Bridges Supporting Mobility and Connectivity Through Three East King County Interchanges

Benefit-Cost Analysis

Prepared for King County

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Contents

Executive Summary

A benefit-cost analysis (BCA) was conducted for the *Bridges Supporting Mobility and Connectivity Through Three East King County Interchanges* (Bridges) project for submission to the United States Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the 2018 BUILD program. The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the Federal Register (80 Fed. Reg. 18651) and conducted for a 23-year analysis period including four years of construction, including a transition year to partial operations, and 20 years of benefits.

Completion of the Eastside Rail Corridor (ERC) trail will play an essential role in alleviating vehicle congestion in the region by providing a safe and mode-separated facility for a growing number of non-motorized vehicle commuters in the area. The trail sits at the crossroads of major roadways and future transit connections:

- I-405 runs in-line with and crosses the trail serving an estimated 200,000 vehicle trips daily.[1]
- NE 8th Street in Bellevue and the intersection of Totem Lake Boulevard and NE 124th Street in Kirkland serve over 75,000 vehicle trips combined daily[2].
- SR 520 and I-90, crossing the central and southern sections of the Corridor and each providing a key trail connection to the ERC, serve as the only major east-west connections over Lake Washington, carrying an estimated total of 85,000 vehicle trips daily.[3]
- Sound Transit is currently expanding their light rail network to East King County with the new Wilburton station set to open in 2023.
- The Totem Lake Transit Center and Bellevue Transit Center serve as regional transportation hubs with 36 local and express connections to Seattle, Redmond and other municipalities throughout the region.[4]

The ERC sits amidst one of the fastest growing urban areas in King County with connections to one of the fastest growing cities in the nation. [5]

Despite significant investment by the partner organizations of the Regional Advisory Council (RAC), the utility of the trail is limited by its lack of paving on the majority of the route and a number of sections without secure pedestrian and bicycle crossings. Ultimately, these limitations result in a facility that does

[1] Washington Department of Transportation (2017). Annual Traffic Report 2016. p. 42. http://www.wsdot.wa.gov/mapsdata/travel/pdf/Annual_Traffic_Report_2016.pdf.
[2] City of Bellevue (2016). 2015 Annual Average Weekday Traffic. http://apps.bellevuewa.gov/gisdownload/PDF/Transportation/AAWT2015_11x17.pdf.
[3] Washington Department of Transportation (2017). Annual Traffic Report 2016. p. 19 & 25. http://www.wsdot.wa.gov/mapsdata/travel/pdf/Annual_Traffic_Report_2016.pdf.
[4] King County Metro Transit. (2018). Boarding Locations. https://kingcounty.gov/depts/transportation/metro/schedules-maps/maps/boarding.aspx.
[5] US Census Bureau. (2018). *Census Bureau Reveals Fastest-Growing Large Cities*. [online] Available at: https://www.census.gov/newsroom/press-releases/2018/estimates-cities.html.

not reach its full potential and restricts safe access to a continuous non-motorized trail that will provide direct bicycle and pedestrian access to existing and future public transit in the region.

To bring this long-standing vision to reality, King County and the City of Kirkland request $24 million in 2018 BUILD grant funding for the *Bridges* project. The project will complete three key bridges within the ERC, allowing for the completion of the entire trail to follow. Upon completion, the *Bridges* project creates a regional pedestrian and bicycle throughway into a safe, mode-shared trail network that attends to the evolving role of the ERC as a regional transportation facility. As the region anticipates the growing need for a comprehensive north-south passage dedicated to non-motorized travel, the partner organizations of the RAC have committed to repurposing the former Burlington Northern Santa Fe rail line into a 16.7-mile engineered route from Renton to Woodinville, connecting to the regional network of trails. Primary components of the *Bridges* project, construction of the pedestrian bridges at NE 8th Street and Totem Lake and the refurbishment of the Wilburton Trestle is slated to begin in 2020.

Total costs for the *Bridges* project through 2040 are provided below in Table 1. Costs include operating and maintenance (O&M), repair and rehabilitation (R&R), and an offsetting residual value at the end of the evaluation period. Including O&M and residual values, which are considered as benefits for purposes of the benefit cost ratio, costs total $21,501,318 in constant 2017 dollars. When discounted to a 2017 present value, the overall costs sum to $43,705,884 at a 7 percent discount rate and $36,537,239 at 3 percent.

Table 1: *Bridges* Project Costs

Cost Category	Costs (2017 $)	Present Value Costs (discounted at 7% to 2018)	Present Value Costs (discounted at 3% to 2018)
Capital Costs	$57,328,545	$50,473,771	$54,201,639
Incremental O&M Costs	$100,000	$46,266	$70,117
Incremental R&R Costs	$7,335,609	$2,950,839	$4,844,033
Residual Value	($43,262,836)	($9,764,992)	($22,578,550)
Total	**$21,501,318**	**$43,705,884**	**$36,537,239**

Source: WSP, 2018

The *Bridges* project creates $54,841,220 in present value benefits, inclusive of O&M costs and residual value, when discounted at 7 percent to 2018 or $92,193,696 when discounted at 3 percent to 2018.

Benefits, excluding incremental O&M cost offsets and residual value, are primarily achieved through livability factors like commuter mobility, recreation, and safety and health benefits. The overall project benefits by category are summarized in Table 2, while Appendix A: Benefit-Cost Model Detail Tables lists the detailed benefits and costs by year.

Table 2: *Bridges* Project Impact and Benefits Matrix

Current Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impact	Population Affected by Impact	Economic Benefit	Results Summary (2017 $ discounted at 7% to 2018)	Results Summary (2017 $ discounted at 3% to 2018)	Page Reference in BCA
Lack of Connectivity for Bicyclists and Pedestrians and Increasing Congestion and Safety Concerns at Current at-Grade Crossings	Replacement of At-Grade Crossings with Grade Separated Crossings	Reduced congestion and wait times	Bicyclists with higher travel speeds; autos with reduced wait time	Travel time savings	$4,275,272	$6,861,704	p. 11
		Improved Health and Safety	Current and new users on the trail	Lower Healthcare Costs and Fewer Collisions	$9,658,724	$14,666,525	p. 13 p. 17
		Improved Commuter and Recreational Experience	Bicyclists and Pedestrians using the Trail	Improved Mobility	$29,957,042	$46,271,057	p. 14
		Reduced Auto Use	Society	Lower emissions, road and vehicle costs	$1,185,190	$1,815,860	p. 16
		Total Project Benefits			**$45,076,228**	**$69,615,147**	**p. 10-18**

Source: WSP, 2018

Table 3 below shows the overall results of the benefit-cost analysis. At a 7 percent discount rate, the *Bridges* project yields a benefit-cost ratio of 1.03 over the 23-year analysis period, while using a 3 percent discount rate yields a benefit-cost ratio of 1.56.

Table 3: Benefit Cost Analysis Summary Results

Scenario	Net Present Value (2017 $ Discounted to 2018)	Benefit-Cost Ratio
Case A (7 percent discount rate)	**$1,370,344**	**1.03**
Case B (3 percent discount rate)	**$33,077,907**	**1.56**

Source: WSP, 2018

Introduction

A benefit-cost analysis (BCA) was conducted for the *Bridges* project for submission to the United States Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the 2018 BUILD program. The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the Benefit-Cost Analysis Guidance for Discretionary Grant Programs[6] and the Notice of Funding Opportunity (80 Fed. Reg. 18651).

Analytical Assumptions

Discount Rates

For project costs and benefits, monetary values in this analysis are expressed in constant, year-end 2017 dollars. In instances where certain cost estimates or benefit valuations were expressed in dollar values from other (historical) years, the U.S. Bureau of Labor Statistics' Consumer Price Index for All Urban Consumers (CPI-U) was used to adjust them to 2017 values.[7]

The real discount rates used for this analysis were 3.0 and 7.0 percent, consistent with U.S. DOT guidance for Discretionary Grant Programs[8] and OMB Circular A-4.[9]

Evaluation Period

For the project, the evaluation period includes the relevant (post-design) construction period of four years, during which capital expenditures are undertaken, plus 20 years of operations starting with the last year of partial project completion. The overall analysis period is 23 years, and used to evaluate ongoing benefits and costs.

For the purposes of this study, it has been assumed that construction of the *Bridges* project will begin in 2018, with construction completed by the middle of 2021 and operations beginning in 2020. As such, the 20-year evaluation period concludes in 2040.

For purposes of present value discounting, all benefits and costs are conservatively assumed to occur at the end of each year. Benefits accruing from the improvements are assumed to begin in the calendar year corresponding to the final construction year.

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[6] US DOT. BUILD 2018 NOFO: Benefit-Cost Analysis Guidance for Discretionary Grant Programs, Updated April 27, 2018; https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance

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

[8] US DOT. BUILD 2018 NOFO: Benefit-Cost Analysis Guidance for Discretionary Grant Programs, Updated April 27, 2018; https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance

[9] 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).

Project Region & Description

The *Bridges* project elements, located along the I-405 interstate highway in Kirkland and Bellevue, Washington, sit along the ERC, a 16.7-mile off-street, multi-use pedestrian and bicycle trail used for commuter and recreational purposes. By virtue of its connection to the Sammamish River Trail at Wilmot Gateway Park in Woodinville, WA, as well as the I-90 and SR 520 trails in Bellevue, WA, the ERC will weave into a larger, 175 mile regional trail network with active development set to expand this network by an additional 150 miles.

The *Bridges* project plays an essential role in alleviating vehicle congestion in the region by providing a safe and mode-separated facility for a growing number of pedestrian and bicycle commuters in the area. The ERC trail corridor traverses major east-west thoroughfares and connects regional transportation hubs:

- SR 520 and I-90, crossing the ERC at Miles 10 and 14, are the only two major east-west connections over Lake Washington connecting East King County to Seattle.
- The Totem Lake Transit Center and Bellevue Transit Center, located less than a mile from the trail corridor, provide local, commuter and Bus Rapid Transit services to throughout King County.
- King County Metro, Sound Transit, and Community Transit operate more than 55 bus routes serving King County.
- Sound Transit is currently expanding their light rail network into East King County, including the new Wilburton station set to open in 2023.

The City of Bellevue's Pedestrian-Bicycle Plan, the City of Kirkland's Nonmotorized Transportation Plan and City of Redmond's Bicycle Program include plans for several new or improved trail facilities. The ERC Trail sits amidst one of the fastest growing urban areas in King County with connections to one of the fastest growing cities in the nation[10].

Despite significant investment by the partner organizations of the Regional Advisory Council (RAC), the utility of the trail is limited by its lack of paving on the majority of the route and a number of sections without secure pedestrian and bicycle crossings. Ultimately, these limitations result in a facility that does not reach its full potential and restricts safe access to a continuous non-motorized trail that will provide direct bicycle and pedestrian access to existing and future public transit in the region.

To bring this long-standing vision to reality, King County and the City of Kirkland request $24 million in 2018 BUILD grant funding for the *Bridges* project. The project will complete three key bridges within the ERC, allowing for the completion of the entire trail to follow. Upon completion, the *Bridges* project transforms a regional pedestrian and bicycle throughway into a safe, mode-shared trail network that attends to the evolving role of the ERC as a regional transportation facility. As the region anticipates the growing need for a comprehensive north-south passage dedicated to non-motorized travel, the partner organizations of the RAC have committed to repurposing the former Burlington Northern Santa Fe rail line into a 16.7-mile engineered route from Renton to Woodinville, connecting to the regional network of

[10] US Census Bureau (2018). *Census Bureau Reveals Fastest-Growing Large Cities*. [online] Available at: https://www.census.gov/newsroom/press-releases/2018/estimates-cities.html.

trails. Primary components of the *Bridges* project, construction of the pedestrian bridges at NE 8th Street and Totem Lake and the refurbishment of the Wilburton Trestle is slated to begin in 2020.

A Conservative Approach

Each assumption or valuation in the BCA was chosen to reflect a conservative approach, and at times guidelines from other documents were modified to reflect increased conservatism. Some of these conservative assumptions include:

- Weekend recreational trail use was assumed to be no greater than weekday trail use;
- Bicycling growth was assumed to increase proportionally to land use growth, though historical bicycling rates have generally increased fast than land use;
- Land use forecasts in the *Bridges* project area do not account for a potential rezone of land on both sides of the Bellevue segment of the trail;
- Health benefits of walking were not quantified in this analysis;
- O&M Costs used the highest value in the range of typical costs cited in the literature, and the estimated trail rehabilitation and replacement costs include additional contingencies.

Travel Demand Sources and Forecast Years for Benefits

In contrast to typical roadway projects undergoing a benefit-cost analysis, this project did not utilize forecasts from a travel demand model. This is because regional travel demand models are not particularly adept at estimating bicycle or pedestrian demand, especially at a facility or corridor level. A method for determining bicycle demand is presented in the National Cooperative Highway Research Program (NCHRP) report, *Guidelines for Analysis of Investments in Bicycle Facilities*[11]. This report provides a foundation for analyzing investments in bicycle facilities, including developing methodologies for estimating facility demand and monetizing benefits. The guidelines for estimating trail demand employ population density within a certain proximity of the facility to estimate usage, largely because most investments for trail facilities are construction of new, not existing, facilities.

Forecasts

The bicycle and pedestrian forecasts for the *Bridges* project were based on an analysis by WSP, which considered future growth due to land use changes, mode shift, and future demand from households within a mile-wide zone of the trail, along with forecasted usage of Sound Transit's East Link light rail extension (opening in 2023). Resulting trips were compared against 2017/2018 observed counts at several locations along the Cross-Kirkland Corridor to confirm trip generation baseline values were aligned with actual experience. The forecasts for number of trail users are based on the segment from NE 8th Street to just south of I-90. For the bridge improvement in Totem Lake, existing counts were used to account for benefits for that portion of the *Bridges* project.

[11] NCHRP Report 552 (2006). *Guidelines for Analysis of Investments in Bicycle Facilities*, Transportation Research Board, Washington, D.C. (http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf)

Methodology

For developing the baseline bicycle forecast for the *Bridges* project, the following data inputs were used in the NCHRP methodology:

- Population within 400, 800, and 1,600 meters of the trail adjacent to the *Bridges* project sites. This was determined through a GIS-analysis of population at the Census blockgroup-level within each of the three distances from the trail. The population estimates were based on 2015 American Community Survey estimates; for blockgroups that were partially within a certain distance buffer, the population captured was assumed to be proportional to the percent of the blockgroup area within the buffer.
- Bicycle commute share for the area. This was estimated from the Washington State Commute Trip Reduction (CTR) survey for years 2007-2014 for commute trips originating at homes with zip codes adjacent to the *Bridges* project. This state-mandated survey is conducted by all medium and large employers across the state every two years to get a comprehensive dataset on how commuters travel, including their choice of mode. Note this share was then adjusted slightly upward to account for recent and planned implementation of floating electric bike share in major cities along the trail.
- Percent of population over 18 years of age. This was estimated as the percent of adults in block groups along the trail corridor. This population share is based on the 2015 ACS 5-year estimates.

Then, using the NCHRP method, the baseline forecast was created for the three primary bicycle user categories:

- Existing Commute Bicyclists
- New Commute Bicyclists
- Total New Cyclists

In determining the number of total new cyclists, the methodology allowed for a range of options in the relationship of the overall bicycling rate to the commuting bicycling share. While not much guidance is provided in the methodology, there is little reason to believe that this relationship is unusually high or low in the *Bridges* project area, so the "moderate" rate calculations were used. The number of total new cyclists minus the number of new and existing commute cyclists reflects the new recreational cyclists.

In addition to bicyclists, the number of pedestrians commuting on the three bridges was also estimated for the baseline forecast. This estimate was designed to be conservative to reflect that the adjacent land use is primarily suburban residential, with some small- and large-scale retail. The number of pedestrian was calculated by taking the ratio of the pedestrian commute and bicycle commute shares (from the CTR survey data) and applying it to the new commute bicyclists volume, then further scaling the value downward, based on average trip length by mode from the CTR data, to reflect that pedestrian trips are relatively short.

Using the three bicycle user categories and the new commute pedestrians, benefits were quantified in five categories for the baseline forecast and the future years (described below):

- Reduced Auto Use

- Annual Health Benefit
- Commuter Mobility Benefit - Bicyclists
- Recreation Benefits - Bicyclists
- Commuter Mobility Benefit – Pedestrians
- Travel time savings – Bicyclists and Vehicles

Future Years Growth

Future growth in bicycle and pedestrian usage was developed using land use forecasts and assumptions regarding expansion of the trail network as shown in Table 4.

Bicycle and pedestrian volumes were assumed to increase proportional to population growth. The land use growth came from the Land Use Vision (v2) land use forecasts from Puget Sound Regional Council, which provides city-level population forecasts. Tracts within 1600 meters of the corridor were selected, and annual population growth rates for each future 5-year period were calculated and then applied to the baseline bicycle and pedestrian forecast. Similar to the 2015 land use, tracts that were partially within the 1600 meter distance buffer, the population captured was assumed to be proportional to the percent of the tract area within the buffer. This approach is conservative as historical bicycling rates have increased faster than background population growth.

In addition to the land use growth, use of the trail would be expected to increase due to completion of other segments of the ERC, though this additional growth was not accounted for in the forecasts.

Table 4: NCHRP 552 Results (Daily)

Factor	Value	Unit
Population (400m)	4,955	people
Population (800m)	10,496	people
Population (1600m)	22,839	people
Existing Bicycle Commuters		
Bicycle Commute Share	1.28%	percent
Adult Commuter Share	40.6%	percent
Existing Adult Bicycle Commuters	199	people
Total Existing Adult Cyclists		
Total Adult Bicycling Rate (High)	4.4%	percent
Total Adult Bicycling Rate (Moderate)	1.9%	percent
Total Adult Bicycling Rate (Low)	1.3%	percent
Adult Share	78.1%	percent
Total Existing Adult Cyclists (Moderate)	579	people
New Commuters		
NCHRP 400m Factor	2.93	factor
NCHRP 800m Factor	2.11	factor
NCHRP 1600m Factor	1.39	factor
New Commuters	157	people
New Cyclists		
Children Who Bike	2.7%	percent
Total Adult Cyclists	455	people
Total Child Cyclists	181	people

Source: WSP 2018

Forecast Values

Future growth in bicycle and pedestrian usage was developed using land use forecasts and assumptions regarding expansion of the trail network. Table 5 on the next page provides the forecast for users of the trail by category over the 20-year horizon for monetized benefits. In regard to annual population growth, values are primarily based on five-year census track block data with compound annual growth rates used to interpolate annual values between the forecast years. Forecast categories generally align with the primary monetized benefits for each of the three bridge project areas and overall growth in the ERC supported by the *Bridges* project enhancements. Primary benefits include; safety benefits at Totem Lake from reduced bicycle and pedestrian interaction with vehicles; reduced vehicle delay at NE 8th street; and access to Link Light Rail through the Wilburton Trestle and SE 8th Street grade separated crossing enhancements.

Table 5: Users of Trail by Category (daily, unless specified otherwise)

year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Population Forecast	213,072	216,014	218,997	222,022	225,088	228,196	230,701	233,234	235,794	238,383	241,000
Population Growth	2.2%	1.4%	1.4%	1.4%	1.4%	1.4%	1.1%	1.1%	1.1%	1.1%	1.1%
Existing Commute Bicyclists	177	180	182	185	187	190	192	194	196	198	201
New Commute Bicyclists	139	141	143	145	147	149	151	153	154	156	158
New Commute Bicyclists-Light Rail Add				19	38	39	39	39	40	40	41
Total New Cyclists	567	574	582	590	599	607	613	620	627	634	641
Commute Pedestrians	454	460	466	473	479	486	491	497	502	508	513
New Commute Pedestrians-Light Rail Add				76	152	154	156	158	160	161	163
Totem Lake Bikes (annual)	23,545	23,870	24,199	24,534	24,872	25,216	25,493	25,773	26,055	26,342	26,631
Totem Lake Peds (annual)	44,432	45,045	45,667	46,298	46,937	47,585	48,108	48,636	49,170	49,710	50,255
Bellevue Motorized Vehicles (peak hour)	3,154	3,222	3,267	3,312	3,358	3,404	3,451	3,489	3,527	3,566	3,605

year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Population Forecast	243,311	245,645	248,001	250,380	252,781	255,556	258,362	261,198	264,066	266,965
Population Growth	1.0%	1.0%	1.0%	1.0%	1.0%	1.1%	1.1%	1.1%	1.1%	1.1%
Existing Commute Bicyclists	202	204	206	208	210	213	215	217	220	222
New Commute Bicyclists	159	161	162	164	165	167	169	171	173	175
New Commute Bicyclists-Light Rail Add	41	42	42	42	43	43	44	44	45	45
Total New Cyclists	647	653	660	666	672	680	687	695	702	710
Commute Pedestrians	518	523	528	533	538	544	550	556	562	568
New Commute Pedestrians-Light Rail Add	165	167	168	170	171	173	175	177	179	181
Totem Lake Bikes (annual)	26,886	27,144	27,404	27,667	27,933	28,239	28,549	28,863	29,180	29,500
Totem Lake Peds (annual)	50,737	51,224	51,715	52,211	52,712	53,291	53,876	54,467	55,065	55,670
Bellevue Motorized Vehicles (peak hour)	3,640	3,674	3,710	3,745	3,781	3,823	3,865	3,907	3,950	3,993

Source: WSP 2018

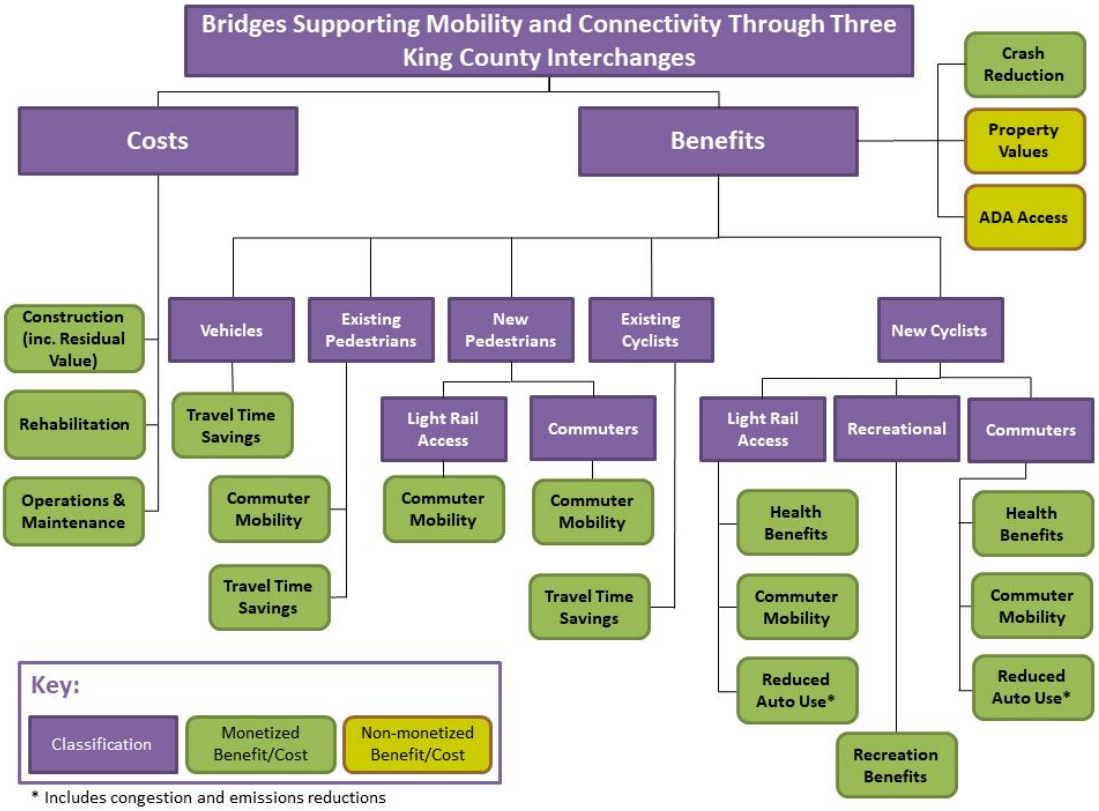
Analysis Tool

This benefit-cost analysis was supported by a detailed Microsoft Excel-based benefit-cost analysis tool which uses a methodology consistent with the most recent guidelines developed by USDOT. The tool determines benefits according to the following five categories: State of Good Repair; Economic Competitiveness; Livability; Sustainability; and Safety.

Overview of Benefits and Costs

The *Bridges* project considers a range of benefits to different users of the trail. Most of these benefits occur because, in the absence of the *Bridges* project improvements, conditions would be substantially worse for a broad range of users. The costs considered are typical for most projects – construction, operations and maintenance (O&M), and rehabilitation and replacement (R&R) costs. Figure 1 provides an overview of these costs and benefits, which are further discussed in the following sections.

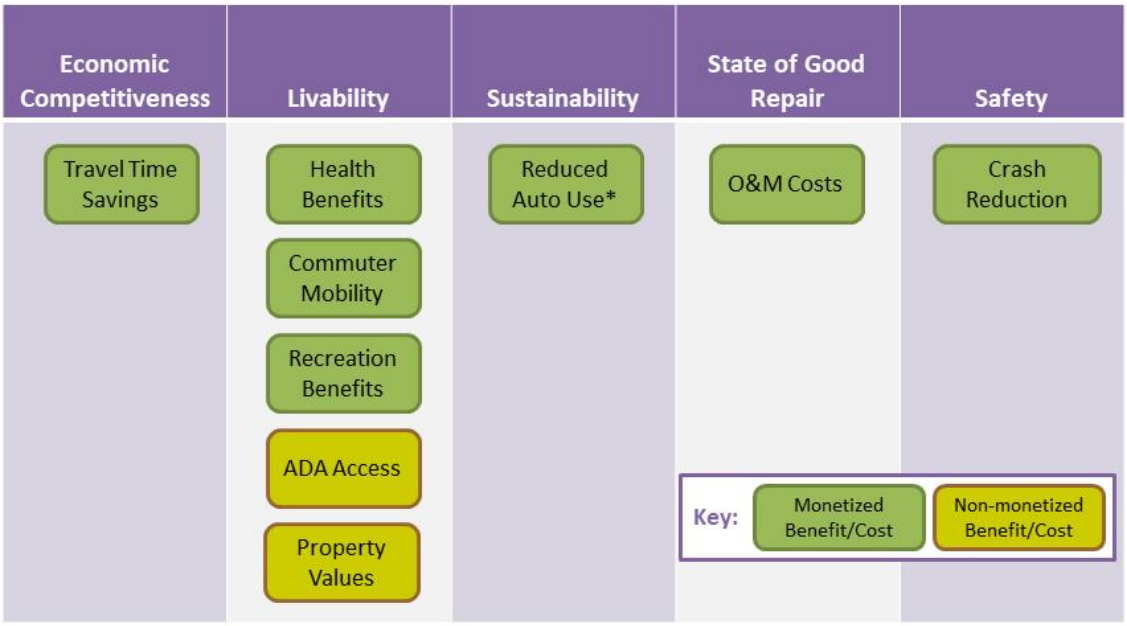
Figure 1: *Bridges* Project Benefits and Costs



Economic Benefits Included

The following section identifies and groups the benefits that are included in the BCA for the Bridges project, also presented in Figure 2. This section discusses the valuations used for each benefit category specifically, and a summary of the model outputs for valuations as used in the sensitivity analysis.

Figure 2: Bridges project Benefits by Category



* Includes congestion and emissions reductions

Economic Competitiveness

Travel Time Savings

Travel time savings was determined for auto drivers, pedestrians and bicyclists. 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. Travel time savings are monetized based upon the average user value of time (VOT), which is discussed in the following section. Afterward, travel time savings for bicycles, and automobiles are presented.

Value of Time Assumptions

Travel time savings benefits must be converted from hours to dollars in order for benefits to be aggregated and compared against monetary 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 (Table 4). This analysis assumes that there is real growth in the average user value of time, at a rate of 1.2 percent per year, consistent with USDOT guidance.[12]

Values of time are based on percentage shares of average wage rates converted from earnings, shown in Table 4, as recommended by USDOT.[13]

[12] US DOT, (2018). *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*
[13] US DOT. Benefit-Cost Analysis Guidance for Discretionary Grant Programs, Updated April 27, 2018; https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance

Table presents the USDOT recommended values of time by travel type and trip purpose, expressed in constant 2017 dollars.

Table 4: U.S. DOT Recommended Values of Time, 2016; (per person-hour as a percentage of total earnings converted to average wage rates)

Category	Surface Modes
Local Travel	
Personal	50%
Business	100%
Vehicle Operators	
All	100%

Source: Office of the Secretary of Transportation, 2016.

Table 5: U.S. DOT Recommended Values of Time, 2017 $

Category	Values of time (2017 U.S $ per person-hour)
General Travel	
Personal	$13.60
Business	$25.40
All Purposes	$14.10

Source: U.S. DOT, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, Table A-3, 2018

Because the exact division between personal and business travel is not known for trips potentially impacted by the *Bridges* project, the values of time for "all purposes" are used; these represent an average of the personal and business values of time heavily weighted towards personal use, per national proportions of personal and business travel documented by USDOT.[14]

Travel Time Savings – Bicyclists & Pedestrians

Travel time savings for bicyclists result from the facility improvements that eliminate points of delay.

At the Totem Lake bridge, the benefits were associated with existing cyclists and existing pedestrians on the trail, conservatively not assuming changes in non-motorized travel in the area due to the improvement. At the NE 8th Street bridge, travel time benefits were considered for existing and new bicyclists and for new pedestrians; the travel time benefits apply to all users at this location due to the elimination of an otherwise-necessary traffic signal along the trail.

Travel time savings are computed by determining the difference in travel time for the average user between existing and improved conditions. This is performed via the following equation:

[14] *Ibid*.

$$Travel\ Time\ Savings_{bicyclists} = b_{e,c} \cdot \left(\frac{1}{\overline{S_{old}}} - \frac{1}{\overline{S_{new}}}\right) \cdot VOT$$

Where:

$b_{e,c}$ *= volume of daily commute and recreational bicyclists*
$\overline{S_{old}}$ *= average travel time at roadway crossings without improvements, seconds*
$\overline{S_{new}}$ *= average travel time at roadway crossings with improvements, seconds*
VOT *= distribution of value of time, 2017$ / hr*

Travel Time Savings – Bicyclists & Pedestrians Accessing Light Rail

In 2023 it is assumed the Sound Transit Link Light Rail East Link line will open with stations at Wilburton and Bellevue Downtown, within close proximity to the ERC. People accessing the station(s) via the ERC will experience a reduction in delays due to access across the Wilberuton Trestle; however, determining their time savings is difficult to accurately estimate, and as a conservative approach this benefit is not quantified. However, commuter benefits are monetized in the form of reduced auto use as described in more detail later in this document.

Travel Time Savings - Automobiles

Travel time savings for auto drivers was assumed to occur at the NE 8th Street crossing, where a traffic signal would be required if the bridge was not built to accommodate trail users. Delay per vehicle would be modest at 15.9 seconds per vehicle based on standard signal timing, but total volume on the street exceeds 3,000 vehicles per hour during peak hours, which is assumed to be approximately six hours per workday. Outside of peak periods vehicle delay has not been monitized as a conservative approach.

Livability

Most of the benefit categories identified for the *Bridges* project are identified as livability benefits. These include health benefit, safety benefits, commuter mobility benefits, and recreation benefits.

Health Benefits

Health benefits apply to new cyclists who would otherwise not be traveling via bicycle under existing conditions. These cyclists realize benefits by increased daily physical activity, which has been shown to improve the health of users and reduce future medical costs. The NCHRP Guidelines for Analysis of Investment in Bicycle Facilities[15] identified ten studies which estimated the overall health benefit of increases in physical activity. These benefits ranged from $19 to $1,175 per new cyclist per year, with a median value of $128 (all values in 2006 $), with detailed review available in appendix E of that document. The median value was adjusted to 2017 dollars resulting in a dollar value of $155.63 per person per year in health benefits. The NCHRP Guidelines state that this benefit is ascribed per daily new user; since our cyclist volumes represent one way trips, we divided the volume by two in order to estimate the number of total users. This is slightly conservative since not all bicyclists use the same route for the return trip. The benefit is thus defined:

[15] *Ibid*. 11, p. 33.

$$Health\ Benefit = \frac{b_n}{2} \cdot H$$

Where:

b_n = *volume of daily new bicyclists, divided by two to convert to trips*
H = *distribution of value of per-capita health benefit, 2017$*

Health benefits have also been studied for pedestrians, but as the value of walking activity is lower, it is not quantified in this analysis, which is a conservative assumption.

Commuter Mobility Benefits

Commute users experience a benefit as research has shown that bicyclists and pedestrians prefer using certain facilities over others, with dedicated trails showing the greatest monetized value of benefit.

Mobility Benefits - Bicyclists

The NCHRP Guidelines for Analysis of Investment in Bicycle Facilities reviewed available research and found that bicycle commuters are willing to spend 20.38 extra minutes per trip[16] to travel on an off-street bicycle trail, for reasons including higher level of safety, more pleasant and lower stress experience, and lack of auto impacts such as road spray and exhaust fumes. These benefits can be directly applied to new commute trip bicyclists according to the following formula (modified from NCHRP Report 552):

$$Commute\ Mobility_{bicylcists} = \frac{20.38}{60} \cdot b_{n,c} \cdot \bar{W} \cdot 5 \cdot VOT$$

Where:

20.38/60 = *additional value of off-road bike facility in minutes, converted to hours*
$b_{n,c}$ = *volume of daily new commute bicyclists*
$\bar{W}$ = *weighted average of workweeks per year (50 weeks)*
5 = *number of work days per week*
VOT = *distribution of value of time, 2017$ / hr*

NCHRP Report 552 Guidelines assumed 50 commute weeks per year. The value of time applied for this benefit is the same as that previously documented and used for travel time savings; that is, the likely values of time for local travel across all trip purposes.

Approximately 20% of the portion of trips due to light rail on the trail were assumed to be bicyclist commuters, and their mobility benefit is also considered.

Mobility Benefits - Pedestrians

Although previous applications of mobility benefits in the United States typically only applied to bicyclists, research in Europe has valued commuter benefits for improved facilities for pedestrians as well. The UK Department for Transport Guidance on the Appraisal of Walking and Cycling Schemes[17] has monetized

[16] *Ibid.* p. 39.
[17] UK Department for Transport, Guidance on the Appraisal of Walking and Cycling Schemes, August 2012. (http://www.dft.gov.uk/webtag/documents/expert/pdf/u3_14_1-walking-and-cycling-120723.pdf)

benefits for pedestrians. Accordingly, improvements in the commute experience for pedestrians can also be monetized. The Department for Transport study identified valuation for several aspects of the commuter experience. Only those aspects which are improved in this Bridges project are included. These aspects are provided in Table 6, using an average 2010 exchange rate of 1 GBP = 1.545 USD[18].

Table 6: Monetized Value of Aspects of the Pedestrian Environment

Category	Value, 2010 pence/km	Value, 2017 $/mi
Street Lighting	3.8	0.06
Reduced Crowding	1.9	0.03
Trail Evenness	0.9	0.02
Total	**6.6**	**0.11**

Source: UK DfT Guidance on the Appraisal of Walking and Cycling Schemes, 2012

Table 7 documents values used and assumptions made for computation of the commuter mobility benefit for pedestrians.

Table 7: Values Used for Pedestrian Commuter Mobility Computations

Category	Value	Source
Average Pedestrian Commute, miles	1.54 miles	Commute Trip Reduction Survey
Light Rail Pedestrian Access Distance, miles	0.50 miles	Conservative estimate
Workweeks in Year	50	Guidance

Source: WSP, 2018

The resulting commuter mobility benefit for pedestrians is computed as follows:

$$Commute\ Mobility_{pedestrians} = p_c \cdot \bar{L} \cdot \bar{W} \cdot 5 \cdot V$$

Where:

p_c = *volume of daily commute pedestrians*
$\bar{L}$ = *weighted average of trip length on trail, miles*
$\bar{W}$ = *weighted average of workweeks per year*
5 = *number of workdays per week*
V = *distribution of value of benefit, 2017$ / mile*

It should be noted that the pedestrian commuter mobility benefit applies to all commute pedestrians, including those using the trail to access light rail, though their assumed trip distance is shorter than those not accessing light rail. The ERC will bring the benefits of reduced crowding, and separated facilities to all pedestrians. However, this benefit was only calculated for commuter pedestrians because the

[18] Average 2010 Conversion Rate from http://fxtop.com/en/historical-exchange-rates.php, http://www.x-rates.com/average/?from=GBP&to=USD&amount=1&year=2010, and http://www.oanda.com/currency/average

recreational value of these improvements is not known. In fact, recreational pedestrians do not have any monetized benefit in the entire BCA, a conservative assumption.

Recreation Benefits

The NCHRP Guidelines for Analysis of Investment in Bicycle Facilities also identified benefits for recreational users of bicycle facilities. These benefits result from the time spent performing recreational activity, since this represents a revealed preference in how recreational cyclists choose to spend their time. This time is assumed to be one hour per bicyclist including preparation and clean-up time.[19] The value of time for this benefit is assumed to be lower than the value of time used for commuters or the population at large. The NCHRP Guidelines indicate a value of $10 per hour in 2006$, which becomes $12.15 per hour in 2017 dollars. The benefit is computed as follows:

$$Recreation\ Benefit = \frac{b_{n,r}}{2} \cdot 365 \cdot VOT_r$$

Where:

$b_{n,r}$ = *volume of daily new recreational bicyclists, divided by two to convert to trips*
365 = *number of recreation days per year, per NCHRP Report 552*
VOT_r = *distribution of recreational value of time, 2017$ / hr*

This benefit is only computed for bicyclists. While a similar argument may be made for recreational pedestrians, the amount of time pedestrians spend in recreational activity is unknown, so it is not monetized. Additionally, though the light rail extension to Wilburton Station would provide the opportunity for recreational cyclists to access the trail via rail, these users and their benefit are not included in this analysis. These factors have the effect of lowering the overall recreation benefit and is conservative.

Sustainability

Reduced Auto Use

The *Bridges* project will create environmental sustainability benefits by encouraging reduced automobile usage. These reduced auto use benefits are detailed in NCHRP Guidelines for Analysis of Investment in Bicycle Facilities.[20] Table 8 documents the values used for this analysis. New bicycle commuters to and from light rail are also included in this benefit, though their average trip length was assumed to be much shorter.

[19] *Ibid*. 11, p. 39.
[20] *Ibid*.

Table 8: Values Used for Reduced Auto Use Computations

Category	Value	Source
Average Bicycle Commute, miles	4.21	Commute Trip Reduction Survey
Light Rail Bicycle Access Distance, miles	1.00	WSP
Workweeks in a Year	50	WSP
Urban congestion, pollution, and user cost savings, $/mi	0.453	US DOT BUILD Grant Benefit-Cost Analysis Guidance

Source: WSP, 2018

The urban congestion, pollution, and user cost savings value is obtained from NCHRP Guidelines, which notes a 2006$ value of $0.13/mile in urban areas. Five cents per mile is derived from reduced emissions, which is why this analysis does not independently consider reductions in greenhouse gases and other emissions, since that would result in double-counting the emissions reduction benefit. The computation for reduced auto use is:

$$Reduced\ Auto\ Use = \frac{b_{n,c}}{2} \cdot \bar{L} \cdot \bar{W} \cdot 5 \cdot \overline{SOV} \cdot \bar{U}$$

Where:

$b_{n,c}$ = *volume of daily new commute bicyclists, divided by two to convert to trips*
$\bar{L}$ = *average bicycle trip length, miles*
$\bar{W}$ = *weighted average of workweeks per year*
5 = *number of work days per week*
$\overline{SOV}$ = *weighted average of SOV rate*
$\bar{U}$ = *distribution of average savings, 2017 $ / mile*

By using the average SOV rate to lower the number of mode-shifted trips, this analysis receives less than a third of the benefit which users strictly following the NCHRP Guidelines would receive, a conservative assumption in this analysis.

Safety

Crash Reduction

Most benefit cost analyses consider the effects of reduced crashes, since many projects offer safety enhancements which lower the risk of collision and injury. The *Bridges* project is no exception, and provides a real benefit to cyclists and pedestrians using the improved facility. The removal of conflict points and at-grade crossings at Totem Lake, NE 8th Street, and near the Wilburton Trestle at SE 8th Street will serve to improve safety and reduce collisions.

Past crash history from 2006-2016 was considered, assuming the trail and bridges would remove a portion—but not all—of crashes observed at or directly adjacent to the grade-separation improvements. The primary intersections evaluated and considered for crash reduction include; SE 8th street and 118th Ave SE; SE 32nd street and 118th Ave SE; NE 8th street and 116th Ave NE; NE 8th street and 120th Ave NE; 8th street rail crossing; and Totem Lake connector. A total of 18 crashes were recorded over the 10-year

period for the intersections evaluated with one critical injury, four serious injuries, 12 injuries and one event recorded with property damage only. Reduction in crashes with the *Bridges* project ranges from 0 to 100 percent depending on the event and location. In general, all crashes are assumed to be mitigated at Totem Lake, while SE 8th street intersections and 118th street are assumed to see reductions of between 50 to 75 percent, and no reductions are assumed at the rail crossing which accounted for two of the 12 incidents in the injuries category.

The economic value of avoided or reduced crashes resulting from a project's safety improvements can be determined by valuating the reduction or prevention of current levels of injury from collisions. The Maximum Abbreviated Injury Scale (MAIS) scoring system monetizes the benefit of avoiding or reducing the severity of vehicle crashes by multiplying a factor based on a level of injury severity (MAIS 1 – MAIS 6) by the U.S. DOT's Value of Statistical Life (VSL). The level of injury severity is determined by evaluating the area of the injury on the body, the injured anatomical structure(s), and the type of injury. Table 9 illustrates the classification of injury severity at each MAIS level and the relative disutility factor as a fraction and value of the VSL.

Table 9: Relative Disutility Factors and Values by Injury Severity Level (MAIS)

MAIS Level	Severity	Fraction of VSL[21]	Value of Injury (2017$)
MAIS 1	Minor	0.003	$28,800
MAIS 2	Moderate	0.047	$451,200
MAIS 3	Serious	0.105	$1,008,000
MAIS 4	Severe	0.266	$2,553,600
MAIS 5	Critical	0.593	$5,692,800
MAIS 6	Fatal	1.000	$9,600,000

Source: WSP, 2018

The computation for monetizing the benefits of avoided injuries from collisions is:

$$Safety\ Benefit = VSL \cdot F_M \cdot \frac{N_M}{20}$$

Where:

VSL = value of statistical life
F_M = Injury severity factor, by MAIS level
N_M = number of reported pedestrian and bicyclist crashes, by MAIS level
20 = length of project operational period, in years

The number of current injuries from crashes are organized by their severity using the MAIS levels and then divided by the length of the Bridges project's operational period from 2020 to 2040 to determine

[21] "2016 Revised Value of a Statistical Life Guidance". US DOT, Office of the Secretary, August 8, 2016. https://www.transportation.gov/sites/dot.gov/files/docs/2016%20Revised%20Value%20of%20a%20Statistical%20Life%20Guidance.pdf.

the occurrence of crashes by year. The yearly injuries are given value using the fractional VSL corresponding with the appropriate MAIS level.

Economic Costs Included and Assumptions

In the benefit-cost analysis, the term "cost" refers to the additional resource costs or expenditures required to implement, operate, and maintain the investments associated with the *Bridges* project.

This BCA uses project costs that have been estimated for the *Bridges* project on an annual basis. Operations and maintenance (O&M) costs and repair and rehabilitation (R&R) costs over time, as well as the initial capital costs, have all been expressed in constant 2017 dollars. All costs not provided in 2017 dollars were converted to constant 2017 dollars using the CPI-U.[22]

Initial Project Investment Costs

Initial investment costs include engineering and design, construction, other capital investments, and contingency factors. Total costs of $57,328,545 (2017$) were included in the *Bridges* project with costs beginning in 2018 and ending in 2021, as shown in Table 10. The improved facility is expected to be open and operational at the end of 2020. The *Bridges* project includes a right of way acquisition with a cost of $5,000,000 (2017$).

Table 10: The *Bridges* Project Capital Cost Schedule

Cost (all in 2017 $)	2018	2019	2020	2021	Total
Capital Costs	$3,041,383	$16,600,075	$20,202,889	$17,484,198	**$57,328,545**

Source: WSP, 2018

Annual Operating and Maintenance Costs

The annual costs of O&M for the *Bridges* project are included in the analysis. Operating and maintenance costs are assumed to begin in 2021 which is year one of operation of two of the three bridges.

The O&M costs reported are the marginal operating costs, or the costs above and beyond those expected in the "no build" scenario. Research shows that the high-end O&M costs for bridges with paved trails range from $1,971[23] per mile of trail (2014$) to $6,919[24] per mile of bridge surface (2002$). The cost of bridge surface adjusted to 2017$ ($9,427) is applied to the NE 8th Street Bridge and the Totem Lake Connector, which equals $4,525. The Wilburton Trestle is currently being maintained and the O&M costs assumed for the Trestle represent the incremental cost of the paved surface of the bridge. Adjusted to 2017$ ($2,041) the incremental costs equals just $388, primarily for occasional cleaning. The cumulative

[22] Bureau of Labor Statistics, Consumer Price Index, All Urban Consumers, U.S. City Average, All Items, Series CUSR0000SA0.

[23] Rails to Trails Conservancy, *Maintenance Practices and Costs of Rail-Trails*, Table 1 (p. 28), June 2015. (https://www.railstotrails.org/resourcehandler.ashx?id=6336)

[24] Dr. Wang, Guijing; Dr. Macera, Caroline A.; Dr. Scudder-Soucie, Barbara; Dr. Schmid, Tom; Dr. Pratt, Michael; Dr. Buchner, David; Dr. Heath, Gregory. (2004). "Cost Analysis of the Built Environment: The Case of Bike and Pedestrian Trials in Lincoln, Neb". *American Journal of Public Health,* 94(4), 549-553. (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1448293/)

incremental annual cost for maintaining the three facilities equals $4,913 in 2017 dollars, rounded to $5,000 for purposes of this analysis.

This analysis is likely conservative as the O&M responsibilities are shared for the trail along the ERC, so the bridges may benefit from an overlap of maintenance activities. Furthermore, a majority of the O&M responsibilities are based on linear trail distance rather than trail area. For example, tree pruning and litter removal are linear in nature. Nevertheless, this analysis is conservative by assuming the highest reasonable cost.

Periodic Major Rehabilitation and Capital Equipment Replacement Costs

Several types of initial asset investments will need to be replaced or rehabilitated during the evaluation period. Minor rehabilitation was assumed to be needed in intervals of five years and equal 5% of construction costs, major rehabilitation was assumed to be needed in intervals of twenty years and equal to 10% of construction costs. Since the rehabilitation and repair of the Wilburton Trestle was planned to happen with or without the *Bridges* project, a lower value of 2.5% of construction costs was assumed.

A value of $1,833,902 in 2017 dollars was applied every five years in this study as a conservative assumption to ensure the future maintenance and quality of the initial investments. As the forecast period is twenty years no major rehabilitation was assumed within the forecast horizon.

Residual Value

The *Bridges* project is assumed to have (at least) a 100-year life cycle, after which point the facility will be in need of major repairs, rehabilitation, and/or replacement. Year 100 of project operations occurs in 2120. The BCA assumes a 20-year evaluation period ending in 2040; therefore, at the end of the analysis period, infrastructure that has been put in place will not have been completely worn out, and will continue to provide benefits into the future. The remaining value of the investments to continue to produce future benefits are captured in the Residual Value calculation, also referred to as "Remaining Capital Value," or RCV.

The RCV is calculated by determining the percentage of useful life remaining beyond the analysis period, and multiplying that percentage by the construction cost for that component. Since we are using a 20-year analysis period and a 100-year design life, the residual value is 80% of the initial cost using the straight-line depreciation method. The remaining capital value is viewed as cost offset or "negative cost" and is applied to the last year of analysis period as a negative value. This residual value, expressed in 2017 dollars, is $43,262,836 in the BCA calculations prior to discounting.

Key Benefit-Cost Evaluation Measures

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

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

Benefit Cost (B/C) Ratio: The benefit-cost ratio calculates the discounted present value of incremental benefits divided by the discounted present value of incremental capital and R&R costs to yield the benefit-cost ratio. The B/C ratio expresses the relation of discounted benefits to discounted costs as the factor by which a project's benefits either exceed or fall short of their associated costs.

Benefit-Cost Analysis Results

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 the U.S. DOT.

- For the Case A at a 7 percent discount rate, the proposed *Bridges* project investments yield a net present value in 2017 of $1,370,344 and a benefit-cost ratio of 1.03.
- For the Case B at a 3 percent discount rate, the proposed King County ERC project investments yield a net present value in 2017 of $33,077,907, and a benefit-cost ratio of 1.56.

Table 11 presents the evaluation results for the two cases. All benefits and costs were estimated in constant 2017 dollars over a three-year construction period and an evaluation period extending 20 years to 2040.

Table 11: Benefit Cost Analysis Summary Results

Scenario	Net Present Value (2017 $ millions disc.)	Benefit Cost Ratio
Case A (7% discount rate)	**$1,370,385**	**1.03**
Case B (3% discount rate)	**$33,077,907**	**1.56**

Source: WSP, 2018

Benefits by Category

Over the entire analysis period, the *Bridges* project exhibits decreases in vehicle miles travelled by automobiles as well as reductions in travel time for auto drivers and passengers as well as bicyclists. With increased bicycle and pedestrian usage of the trail health and mobility benefits, measured in people, hours and miles, increases substantially.

Table 12 below outlines the changes in some of the primary underlying drivers of project benefits.

Table 12: *Bridges* Project Impacts, Cumulative to 2040

Category	Direction of Change
Travel Time Savings – Auto Drivers and Passengers	446,892 hours ▼
Travel Time Savings - Bicyclists	132,853 hours ▼
Reduction in Vehicle Miles Traveled	6,844,034 miles ▼
Annual Health Benefit	13,586 people ▲
Commuter Mobility Benefits – Bicyclists	1,282,536 hours ▲
Commuter Mobility Benefits – Pedestrians	8,292,113 miles ▲
Recreation Benefits – Bicyclists	3,538,472 people ▲

Source: WSP, 2018

Over the 20-year analysis period, there are $143,910,630 in benefits, including incremental O&M costs and residual value, in 2017 dollars, which are discounted to $54,794,954 at 7% and $92,123,579 at 3% in 2018.

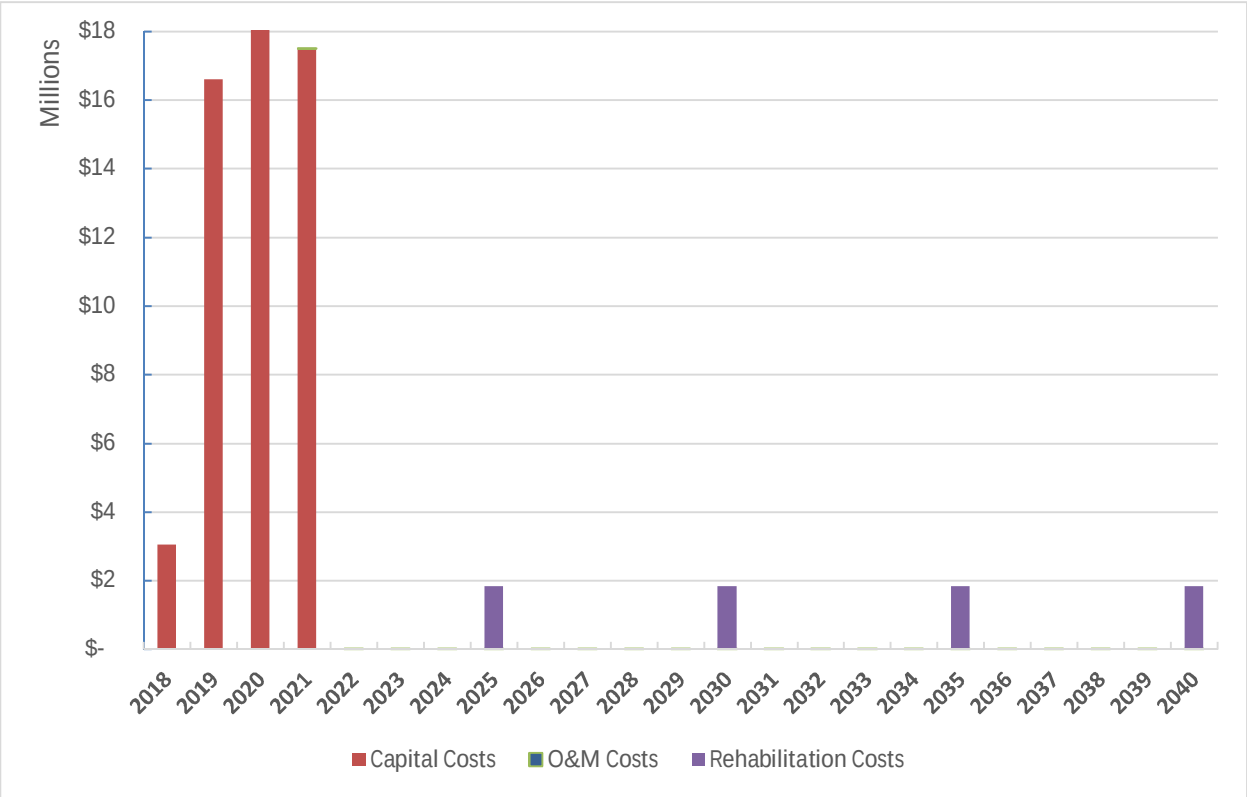
Costs over Time

Figure 3 presents the capital expenditures over time, expressed in constant 2017 dollars before discounting. The capital investments were assumed to begin in 2018 and conclude by 2021. These capital costs translate to $50,473,771 when discounted to a 2017 present value at 7 percent and $54,201,639 when discounted to 2017 at 3 percent in 2018.

Annual incremental O&M costs over the economic evaluation period (2021-2040) are also expressed in constant 2017 dollars before discounting. O&M costs will likely keep pace with general inflation when expressed in year of expenditure dollars, meaning that in real terms, they will remain generally constant through 2040. Incremental O&M costs accumulate to $100,000 over 20 years, or $46,266 when discounted to 2017 at 7 percent and $70,117 when discounted at 3 percent in 2018.

Periodic R&R of the *Bridges* project through 2040 is conservatively predicted to total $7,335,609 in constant 2017 dollars, or $2,950,839 when discounted back to 2017 at 7 percent and $4,844,033 discounted to 2017 at 3 percent in 2018.

Figure 3: Capital, O&M, and Rehabilitation Expenditures in Constant 2017 Dollars Before Discounting



Source: WSP, 2018

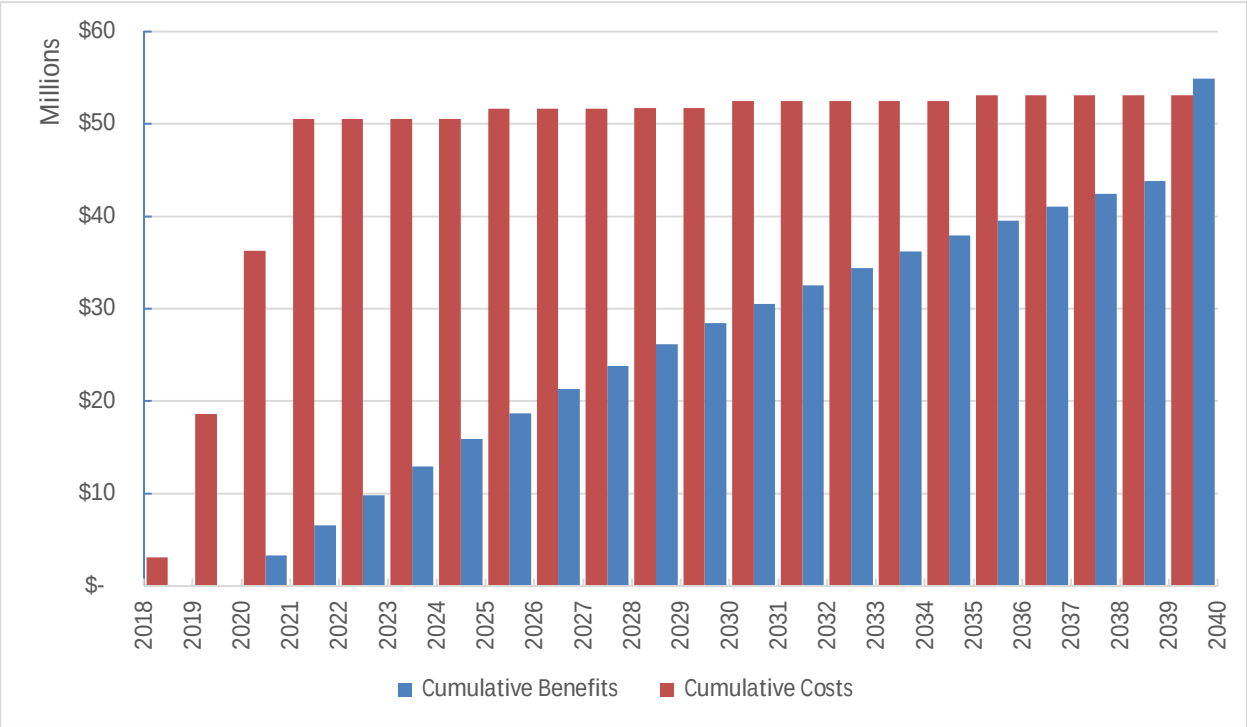
Residual Value

The remaining capital value of this Bridges project in 2017 dollars is $9,764,992 when discounted at 7 percent and $22,578,550 when discounted at 3 percent in 2018.

Cumulative Benefits and Costs

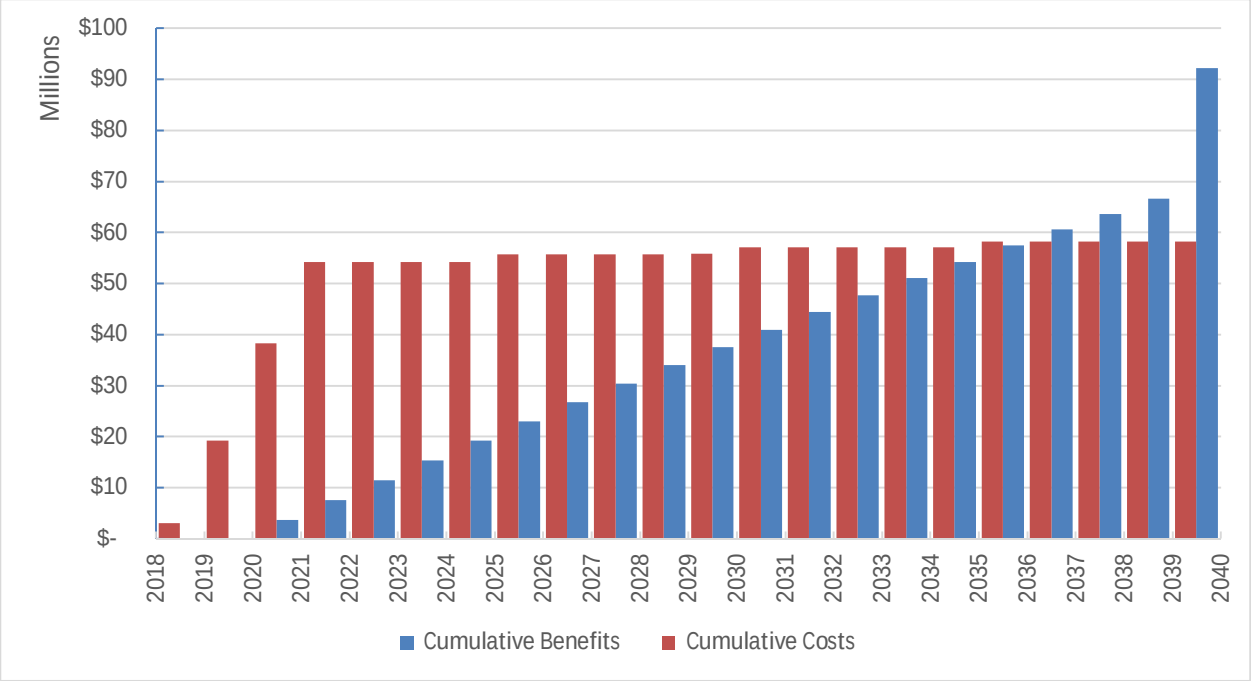
Figure 4 and Figure 5 compare the cumulative 2017 present value discounted benefits with the cumulative 2017 present value discounted costs over time for both cases, applying the 7 and 3 percent real discount rates, respectively. The figures show that the cumulative present value discounted benefits exceed the cumulative discounted costs by $1,370,344 with a 7 percent discount rate, and by $33,077,907 with a 3 percent discount rate.

Figure 4: Cumulative Benefits and Costs in 2017 Dollars (Discounted at 7 percent)



Source: WSP, 2018

Figure 5: Cumulative Benefits and Costs in 2017 Dollars (Discounted at 3 percent)



Source: WSP, 2018

APPENDIX A - Benefit-Cost Model Detail Tables

Table 13: Economic Competitiveness Savings by Year, 2017 Dollars

	Travel Time Savings			Reduced Vehicle O&M			Fuel Savings			Reduced Incidents		
Year	Undiscounted Travel Time Savings	Discounted Travel Time Savings	Discounted Travel Time Savings	Undiscounted Reduced Vehicle O&M	Discounted Reduced Vehicle O&M	Discounted Reduced Vehicle O&M	Undiscounted Fuel Savings	Discounted Fuel Savings	Discounted Fuel Savings	Undiscounted Reduced Incidents	Discounted Reduced Incidents	Discounted Reduced Incidents
	2017$, undiscounted	7% disc to 2018	3% disc to 2018	2017$, undiscounted	7% disc to 2018	3% disc to 2018	2017$, undiscounted	7% disc to 2018	3% disc to 2018	2017$, undiscounted	7% disc to 2018	3% disc to 2018
2018	-	-	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-	-	-	-	-
2021	38,838	31,704	35,543	86,865	70,907	79,494	28,522	23,282	26,102	931,602	760,456	852,400
2022	241,376	184,145	214,460	88,064	67,184	78,244	29,061	22,170	25,820	937,165	714,942	832,514
2023	448,774	319,970	387,116	90,667	64,644	78,210	29,772	21,227	25,681	942,565	672,020	813,064
2024	460,431	306,805	385,604	93,286	62,161	78,126	30,551	20,357	25,586	942,565	628,056	789,383
2025	472,391	294,181	384,097	94,575	58,896	76,898	29,971	18,665	24,369	942,565	586,969	766,391
2026	484,357	281,900	382,356	95,621	55,652	75,484	29,418	17,122	23,223	942,565	548,569	744,069
2027	495,551	269,547	379,798	96,671	52,582	74,090	29,148	15,855	22,340	942,565	512,681	722,397
2028	507,003	257,735	377,258	97,732	49,682	72,722	29,007	14,745	21,584	942,565	479,141	701,357
2029	518,720	246,440	374,734	98,805	46,941	71,379	28,985	13,771	20,939	942,565	447,796	680,929
2030	530,707	235,640	372,227	99,889	44,352	70,060	28,774	12,776	20,182	942,565	418,500	661,096
2031	542,227	225,005	369,230	100,852	41,850	68,675	28,886	11,987	19,670	942,565	391,122	641,841
2032	553,997	214,849	366,257	101,819	39,487	67,314	28,740	11,146	19,001	942,565	365,535	623,146
2033	566,022	205,152	363,308	102,795	37,258	65,980	28,679	10,395	18,408	942,565	341,621	604,996
2034	578,308	195,893	360,382	103,781	35,154	64,673	28,787	9,751	17,939	942,565	319,272	587,375
2035	590,861	187,051	357,480	104,777	33,170	63,392	28,765	9,106	17,403	942,565	298,385	570,267
2036	604,516	178,854	355,089	105,923	31,339	62,218	28,762	8,510	16,895	942,565	278,865	553,657
2037	618,486	171,017	352,714	107,086	29,610	61,069	29,259	8,090	16,686	942,565	260,621	537,531
2038	632,780	163,522	350,355	108,261	27,977	59,942	29,400	7,597	16,278	942,565	243,571	521,875
2039	647,404	156,356	348,011	109,450	26,434	58,835	29,643	7,159	15,935	942,565	227,637	506,675
2040	662,365	149,505	345,683	110,651	24,975	57,748	29,963	6,763	15,637	942,240	212,676	491,917
Total	10,195,113	4,275,272	6,861,704	1,997,568	900,256	1,384,552	584,093	270,475	409,678	18,834,604	8,708,435	13,202,881

Source: WSP, 2018

Table 14: Environmental Protection and State of Good Repair 2017 Dollars

Year	Reduced Noise Pollution			Reduced Emissions			Reduced Road Damage		
	Undiscounted Noise Pollution	Discounted Noise Pollution	Discounted Noise Pollution	Undiscounted Reduced Emissions	Discounted Reduced Emissions	Discounted Reduced Emissions	Undiscounted Reduced Road Damage	Discounted Reduced Road Damage	Discounted Reduced Road Damage
	2017$, undiscounted	7% disc to 2018	3% disc to 2018	2017$, undiscounted	7% disc to 2018	3% disc to 2018	2017$, undiscounted	7% disc to 2018	3% disc to 2018
2018	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-	-
2021	382	311	349	779	636	713	519	424	475
2022	387	295	344	739	563	656	526	401	467
2023	398	284	344	721	514	622	542	386	467
2024	410	273	343	696	464	583	557	371	467
2025	415	259	338	664	413	540	565	352	459
2026	420	244	332	629	366	496	571	332	451
2027	425	231	325	592	322	454	577	314	443
2028	429	218	319	555	282	413	584	297	434
2029	434	206	314	518	246	374	590	280	426
2030	439	195	308	486	216	341	597	265	419
2031	443	184	302	451	187	307	602	250	410
2032	447	173	296	418	162	276	608	236	402
2033	452	164	290	385	140	247	614	223	394
2034	456	154	284	354	120	220	620	210	386
2035	460	146	278	323	102	195	626	198	379
2036	465	138	273	314	93	185	633	187	372
2037	470	130	268	307	85	175	640	177	365
2038	476	123	263	301	78	167	647	167	358
2039	481	116	258	297	72	159	654	158	351
2040	486	110	254	293	66	153	661	149	345
Total	8,774	3,954	6,081	9,822	5,128	7,278	11,932	5,378	8,271

Source: WSP, 2018

Table 15: Quality of Life 2017 Dollars

Year	Health Benefits			Commuter Mobility			Recreational Benefits		
	Undiscounted Health Benefits	Discounted Health Benefits	Discounted Health Benefits	Undiscounted Commuter Mobility	Discounted Commuter Mobility	Discounted Commuter Mobility	Undiscounted Recreational Benefits	Discounted Recreational Benefits	Discounted Recreational Benefits
	2017$, undiscounted	7% disc to 2018	3% disc to 2018	2017$, undiscounted	7% disc to 2018	3% disc to 2018	2017$, undiscounted	7% disc to 2018	3% disc to 2018
2018	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-	-
2021	89,374	72,956	81,790	909,646	742,542	832,455	1,923,576	1,570,211	1,760,345
2022	90,608	69,125	80,504	932,483	711,387	828,499	1,950,140	1,487,752	1,732,674
2023	94,816	67,602	81,789	983,240	701,036	848,151	1,977,070	1,409,624	1,705,438
2024	99,041	65,995	82,945	1,035,208	689,803	866,971	2,004,372	1,335,598	1,678,630
2025	100,408	62,529	81,641	1,061,231	660,881	862,878	2,032,052	1,265,460	1,652,244
2026	101,528	59,090	80,147	1,085,042	631,504	856,542	2,054,360	1,195,656	1,621,731
2027	102,642	55,831	78,667	1,109,231	603,348	850,134	2,076,913	1,129,703	1,591,781
2028	103,769	52,751	77,214	1,133,970	576,453	843,780	2,099,714	1,067,388	1,562,384
2029	104,908	49,841	75,788	1,159,270	550,761	837,482	2,122,765	1,008,510	1,533,531
2030	106,060	47,092	74,388	1,185,146	526,219	831,237	2,146,069	952,880	1,505,210
2031	107,086	44,437	72,920	1,210,035	502,122	823,975	2,166,652	899,084	1,475,385
2032	108,113	41,928	71,476	1,235,367	479,097	816,723	2,187,433	848,324	1,446,151
2033	109,150	39,561	70,059	1,261,240	457,131	809,542	2,208,412	800,430	1,417,496
2034	110,197	37,328	68,671	1,287,665	436,177	802,431	2,229,593	755,240	1,389,409
2035	111,254	35,220	67,310	1,314,655	416,186	795,388	2,250,977	712,602	1,361,878
2036	112,466	33,275	66,062	1,343,968	397,632	789,439	2,275,690	673,295	1,336,728
2037	113,701	31,439	64,842	1,374,046	379,935	783,599	2,300,674	636,156	1,312,042
2038	114,949	29,705	63,644	1,404,808	363,029	777,808	2,325,932	601,065	1,287,812
2039	116,211	28,066	62,469	1,436,271	346,878	772,066	2,351,468	567,910	1,264,030
2040	117,487	26,518	61,316	1,468,449	331,448	766,373	2,377,284	536,584	1,240,687
Total	2,113,769	950,290	1,463,644	23,930,972	10,503,570	16,395,473	43,061,146	19,453,472	29,875,584

Source: WSP, 2018

Table 16: Cost Summary by Year, 2017 Dollars

Year	Capital Costs	Net O&M Costs	Net R&R Costs	Residual Value	Total Costs (excl Residual Value)		
					Undiscounted Costs	Discounted Costs	Discounted Costs
	2017$, undiscounted	2017$, undiscounted	2017$, undiscounted	2017$, undiscounted	2017$, undiscounte	7% disc to 2018	3% disc to 2018
2018	3,041,383	-	-	-	3,041,383	3,041,383	3,041,383
2019	16,600,075	-	-	-	16,600,075	15,514,089	16,116,578
2020	20,202,889	-	-	-	20,202,889	17,645,985	19,043,160
2021	17,484,198	5,000	-	-	17,489,198	14,276,395	16,005,094
2022	-	5,000	-	-	5,000	3,814	4,442
2023	-	5,000	-	-	5,000	3,565	4,313
2024	-	5,000	-	-	5,000	3,332	4,187
2025	-	5,000	1,833,902	-	1,838,902	1,145,176	1,495,196
2026	-	5,000	-	-	5,000	2,910	3,947
2027	-	5,000	-	-	5,000	2,720	3,832
2028	-	5,000	-	-	5,000	2,542	3,720
2029	-	5,000	-	-	5,000	2,375	3,612
2030	-	5,000	1,833,902	-	1,838,902	816,495	1,289,769
2031	-	5,000	-	-	5,000	2,075	3,405
2032	-	5,000	-	-	5,000	1,939	3,306
2033	-	5,000	-	-	5,000	1,812	3,209
2034	-	5,000	-	-	5,000	1,694	3,116
2035	-	5,000	1,833,902	-	1,838,902	582,149	1,112,566
2036	-	5,000	-	-	5,000	1,479	2,937
2037	-	5,000	-	-	5,000	1,383	2,851
2038	-	5,000	-	-	5,000	1,292	2,768
2039	-	5,000	-	-	5,000	1,208	2,688
2040	-	5,000	1,833,902	(43,262,836)	1,838,902	415,064	959,709
Total	57,328,545	100,000	7,335,609	(43,262,836)	64,764,154	53,470,876	59,115,790

Source: WSP, 2018

Table 17: Benefit & Cost Summary by Year, 2017 Dollars

Year	Undiscounted Costs	Total Undiscounted Benefits	Net Benefits		
			Undiscounted Net Benefits	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
	2017$, undiscounted	2017$, undiscounted	2017$, undiscounted	7% disc to 2018	3% disc to 2018
2018	3,041,383	-	(3,041,383)	(3,041,383)	(3,041,383)
2019	16,600,075	-	(16,600,075)	(15,514,089)	(16,116,578)
2020	20,202,889	-	(20,202,889)	(17,645,985)	(19,043,160)
2021	17,489,198	4,010,103	(13,479,095)	(11,002,965)	(12,335,430)
2022	5,000	4,270,548	4,265,548	3,254,150	3,789,740
2023	5,000	4,568,564	4,563,564	3,253,743	3,936,571
2024	5,000	4,667,117	4,662,117	3,106,552	3,904,450
2025	1,838,902	4,734,836	2,895,934	1,803,429	2,354,659
2026	5,000	4,794,511	4,789,511	2,787,526	3,780,884
2027	5,000	4,854,315	4,849,315	2,637,695	3,716,596
2028	5,000	4,915,327	4,910,327	2,496,150	3,653,744
2029	5,000	4,977,560	4,972,560	2,362,418	3,592,283
2030	1,838,902	5,040,732	3,201,830	1,421,641	2,245,699
2031	5,000	5,099,800	5,094,800	2,114,152	3,469,311
2032	5,000	5,159,506	5,154,506	1,998,998	3,407,736
2033	5,000	5,220,314	5,215,314	1,890,262	3,347,512
2034	5,000	5,282,325	5,277,325	1,787,605	3,288,655
2035	1,838,902	5,345,262	3,506,360	1,110,017	2,121,405
2036	5,000	5,415,301	5,410,301	1,600,707	3,177,982
2037	5,000	5,487,233	5,482,233	1,515,877	3,126,441
2038	5,000	5,560,118	5,555,118	1,435,543	3,075,734
2039	5,000	5,634,442	5,629,442	1,359,579	3,026,102
2040	1,838,902	48,972,715	47,133,813	10,638,722	24,598,953
Total	64,764,154	144,010,631	79,246,477	1,370,344	33,077,907

Source: WSP, 2018