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Memorandum

TO: Virginia H. Porta, P.E.

FROM: Kia Mostaan, Paula Dowell

DATE: December 13, 2016

RE: I-555, Jonesboro to I-55 FASTLANE Grant Benefit/Cost Analysis Tech Memo

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Executive Summary

This memorandum summarizes the approach used for conducting benefit-cost analysis (BCA) for the Interstate 555 from Jonesboro to I-55 resurfacing/reconstruction project. Table 1 summarizes the project matrix for the I-555 resurfacing/reconstruction. The project matrix describes status quo or baseline conditions; proposed alternatives; types of impacts to users, summary of results, and page reference in this memorandum.

Baseline Conditions

Newly designated Interstate 555 (I-555) is on the National Highway Freight Network (NHFN) and connects the City of Jonesboro to Interstate 55 (I-55) north of Memphis in rural northeast Arkansas. The current pavement condition along I-555 is rated predominantly as fair to poor. Several segments of I-555 experience higher crash rates than other similar facilities of the same type in the State. Interstate 555 from the City of Jonesboro to Interstate 55 is in need of repairs ranging from minor preventive maintenance to full depth reconstruction. The estimated cost to address the needs of this important interstate corridor is $88.8 million. If funding is awarded, it will be used to let projects to contract beginning in calendar year 2017. An improved I-555 means a benefitted economy in the mid-south region of this nation and improved safety for the motorists who drive it.

The estimated costs to users under the baseline conditions (assuming that current conditions will continue) in the next 20 years is categorized into the following two areas:

- User operating costs due to poor roadway conditions
- Travel time delay costs due to reduced free-flow speed

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Table 1. Project Matrix

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impact	Population Affected by Impact	Economic Benefit	Summary of Results		Page Reference in BCA
					Discounted @ 7%	Discounted @ 3%	
Fair to poor roadway conditions along the 44 mile stretch of I-555 from Jonesboro to I-55. The I-555 corridor has a 23.35% truck traffic and is critical for freight movement. Several segments of I-555 experience higher crash rates than other similar facilities of the same type in the State.	Interstate 555 from the City of Jonesboro to Interstate 55 is in need of repairs ranging from minor preventive maintenance to full depth reconstruction.	Faster travel time for travelers. Reduced truck delays and improved throughput	Intercity travelers on the I-555 corridor Jonesboro population	Reduced vehicle operating costs	$118,532,232	$175,646,512	pp. 5-6
				Reduced travel time cost savings	$6,551,511	$9,708,331	pp. 6-7
				Emission reduction cost savings	$6,655,796	$8,690,817	pp. 7-10
				State-of-good repair O&M cost savings	$3,252,043	$4,399,030	p. 11

User Operating Costs Due to Poor Roadway Conditions

Pavement condition is measured using the International Roughness Index (IRI), consistent with MAP-21/FAST requirements. Pavements with an IRI rating of more than 170 are considered to have a poor ride quality according to FHWA standards, while those with an IRI of less than 95 are considered to have a good ride quality (Table 2). Pavements with IRI values between 95 and 170 are considered to be in fair condition.

Table 2. Travel time delay costs due to reduced free-flow speed

IRI	Pavement Condition
<95	Good
95 – 170	Fair
>170	Poor

In order to estimate the user operating cost due to poor roadway conditions we estimate the impacts of roadway IRI on fuel, tire, and maintenance and repair costs. A study by Chatti and Zaabar (2012) on the effects of pavement condition on vehicle operating costs conducted under the National Cooperative highway Research program (NCHRP) Report 720[1], shows that on average reduction of 63.4 inch/mile in IRI results in 4.8% reduction in vehicle operating costs. Currently, the pavement conditions are rated at fair or poor, which translate to average IRI of 133 in/mi to 170 in/mi and even worse. Roadway resurfacing and reconstruction as part of the proposed project may improve the roadway conditions. It is assumed that the resurfaced pavement has an average IRI of 63.4 inch/mile (1 unit of IRI). Table 3 summarizes the impacts of IRI on vehicle operating costs based on NCHRP 720.

Table 3. Impact of Poor Roadway Conditions on User Costs

User Cost Category	Average Increase per unit IRI	Overall Impact (1 unit change in IRI)
Fuel Costs	3%	3%
Tire Wear	1%	1%
Repair and Maintenance	20%	20%
Overall Operating Costs	4.8%	4.8%

Source: NCHRP 720, Chatti, K., & Zaabar, I. (2012)

Provided that the user operating costs average at 63.8 cents/mile for autos and 1.1 dollars/mile for trucks (NCHRP 720 study), the annual increase in operating costs due to poor roadway conditions are calculated for the I-555 corridor. The estimates assume an annual daily traffic (ADT) of 14000 for 2015 with an annual growth factor of 1.6%. The estimates also assume a 23.25% truck traffic, based on traffic counts provided by Arkansas DOT on four locations along the I-555 corridor.

[1] Chatti, K., & Zaabar, I. (2012). "Estimating the effects of pavement condition on vehicle operating costs" (NCHRP 720). Transportation Research Board.

The net present value (NPV) of annual operating costs are then calculated using the 7% discount rate as recommended by USDOT FASTLANE grant guidelines[2]. Table B1 in the Benefit-Cost Analysis Spreadsheet summarizes the operating cost and additional costs due to poor roadway conditions in the next 24 years. The NPV (discount rate =7%) of operating costs to users assuming that current conditions exist for the next 24 years is estimated to be $118,532,232.

Travel Time Delay Costs Due to Poor Roadway Conditions

The poor roadway conditions have direct impact on free-flow travel speed. A study on the impacts of pavement roughness on free-flow speed conducted by Wang et al. (2013)[3] for the California Department of Transportation shows that when holding other variables constant, increase in one unit of IRI results in 0.3 to 0.5 MPH free-flow speed reduction.

The speed limit (free-flow speed) for the I-555 corridor is assumed to be 70 MPH. The impact of 1 unit IRI, due to poor roadway conditions is assumed to have an average impact of 1×0.4 MPH on the free-flow speed. Hence, the free-flow speed is assumed to decrease by 0.4 MPH, which yields 69.6 MPH. The change in vehicle hours traveled (VHT), due to this speed reduction is 0.57%.

The NPV of annual travel time delay costs are then calculated using the 7% discount rate as recommended by USDOT FASTLANE grant guidelines. Table B2 in the Benefit-Cost Analysis Spreadsheet summarizes the travel delay costs due to poor roadway conditions in the next 24 years. The NPV (discount rate =7%) of delay costs to users assuming that current conditions exist for the next 24 years is estimated to be $6,551,511.

The overall impacts to users due to inaction in the next 24 years is the sum of increased operating costs ($118,532,232) and travel time delays ($6,551,511). The total NPV of both these impacts are $125,083,743.

Proposed Alternative Benefit-Cost Analysis

This section describes the method used for estimating benefits and life cycle costs for the I-555 resurfacing/reconstruction project. The project's life cycle benefits and costs are calculated using the guidelines provided by USDOT FASTLANE grant applications and follow the same methodology in the previous section. The project life-cycle benefits are evaluated in the following three areas:

- Vehicle Operating Cost Savings
- Travel Time Cost Savings
- Emissions Reduction Cost Savings

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[2] US Department of Transportation (USDOT) (2015). "Benefit-Cost Analyses Guidance for FASTLANE Grant Applicants." https://www.transportation.gov/buildamerica/fastlanegrants/bca-and-project-readiness-guidance.

[3] Wang, T., Harvey, J., Lea, J., and Kim, C. (2014). "Impact of Pavement Roughness on Vehicle Free-Flow
Speed." Prepared for California Department of Transportation.

- State-of-Good Repair Cost Savings

Vehicle Operating Cost Savings

As described in the previous section the poor roadway conditions and high values of IRI have direct impact on user operating costs. The impacts of high IRI on vehicle operating costs are summarized in Table F1. The benefits of the reconstruction of the pavement can be characterized by reducing the user operating costs due to improved pavement performance. As mentioned above on average reduction of 63.4 inch/mile in IRI results in 4.8% reduction in vehicle operating costs.

Provided that the user operating costs average at 63.4 cents/mile for autos and 1.1 dollars/mile for trucks (NCHRP 720 study), the annual increase in operating costs due to poor roadway conditions are calculated for the I-555 corridor. The estimates assume an annual daily traffic (ADT) of 14000 for 2015 with an annual growth factor of 1.6%. The estimates also assume a 23.25% truck traffic, based on traffic counts provided by Arkansas DOT on four locations along the I-555 corridor.

The NPV (discount rate=7%) of annual operating cost savings are then calculated using the 7% discount rate as recommended by USDOT FASTLANE grant guidelines. Table F1 in the Benefit-Cost Analysis Spreadsheet summarizes the operating cost savings due to improvements in roadway conditions in the next 24 years. The NPV of user operating benefits following roadway improvements are estimated to be $118,532,232. Table 4 provides a summary of user operating cost savings.

Table 4. Summary of Annual User Operating Cost Savings

Year	Auto Operating Costs (76.75% Auto Traffic)	Truck Operating Costs (23.25% Truck Traffic)	DALIY Operating Costs ($ 2015)	Annual Operating Costs ($ 2015)	Impact of Improved Roadway Condition on User Operating Costs	NPV of Veh. Operating Cost Savings (Discounted @ 7%)	NPV of Veh. Operating Costs Savings (Discounted @ 3%)
2016	$87,594	$95,292	$182,886	$66,753,490	$4,806,251	$8,239,654	$8,239,654
2017	$88,996	$96,817	$185,812	$67,821,546	$4,883,151	$7,823,821	$8,127,658
2018	$90,420	$98,366	$188,785	$68,906,691	$4,961,282	$7,428,974	$8,017,185
2019	$91,867	$99,939	$191,806	$70,009,198	$5,040,662	$7,054,053	$7,908,214
2020	$93,336	$101,538	$194,875	$71,129,345	$5,121,313	$6,698,054	$7,800,724
2021	$94,830	$103,163	$197,993	$72,267,415	$5,203,254	$6,360,022	$7,694,694
2022	$96,347	$104,814	$201,161	$73,423,693	$5,286,506	$6,039,049	$7,590,106
2023	$97,889	$106,491	$204,379	$74,598,473	$5,371,090	$5,734,274	$7,486,940
2024	$99,455	$108,195	$207,649	$75,792,048	$5,457,027	$5,444,881	$7,385,175
2025	$101,046	$109,926	$210,972	$77,004,721	$5,544,340	$5,170,093	$7,284,794
2026	$102,663	$111,684	$214,347	$78,236,796	$5,633,049	$4,909,172	$7,185,778
2027	$104,306	$113,471	$217,777	$79,488,585	$5,723,178	$4,661,419	$7,088,107
2028	$105,974	$115,287	$221,261	$80,760,402	$5,814,749	$4,426,170	$6,991,764
2029	$107,670	$117,132	$224,802	$82,052,569	$5,907,785	$4,202,793	$6,896,730
2030	$109,393	$119,006	$228,398	$83,365,410	$6,002,310	$3,990,690	$6,802,988
2031	$111,143	$120,910	$232,053	$84,699,257	$6,098,346	$3,789,291	$6,710,520
2032	$112,921	$122,844	$235,766	$86,054,445	$6,195,920	$3,598,055	$6,619,309
2033	$114,728	$124,810	$239,538	$87,431,316	$6,295,055	$3,416,471	$6,529,338
2034	$116,564	$126,807	$243,370	$88,830,217	$6,395,776	$3,244,051	$6,440,590
2035	$118,429	$128,836	$247,264	$90,251,500	$6,498,108	$3,080,333	$6,353,048
2036	$120,324	$130,897	$251,221	$91,695,524	$6,602,078	$2,924,877	$6,266,696
2037	$122,249	$132,991	$255,240	$93,162,653	$6,707,711	$2,777,266	$6,181,517
2038	$124,205	$135,119	$259,324	$94,653,255	$6,815,034	$2,637,105	$6,097,497
2039	$126,192	$137,281	$263,473	$96,167,707	$6,924,075	$2,504,017	$6,014,618
2040	$128,211	$139,478	$267,689	$97,706,391	$7,034,860	$2,377,646	$5,932,866
Total						**$118,532,232**	**$175,646,512**

Travel Time Cost Savings

The speed limit (free-flow speed) for the I-555 corridor is assumed to be 70 MPH. The impact of 1.5 unit IRI, due to poor roadway conditions is assumed to have an average impact of 1.5 × 0.4 MPH on the free-flow speed. Hence, the free-flow speed is assumed to decrease by 0.6 MPH, which yields 69.4 MPH. The change in VHT due to this speed reduction is 0.86%. The value gained from increase in free-flow speed represents itself in terms of reduced VHT.

The NPV (discount rate=7%) of annual travel time savings are calculated using the 7% discount rate as recommended by USDOT FASTLANE grant guidelines. Table F2 in the Benefit-Cost Analysis Spreadsheet summarizes the travel savings due to improved roadway conditions in the next 24 years. The NPV of travel time savings to users assuming that current conditions exist for the next 24 years is estimated to be $7,912,858. Table 5 provides a summary of user operating cost savings.

Table 5. Summary of Annual Travel Time Savings

Year	Total Daily VHT (70mph Speed Limit)	Increase in Daily VHT (69.6 mph Speed)	Total Daily Auto Time Savings Hours (76.75% Auto)	Total Daily Truck Time Savings Hours (23.25% Truck)	Total Daily Cost Savings ($ 2015)	Annual Travel Time Savings ($ 2015)	NPV of Annual Cost Savings (Discounted @ 7%)	NPV of Annual Cost Savings (Discounted @3%)
2016	9,008	52	40	12	$1,248	$455,422	$455,422	$455,422
2017	9,152	53	40	12	$1,268	$462,709	$432,438	$449,232
2018	9,298	53	41	12	$1,288	$470,112	$410,614	$443,126
2019	9,447	54	42	13	$1,309	$477,634	$389,892	$437,103
2020	9,598	55	42	13	$1,330	$485,276	$370,215	$431,161
2021	9,752	56	43	13	$1,351	$493,040	$351,531	$425,301
2022	9,908	57	44	13	$1,372	$500,929	$333,790	$419,520
2023	10,066	58	44	13	$1,394	$508,944	$316,945	$413,818
2024	10,228	59	45	14	$1,417	$517,087	$300,949	$408,193
2025	10,391	60	46	14	$1,439	$525,360	$285,761	$402,645
2026	10,557	61	47	14	$1,462	$533,766	$271,340	$397,172
2027	10,726	62	47	14	$1,486	$542,306	$257,646	$391,774
2028	10,898	63	48	15	$1,510	$550,983	$244,643	$386,449
2029	11,072	64	49	15	$1,534	$559,799	$232,297	$381,196
2030	11,250	65	50	15	$1,558	$568,756	$220,573	$376,015
2031	11,429	66	50	15	$1,583	$577,856	$209,442	$370,904
2032	11,612	67	51	16	$1,608	$587,102	$198,872	$365,862
2033	11,798	68	52	16	$1,634	$596,495	$188,835	$360,889
2034	11,987	69	53	16	$1,660	$606,039	$179,305	$355,984
2035	12,179	70	54	16	$1,687	$615,736	$170,256	$351,146
2036	12,374	71	55	17	$1,714	$625,588	$161,664	$346,373
2037	12,572	72	55	17	$1,741	$635,597	$153,505	$341,665
2038	12,773	73	56	17	$1,769	$645,767	$145,758	$337,021
2039	12,977	75	57	17	$1,798	$656,099	$138,402	$332,440
2040	13,185	76	58	18	$1,826	$666,596	$131,417	$327,921
Total							**6,551,511**	**9,708,331**

Emission Reduction Cost Savings

The third category of project benefits are reduction emission savings that are a byproduct of resurfaced roadway improvements and increased free-flow speed. According to Chatti and Zaabar (2012) (NCHRP 720), average fuel consumption impact per 63.4 unit IRI change is 3%. Therefore, improvements in pavement roughness in the I-555 corridor will results in reduced emissions due to less fuel consumption.

The proposed I-555 resurfacing/reconstruction will enhance roadway IRI values. Currently, the pavement conditions are rated at fair or poor, which translate to average IRI of 133 in/mi to 170 in/mi and even worse. Roadway resurfacing and reconstruction as part of the proposed project may improve the roadway conditions. It is assumed that the resurfaced pavement has an

average IRI of 63.4 inch/mile (1 unit of IRI). These improvements will lower fuel consumption by 3% points.

In order to evaluate the emission reduction cost savings, first the total emissions resulting from the total annual vehicles miles traveled (VMT) has to be calculated. Then using the 4.5% decrease in fuel consumption factor the total emission cost savings is summed-up throughout the project's life-cycle. The emission indicators considered in the analysis include Carbon Dioxide (CO2), Volatile Organic Compounds (VOCs), Nitrogen Oxides (NOx), and Particular Matter (PM10 and PM2.5). The amount of emissions per mile driven are provided by the Environmental Protection Agency (EPA), Office of Transportation and Air Quality emission fact sheet. The data present the average emissions per mile of passenger vehicles, SUVs, and small trucks. These emission estimates are used to calculate the social cost of carbon (SCC) and dollar value of benefits in terms of emission savings resulted from roadway improvements. Table 6 describes the emission input values.

The cost of CO2 emission are calculated using the SCC inputs provided by USDOT FASTLANE grant guidelines. The cost per unit of emissions are also provided USDOT FASTLANE grant guidelines. Table F3 in the Benefit-Cost Analysis Spreadsheet summarizes the emission reduction savings due to improved roadway conditions in the next 24 years.

Table 6. Emission Values Provided by EPA Office of Transportation and Air Quality (2008)

Emission Type	Average Emission (gram/M)		Metric Ton Equivalent for 1 Veh. (ton/Mile)		Monetized Values
	Cars	Trucks	Cars	Trucks	
CO2 (Metric Ton/Mile)	368.4	513.5	0.0003684	0.0005135	(Varies)
VOCs (ShortTon/Mile)	1.034	1.224	1.13895E-06	1.34824E-06	$1,844
NOx (ShortTon/Mile)	0.693	0.95	7.6334E-07	1.04643E-06	$7,266
PM (ShortTon/Mile)	0.0085	0.0094	9.36275E-09	1.03541E-08	$332,405

Source: U.S. EPA, Office of Transportation and Air Quality, Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks, pages 4-5 (EPA420-F-08-024, October 2008).

The total benefits resulting from reduction in CO2 and non-carbon emissions is discounted at 7% per USDOT FASTLANE grant guidelines, Table 7 provides the annual summary of emission reduction costs savings. The total NPV (discount rate=7%) of emission reduction costs savings due to roadway improvements is $6,655,796.

Table 7. Summary of Annual Emission Reduction Cost Savings

Year	Total Daily VMT	Total Annual VMT	Total Annual CO2 Emission Costs Savings	NPV of Emission Cost Savings (Discounted @ 7%)	NPV of Emission Cost Savings (Discounted @ 3%)
2016	630,550	230,150,721	$138,876	N/A	$138,876
2017	640,639	233,833,132	$144,380	N/A	$134,934
2018	650,889	237,574,462	$150,024	N/A	$131,037
2019	661,303	241,375,654	$155,811	N/A	$127,188
2020	671,884	245,237,664	$161,746	N/A	$123,395
2021	682,634	249,161,467	$164,334	N/A	$117,168
2022	693,556	253,148,050	$174,068	N/A	$115,989
2023	704,653	257,198,419	$180,462	N/A	$112,383
2024	715,928	261,313,594	$187,017	N/A	$108,845
2025	727,382	265,494,611	$193,734	N/A	$105,379
2026	739,021	269,742,525	$200,619	N/A	$101,985
2027	750,845	274,058,406	$207,675	N/A	$98,665
2028	762,858	278,443,340	$214,905	N/A	$95,421
2029	775,064	282,898,434	$218,344	N/A	$90,605
2030	787,465	287,424,808	$229,904	N/A	$89,161
2031	800,065	292,023,605	$237,681	N/A	$86,146
2032	812,866	296,695,983	$245,647	N/A	$83,209
2033	825,872	301,443,119	$253,807	N/A	$80,349
2034	839,086	306,266,209	$262,166	N/A	$77,566
2035	852,511	311,166,468	$270,727	N/A	$74,858
2036	866,151	316,145,132	$279,496	N/A	$72,227
2037	880,009	321,203,454	$288,475	N/A	$69,670
2038	894,090	326,342,709	$302,250	N/A	$68,222
2039	908,395	331,564,192	$311,738	N/A	$65,760
2040	922,929	336,869,219	$321,453	N/A	$63,373
Total				**$2,432,411**	**$2,432,411**

Note: Per USDOT Recommendation the Carbon Emission Costs/benefits are discounted at 3% discount rate.

Table 8. Summary of Annual Emission Reduction Cost Savings

Year	Total Daily VMT	Total Annual VMT	Annual Non-carbon Emission Savings Due to IRI Improvements	NPV of Emission Cost Savings (Discounted @ 7%)	NPV of Emission Cost Savings (Discounted @ 3%)
2016	630,550	230,150,721	$293,585	$293,585	$293,585
2017	640,639	233,833,132	$298,282	$278,768	$289,594
2018	650,889	237,574,462	$303,054	$264,699	$285,658
2019	661,303	241,375,654	$307,903	$251,341	$281,775
2020	671,884	245,237,664	$312,830	$238,656	$277,945
2021	682,634	249,161,467	$317,835	$226,612	$274,167
2022	693,556	253,148,050	$322,920	$215,175	$270,441
2023	704,653	257,198,419	$328,087	$204,316	$266,765
2024	715,928	261,313,594	$333,336	$194,005	$263,139
2025	727,382	265,494,611	$338,670	$184,214	$259,562
2026	739,021	269,742,525	$344,089	$174,917	$256,034
2027	750,845	274,058,406	$349,594	$166,090	$252,554
2028	762,858	278,443,340	$355,187	$157,707	$249,121
2029	775,064	282,898,434	$360,870	$149,748	$245,735
2030	787,465	287,424,808	$366,644	$142,191	$242,395
2031	800,065	292,023,605	$372,511	$135,015	$239,100
2032	812,866	296,695,983	$378,471	$128,201	$235,851
2033	825,872	301,443,119	$384,526	$121,731	$232,645
2034	839,086	306,266,209	$390,679	$115,588	$229,483
2035	852,511	311,166,468	$396,930	$109,754	$226,363
2036	866,151	316,145,132	$403,281	$104,215	$223,287
2037	880,009	321,203,454	$409,733	$98,956	$220,252
2038	894,090	326,342,709	$416,289	$93,962	$217,258
2039	908,395	331,564,192	$422,949	$89,220	$214,305
2040	922,929	336,869,219	$429,717	$84,717	$211,392
Total			**$8,937,972**	**$4,223,385**	**$6,258,406**

State-of-Good-Repair Benefits

The operations and maintenance (O&M) costs for the 44 mile length of the I-555 corridor are estimated to be $727,012 annually. For both the build and no-build scenarios this cost will carry-on until 2018. For the build scenario the O&M costs will be zero during the construction period from 2018 to 2020 and then the O&M costs will decrease to 545,259 annually through 2040. Hence, the I-555 resurfacing/reconstruction has a significant O&M cost savings impact due to major maintenance intervention from 2018 to 2020. The NPV of these O&M cost savings due to state-of-good repair, discounted at 7%, are estimated to be a total of $3,252,043.

Table F4 in the Benefit-Cost Analysis Spreadsheet summarizes the state-of-good repair O&M cost savings due to improved roadway conditions in the next 24 years. Table 9 below, provides a summary of annual O&M cost savings for the next 24 years.

Table 9. Summary of Annual O&M Cost Savings

Year	Build O&M Costs	No-Build O&M Costs	Total Operations and Maintenance (O&M) Cost Savings	NPV of O&M Cost Savings Discounted @ 7%	NPV of O&M Cost Savings Discounted @ 3%
2016	$727,012	$727,012	$0	$0	$0
2017	$727,012	$727,012	$0	$0	$0
2018	$0	$727,012	$727,012	$635,000	$685,279
2019	$0	$727,012	$727,012	$593,458	$665,319
2020	$0	$727,012	$727,012	$554,634	$645,941
2021	$545,259	$727,012	$181,753	$129,587	$156,782
2022	$545,259	$727,012	$181,753	$121,110	$152,215
2023	$545,259	$727,012	$181,753	$113,187	$147,782
2024	$545,259	$727,012	$181,753	$105,782	$143,477
2025	$545,259	$727,012	$181,753	$98,862	$139,299
2026	$545,259	$727,012	$181,753	$92,394	$135,241
2027	$545,259	$727,012	$181,753	$86,350	$131,302
2028	$545,259	$727,012	$181,753	$80,701	$127,478
2029	$545,259	$727,012	$181,753	$75,421	$123,765
2030	$545,259	$727,012	$181,753	$70,487	$120,160
2031	$545,259	$727,012	$181,753	$65,876	$116,660
2032	$545,259	$727,012	$181,753	$61,566	$113,262
2033	$545,259	$727,012	$181,753	$57,538	$109,964
2034	$545,259	$727,012	$181,753	$53,774	$106,761
2035	$545,259	$727,012	$181,753	$50,256	$103,651
2036	$545,259	$727,012	$181,753	$46,968	$100,632
2037	$545,259	$727,012	$181,753	$43,896	$97,701
2038	$545,259	$727,012	$181,753	$41,024	$94,856
2039	$545,259	$727,012	$181,753	$38,340	$92,093
2040	$545,259	$727,012	$181,753	$35,832	$89,410
Total	**$12,359,204**	**$18,175,300**	**$5,816,096**	**$3,252,043**	**$4,399,030**

Project Life-Cycle Cost Analysis

The latest project cost estimates put the total project cost at $108,711,000. This total cost includes construction and Construction Engineering and Inspection (CE&I). In addition, the project maintenance costs are estimated at $727,012 annually through 2017. However, if the project is funded, the maintenance costs are estimated to decrease to 545,259 following project close-out in 2021 and onward. If conditions stay the same the project maintenance costs are estimated to be $727,012 through 2040. Hence, the project maintenance costs in the long-term will benefit from major resurfacing/reconstruction. The construction and CE&I costs are distributed in three year, 2018, 2019, and 2020. Table 10 presents the summary of project costs.

Table 10. Summary of Project Costs

Work Item	Costs
Annual Maintenance (after improvements)	$545,259
Annual Maintenance (without improvements)	$727,012
Construction and CE&I	$108,711,000

Table F5 in the Benefit-Cost Analysis Spreadsheet summarizes the project life-cycle cost analysis for both the build and no-build scenarios in the next 24 years. Table 11 below, provides a summary of annual project costs for the next 24 years. The NPV of project costs discounted at 7% is $108,155,266.

Table 11. Summary of Project Life-Cycle Costs

Year	Annual Construction and CEI+ O&M Costs	NPV of Project Costs Discounted @ 7%	NPV of Project Costs Discounted @ 3%
2016	$727,012	$727,012	$727,012
2017	$727,012	$679,450	$705,837
2018	$36,237,000	$31,650,799	$34,156,848
2019	$36,237,000	$29,580,186	$33,161,988
2020	$36,237,000	$27,645,034	$32,196,105
2021	$545,259	$388,762	$470,345
2022	$545,259	$363,329	$456,646
2023	$545,259	$339,560	$443,345
2024	$545,259	$317,346	$430,432
2025	$545,259	$296,585	$417,896
2026	$545,259	$277,182	$405,724
2027	$545,259	$259,049	$393,907
2028	$545,259	$242,102	$382,434
2029	$545,259	$226,263	$371,295
2030	$545,259	$211,461	$360,480
2031	$545,259	$197,627	$349,981
2032	$545,259	$184,698	$339,787
2033	$545,259	$172,615	$329,891
2034	$545,259	$161,322	$320,282
2035	$545,259	$150,769	$310,954
2036	$545,259	$140,905	$301,897
2037	$545,259	$131,687	$293,104
2038	$545,259	$123,072	$284,567
2039	$545,259	$115,021	$276,278
2040	$545,259	$107,496	$268,231
Total	**$121,070,204**	**$94,689,332**	**$108,155,266**

Summary of Benefit-Cost Analysis

This memorandum describes the methodology used for conducting benefit-costs analysis for the I-555 resurfacing/reconstruction. The economic benefits of implementing project include cost savings for users due to reduced vehicle operating costs and reduces travel delays. Furthermore, the roadway improvements will reduce fuel consumption of traveling vehicles and result in less carbon and non-carbon emissions. The B/C ratio of this project is 1.43 at a 7% discount rate and 1.83 at a 3% discount rate. Table 12 summaries the benefit-cost analysis.

Table 12. Summary of Project Costs

Benefit/Cost Category	Discounted at 7%	Discounted at 3%
Vehicle Operating Cost Savings	$118,532,232	$175,646,512
Travel Time Cost Savings	$6,551,511	$9,708,331
Carbon Emissions Reduction Cost Savings	$2,432,411	$2,432,411
Non-Carbon Emissions Reduction Cost Savings	$4,223,385	$6,258,406
State-of-Good Repair Benefits	$3,252,043	$4,399,030
Sum of all Benefits	**$134,991,582**	**$198,444,690**
Project Life Cycle Costs	**$94,689,332**	**$108,155,266**
B/C Ratio	**1.43**	**1.83**

Note: Per USDOT Recommendation the Carbon Emission Costs/benefits are discounted at 3% discount rate.