EAST WEST BRT

a feasibility study

MILWAUKEE COUNTY EAST-WEST BUS RAPID TRANSIT

Tech Memo #5: Operating and Maintenance Costs

REVISION #0

DATE June 28, 2016

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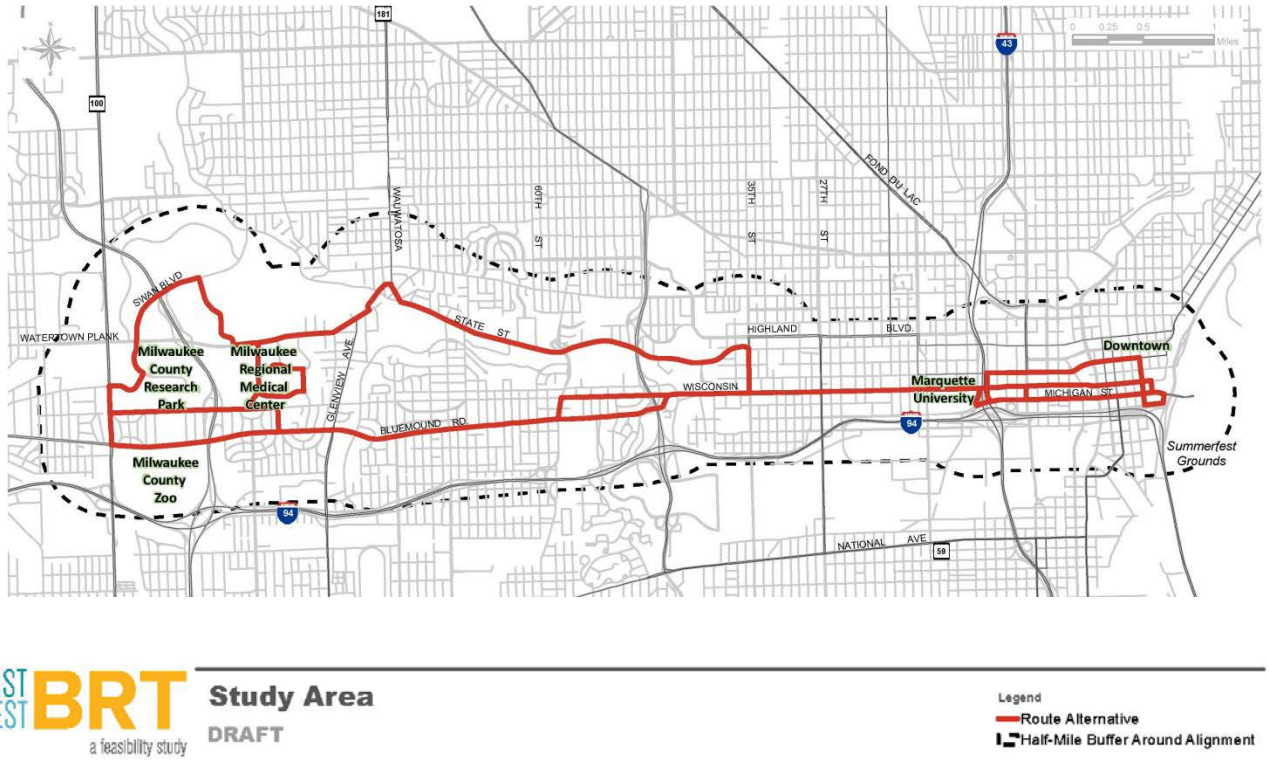
1. INTRODUCTION

1.1 Project Description

Milwaukee County and its partners have initiated a feasibility study to evaluate transit investment in the seven-mile East-West Corridor connecting major employment and activity centers between downtown Milwaukee, the Milwaukee Regional Medical Center (MRMC), and Milwaukee County Research Park (MCRP). Completing the feasibility study is a first step towards applying for funding through the Federal Transit Administration's (FTA) Small Starts program.

Figure 1-1: East-West Study Corridor



EAST WEST BRT a feasibility study

Study Area

DRAFT

Legend
Route Alternative
Half-Mile Buffer Around Alignment

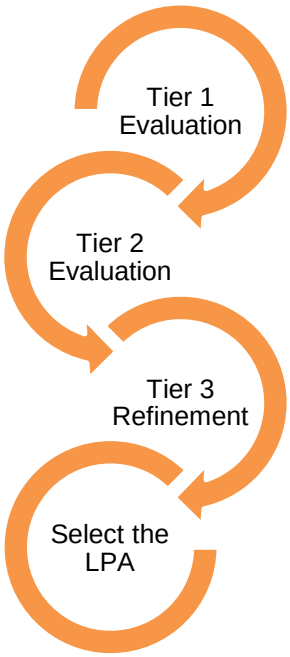
2. OVERVIEW OF PROJECT EVALUATION PROCESS

In order to evaluate the initial group of transit modes and alignment options and identify the appropriate mode-alignment pairings that will comprise the detailed alternatives, the East-West Corridor Study will follow a three-step method.

- The first step ("Tier 1 Evaluation") will entail the assessment of each mode and alignment relative to overall implementation viability.
- The second step ("Tier 2 Evaluation") will assess the mode/alignment pairings that passed the Tier 1 Evaluation and compare the benefits and impacts of each.
- The alternative(s) that fare(s) best against the detailed criteria in this second step will be identified as Preferred Alternative(s) and further refined in the third step ("Tier 3"). The Locally Preferred Alternative will be identified at the conclusion of the third step.

The evaluation criteria associated with each step are a combination of quantitative and qualitative performance measures.

- The Tier 1 Evaluation will apply fewer and broader measures, including information from previous corridor/area studies. The analysis will largely rely on order-of-magnitude estimates and the outcomes of similar transit projects from around the country.
- The Tier 2 Evaluation will apply more detailed and alternative-specific evaluation results.
- The Tier 3 Evaluation will evaluate the Preferred Alternative(s) against federal criteria to identify and refine the Locally Preferred Alternative.



This three-step process will result in the identification of an LPA that not only meets locally-identified project purpose and needs, but is also competitive for federal funding.

3. TECH MEMO #5 OVERVIEW

This report is the fifth in a series of technical memoranda (tech memos) that report the results of the Tier 2 Detailed Evaluation of Alternatives; the five other tech memos are available under separate cover:

- Tech Memo #1: Station Area
- Tech Memo #2: Transportation
- Tech Memo #3: Environmental Impacts
- Tech Memo #4: Capital Costs
- Tech Memo #5 (this memo): Operating and Maintenance Costs
- Tech Memo #6: Ridership

Results contained in the six tech memos are summarized in the Detailed Evaluation of Alternatives Report, also available under separate cover.

This tech memo includes the operating and maintenance (O&M) costs that were used to evaluate the performance of the BRT alternatives that are under consideration as part of the Tier 2 evaluation.

The Tier 2 alternatives and station locations under evaluation are described in Section 4. The methodology, data sources, and results of the evaluation are presented in Section 5.

4. THE ALTERNATIVES

Four modes are being evaluated as part of Tier 2:

- No Build
- BRT in Mixed Traffic
- BRT in Dedicated Center Lane
- BRT in Dedicated Curb Lane

Three routes are being evaluated as part of Tier 2; any of the modes listed above (or combination of the modes) could operate on these routes:

- Alternative 1: from Swan Park-and-Ride lot to the Downtown Transit Center via Wisconsin Avenue through downtown Milwaukee
- Alternative 2: from Swan Park-and-Ride lot to the Downtown transit Center via Wells Avenue
- Alternative 3: from Swan Park-and-Ride lot to the Downtown Transit Center via a hybrid of Wisconsin Avenue and Wells Street through downtown Milwaukee (called the Hybrid alternative)

The routes and station locations are shown in Figure 4-1; the station locations for each alternative are listed in Table 4-1. Additional detail regarding these alternatives can be found in the Tier 2: Detailed Definition of Alternative Reports, which is available on the project website (eastwestbrt.org).

Figure 4-1: Alternative Alignments and Stations

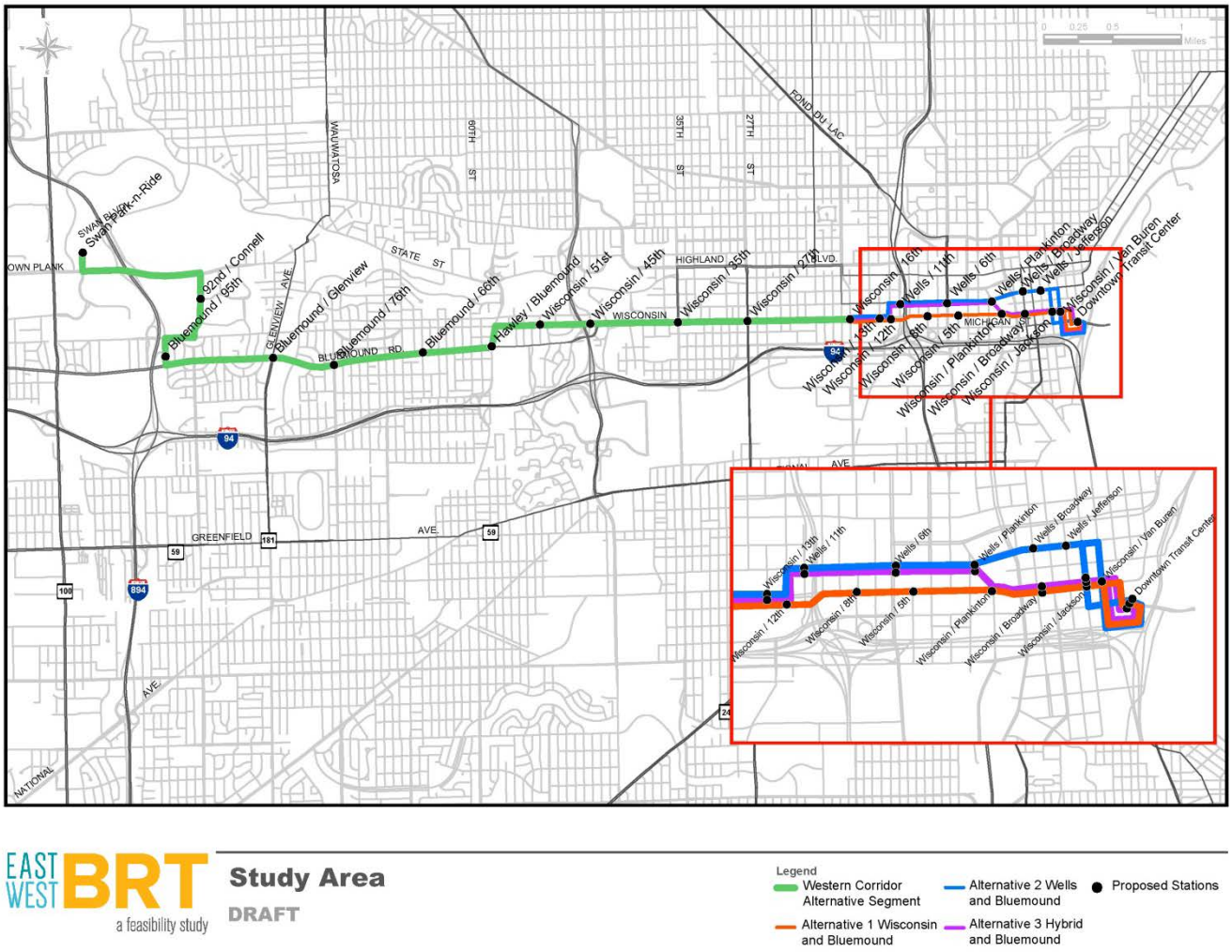


Table 4-1: Stop Location by Route Alternative

Stop Locations	Route Alternatives		
	Wisconsin	Wells	Wells/Wisconsin Hybrid
Downtown Transit Center	X	X	X
Van Buren/Wisconsin		X	

Stop Locations	Route Alternatives		
	Wisconsin	Wells	Wells/Wisconsin Hybrid
Wisconsin/Jefferson	X	X	X
Wisconsin/Broadway	X		X
Wells/Jefferson		X	
Wells/Broadway		X	
Wisconsin/Plankinton	X		
Wells/Plankinton		X	X
Wisconsin/5th St.	X		
Wells/6th St.		X	X
Wisconsin/8th St.	X		
Wells/11th St.		X	X
Wisconsin/12th St.	X		
Wisconsin/13th St.		X	X
Wisconsin/16th St.	X	X	X
Wisconsin/27th St.	X	X	X
Wisconsin/35th St.	X	X	X
Wisconsin/45th St.	X	X	X
Wisconsin/51st St.	X	X	X
Hawley/Bluemound	X	X	X
Bluemound/66th St.	X	X	X
Bluemound/76th St.	X	X	X
Bluemound/Glenview	X	X	X
Bluemound/95th St.	X	X	X
92nd & Connell (MRMC)	X	X	X
Swan Road Park & Ride	X	X	X

5. O&M COSTS

5.1 Methodology

An O&M cost spreadsheet model has been developed for this project to estimate the annual cost to operate, maintain, and administer a transit system for a given set of indicators. O&M costs are expressed as the annual total of employee earnings and fringe benefits, contract services, materials and supplies, utilities, and other day-to-day expenses incurred in the operation and maintenance of a transit system.

The Federal Transit Administration (FTA) believes a fully-allocated cost model is the best approach to O&M costing because it is a) able to reflect cost differences by mode and service type; b) structured based on actual operating experience; and c) sensitive to future changes in cost factors. The FTA has issued guidelines that specify the following methodology for calculating O&M costs:

- Estimate labor and materials needed to provide a specific level of service and then apply current unit costs to the estimated future labor and non-labor items.
- Calculate costs based on operating characteristics by mode (e.g., HRT train-hours) rather than for all modes combined (e.g., system-wide passengers).
- Model each reported labor and non-labor expense separately to ensure that equations are mutually exclusive and cover all operating costs.
- Model expense items as variable, so that cost estimates will change with projected changes in service.

A cost allocation model assumes that each operating expense incurred by a transit system is driven by a key supply variable such as revenue-hours, revenue-miles, or the number of vehicles operated during peak periods. Combining recent actual O&M costs with the quantity of relevant supply variables establishes unit costs and productivity ratios that can be applied to a different set of service indicators (such as projected future expansions or cut-backs). The result is an estimated annual O&M cost that is specific for a test scenario.

The structure of this project's O&M cost models is consistent with the spreadsheets presented in Chapter 4, Operating and Maintenance Costs of the FTA's *Procedures and Technical Methods for Transit Project Planning* (Draft, Version 3). The models' data and

calculations progress from the base year expense items and amounts on the left side of the spreadsheet, through the assignment of key supply variables as “cost drivers”, to productivity and inflation, and end with the estimated incremental cost of a study alternative on the right side of the worksheet.

Two spreadsheet models were developed to estimate annual O&M costs for the East-West BRT study alternatives. A Milwaukee County Transit System (MCTS) background bus O&M cost model was developed with recent actual expenses, system characteristics and service statistics as reported to the National Transit Database (NTD) for the 2014 report year. The FY 2014 NTD data was the most current actual expenditure data available. FY 2015 data had not yet been submitted and accepted by NTD at the time of this study. A separate BRT O&M cost model was also developed, pivoting from the background bus cost model. The BRT model captures all of that mode’s service-related expenses and costs unique to that mode (e.g., BRT facilities). The BRT cost model is based on the MCTS background bus model, supplemented with BRT-specific expense data from other locations in the US planning or operating BRT service.

The demand response mode has not been modeled because these operations in the project corridor are not expected to change from one study alternative to another.

5.2 Data Sources

As noted above, the cost model developed to estimate MCTS O&M cost impacts is based on MCTS’ 2014 NTD submittal. In FY 2014, MCTS reported $133.3 million in annual O&M expenditures for Motor Bus operations. They also reported 1,258,386 annual revenue bus-hours of service and 15,488,077 annual revenue bus-miles of service, with a maximum 334 buses in peak period service.

Key supply variables selected as the model’s cost-driving inputs are:

- *Annual Revenue Bus-Hours* – The hours that vehicles travel while in revenue service over the entire fiscal year. Revenue bus-hours include layover and schedule recovery but exclude time for deadhead, operator training, and maintenance testing.
- *Annual Revenue Bus-Miles* – The miles that vehicles travel while in revenue service over the entire fiscal year. Revenue bus-miles include layover and schedule recovery but exclude miles for deadhead, operator training, and maintenance testing.

- *Peak Buses* – The maximum number of passenger service vehicles operated simultaneously on an average weekday. In some cases, peak buses may be used as a supply variable when the model needs to base a line item expense on overall bus system size.
- *Operating Divisions & Heavy Maintenance Facilities* – The total number of garage facilities allocated to the bus mode.

After selecting key supply variables, the next step in model development was to record MCTS' bus expenses as a series of line items. The NTD report format categorizes operating expenses within the four functional areas of Vehicle Operations, Vehicle Maintenance, Non-Vehicle Maintenance, and General Administration. For each functional area, line item expenses are further classified as salaries/wages, fringe benefits, services, materials/supplies, utilities, casualty and liability, taxes/fees, and miscellaneous.

After the list of line items was established, each was assigned a key supply variable as its most relevant cost driver. One General Administration line item expense, Casualty and Liability, was deemed to be strongly influenced by both annual revenue bus-miles and peak buses, so this expense was evenly divided between those two supply variables.

In addition to the supply variables listed above, from which line item unit costs are derived, the model also incorporates resource variables specifically to provide labor productivity ratios. NTD-reported employee work hours are included as a resource variable for estimating salaries and wages by functional area for the project alternatives. For Vehicle Operations, NTD does not subdivide total work hours by operator and non-operator so the model applies their respective ratios of reported earnings to total work hours as an estimated allocation.

For all non-labor line items, the model calculates productivity using key supply variables. In addition, the model results have been inflated to 2015 dollars using a two percent inflation factor. While the consumer price index measure was flat in Milwaukee between 2014 and 2015, the consultant team decided to use a two percent increase to better reflect typical cost increases incurred in the MCTS budget due to factors such as labor, fringe benefit, and health care cost escalation.

Table 5-1 presents aggregated O&M unit costs for MCTS background bus service in 2014 dollars. The unit costs in this table reflect the dollar amount the model will adjust for each added or deleted unit of a supply variable – in other words, the incremental change from the calibration. For example, for each MCTS-operated revenue bus-mile added, the model will increase its total estimate by $2.03; for each revenue bus-hour deleted, the model will

subtract $60.60 from its estimate, and so forth. The full spreadsheet model is presented in Appendix 2.

Table 5-1: MCTS Bus O&M Unit Costs (In 2015 dollars)

Service Variable	Unit Cost
Peak Buses	$44,214 per peak bus
Annual Revenue Bus-Hours	$60.60 per rev. bus-hour
Annual Revenue Bus-Miles	$2.03 per rev. bus-mile
Operating Bases	$3,379,436 per operating base

5.2.1 BRT O&M Cost Model

This study requires estimating the cost of BRT operations for the study's Build alternatives. Potential future BRT operating costs will be estimated with a cost model that is based on the MCTS background bus model, but includes some line items that reflect BRT-specific expenses not currently part of the MCTS bus environment.

Supply variables used in the BRT spreadsheet model are for estimating annual O&M costs for operating new service and for maintaining new facilities and equipment are as follows:

- *BRT Annual Revenue Bus-Hours* – The hours that BRT vehicles travel while in revenue service over the entire fiscal year. Revenue bus-hours include layover and schedule recovery but exclude time for deadhead, operator training, and maintenance testing.
- *BRT Annual Revenue Bus-Miles* – The miles that BRT vehicles travel while in revenue service over the entire fiscal year. Revenue bus-miles include layover and schedule recovery but exclude miles for deadhead, operator training, and maintenance testing. The model distinguishes between standard and articulated bus-miles, as described below.
- *BRT Peak Buses* – The maximum number of BRT service vehicles operated simultaneously on an average weekday.
- *BRT Stations* – Bus passenger facilities in the Build alternatives that include features typically not included at standard bus stops, such as corridor-specific passenger shelters, enhanced and possible lighted signage and ITS features (e.g., next bus arrival real time information).

- *Fare Vending Machines* – The total number of this type of equipment to be installed at BRT stations.
- *TSP Signalized Intersections* – The number of intersections in the study corridor that are anticipated to provide Transit Signal Prioritization (TSP) for BRT service.
- *Exclusive Lane Miles* – The number of directional lane miles that will be dedicated for BRT operations, reflecting new pavement that needs to be maintained.

The BRT model carries over line items from the MCTS baseline bus model for Vehicle Operations, Vehicle Maintenance, and General Administration. Should articulated buses be proposed, a 25 percent adjustment has been made to account for select unit costs that are likely to be higher for articulated vehicles compared to standard-sized buses. Line items factored up for articulated buses are:

- Vehicle Operations consumables (fuel/lube, tires/tubes), and
- Vehicle Maintenance labor costs and repair/maintenance supplies.

This assumption is consistent with other planning studies for agencies that operate articulated buses.

BRT service in this project's build alternatives are anticipated to include unique features that will result in new O&M costs that are not reflected in the MCTS current bus expenses. These BRT-specific O&M expenses are modeled as follows:

- *BRT Security Enforcement* – Additional security enforcement is assumed for BRT operations beyond what is provided for background bus service. A rate of one work hour for every eight revenue bus-hours was assumed for BRT Security Enforcement. An average of 1,800 work hours for every full-time employee was assumed. Annual average wages and fringe benefits were assumed to be approximately $80,000 for every full-time employee. This works out to a unit cost of approximately $5.49 per revenue-hour for BRT security enforcement. It is important to note that it has been assumed riders will continue to utilize M-Cards for fare payment on buses, and that no additional personnel will be needed for fare enforcement.
- *BRT Stop Maintenance* – It is assumed that additional MCTS staff or contracted services will be required annually to pay for periodic cleaning and maintenance of each BRT stop. A unit cost of $1,975 per BRT station platform has been used, which is comparable to unit costs used in other BRT studies. It is anticipated that the BRT stops in the East West Corridor will be curb lane or center median stops without extensive furnishings and with moderate passenger activity.

- *Fare Equipment Maintenance* – Fare collection O&M could include the maintenance of vending machines and validators at BRT stations. For BRT projects in Nashville and Minneapolis, transit agencies provided cost data to consultant staff that suggested a range of $3,000 to $10,000 in annual maintenance costs for each machine to stock, clean and repair them. The BRT model for this project uses the average of this range, inflated to be more representative of current year dollars ($8,100 per fare vending machine and validator). One ticket vending machine and one validator has been assumed for each station platform.
- *ITS Signage Maintenance* – Planning level unit costs for ITS have ranged from $2,600 to $4,500 per directional stop in other BRT studies. For purposes of this project, an annual unit cost of $2,850 per directional stop is proposed (the lower cost from other studies, inflated). Real time informational signage is assumed at all proposed BRT stations.
- *Surface Park-and-Ride Maintenance* – Planning-level maintenance costs used in recent BRT projects in Minneapolis have been $70 per surface space.
- *TSP Maintenance* – Project build alternatives may assume transit signal prioritization at selected intersections in the study corridor. A typical unit cost for ongoing TSP maintenance in other BRT studies has been $2,850 per intersection.
- *Exclusive Lane Mile Maintenance* – Alternatives with exclusive lanes may require additional lane maintenance. At this time, alternatives are not assuming additional lane miles. Rather, any exclusive lanes will likely reflect use of an existing traffic lane or curbside parking. A unit cost of $7,360 per lane mile has been assumed for new lane mile maintenance, based on data provided in the 21st Annual Report on the Performance of Highway Systems (1984-202), Reason Foundation, September 2014.

Table 5-2 presents the project's BRT O&M cost model in FY 2015 dollars. The full spreadsheet model is presented in Appendix 2.

Table 5-2: BRT O&M Unit Costs (in 2015 dollars)

Service Variable	Unit Cost
Peak Buses	$43,347 per peak bus
Annual Revenue Bus-Hours	$64.90 per rev. bus-hour
Annual Revenue Bus-Miles – Standard	$1.99 per rev. bus-mile
Annual Revenue Bus-Miles – Articulated	$2.49 per rev. bus-mile
BRT Station Platforms	$4,825 per station platform

Service Variable	Unit Cost
Fare Vending Machines/Validators	$8,100 per station platform
BRT Park-Ride Surface Spaces	$70.00 per space
TSP Signalized Intersections	$2,850 per signal
Exclusive Guideway Lane Miles	$7,360 per lane mile

5.3 Summary of Results

Service requirements presented in Section 5 of a separate technical memo have been applied to the O&M unit costs presented in Tables 5-1 and 5-2. Table 5-3 presents resulting O&M cost estimates. Detailed O&M cost tables are provided in Appendix 2. BRT O&M costs have been prepared for all three alternatives and for two scenarios – without and with dedicated lanes. At this time, no O&M costs for exclusive lane miles have been assumed for the dedicated lanes scenarios since no new pavement is anticipated to be added. Maintenance of a 150 space parking lot is assumed at the Bluemound/95th Street Station. Articulated buses have not been assumed for Opening Year, but may be needed in the future based on forecasted ridership growth. As noted in Table 5-3, BRT O&M costs are in the general range of $5.9 to $6.0 million for scenarios without dedicated lanes and $5.5 to $5.6 million for scenarios with dedicated lanes. All alternatives are anticipated to benefit from $1.8 million in savings in background bus service changes. This results in a total incremental O&M cost estimate of approximately $4.1 million for alternatives without dedicated lanes, and $3.7 million for scenarios with dedicated lanes. The dedicated lane alternatives realize a cost savings by operating the BRT with a shorter cycle time, which reduces the number of required revenue hours.

Note that these cost estimates will likely change as the project advances and more information is known regarding facility characteristics (e.g., number of TSP intersections, number of exclusive lane-miles, number of station platforms, etc.).

Table 5-3: Incremental O&M Cost Estimates (in 2015 dollars)

Mode	Key Supply Variable	Unit Cost (in $2015)	Incremental Change in Corridor Transit Operating Statistics and Costs					
			TSP, No Dedicated Lanes			TSP, With Dedicated Lanes		
			Wisconsin Ave.	Wells St.	Hybrid	Wisconsin Ave.	Wells St.	Hybrid
BUS								
	Annual Revenue Bus-Hours	$60.60	-17,494	-17,494	-17,494	-17,494	-17,494	-17,494
	Annual Revenue Bus-Miles	$2.03	-276,831	-276,831	-276,831	-276,831	-276,831	-276,831
	Peak Buses	$44,214	-5	-5	-5	-5	-5	-5
	Op. Divisions & Heavy Maint. Facilities	$3,379,436	0			0		
Total Incremental Bus Costs			**($1,844,000)**	**($1,844,000)**	**($1,844,000)**	**($1,844,000)**	**($1,844,000)**	**($1,844,000)**
BUS RAPID TRANSIT								
	Articulated Buses (Y/N)		N	N	N	N	N	N
	BRT Annual Revenue Bus-Hours	$66.20	54,900	54,900	54,900	50,000	50,000	50,000
	BRT Annual Revenue Bus-Miles - Standard	$2.03	586,700	607,300	597,600	586,700	607,300	597,600
	BRT Annual Revenue Bus-Miles - Articulated	$2.54	0	0	0	0	0	0
	BRT Peak Buses	$44,214	10	10	10	9	9	9
	BRT Station Platforms	$4,922	36	38	36	36	38	36
	Fare Vending Machines/Validators	$8,262	36	38	36	36	38	36
	BRT Park-Ride Surface Spaces	$71.40	150	150	150	150	150	150
	TSP Signalized Intersections	$2,907	53	58	63	53	58	63
	Exclusive Guideway Lane Miles	$7,507	0	0	0	0	0	0
Total BRT O&M Costs			***$5,908,500***	***$5,991,300***	***$5,959,800***	***$5,540,000***	***$5,622,700***	***$5,591,200***
TOTAL INCREMENTAL O&M COSTS			**$4,064,500**	**$4,147,300**	**$4,115,800**	**$3,696,000**	**$3,778,700**	**$3,747,200**