. New sidewalk and Metro station lighting will be more modern and energy efficient.

3 Benefit-Cost Analysis Data and Assumptions

This section details the process by which benefits were quantified and monetized for the BCA. Cost inputs for the BCA were described in Section 2.

3.1 User Travel Time Savings/Delays

Travel time savings includes in-vehicle travel time savings for auto drivers and passengers as well as truck drivers. Travel time is considered a cost to users, and its value depends on the disutility that travelers attribute to time spent traveling. A reduction in travel time translates into more time available for work, leisure, or other activities.

3.1.1 Analysis Overview

The introduction of bus-only lanes to North Avenue, one of several project elements, is the primary source of quantifiable economic benefits. To quantify these benefits, an analysis was performed to estimate the value of the bus-only lanes to transit users, relative to any costs to other motorized traffic using the transit-enhanced street.

The analysis compares the bus travel time savings expected from this project's transit enhancements on North Avenue to the additional potential delay experienced by motorists and passengers in vehicles other than buses. The result of this analysis is an overall person-hours traveled (PHT) value for annual travel time savings, which is then monetized according to standard U.S. DOT methodology. Annual figures project travel time savings for the first year of operations, 2021; these values are increased according to growth factors detailed in Section 3.1.5.

3.1.2 Analysis Methodology

Several analytical methods were used to predict the travel time savings for buses and the additional delay for other motor vehicles, with emphasis on methods that provide the most tested and reproducible results for each mode. Travel time savings for bus passengers used TCRP Report 165 and Transit Capacity and Quality of Service Manual, 3rd Edition (TCQSM-3) to estimate bus travel time savings for various transit preferential treatments. The values calculations provide a range of expected outcomes based on the project's features.

Synchro analysis was used to quantify North Avenue's operational conditions and estimate travel time and delay for general traffic in corridor segments where an existing travel lane is designated for bus-only use. The average vehicle delay was then calculated for the morning and afternoon peak hours. The additional auto delay that is predicted from the project is congestion delay, which is typically concentrated in the peak hours, as non-peak hours experience minimal levels of congestion-based auto delay in this corridor. Thus, 90% of the additional delay was assumed to take place during these hours.

Travel time savings and delays are reported on a daily basis, and apply to the first year of the project's operations, in 2021. Annualization and growth factors are described below, in Sections 3.1.5 and 3.1.6, respectively.

3.1.3 Travel Time Savings for Bus Passengers

According to the TCQSM-3, observed time-savings-per-mile for buses on urban streets with bus lanes ranges from 0.1 minutes to 1.5 minutes, or, in the case of New York and San Francisco, where savings was measured as a percentage of run time, 34% to 43% time savings. TCQSM-3 also provides a generalized range of travel time savings based on a four-mile arterial bus lane of three to five minutes, as shown in **Error! Reference source not found.**. Using the mean value of this range, each bus traveling he bus-only lane for the 4.6-mile length of the North Avenue corridor can be expected to gain 4.6 minutes of travel time savings. According to the average speeds calculated using Automatic Vehicle Location (AVL) data, this 4.6 minutes of savings represents an approximately 11% savings; compared to the 34%-to-43% range observed in New York and San Francisco, this therefore represents a conservative estimate, well within the range of observed outcomes reported in the TCQSM-3.

Figure 1. Travel Time Savings Predictions from TCQSM-3

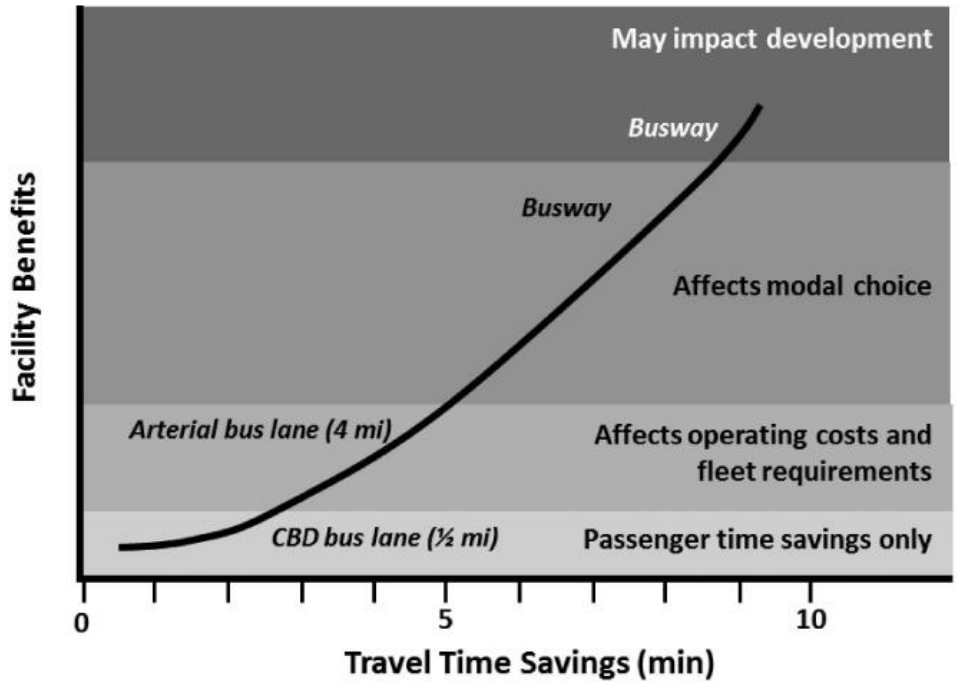


*Image Source: TCQSM-3, Exhibit 6-35

This savings can be multiplied by the number of passengers on the bus to yield the total amount of time per day saved by bus riders on the corridor due to the installation of the bus-only lanes. Since ridership projections are not yet complete for the service that will be introduced on North Avenue, the existing ridership on existing MTA bus routes along the North Avenue corridor was assumed as a conservative ridership proxy.

MTA's Automatic Passenger Count (APC) Data was used to calculate an average number of weekday bus riders for each corridor section; the amount of bus travel time savings gained per passenger was then calculated using this APC data, as shown in **Error! Reference source not found.**. North Avenue is a high idership corridor along its entire length, with particularly high ridership segments near major transfer points like the Penn-North Metro Station and the local and QuickBus routes on Greenmount Avenue. While the travel time savings for each short section of bus-only lane are only a few seconds, North Avenue's high ridership numbers—which range from approximately 2,000 to 11,000 daily passengers by segment—mean that the total expected travel time savings in the bus lane on an average weekday is approximately 37,088 minutes, or 618 hours.

Figure 2. Average Weekday Bus Passengers on North Avenue

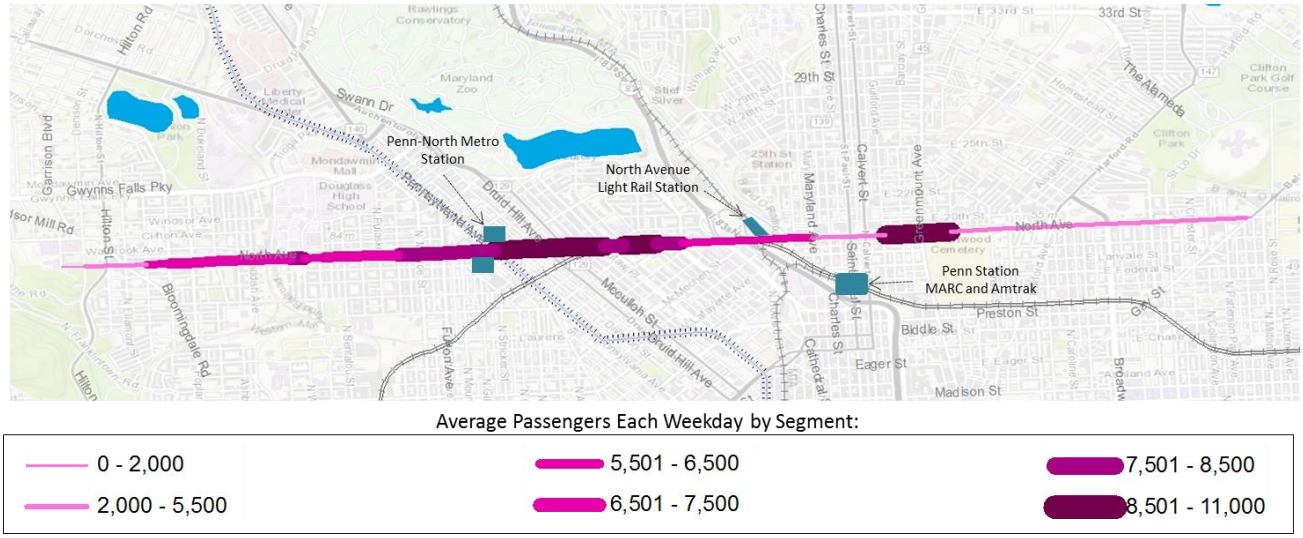


Table 3. Travel Time Savings from installation of Bus Only Lane by Corridor Segment

Segment	Average Number of Weekday Riders	Length (miles)	Travel Time Savings (seconds) for Each Bus	Total Seconds Saved on an Average Weekday
Bloomingdale Road to Braddish Avenue	31,482	0.94	57	4,135
Braddish Avenue to Fulton Avenue	49,075	0.69	41	10,535
Fulton Avenue to Eutaw Street	67,168	0.87	52	17,360
Eutaw Street to Charles Street	50,129	1.20	72	20,754
Charles Street to Greenmount Avenue	24,142	0.49	30	10,043
Greenmount Avenue to Milton Avenue	48,488	1.76	106	23,482

Grand Total		
Seconds	**Minutes**	**Hours**
2,225,307	37,088	618

3.1.4 Projected Change in Auto Delay from Bus Only Lanes

Designating a lane for bus travel is expected to have some impacts to traffic operations, particularly during the morning and afternoon peak hours, when traffic is heaviest. While autos experience some delay on North Avenue during all parts of the day due to traffic signal controls, for the purposes of this evaluation it has been assumed this type of delay is not projected to change due to the installation of the bus-only lane. Thus, 90% of the added delay from the bus lane is assumed to occur during the morning and afternoon peak hours, when congestion-based delay is expected to be highest. The added average peak hour delay per vehicle (i.e., automobile) was predicted by simulating the bus lane recommendations in Synchro, and recording the change in delay for the affected movements (eastbound and westbound).

This predicted delay was then multiplied by the number of auto users expected to experience that delay: the assumed number of motorists and their passengers. The occupancy factor 1.13 found in "A Profile of Travel Trends: A Statistical Abstract for 1980, 1990, 2000, and 2006" compiled by the Baltimore Metropolitan Council was applied to the number of vehicles, and the delay adjusted to reflect only 90% occurring in the peak hours. For the four intersections where turning movement counts were not available, the average additional intersection delay over the course of the corridor was applied instead (22.5 seconds). This is a conservative estimate since these intersections were typically with minor streets.

Table 4 shows a summary of the projected additional auto delay per weekday by segment. The additional delay at each intersection of the segment was summed, and applied to the average auto person-throughput for that segment.

Table 4. Impacts to Auto Delay

Segment	Movement	Peak Hour	Average Additional Delay (Seconds)	Auto Person Throughput	Total Additional Person-Delay (Seconds)
Bloomingdale Road to Braddish Avenue	EB	AM	19.5	591	11,525
		PM	23.3	572	13,328
	WB	AM	80.9	413	33,412
		PM	83.5	647	54,025
Braddish Avenue to Fulton Avenue	EB	AM	50.0	516	25,800
		PM	54.1	549	29,701
	WB	AM	53.9	469	25,279
		PM	54.7	620	33,914
Fulton Avenue to Eutaw Street	EB	AM	44.2	893	39,471
		PM	49.2	777	38,228
	WB	AM	13.1	655	8,581
		PM	40.5	878	35,559
Eutaw Street to Charles Street	EB	AM	38.5	1109	42,697
		PM	12.1	1019	12,330
	WB	AM	34.6	1096	37,922
		PM	53.1	1152	61,171
Charles Street to Greenmount Avenue	EB	AM	19.7	981	19,326
		PM	3.9	747	2,913
	WB	AM	19.8	901	17,840
		PM	0	844	0
Greenmount Avenue to Milton Avenue	EB	AM	75.7	471	35,655
		PM	105.2	496	52,179
	WB	AM	90.0	634	57,060
		PM	76.0	561	42,636
Grand Total (Per Weekday)					
Seconds	**Minutes**			**Hours**	
730,549	12,176			203	

The additional 203 hours of projected daily auto delay can be compared to the 618 daily projected hours of travel time savings experienced by bus passengers. Appendix B Shows the complete auto delay calculations.

3.1.5 Annualizing Factor Assumptions

As described in Section 2.2.4, ridership models produce outputs on a basis. An annualization factor is thus necessary to convert the outputs into to yearly values. For bus ridership (and associated travel time savings for bus passengers), an annualization factor of 300 was applied. As described above, auto user delays associated with the proposed interventions would occur only during peak-hour trips on weekdays; as a result, auto user projections were annualized using a factor of 260.

3.1.6 Growth Factor Assumptions

The results reported above apply to the first year of the project's operations, in 2020. In order to project travel time savings and delays for the remaining 29 years of the project's operations, growth factor assumptions were developed and applied to the 2021 values.

For bus passenger travel time savings, the observed rate of system-wide ridership growth for MTA buses from 2006-2014, 1.5 percent, was applied as an annual growth factor. As described earlier, the ridership projections for the North Avenue corridor do not incorporate any estimates for induced demand

resulting from the enhanced bus service; the annual growth factor also does not incorporate any induced demand. As a result, the ridership projections are likely very conservative.

For auto user delays, travel volume data from the Maryland State Highway Administration (SHA) were analyzed.[6,7] Based on 2013 and 2014 data for urban VMT in Baltimore City from that reporting, which indicate that auto VMT rates are either flat or declining, an annual growth factor of 0 was applied. As with the bus ridership projections, the auto user projections and growth factor do not assume any induced decrease in auto travel along the North Avenue corridor. In all likelihood, the disutility for auto users caused by the enhanced bus service along North Avenue would impel drivers to select alternative routes; further, over the 30-year operations period of the proposed project, overall auto VMT in Baltimore is likely decline. As a result, the 0 growth factor is likely very conservative.

3.1.7 Results

The resulting travel time savings projections are presented in Table 5.

Table 5: Bus Passenger and Auto User Projected Travel Time Savings/Delays

Variable	Project Opening Year: 2021	Final Year of Analysis: 2050
	Relative to Baseline Condition	Relative to Baseline Condition
Bus Passenger Travel Time Savings (PHT)	185,442	285,577
Auto User Delays (PHT)	52,762	52,762
Total Savings (PHT)	132,680	232,815

3.1.8 Value of Time Assumptions

Travel time savings must be converted from hours to dollars in order for benefits to be aggregated and compared against costs. This is performed by assuming that travel time is valued as a percentage of the average wage rate, with different percentages assigned to different trip purposes.

Values are broken down as low, medium, and high for use in the PRISM™ analysis based on the dollar values in **Table 6**, as recommended by U.S. DOT.

[6] 2014 Maryland State Highway Mobility Report: http://www.marylandroads.com/OPPEN/Vehicle_Miles_Traveled.pdf

[7] 2015 Maryland State Highway Mobility Report: http://www.roads.maryland.gov/OPPEN/Traffic_Volume_Trends1.pdf

Table 6. U.S. DOT Recommended Values of Time, 2015 $

Category	Values of time (2015 U.S $ per person-hour) Low	Values of time (2015 U.S $ per person-hour) Medium	Values of time (2015 U.S $ per person-hour) High
Surface (except High-Speed Rail)			
Local Travel			
Personal	$10.33	$12.92	$15.50
Business	$19.94	$24.93	$29.92
All Purposes	$10.77	$13.47	$16.16
Intercity Travel			
Personal	$14.47	$18.08	$21.70
Business	$19.94	$24.93	$29.92
All Purposes	$15.64	$19.55	$23.46
Air and High-Speed Rail			
Intercity Travel			
Personal	$27.48	$34.35	$41.22
Business	$49.59	$61.98	$74.38
All Purposes	$36.41	$45.51	$54.62
Other			
Truck Drivers	$21.37	$26.71	$32.05
Bus Drivers	$22.11	$27.63	$33.16
Transit Rail Operators	$36.65	$45.81	$54.98
Locomotive Engineers	$32.14	$40.18	$48.21
Airline Pilots and Engineers	$69.68	$87.10	$104.52

3.2 Operating Cost Savings

The project will accrue benefits directly to MTA in the form of a net decrease in operations and maintenance expenditures resulting from the installation of efficient LED lighting along North Avenue and at the Penn North Metro station. Decreased O&M expenditures will allow MTA to direct additional resources elsewhere across the transit system, including undertaking additional system maintenance, increasing service levels, decreasing reliance on outside operating subsidies, or other potential uses that benefit the transit user base and the entire study region.

According to a lifecycle cost analysis performed by MTA and BCDOT, the lighting upgrades will save the MTA $104,000 in annual utility costs and reduce lighting failures; in addition, the installation of energy-efficient LED lighting will reduce the overall environmental footprint of the MTA system.

For the purposes of a conservative analysis, the annual O&M savings were expected to remain constant (i.e., a growth rate of 0) in real terms throughout the 30-year operational period of the project. Although the O&M cost savings represent an economic benefit generated by the project, for conservative analysis purposes, they are considered a reduction in costs from the BCA perspective, rather than a benefit.

Table 7: Operating Cost Savings Assumptions and Sources

Variable	Unit	Value	Source
Energy Savings from LED Lighting	$ per year	$104,000	MTA Lifecycle Cost Analysis

4 SUMMARY OF RESULTS

4.1 EVALUATION MEASURES

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the project into monetary units and compares them. The following common benefit-cost evaluation measures are included in this BCA:

- **Net Present Value (NPV)**: NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- **Benefit Cost Ratio (BCR):** The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.

4.2 RESULTS IN BRIEF

There were two "cases" conducted for this analysis. Case A assumes a 7.0 percent discount rate, and Case B assumes a 3.0 percent discount rate, as prescribed by U.S. DOT.

- At a 7 percent discount rate, the proposed project yields a net present value of $3.2 million, and a benefit-cost ratio of 1.16.
- At a 3 percent discount rate, the proposed project yields a net present value of $26.9 million, and a benefit-cost ratio of 2.17.

Table 8 presents the evaluation results for the two cases.

Table 8: Benefit Cost Analysis Summary Results

Scenario	NPV (2015 $)	B-C Ratio
Case A (7 percent discount rate)	$3.2 million	1.16
Case B (3 percent discount rate)	$26.9 million	2.17

Source: WSP|Parsons Brinckerhoff, 2016

4.3 BENEFITS BY CATEGORY

Table 9 outlines the changes in some of the impact categories. As a result of the project, the 30-year operational period will result in a nearly 7-million-PHT reduction in bus passenger time, which is partially offset by a 1.6-million PHT increase in auto user time. Reduced O&M expenses will generate an

economic benefit; however, for purposes of conservative analysis, they are considered a reduction in costs, rather than a benefit, from the BCA perspective.

Table 9: Project Impacts for Go Uptown Cumulative 2019-2048

Category	Unit	Quantity	Direction
Bus Passenger Time	PHT	6,961,256	▼
Auto User Time	PHT	1,582,856	▲
O&M Costs	$ (undisc.)	$3,120,000	▼

Source: WSP|Parsons Brinckerhoff, 2016

Over the 34-year analysis period, the project is expected to generate $23.9 million in discounted benefits using a 7 percent discount rate, and $49.8 million using a 3 percent discount rate. These benefits result from travel time savings for bus users along the corridor, and are partially offset by corresponding delays for auto users along the corridor. Because the reduction in O&M expenses are considered a reduction in cost, rather than a benefit, the travel time savings comprise 100 percent of the quantified benefits generated by the project. See **Table 10** for a summary of the benefits and monetized values.

Table 10: Project Impacts and Benefits Summary, Monetary Values in Millions of 2015 Dollars

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impact	Population Affected by Impact	Economic Benefit	Summary of Results (at 7% discount rate)	Summary of Results (at 3% discount rate)
Congestion along the North Avenue Corridor	Dedicated Bus Lanes	Reduced congestion for buses; decreased travel times	MTA bus riders	Passenger Time Savings	$31.6 million	$64.8 million
Congestion along the North Avenue Corridor	Dedicated Bus Lanes	Increased travel time for auto users during weekday peak-hour trips	Auto Users along North Avenue	Passenger Delay	-$7.6 million	-$15.0 million
Excessive O&M Costs	Installation of new energy-efficient LED lighting	Reduced O&M costs	MTA/City of Baltimore	O&M Cost Savings	$0.9 million	$1.8 million

Source: WSP|Parsons Brinckerhoff, 2016

4.4 COSTS OVER TIME

The total capital investments ($27.3 million) were assumed to begin in 2017 and conclude by the end of 2020. At a 7 percent real discount rate, these costs are $21.7 million; at a 3 percent discount rate, these costs are $24.7 million. As a result of the project, operations and maintenance costs along the corridor are projected to be reduced by $104,000 per year in the long term. Over the entire 34-year analysis

period the total costs of the project accumulate to $24.2 million in undiscounted 2015 dollars, $20.7 million when discounted at 7 percent, and $22.9 million when discounted at 3 percent.

Table 11: Project Elements and Costs, 2015 Dollars

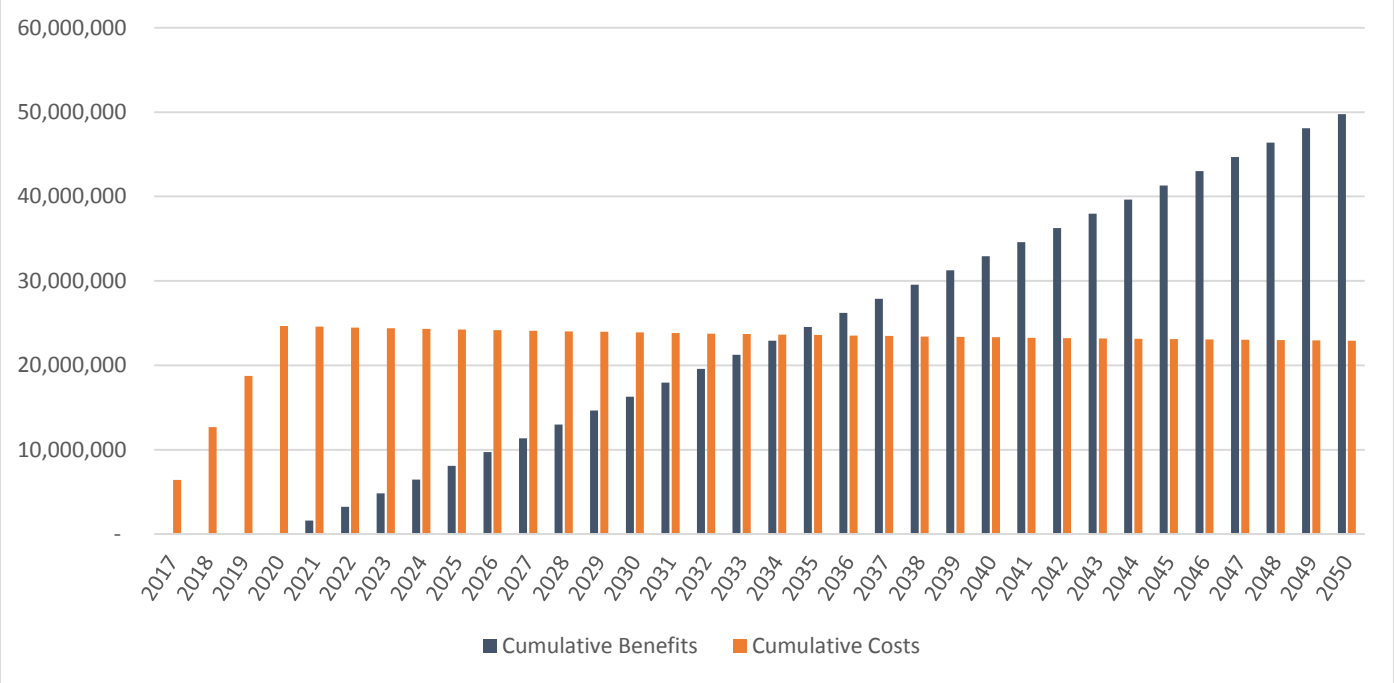
Project Element	Cost (2015 $)
Dedicated Bus Lanes	$3,300,000
Traffic Signal Priority	$1,960,000
Repaving	$3,380,000
Penn North Intersection Improvements	$2,000,000
Enhanced Bus Stops	$2,210,000
Penn North Station Improvements	$4,915,000
Bike Lanes	$425,000
Bikeshare Equipment	$240,000
Streetscaping	$8,900,000
Total	$27,330,000

Source: MTA, 2016

4.5 Cumulative Benefits and Costs

Figure 3 and **Figure 4** compare the cumulative present value of benefits with the cumulative present value of costs over time for both cases. The figure shows that the cumulative discounted benefits exceed the cumulative discounted costs by mid-2035 with either discount rate.

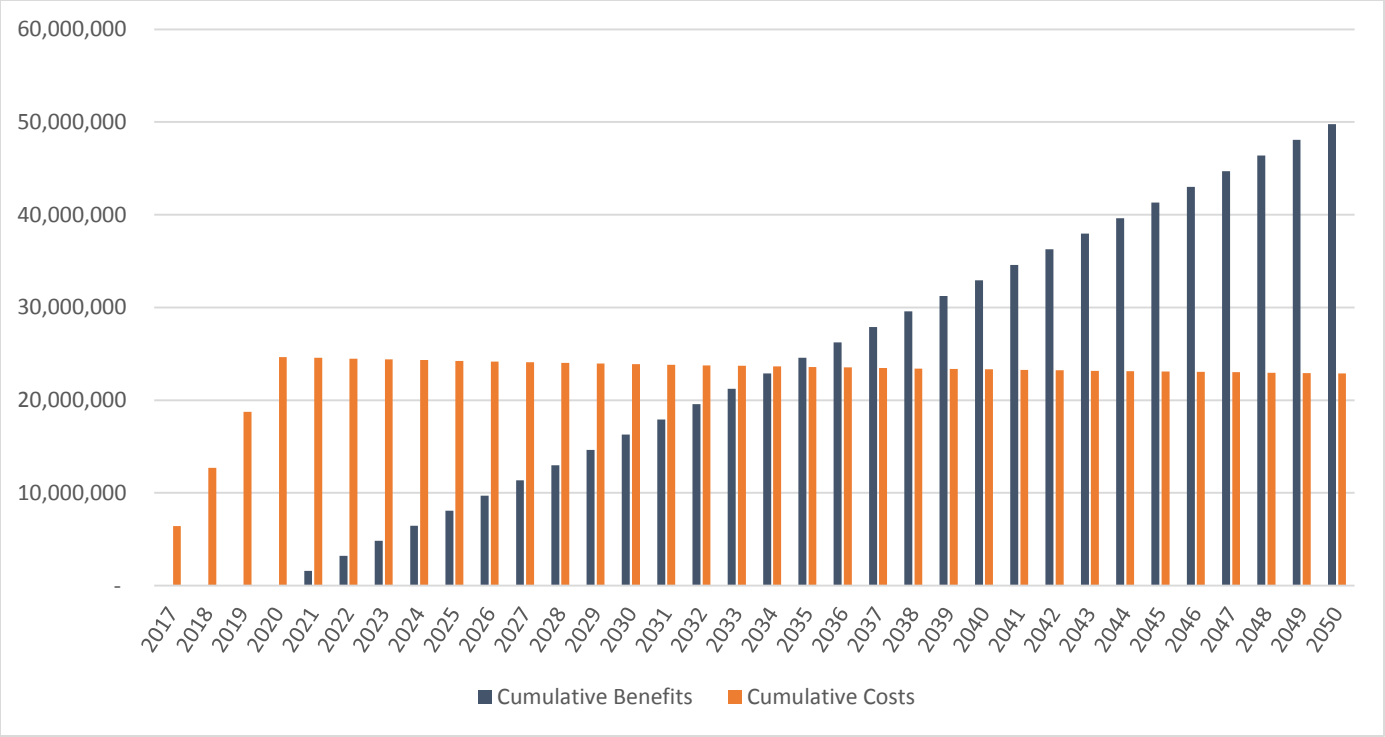
Figure 3: Cumulative Benefits and Costs in 2015 Dollars (Discounted at 3 percent)



Source: WSP|Parsons Brinckerhoff, 2016

Figure 4: Cumulative Benefits and Costs in 2015 Dollars (Discounted at 7 percent)

Appendix D: Benefit-Cost Analysis



Source: WSP|Parsons Brinckerhoff, 2016

6 APPENDIX I - BENEFIT-COST MODEL DETAIL TABLES

Table 12: Detailed Bus Passenger Time Savings

	Bus Passenger Time Savings (Hours)	Bus Passenger Time Savings Undiscounted (2015 $)	Bus PassengerTime Savings Discounted 3% (2015 $)	Bus Passenger Time Savings Discounted 7% (2015 $)
2017	-	$0	$0	$0
2018	-	$0	$0	$0
2019	-	$0	$0	$0
2020	-	$0	$0	$0
2021	185,442	$2,682,833	$2,246,831	$1,787,685
2022	188,224	$2,755,753	$2,240,679	$1,716,144
2023	191,047	$2,830,654	$2,234,545	$1,647,467
2024	193,913	$2,907,591	$2,228,427	$1,581,537
2025	196,822	$2,986,620	$2,222,326	$1,518,246
2026	199,774	$3,067,796	$2,216,241	$1,457,488
2027	202,771	$3,151,179	$2,210,173	$1,399,161
2028	205,812	$3,236,828	$2,204,122	$1,343,168
2029	208,899	$3,324,805	$2,198,088	$1,289,417
2030	212,033	$3,415,173	$2,192,070	$1,237,816
2031	215,213	$3,507,997	$2,186,068	$1,188,280
2032	218,441	$3,603,345	$2,180,083	$1,140,727
2033	221,718	$3,701,284	$2,174,114	$1,095,076
2034	225,044	$3,801,885	$2,168,162	$1,051,253
2035	228,420	$3,905,220	$2,162,226	$1,009,183
2036	231,846	$4,011,364	$2,156,306	$968,797
2037	235,323	$4,120,393	$2,150,402	$930,027
2038	238,853	$4,232,385	$2,144,514	$892,808
2039	242,436	$4,347,421	$2,138,643	$857,079
2040	246,073	$4,465,584	$2,132,788	$822,780
2041	249,764	$4,586,958	$2,126,948	$789,854
2042	253,510	$4,711,632	$2,121,125	$758,245
2043	257,313	$4,839,694	$2,115,318	$727,901
2044	261,173	$4,971,237	$2,109,526	$698,771
2045	265,090	$5,106,355	$2,103,751	$670,807
2046	269,067	$5,245,146	$2,097,991	$643,962
2047	273,103	$5,387,709	$2,092,247	$618,192
2048	277,199	$5,534,147	$2,086,519	$593,453
2049	281,357	$5,684,565	$2,080,806	$569,703
2050	285,577	$5,839,072	$2,075,109	$546,905
Total	**6,961,256**	**$121,962,624**	**$64,796,146**	**$31,551,931**

Table 13: Detailed Auto User Delays

	Auto User Delays (Hours)	Auto User Delays Undiscounted (2015 $)	Bus PassengerTime Savings Discounted 3% (2015 $)	Auto User Delays Discounted 7% (2015 $)
2017	-	$0	$0	$0
2018	-	$0	$0	$0
2019	-	$0	$0	$0
2020	-	$0	$0	$0
2021	(52,762)	-$763,317	-$639,266	-$508,631
2022	(52,762)	-$772,477	-$628,095	-$481,060
2023	(52,762)	-$781,747	-$617,118	-$454,984
2024	(52,762)	-$791,128	-$606,334	-$430,321
2025	(52,762)	-$800,621	-$595,738	-$406,995
2026	(52,762)	-$810,229	-$585,327	-$384,934
2027	(52,762)	-$819,952	-$575,098	-$364,068
2028	(52,762)	-$829,791	-$565,047	-$344,334
2029	(52,762)	-$839,749	-$555,173	-$325,669
2030	(52,762)	-$849,825	-$545,471	-$308,016
2031	(52,762)	-$860,023	-$535,938	-$291,320
2032	(52,762)	-$870,344	-$526,572	-$275,529
2033	(52,762)	-$880,788	-$517,370	-$260,593
2034	(52,762)	-$891,357	-$508,329	-$246,468
2035	(52,762)	-$902,054	-$499,445	-$233,108
2036	(52,762)	-$912,878	-$490,717	-$220,472
2037	(52,762)	-$923,833	-$482,141	-$208,521
2038	(52,762)	-$934,919	-$473,716	-$197,218
2039	(52,762)	-$946,138	-$465,437	-$186,528
2040	(52,762)	-$957,491	-$457,303	-$176,417
2041	(52,762)	-$968,981	-$449,312	-$166,854
2042	(52,762)	-$980,609	-$441,459	-$157,810
2043	(52,762)	-$992,376	-$433,745	-$149,256
2044	(52,762)	-$1,004,285	-$426,165	-$141,165
2045	(52,762)	-$1,016,336	-$418,717	-$133,513
2046	(52,762)	-$1,028,532	-$411,400	-$126,276
2047	(52,762)	-$1,040,875	-$404,210	-$119,431
2048	(52,762)	-$1,053,365	-$397,146	-$112,957
2049	(52,762)	-$1,066,006	-$390,206	-$106,834
2050	(52,762)	-$1,078,798	-$383,387	-$101,043
Total	**(1,582,856)**	**-$27,368,824**	**-$15,025,380**	**-$7,620,325**

Table 14: Detailed O&M Cost Savings

	O&M Savings Undiscounted (2015 $)	O&M Savings Discounted 3% (2015 $)	O&M Savings Discounted 7% (2015 $)
2017	$0	$0	$0
2018	$0	$0	$0
2019	$0	$0	$0
2020	$0	$0	$0
2021	-$104,000	-$87,098	-$69,300
2022	-$104,000	-$84,562	-$64,766
2023	-$104,000	-$82,099	-$60,529
2024	-$104,000	-$79,707	-$56,569
2025	-$104,000	-$77,386	-$52,868
2026	-$104,000	-$75,132	-$49,410
2027	-$104,000	-$72,944	-$46,177
2028	-$104,000	-$70,819	-$43,156
2029	-$104,000	-$68,756	-$40,333
2030	-$104,000	-$66,754	-$37,694
2031	-$104,000	-$64,809	-$35,228
2032	-$104,000	-$62,922	-$32,924
2033	-$104,000	-$61,089	-$30,770
2034	-$104,000	-$59,310	-$28,757
2035	-$104,000	-$57,582	-$26,876
2036	-$104,000	-$55,905	-$25,117
2037	-$104,000	-$54,277	-$23,474
2038	-$104,000	-$52,696	-$21,938
2039	-$104,000	-$51,161	-$20,503
2040	-$104,000	-$49,671	-$19,162
2041	-$104,000	-$48,224	-$17,908
2042	-$104,000	-$46,820	-$16,737
2043	-$104,000	-$45,456	-$15,642
2044	-$104,000	-$44,132	-$14,619
2045	-$104,000	-$42,847	-$13,662
2046	-$104,000	-$41,599	-$12,768
2047	-$104,000	-$40,387	-$11,933
2048	-$104,000	-$39,211	-$11,152
2049	-$104,000	-$38,069	-$10,423
2050	-$104,000	-$36,960	-$9,741
Total	**-$3,120,000**	**-$1,758,381**	**-$920,137**

Table 15: Detailed Cost

	Capital Costs Undiscounted (2015 $)	Capital Costs Discounted 3% (2015 $)	Capital Costs Discounted 7% (2015 $)
2017	$6,832,500	$6,440,287	$5,967,770
2018	$6,832,500	$6,252,705	$5,577,355
2019	$6,832,500	$6,070,588	$5,212,482
2020	$6,832,500	$5,893,775	$4,871,478
2021	$0	$0	$0
2022	$0	$0	$0
2023	$0	$0	$0
2024	$0	$0	$0
2025	$0	$0	$0
2026	$0	$0	$0
2027	$0	$0	$0
2028	$0	$0	$0
2029	$0	$0	$0
2030	$0	$0	$0
2031	$0	$0	$0
2032	$0	$0	$0
2033	$0	$0	$0
2034	$0	$0	$0
2035	$0	$0	$0
2036	$0	$0	$0
2037	$0	$0	$0
2038	$0	$0	$0
2039	$0	$0	$0
2040	$0	$0	$0
2041	$0	$0	$0
2042	$0	$0	$0
2043	$0	$0	$0
2044	$0	$0	$0
2045	$0	$0	$0
2046	$0	$0	$0
2047	$0	$0	$0
2048	$0	$0	$0
2049	$0	$0	$0
2050	$0	$0	$0
Total	**$27,330,000**	**$24,657,354**	**$21,629,085**

Table 16: Detailed Cost/Benefit Summary

	Total Costs Discounted 3% (2015 $)	Total Costs Discounted 7% (2015 $)	Total Benefits Discounted 3% (2015 $)	Total Benefits Discounted 7% (2015 $)	Net Benefits Discounted 3% (2015 $)	Net Benefits Discounted 7% (2015 $)
2017	$6,440,287	$5,967,770	$0	$0	-$6,440,287	-$5,967,770
2018	$6,252,705	$5,577,355	$0	$0	-$6,252,705	-$5,577,355
2019	$6,070,588	$5,212,482	$0	$0	-$6,070,588	-$5,212,482
2020	$5,893,775	$4,871,478	$0	$0	-$5,893,775	-$4,871,478
2021	-$87,098	-$69,300	$1,607,564	$1,279,055	$1,694,663	$1,348,354
2022	-$84,562	-$64,766	$1,612,585	$1,235,084	$1,697,146	$1,299,850
2023	-$82,099	-$60,529	$1,617,426	$1,192,483	$1,699,525	$1,253,012
2024	-$79,707	-$56,569	$1,622,093	$1,151,216	$1,701,800	$1,207,785
2025	-$77,386	-$52,868	$1,626,588	$1,111,251	$1,703,974	$1,164,119
2026	-$75,132	-$49,410	$1,630,915	$1,072,554	$1,706,046	$1,121,964
2027	-$72,944	-$46,177	$1,635,076	$1,035,093	$1,708,019	$1,081,270
2028	-$70,819	-$43,156	$1,639,075	$998,835	$1,709,894	$1,041,991
2029	-$68,756	-$40,333	$1,642,915	$963,748	$1,711,671	$1,004,081
2030	-$66,754	-$37,694	$1,646,599	$929,800	$1,713,353	$967,494
2031	-$64,809	-$35,228	$1,650,130	$896,960	$1,714,939	$932,189
2032	-$62,922	-$32,924	$1,653,511	$865,198	$1,716,432	$898,122
2033	-$61,089	-$30,770	$1,656,744	$834,483	$1,717,833	$865,253
2034	-$59,310	-$28,757	$1,659,833	$804,785	$1,719,143	$833,542
2035	-$57,582	-$26,876	$1,662,780	$776,075	$1,720,363	$802,951
2036	-$55,905	-$25,117	$1,665,589	$748,325	$1,721,494	$773,442
2037	-$54,277	-$23,474	$1,668,261	$721,506	$1,722,537	$744,980
2038	-$52,696	-$21,938	$1,670,799	$695,590	$1,723,495	$717,529
2039	-$51,161	-$20,503	$1,673,206	$670,551	$1,724,367	$691,055
2040	-$49,671	-$19,162	$1,675,485	$646,363	$1,725,155	$665,525
2041	-$48,224	-$17,908	$1,677,637	$622,999	$1,725,861	$640,908
2042	-$46,820	-$16,737	$1,679,666	$600,435	$1,726,485	$617,172
2043	-$45,456	-$15,642	$1,681,573	$578,645	$1,727,029	$594,287
2044	-$44,132	-$14,619	$1,683,362	$557,606	$1,727,494	$572,224
2045	-$42,847	-$13,662	$1,685,034	$537,294	$1,727,880	$550,956
2046	-$41,599	-$12,768	$1,686,591	$517,686	$1,728,190	$530,455
2047	-$40,387	-$11,933	$1,688,037	$498,761	$1,728,424	$510,694
2048	-$39,211	-$11,152	$1,689,372	$480,495	$1,728,583	$491,648
2049	-$38,069	-$10,423	$1,690,600	$462,869	$1,728,669	$473,292
2050	-$36,960	-$9,741	$1,691,722	$445,861	$1,728,682	$455,602
Total	**$22,898,973**	**$20,708,948**	**$49,770,766**	**$23,931,606**	**$26,871,793**	**$3,222,659**

7 APPENDIX II: TRAVEL TIME SAVINGS CALCULATIONS

Table 17: Detailed Projected Bus Passenger Travel Time Savings

North Avenue Projected Bus Passenger Travel Time Savings from Installation of Bus Only Lane

Segment Limits (West to East)	Average Number of Weekday Riders	Length (miles)	Travel Time Savings (seconds) for Each Bus	Proportion of Passengers on Route 13	Total Seconds Saved on an Average Weekday
Edgewood Street to Denison Street	-	0.12	7.4	0.0%	-
Denison Street to Ellamont Street	2,043	0.21	12.4	47.6%	25,391
Ellamont Street to Rosedale Street	5,240	0.12	7.2	27.2%	37,959
Rosedale Street to Longwood Street	5,718	0.12	7.3	31.1%	41,979
Longwood Street to Poplar Grove Street	5,987	0.13	7.5	33.3%	44,960
Poplar Grove Street to Dukeland Street	6,134	0.13	7.5	34.5%	46,277
Dukeland Street to Ashburton Street	6,360	0.12	7.1	35.7%	45,403
Ashburton Street to Thomas Avenue	6,654	0.28	17.0	37.4%	112,807
Thomas Avenue to Warwick Avenue	6,703	0.07	4.0	39.0%	26,477
Warwick Avenue to Moreland Avenue	5,615	0.09	5.1	47.1%	28,650
Moreland Avenue to Wheeler Avenue	5,682	0.02	1.3	47.4%	7,157
Wheeler Avenue to Ruxton Avenue	5,749	0.05	3.3	47.7%	18,812
Ruxton Avenue to Bentalou Street	5,752	0.05	3.2	47.7%	18,356
Bentalou Street to Smallwood Street	6,283	0.10	5.8	50.8%	36,608
Smallwood Street to Payson Street	6,534	0.19	11.6	51.7%	75,990
Payson Street to Monroe Street	6,757	0.12	7.2	52.5%	48,654
Monroe Street to Fulton Avenue	6,870	0.12	7.2	53.1%	49,598
Fulton Avenue to Woodyear Street	7,069	0.15	9.1	54.7%	64,210
Woodyear Street to Carey Street	7,097	0.04	2.3	54.9%	16,399
Carey Street to Pennsylvania Avenue	7,147	0.08	5.1	55.6%	36,149
Pennsylvania Avenue to Sanford Place	8,405	0.15	9.1	61.2%	76,860
Sanford Place to Druid Hill Avenue	8,405	0.14	8.2	61.2%	68,766
Druid Hill Avenue McCulloh Street	8,781	0.09	5.6	59.7%	48,739
McCulloh Street Madison Avenue	10,113	0.09	5.4	53.4%	54,743
Madison Avenue to Eutaw Place	10,151	0.12	7.2	53.9%	72,925
Eutaw Place to Linden Avenue	7,412	0.10	6.1	74.3%	44,888
Linden Avenue to Bolton Street	7,469	0.18	10.8	74.9%	80,808
Bolton Street to Park Avenue	7,457	0.13	8.0	74.9%	59,298
Park Avenue to Mount Royal Avenue	5,665	0.21	12.4	100.0%	70,507
Mount Royal Avenue to Light Rail Station Entrance	5,663	0.16	9.4	100.0%	53,186
Light Rail Station Entrance to Howard Street	5,713	0.24	14.1	100.0%	80,567
Howard Street to Maryland Avenue	5,518	0.10	5.9	100.0%	32,528
Maryland Avenue to Charles Street	5,232	0.09	5.6	100.0%	29,129
Charles Street to Saint Paul Street	5,233	0.11	6.6	100.0%	34,674
Saint Paul Street to Calvert Street	5,282	0.08	4.9	100.0%	25,869
Calvert Street to Guilford Avenue	5,250	0.10	6.2	100.0%	32,458
Guilford Avenue to Greenmount Avenue	8,377	0.20	11.8	61.4%	98,921
Greenmount Avenue to Homewood Avenue	8,324	0.16	9.5	59.9%	79,314
Homewood Avenue to Aisquith Street	5,016	0.31	18.8	100.0%	94,313
Aisquith Street to Harford Road	4,747	0.23	13.6	100.0%	64,588
Harford Road to Bond Street	4,241	0.16	9.6	100.0%	40,661
Bond Street to Broadway	4,177	0.13	8.0	100.0%	33,275
Broadway to Wolf Street	4,083	0.24	14.2	100.0%	58,155
Wolfe Street to Washington Street	3,672	0.09	5.4	100.0%	19,959
Washington Street to Chester Street	3,643	0.12	7.2	100.0%	26,306
Chester Street to Collington Avenue	3,634	0.08	4.9	100.0%	17,934
Collington Avenue to Patterson Park Avenue	3,609	0.10	6.2	100.0%	22,205
Patterson Park Avenue to Montford Avenue	3,342	0.11	6.6	100.0%	21,894
Montfor Avenue to Belair Road	-	0.03	1.7	0.0%	-

Grand Total Weekday Bus Passenger Travel Time Savings:	Seconds	Minutes	Hours
	2,225,307	**37,088**	**618**

Table 18: Detailed Auto User Delays

Projected Additional Auto Delay Due to Installation of Bus Only Lane

Segment	Movement	Peak Hour	Average Additional Delay (Seconds)	Non-Bus Vehicle Person Throughput	Total Additional Person-Delay (Seconds)
Bloomingdale Road to Braddish Avenue	EB	a.m.	19.5	591	11,525
		p.m.	23.3	572	13,328
	WB	a.m.	80.9	413	33,412
		p.m.	83.5	647	54,025
Braddish Avenue to Fulton Avenue	EB	a.m.	50	516	25,800
		p.m.	54.1	549	29,701
	WB	a.m.	53.9	469	25,279
		p.m.	54.7	620	33,914
Fulton Avenue to Eutaw Street	EB	a.m.	44.2	893	39,471
		p.m.	49.2	777	38,228
	WB	a.m.	13.1	655	8,581
		p.m.	40.5	878	35,559
Eutaw Street to Charles Street	EB	a.m.	38.5	1109	42,697
		p.m.	12.1	1019	12,330
	WB	a.m.	34.6	1096	37,922
		p.m.	53.1	1152	61,171
Charles Street to Greenmount Avenue	EB	a.m.	19.7	981	19,326
		p.m.	3.9	747	2,913
	WB	a.m.	19.8	901	17,840
		p.m.	n/a	844	n/a
Greenmount Avenue to Milton Avenue	EB	a.m.	75.7	471	35,655
		p.m.	105.2	496	52,179
	WB	a.m.	90	634	57,060
		p.m.	76	561	42,636

Grand Total		
Seconds	Minutes	Hours
730,549	12,176	203