Memorandum

Date: November 21, 2018

To: ADOT&PF

From: Patrick Burden and Leah Cuyno

Re: Benefit-Cost Analysis of Southcoast Region Bridge Rehabilitation and Replacement

This memorandum is provided in support of the Alaska Department of Transportation and Public Facilities (ADOT&PF) Bridge Section's application for grant funding for the FHWA's Competitive Highway Bridge Program for Fiscal Year 2018.

This memorandum describes the benefit-cost analysis (BCA) conducted for the proposed bridge projects in ADOT&PF's Southcoast Region. A BCA spreadsheet model was developed to determine the net present value (NPV) of the expected benefits of three proposed bridge projects in the Southcoast Region. The analysis also considered the cost effectiveness of bundling the projects during construction to generate cost savings.

Net Present Value and Benefit-Cost (B/C) Ratio

The following table summarizes the expected outcomes with respect to benefits and costs of the three proposed bridge projects in the ADOT&PF's Southcoast Region. Constructing the three bridge rehabilitation projects as a bundle would be more cost effective, with an estimated construction cost savings of about $1.0 million.

Table 1. Expected Net Benefits (in millions of 2018 $) and B/C Ratio of the Proposed Southcoast Region Bridge Rehabilitation Projects

Southcoast Region Projects	Present Value of Estimated Benefits	Present Value of Estimated Costs	Net Present Value	B/C Ratio
Herring Cove (#253)	$73.01	$6.06	$66.95	12
Hoadley Creek (#725)	$159.09	$4.75	$154.34	34
Ward Creek (#747)	$742.22	$3.00	$739.22	247
Total (*as separate projects*)	$974.32	$13.81	$960.51	71
Total (as *bundled*)	$974.32	$12.88	$961.44	76

Source: Northern Economics estimates based on the B/C model developed for this study.

Proposed Bridge Rehabilitation and Replacement Projects in the Southcoast Region

The proposed project will replace or rehabilitate three rural bridges in the Southcoast Region of Alaska: Herring Cove Bridge (253), the Hoadley Creek Bridge (725), and the Ward Creek Bridge (747).

The Herring Cove Bridge, at approximately Milepost 10.4 of the South Tongass Highway was first constructed in 1952 and is currently rated in the National Bridge Inventory (NBI) as "poor condition". The existing two-lane bridge has no pedestrian walkways or sidewalks and, due to high volume of tourist and other pedestrian traffic during the summer, it creates a pinch point for pedestrians. This bridge would be completely replaced.

The Hoadley Creek Bridge, at approximately Milepost 1 of the South Tongass Highway, was constructed in 1957 and is also currently rated in poor condition in the NBI. This bridge sits next to the Ketchikan Transfer facility on the city's main thoroughfare. The latest recorded traffic count on this route, measured as annual average daily traffic, was 13,836 vehicles. This bridge would also be replaced.

The Ward Creek Bridge, at approximately Milepost 4.6 of the North Tongass Highway, was constructed in 1975 and is currently rated as a "poor condition" bridge in the NBI. This bridge would be rehabilitated in advance of a larger separate future ADOT&PF project to extend Revilla Road to Shelter Cove Road on Carroll Inlet. The Ward Creek Bridge requires rehabilitation to the north end abutment to mitigate the differential settlement in the pile cap beam that has caused large vertical and diagonal cracking of the section. Retrofit will include a new outrigger pile-supported abutment cap beam that encapsulates the existing cap beam. The retrofitted abutment will provide a new load path from the superstructure to the outrigger piles. Work will also include associated approach roadway and embankment repair and new approach guardrail.

The Tongass Highway is a 37-mile stretch of state-owned and maintained roadway which extends north and south of the City of Ketchikan. This main thoroughfare provides critical access to goods, services and recreational and subsistence activities for residents, visitors, and business owners in the community. Ketchikan is not connected to any regional or statewide road system and relies on the Tongass Highway and other local roads for all transportation needs. Topographic constraints have made it impossible to establish alternative transportation corridors in Ketchikan, with the community bordered to the east by a series of low mountain ranges and the Inside Passage waterway to the west. It is important that the North and South Tongass Highway be maintained and operated to be safe and accessible year-round.

Assumptions and Values of Key Input Parameters

All benefits and costs in the analysis are presented in 2018 dollars. The analysis uses 2018 as the base year and all future benefits and costs are discounted to 2018 dollars using a 7 percent real discount rate. The Alaska Consumer Price Index (CPI) is used as the cost deflator. [The Alaska CPI and the 2018 Deflator is shown in the *Alaska CPI* tab of the BC spreadsheet model].

General model assumptions used in the BCA are shown in Table 2 below.

Table 2. General Model Assumptions used in the Benefit Cost Analysis

B/C Model Parameters	Value
Year of dollar values in the model	2018
Discount Rate (Real), percent	7
Design Life of New Bridge, # of years	75
Design Life of Rehabilitated Bridge, # of years	50
Occupancy rate for personal vehicles, # of persons	1.7

B/C Model Parameters	Value
Occupancy rate for buses, # of persons	10.7
Occupancy rate for commercial vehicles, # of persons	1.0
Replacement Year for Polyester Concrete Overlay	30
Operating Period for this Analysis, # of years	30

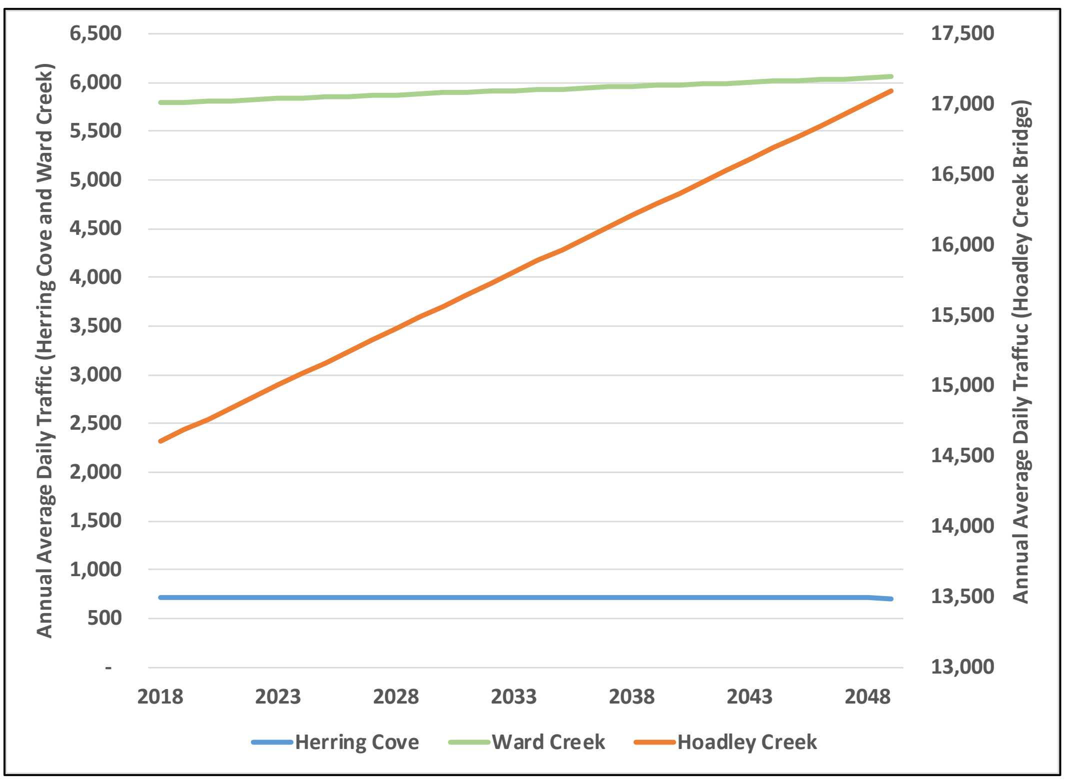
Sources:

1) Discount rate is based on the Office of Management and Budget Circular A-94.
2) Occupancy rates for personal vehicles and for buses are from “Average Vehicle Occupancy Factors for Computing Travel Time April 2018.” https://www.fhwa.dot.gov/tpm/guidance/avo_factors.pdf. Accessed on Oct. 20, 2018.
3) Design life of a new/rehabilitated bridge is based on AASHTO bridge code, provided by ADOT&PF.

The projected traffic volumes, measured as annual average daily traffic (AADT), used in this BCA analysis were based on historical data provided by ADOT&PF. The projected traffic volumes were determined using a simple regression of the past 10 years of data. Figure 1 shows the projected traffic volumes for the various bridges. [The data and calculations are shown in the *Traffic* tab of the BC spreadsheet model].

Traffic counts were measured on Milepost 10 of the South Tongass Highway (Herring Cove Bridge), Milepost 1 of the South Tongass Highway (Hoadley Creek Bridge), and Milepost 4.8 of the North Tongass Highway (Ward Creek Bridge).

Figure 1. Projected Annual Average Daily on the Herring Cove, Hoadley Creek and Ward Creek Bridges



Source: Alaska Department of Transportation and Public Facilities.

The total projected AADT counts shown above were allocated to different types of vehicles according to the percentages shown in the table below.

Table 3. Allocation of Traffic Volume per Type of Vehicle, Percent of Annual Average Daily Traffic

Types of Vehicles	Herring Cove Bridge	Hoadley Creek Bridge	Ward Creek Bridge
Commercial vehicles			
Trucks (Classes 5-13)	16.0	16.0	6.3
Buses (Class 4)	2.8	2.8	0.5
Other Business Travel	4.6	4.6	4.6
Personal	76.6	76.6	88.6

Sources:

1) Commercial vehicle estimates are from the Alaska Department of Transportation and Public Facilities.
2) Other Business Travel vehicle estimates are based on 2016 estimate for local business travel.

Baseline (No Build) Description

The following describes the baseline conditions, which is the basis for determining or quantifying the effects of the no build case. If the bridges are not replaced or rehabilitated, load limits and single-lane operations will be imposed, and the bridges will eventually be closed to traffic.

The assumptions and calculations associated with the baseline conditions for each of the bridges are shown in the *253 Baseline* tab, *725 Baseline* tab, and the *747 Baseline* tab.

Herring Cove Bridge No. 253

This bridge is a two-span, steel girder bridge with a concrete deck constructed in 1952 and located near milepost (MP) 10 of South Tongass Highway.

The 253 bridge deck is near the end of its expected service life. Currently, the bridge deck has an NBI rating of 4.

Given this current NBI rating, the following are assumed under the No Build scenario for this analysis:

- The bridge deck will have 2.6 years at NBI rating 3 before closure at NBI rating 2.
- The bridge deck will fall to rating 3 at the next inspection in 2019.
- Load limits will be imposed the year after a rating 3 is reached (Year 2020).
- In the third year of the NBI rating 3 (year 2022), single lane operations will be put in place. Single lane operations will result in an average delay of 4 minutes per vehicle.
- The bridge will be closed at the end of year 2022.

Hoadley Creek Bridge No. 725

The Hoadley Creek Bridge is a single-span concrete girder bridge originally constructed in 1957 and is located near MP 1 of the South Tongass Highway. The superstructure is comprised of pre-stressed concrete beams with a reinforced concrete deck and asphalt wearing surface. The bridge is 45 feet long and 60feet wide, consisting of two traffic lanes, a center turn lane, shoulders for public parking, and a pedestrian walkway on each side.

The Hoadley Creek bridge deck has exceeded its expected service life. Its current NBI rating is a 4.

Given this current NBI rating, the following are assumed under the No Build scenario:

- The bridge deck will have an expected 2.6 years at NBI rating 3 before closure at rating 2.
- The bridge deck will drop to rating 3 at the next inspection in 2019
- At NBI rating 3, load limits are imposed in year 2020.
- In the third year of the NBI rating 3 (2022), single lane operations will be put in place.
- The bridge will be closed at the end of 2022.

Ward Creek Bridge No. 747

The Ward Creek Bridge is a three-span concrete girder bridge with a monolithic concrete deck located near MP 4.8 of the North Tongass Highway. It is 30 feet wide and 160 feet long and was constructed in 1975 with no significant alterations since original construction.

The substructure is nearing its expected service life. It has an NBI rating of 3 and has been at that level for 2 years.

Given this current NBI rating, the following are assumed under the Baseline:

- The substructure has about 6 months of service life remaining based on the deterioration model.
- The bridge substructure will drop to an NBI rating of 2 in the next inspection cycle (2019).
- Bridge 747 will be closed at the end of year 2019.

Project Benefits

The benefits of the project are evaluated based on the avoided costs associated with imposing the no build or baseline conditions described above.

1) **Avoided Costs of Load Limits**

Load limits imposed on the bridges will result in an increase in truck traffic by 4 percent, as some loads will have to be split between trucks to stay within the load limits. This increases operating costs and travel time of affected trucks.

The marginal costs of operating a truck per hour are based on the published report by the American Transportation Research Institute (ATRI)-- *An Analysis of the Operational Costs of Trucking* released in October 2018. The operating costs include fuel, repair and maintenance, insurance, permits/licenses, and tires. [Assumptions and calculations for vehicle operating costs are shown in *Vehicle Opg Cost* tab in the BC spreadsheet model].

The value of travel time for truck drivers are based on hourly compensation of heavy and tractor-trailer and light truck or delivery service drivers as published by the Bureau of Labor Statistics (BLS). [Wage and income data are shown in the *Wage & Income* tab in the BC spreadsheet model].

Load limits on Bridges 253 and 725 will be in effect from 2020 through 2022. No load limits are imposed on Bridge 747.

Table 4. Estimated Net Effects of Load Limits Imposed on the 253 Bridge, in 2018 $

Category	Net Present Value	2019	2020	2021	2022
Increased Truck Operating Cost	$33,035	$0	$13,470	$13,469	$13,468
Increased Driver Travel Time	$42,278	$0	$17,239	$17,238	$17,237
Total	**$75,314**	**$0**	**$30,709**	**$30,707**	**$30,705**

Source: Northern Economics estimates based on the BC model developed for this study.

Table 5. Estimated Net Effects of Load Limits Imposed on the 725 Bridge, in 2018 $

Category	Net Present Value	2019	2020	2021	2022
Increased Truck Operating Cost	$81,086	$0	$32,890	$33,069	$33,248
Increased Driver Travel Time	$217,924	$0	$88,395	$88,875	$89,355
Total	**$299,010**	**$0**	**$121,285**	**$121,944**	**$122,602**

Source: Northern Economics estimates based on the BC model developed for this study.

2) Avoided Costs of Single Lane Operations

Single lane operations will take effect on the Bridge 253 and the Bridge 725 in year 2022. Single lane operations will not be imposed on Bridge 747.

Single lane operations will cause a 4-minute delay on both Bridges 253 and 725. The time delay was quantified for each type of vehicle using the appropriate compensation or wage data for the type of travel [see *Wage & Income* tab in the BC spreadsheet model].

Table 6 presents the estimated effects of the single lane operations imposed on the two bridges.

Table 6. Net Present Value of Estimated Effects of Single Lane Operations on Bridges 253 and 725, in 2018 $

Type of Travel	Herring Cove (253)	Hoadley Creek (725)
Truck Drivers	$85,474	$1,772,378
Bus Drivers	$11,769	$244,045
Bus (Passengers)	$56,847	$1,178,777
Other Business Travel Time	$25,472	$528,183
Personal Travel Time	$273,533	$5,671,965
Total	**$453,094**	**$9,395,348**

Source: Northern Economics estimates based on the BC model developed for this study.

3) Avoided Costs of Bridge Closures

As noted in the baseline description above, Bridge 253 and Bridge 725 will be closed at the end of year 2022, and Bridge 747 will be closed at the end of year 2019.

The following travel scenarios are assumed following these bridge closures:

Bridge 253 Closure

The bridge route assumes travel is from the Ketchikan’s Visitor’s Bureau in downtown Ketchikan to Power House Road (on the east side of Herring Cove across the bridge). No road or highway detour is available with this bridge closure. Instead, ferries and landing craft will be used to transport people and vehicles from Saxman to an area just past Power House Road.

Besides the ferry/landing craft fares that travelers will have to incur, additional costs will be incurred for improvements to the existing dock at Saxman (worth $150,000), new launch facilities (estimated to cost $1 million) east of Herring Cove, and annual land and dock rental payments of about $120,000 per year.

The incremental travel costs for motorists take into account the vehicle operating cost savings associated with the reduction in the distance traveled by road (vehicles will have to drive 2.6 miles after the ferry ride to Power House Road but will avoid the 8.4 miles of driving on the bridge route) and the additional ferry fares that will be incurred. The net effect results in an increase in vehicle operating costs.

Operating costs for the ferries and landing craft were based on 2017 data on the Ketchikan airport ferry (updated to 2018 $). Fares represent the amount required to cover the ferry operating expenses given the number of daily passengers that are expected. The analysis assumes that trucks and buses are charged about twice the average fare.

Bridge 725 Closure

After closure of Bridge 725, motorists will have to take a detour, which will add 1 mile to the trip distance, 4 minutes to the travel time. This results in additional operating costs and higher driver and passenger time values.

Bridge 747 Closure

The bridge route assumes that travel is from the Ketchikan Visitor's Center to Ward Cove Industrial Park just across Ward Creek Bridge. No road or highway detour is available with this bridge closure so a mix of ferries and landing craft will be used to transport people and vehicles between Ward Cove Industrial Park to industrial lands/docks on the south side of Ward Cove.

Besides the ferry/landing craft fares that travelers will have to incur, additional costs will be incurred for dock improvements on both the north and south sides of Ward Cove ($500,000) and annual land and dock rental payments of about $240,000 per year.

The incremental travel costs for motorists consider the vehicle operating cost savings associated with the reduction in the distance traveled by road (vehicles will have to drive 6.5 miles after the ferry ride but will avoid the 7.4 miles of driving on the bridge route) and the additional ferry or landing craft fares that will be incurred. The net effect results in an increase in vehicle operating costs.

Operating costs for the ferries and landing craft were based on 2017 data on the Ketchikan airport ferry (updated to 2018 $). Fares represent the amount required to cover the ferry operating expenses given the number of daily passengers that are expected. The analysis assumes that trucks and buses are charged 2.5 times the fare for cars and pick-ups.

Table 7, Table 8, and Table 9 show the net present values of the estimated costs of the bridge closures.

Table 7. Net Present Value of Estimated Effect of the 253 Bridge Closure, *in millions* of 2018 $

Category	Net Present Value
Increased Truck Operating Cost	$7.98
Increased Truck Driver Travel Time	$8.36
Increased Bus Operating Cost	$1.39
Increased Bus Driver Travel Time	$1.20
Increased Bus Passenger Travel Time	$5.78
Increased Other Business Vehicle Operating Cost	$0.85
Increased Other Business Travel Time	$2.59
Increased Personal Vehicle Operating Cost	$14.10
Increased Personal Travel Time	$27.81
Required Dock Improvements and New Facilities	$0.88
Land and Dock Rental Payments	$1.10
Total:	**$72.03**

Source: Northern Economics estimates based on the BC model developed for this study.

Table 8. Net Present Value of Estimated Effect of the 725 Bridge Closure, *in millions* of 2018 $

Category	Net Present Value
Increased Truck Operating Cost	$8.23
Increased Truck Driver Travel Time	$22.11
Increased Bus Operating Cost	$1.43
Increased Bus Driver Travel Time	$3.17
Increased Bus Passenger Travel Time	$15.29
Increased Other Business Vehicle Operating Cost	$1.04
Increased Other Business Travel Time	$6.85
Increased Personal Vehicle Operating Cost	$17.34
Increased Personal Travel Time	$73.58
Total:	**$149.04**

Source: Northern Economics estimates based on the BC model developed for this study.

Table 9. Net Present Value of Estimated Effect of the 747 Bridge Closure, *in millions* of 2018 $

Category	Net Present Value
Increased Truck Operating Cost	$23.91
Increased Truck Driver Travel Time	$29.21
Increased Bus Operating Cost	$1.89
Increased Bus Driver Travel Time	$1.90
Increased Bus Passenger Travel Time	$9.19
Increased Other Business Vehicle Operating Cost	$17.98
Increased Other Business Travel Time	$22.97
Increased Personal Vehicle Operating Cost	$346.31
Increased Personal Travel Time	$285.26
Required Dock Improvements	$0.47
Land and Dock Rental Payments	$2.98
Total:	**$742.076**

Source: Northern Economics estimates based on the BC model developed for this study.

The assumptions, data, and calculations for the various avoided costs associated with the bridge closures are provided in the *253 Baseline* tab, *725 Baseline* tab, and the *747 Baseline tab* in the BC spreadsheet model.

4) Avoided Baseline Maintenance and Operating Costs

Table 10 shows the net present values and the future avoided maintenance and operating costs for the three bridges. These baseline costs are based on historical maintenance costs provided by ADOT&PF. The baseline costs are quantified only until the last year the bridges will be open to motorists.

The data, assumptions, and calculations are shown in the *M&O* tab in the BC spreadsheet model.

Table 10. Net Present Value of the Estimated Baseline Maintenance and Operating Costs for the 253, 725, and 747 Bridges, in 2018 $

Bridge/Cost Category	NPV	2019	2020	2021	2022
Herring Cove (253)					
Pavement	$38	$0	$0	$0	$49
Bridge	$705	$208	$208	$208	$208
Total	$743	$208	$208	$208	$257
Hoadley Creek (725)					
Pavement	$0	$0	$0	$0	$0
Bridge	$190	$56	$56	$56	$56
Total	$190	$56	$56	$56	$56
Ward Creek (747)					
Pavement	$0	$0			
Bridge	$402	$430			
Total	$402	$430			

Source: Northern Economics estimates based on the BC spreadsheet model developed for this study; ADOT&PF provided historical maintenance costs for the bridges.

5) Residual Value of Bridge

The residual values for the bridges were quantified and included in the BCA. For this calculation, it is assumed that the value (=capital cost) of the bridge depreciates in a linear manner over its service life. The design life for a rehabilitated bridge is 50 years and the design life of a new bridge is 75 years, while the operating period assumed for this analysis is 30 years. The discounted residual values for the three bridges are shown in the table below.

Table 11. Estimated Discounted Residual Values of Bridge 253, 725, and 747, in 2018 $

Bridge	Present Value
Herring Cove (253)	$445,301
Hoadley Creek (725)	$349,216
Ward Creek (747)	$146,194

Source: Northern Economics estimates based on the BC spreadsheet model developed for this study; ADOT&PF provided capital costs of the bridge rehabilitation and replacement projects.

6) Avoided Emissions Costs

This analysis evaluated the net costs of emissions under the *no build baseline conditions* (without the bridge projects) and under the *with bridge project scenarios*. This includes the differences in emissions associated with the detour route or the alternative mode of travel, and the bridge route.

The costs of emissions are based on the recommended monetized values provided in the U.S. DOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs. The Guidance only provided monetized costs for volatile organic compounds (VOCs), nitrogen oxides (NO_x), particulate matter (PM), and sulfur dioxide (SO_2). According to the document, DOT does not currently have a recommended value for the damage costs from CO_2 emissions; hence CO_2 emissions cost were not monetized. SO_2 emissions were also not monetized since there are no data on SO_2 emissions from passenger vehicles and trucks.

The data, assumptions, and calculations for the costs of emissions are in provided in the *253 Emissions* tab, *725 Emissions* tab, and the *747 Emissions* tab of the BC spreadsheet model.

Table 12. Estimated Monetized Effects of Net Emissions, in 2018 $

Bridge	Net Present Value
Herring Cove (253)	$513,840
Hoadley Creek (725)	$1,954,224
Ward Creek (747)	$451,846

Source: Northern Economics estimates based on the BC spreadsheet model developed for this study

Project Costs

Total project costs in this BCA include the estimated costs of upgrading and replacing the bridges, as well as the future maintenance and operations of the bridges.

1) **Capital Costs**

The undiscounted project capital costs for each bridge project are shown in Table 13. The table also compares the total costs for all the bridges if they were implemented separately versus the total costs for all the bridges if they were implemented together (or bundled).

Table 13. Estimated Project Costs of the 253, 725, and 747 Bridges, Undiscounted, in 2018 $

Bridge	**Amount: Stand-Alone**	**Amount: Bundled**
Herring Cove (253)	$6,468,192	$6,065,299
Hoadley Creek (725)	$5,807,525	$5,434,703
Ward Creek (747)	$3,185,306	$2,919,464
Total	**$15,461,023**	**$14,419,466**

Source: Alaska Department of Transportation and Public Facilities (ADOT&PF).

The BC spreadsheet model provides a detailed break-down of the cost information in the *Construction Cost Estimate* tab.

2) Maintenance and Operations Costs

New bridges in Alaska are designed to be resilient structures with limited maintenance due to logistical challenges associated with short construction seasons and remote locations. Besides wearing surface replacement and minor upkeep, maintenance and operations work is assumed to be minimal. The table below shows the discounted estimated maintenance costs of the new and upgraded bridges.

Data, assumptions, and calculations are provided in the *M&O* tab in the BC spreadsheet model.

Table 14. Present Value of Maintenance & Operating Costs of the New 253 and 725 Bridges, and the Rehabilitated 747 Bridge, in 2018 $

Bridge/Cost Category	Present Value
Herring Cove (253)	
Pavement	$9,481
Bridge	$7,408
Total	$16,889
Hoadley Creek (725)	
Pavement	$3,273
Bridge	$3,008
Total	$6,281
Ward Creek (747)	
Pavement	$14,761
Bridge	$7,870
Total	$22,631

Source: Based on Alaska Department of Transportation and Public Facilities (ADOT&PF) Transportation Asset Management Plan and historical data on maintenance and operating costs, and Northern Economics assumptions about minor annual activities.

Summary Results: Benefit-Cost Analysis

The BCA results of the proposed bridge projects in the Southcoast Region are presented in Table 15. All of the bridge projects have a B/C ratio greater than 1. As a bundle, the estimated cost savings in present value terms amount to $1.0 million (2018 $).

Table 15. Net Present Values of Proposed Southcoast Region Bridge Projects' Benefits and Costs

Category	Net Present Value (*in millions of 2018$*)				
Project Benefits	Herring Cove	Hoadley Creek	Ward Creek	All Bridges (Separate)	All Bridges (Bundled)
Avoidance of Load Limit Costs	$0.08	$0.30	$0.00	$0.37	$0.37
Avoidance of Single Lane Operation	$0.45	$9.40	$0.00	$9.85	$9.85
Avoidance of Bridge Closure	$72.03	$149.04	$742.08	$963.15	$963.15
Avoidance of M&O Costs until Bridge Closure	$0.00	$0.00	$0.00	$0.00	$0.00
Residual Value of Bridge	$0.45	$0.35	$0.15	$0.94	$0.94
Avoided Emissions Costs	$0.51	$1.95	$0.45	$2.92	$2.92
Total Project Benefits	$73.01	$159.09	$742.22	$977.24	$977.24
Project Costs					
Capital Expenditures	$6.05	$4.74	$2.98	$13.76	$12.83
M&O Expenditures	$0.02	$0.01	$0.02	$0.05	$0.05
Total Project Costs	$6.06	$4.75	$3.00	$13.81	$12.88
Net Benefits	$66.95	$154.34	$739.22	$963.43	$964.36
B/C Ratio	12	34	247.5	71	76

Source: Northern Economics estimates based on the BC spreadsheet model developed for this study.