BCA TECHNICAL MEMORANDUM

MCCLELLAN-KERR ARKANSAS RIVER NAVIGATION SYSTEM (MKARNS) MOORING MODERNIZATION PROJECT

MKARNS WATERWAY, OKLAHOMA

EXECUTIVE SUMMARY

The McClellan-Kerr Arkansas River Navigation System (MKARNS) Mooring Modernization Project provides a benefit-cost ratio **(BCR) of 5.38** and an **internal rate of return of 19.39 percent**. At this rate, the proposed **total capital project cost of $21.9 million** (2019$) will produce a **positive net user benefit of about $61.6 million (NPV)** over 20 years.

The Benefit Cost Analysis (BCA) identified that the Project will significantly improve safety in the event of a flood, reduce operations and maintenance (O&M) costs over time, and demonstrate the savings associated with loss of use of the waterway if the Project were not constructed. The MKARNS Mooring Modernization Project will construct modernized mooring infrastructure at three Port locations - the Tulsa Port of Catoosa, Port of Muskogee, and in the Grand River which will serve Oakley's Terminal Muskogee located along the waterway system in Oklahoma. Modernized mooring infrastructure will replace obsolete anchors with improved tie down solutions in the waterway that will enable safe harbor for mariners, improved reliability in the event of a flood, and reduce ongoing maintenance costs for each port location. Over the life of the Project, these investments will produce the following benefits:

- **Operations & Maintenance** **$205,793 net present value (NPV)**
- **Flood Damage Savings** **$57,833 (NPV)**
- **Loss of Use Savings** **$75,364,058 (NPV)**

The Benefit Cost Analysis (BCA) was prepared in accordance with the 2020 FHWA BCA Guidance for Discretionary Grant Programs using total quantifiable project costs and benefits adjusted for inflation, then discounted to reflect the time value of money.

METHODOLOGY

The Benefit Cost Analysis (BCA) for the McClellan-Kerr Arkansas River Navigation System (MKARNS) Mooring Modernization Project was prepared following 2021 FHWA BCA Guidance for Discretionary Grant Programs using total quantifiable project costs and benefits adjusted for inflation, then discounted to reflect the time value of money.

In summary, the BCA was created by:

1. Identifying Project benefits and costs for improvements versus a no-build scenario;
2. Deriving current and forecasted use levels for the baseline and the "build case";
3. Denominating all benefits and costs in constant 2019 dollars;
4. Discounting dollar amounts by 7 percent to reflect the time value of money; and
5. Setting an appropriate analysis period of 20 years for the Project's construction and subsequent operational service.

PROJECT OVERVIEW

The MKARNS is 445-mile long marine highway which consists of the Verdigris, Arkansas, and White Rivers. The MKARNS serves a 12-state region and is the most westerly inland ice-free waterway system in the Country. As such, the waterway provides access to port terminals to transfer freight from barge to either rail or truck. The MKARNS is synonymous with the Arkansas River in Oklahoma from the Port of Muskogee downstream to the State of Arkansas border. Upstream from the Port of Muskogee, MKARNS leaves the Arkansas River to join the Verdigris River and terminates at Tulsa Port of Catoosa.

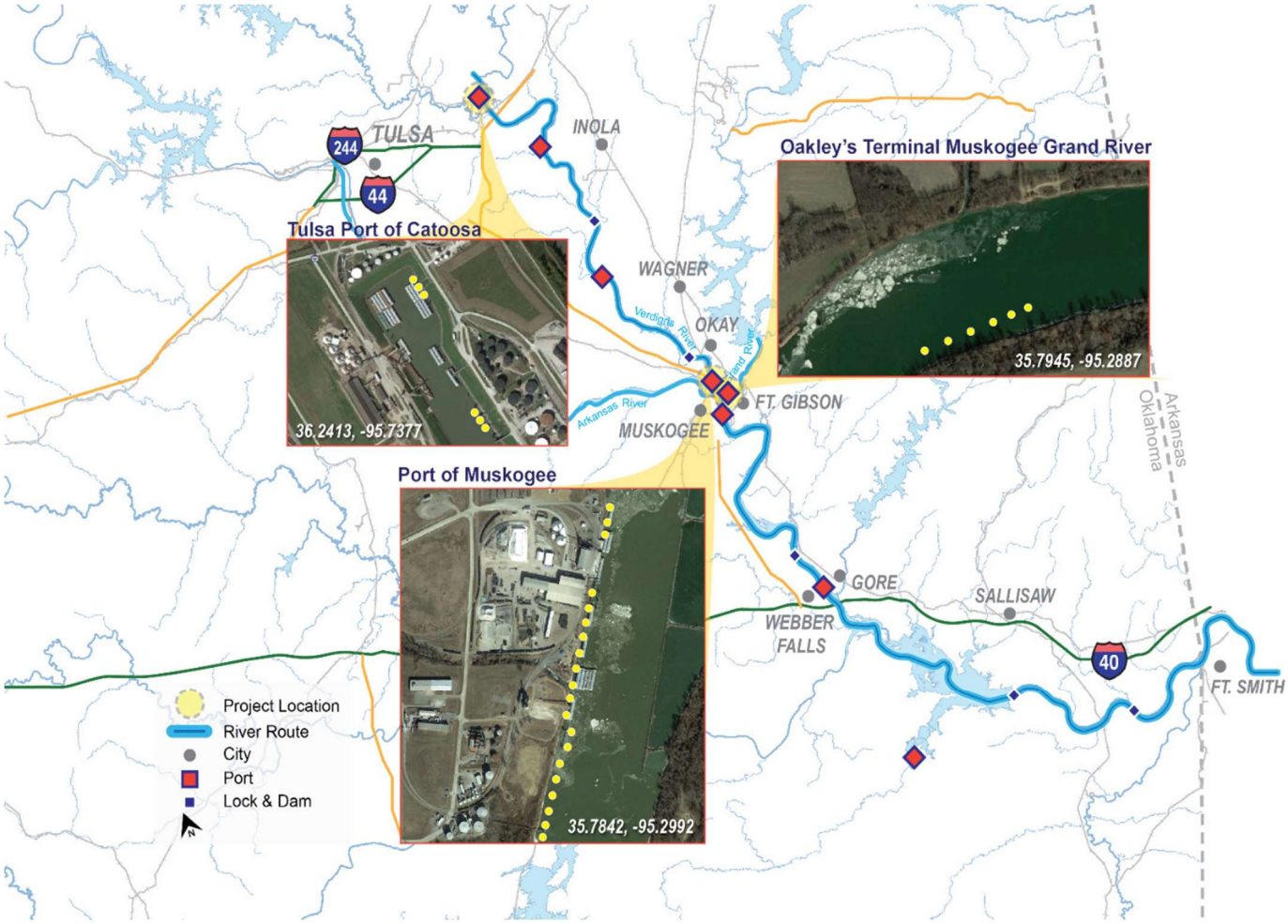
The Project will consist of constructing 32 mooring structures at the Tulsa Port of Catoosa, Port of Muskogee and the Grand River which will serve Oakley's Terminal Muskogee, all of which are located in Northeast Oklahoma's 2nd Congressional District. These three ports include the two largest public ports (Tulsa Port of Catoosa and Port of Muskogee) and the largest private port (Oakley's Terminal Muskogee) along the MKARNS waterway in Oklahoma. The specific geospatial coordinates of proposed mooring structures.

The proposed Project consists of key improvements for each of the three Port locations as follows:

1. Replacing 6 dolphin structures with 6 modernized mooring structures at the Tulsa Port of Catoosa
2. Replacing 20 dolphin structures with 20 modernized mooring structures at the Port of Muskogee
3. Replacing 10 dead-man anchors with 6 modernized mooring structures at Oakley's Terminal Muskogee along the Grand River

The delegations of mooring construction at each Port location is shown below in ***Figure 1***.

FIGURE 1: PROPOSED IMPROVEMENTS



PROJECT BENEFICIARIES

The Project will benefit the Tulsa Port of Catoosa, Port of Muskogee, and Oakley's Terminal Muskogee as well as local residents, workers and businesses that rely on the MKARNS in Oklahoma to continue to provide jobs and economic growth for the region.

The proposed improvements will increase safety, reduce operations and maintenance (O&M) costs and decrease emissions by encouraging freight movement by the waterway. Oklahoma produces and supplies a variety of products including, but not limited to, agriculture, chemical fertilizers, petroleum, and iron and steel throughout the U.S. and internationally. **Collectively, the three port locations process nearly 5.5 million tons of cargo annually**.[1] The mooring infrastructure improvements provided by the Project are vital for Oklahoma to remain a key component of the regional and national freight transportation system. The Project will preserve the waterway's economic vitality and prepare for future freight traffic demand.

PROJECT BENEFIT CATEGORIES

The Project will provide substantial benefits by improving safety, increased capacity, reduced emissions, operations and maintenance savings and economic vitality for the surrounding area. These benefits are quantified in the following subsections.

- Operations and Maintenance
- Flood Damage Savings
    - Flood Safety
    - Flood Environmental Savings
    - Flood Travel Time Savings
- Loss of Use (Existing infrastructure)
    - Loss of Use Safety Crash Savings
    - Loss of Use Environmental Savings
    - Loss of Use Economic Savings

Benefits were calculated using data provided by the Oklahoma Department of Transportation (ODOT) and corresponding Port Partners (Tulsa Port of Catoosa, Port of Muskogee, and Oakley's Terminal Muskogee). Calculations for all figures as well as sources cited can be found within the BCA spreadsheets that are included with the RAISE grant submittal. The benefits are based upon the reduced operating capacity of the ports if the dolphin moorings and deadman anchors are not replaced as they are nearing their end of life.

[1] Waterway Fact Sheet (2019)

OPERATIONS AND MAINTENANCE

The operations and maintenance cost savings calculated for this Project are **$205,793 (NPV).** Each port location provided their existing annual maintenance costs per existing structure as follows:

- Port of Muskogee = $200 per dolphin mooring over a 20-year period
- Tulsa Port of Catoosa = 200 per dolphin mooring over a 20-year period
- Oakley's Terminal Muskogee = $450 per year per deadman anchor

These costs were each applied to the existing infrastructure at each location to be replaced by this project:

- 20 Dolphin Structures at the Port of Muskogee
- 6 Dolphin Structures at the Tulsa Port of Catoosa
- 6 Deadman Anchors at Oakley's Terminal Muskogee

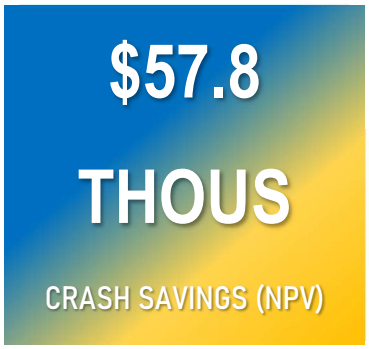
This equates to approximately $9,700 in maintenance costs per year if no Project is constructed. However, it is important to note that although the existing maintenance costs are minimal there is an extreme urgency and need for modernized mooring infrastructure at these three port locations because the existing infrastructure to be replaced by this Project **will reach their end of life by 2025**. This means that **existing dolphin and deadman anchors will be unusable in less than 4 years.** The Tulsa Port of Catoosa liquid capacity structures would **lose 100 percent of their capacity in 2025** while the Muskogee Dolphin line would **lose 30 percent of its capacity**. Freight movement by waterway is anticipated to grow by 35 percent by year 2045 and without these improvements the remaining infrastructure will become strained and decrease the efficiency of the waterway.[2] The calculated Operations and Maintenance cost savings for the Build and No Build scenarios are show in ***Table 1***.

[2] Oklahoma Freight Transportation Plan 2018-2022

TABLE 1: OPERATIONS AND MAINTENANCE COSTS

Year	No Build Scenario		Build Scenario		Operations & Maintenance Savings	Operations & Maintenance Savings (NPV)
	Infrastructure Condition	Mooring O&M	Infrastructure Condition	Mooring O&M		
2022	Poor	$ 9,700	N/A	$ -	$ -	$ -
2023	Poor	$ 9,700	N/A	$ -	$ -	$ -
2024	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 4,634
2025	Poor	$ 239,700	Good	$ 3,200	$ 236,500	$ 157,590
2026	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 4,048
2027	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 3,783
2028	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 3,536
2029	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 3,304
2030	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 3,088
2031	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 2,886
2032	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 2,697
2033	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 2,521
2034	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 2,356
2035	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 2,202
2036	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 2,058
2037	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 1,923
2038	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 1,797
2039	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 1,680
2040	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 1,570
2041	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 1,467
2042	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 1,371
2043	Poor	$ 9,700	Good	$ 3,200	$ 6,500	$ 1,281
Total		**$ 433,700**		**$ 64,000**	**$ 360,000**	**$ 205,793**

FLOOD RISK REDUCTION SAVINGS



The Project produces $57,833 (NPV) savings for risk reduction in the event of a flood. This category accounts for the totals of the following sections for flood safety, environmental, and travel time calculate the complete risk total for a flood event. It is important to note that the following sections for flood safety, environmental, and travel time all wrap into the $57,833 NPV savings and are risk adjusted.

Data from the extreme flood event of 2019 on the MKARNS Oklahoma segment was utilized to calculate the probability of a barge breaking free from existing mooring infrastructure as well as the probability of a barge breaking free once the modernized moorings are provided by the Project.

The reported flood losses from the 2019 flood were approximately $266 million, which encompassed the loss of cargo of two barges that broke free and struck the Webber's Fall Lock and Dam, the dredging to recover said barges, closure of the waterway, and any additional damages caused by this incident. The damages assumed for a future loose barge were determined basing the scenario that a barge could hit a pier of the US-62 bridge before, which was assumed to be $20 million for this calculation. The flood event of 2019 was determined to be a 100-year flood, so the probability of 1 percent was used for this exercise to pose as the probability for another event of the same magnitude to occur within this timeframe while a probability of 0.01 percent was assumed for the odds that a barge would break loose once improved infrastructure is provided. An inflation rate of 2 percent was utilized as costs can vary based on any given year. The values for reduced fatalities and injuries were also informed by the 2021 BCA Guidance, which provides monetized values for non-injury, potential injury, injury, death and number of accidents reported. A per vehicle property damage value also informed by the 2021 BCA guidance was incorporated into this calculated to provide a cost per vehicle. The estimated flood risk reduction savings are displayed in ***Table 2***.

TABLE 2: FLOOD RISK REDUCTION SAVINGS

Flood Risk Reduction				
Year	No Build Cost Potential	Build Cost Potential	Savings	NPV
2024	$ 6,429	$ 64	$ 6,364	$ 4,241
2025	$ 6,564	$ 66	$ 6,498	$ 4,047
2026	$ 6,705	$ 67	$ 6,638	$ 3,863
2027	$ 6,853	$ 69	$ 6,785	$ 3,690
2028	$ 7,006	$ 70	$ 6,936	$ 3,526
2029	$ 7,166	$ 72	$ 7,095	$ 3,371
2030	$ 7,335	$ 73	$ 7,262	$ 3,224
2031	$ 7,510	$ 75	$ 7,435	$ 3,085
2032	$ 7,693	$ 77	$ 7,616	$ 2,954
2033	$ 7,886	$ 79	$ 7,807	$ 2,830
2034	$ 8,090	$ 81	$ 8,009	$ 2,713
2035	$ 8,307	$ 83	$ 8,224	$ 2,603
2036	$ 8,538	$ 85	$ 8,452	$ 2,501
2037	$ 8,785	$ 88	$ 8,697	$ 2,405
2038	$ 9,050	$ 91	$ 8,960	$ 2,315
2039	$ 9,337	$ 93	$ 9,244	$ 2,233
2040	$ 9,649	$ 96	$ 9,553	$ 2,156
2041	$ 9,990	$ 100	$ 9,890	$ 2,086
2042	$ 10,364	$ 104	$ 10,260	$ 2,023
2043	$ 10,779	$ 108	$ 10,671	$ 1,966
		Total	$ 162,398	$ 57,833

Flood Safety Savings

The Flood safety savings calculated for this Project were **$58,089,087 NPV.** The purpose of this category is to calculate how the improvements for this Project would reduce the likelihood of fatalities, injuries, and property damages on the waterway by reducing the number of such crashes and/or their severity. This was calculated for this Project by assuming cargo that is unable to be ship via the MKARNS due to a flood incident would result in 25 percent goods not moved, while 90 percent of the remaining tons would be diverted to rail and 10 percent diverted to truck. The large percentage diverted to rail versus truck is simply because of the volume of cargo that can be handled via rail. Additional assumptions include safety rates per ton-mile for rail, truck, and waterway that report fatalities and injuries per ton-mile for each of these modes of transportation.[3]

The diversion distance assumed was from Mississippi to Muskogee, however, to be conservative Little Rock was used as the starting distance. These assumptions were compiled to determine the total ton-miles diverted from the waterway to rail and truck. These ton-miles were then applied to the assumed fatality and injury factors to calculate the amount of fatalities and injuries that occur from the diversion. The expected annual fatalities and injuries were calculated for both the no-build and build conditions. **The final value for the increased crash cost as a result of the tonnage diversion** due to waterway closure **produced $58,089,087 NPV. The flood waterway diversion increased crash costs are shown in *Tables 3 and 4*.**

[3] Bureau of Transportation Statistics

TABLE 3: WATERWAY DIVERSION INCREASED CRASH COSTS - PART 1

Year	Flood Waterway Diversion					
	Waterway Tons Diverted			Waterway Ton-Miles Diverted		
	Catoosa	Port 33	Muskogee	Catoosa	Port 33	Muskogee
2018	556,900	351,612	164,576	247,820,611	151,896,248	64,678,408
2019	559,685	353,370	165,399	249,059,714	152,655,729	65,001,800
2020	565,296	356,912	166,226	251,556,538	154,186,103	65,326,809
2021	573,817	362,293	167,057	255,348,784	156,510,477	65,653,443
2022	585,380	369,593	167,892	260,494,190	159,664,242	65,981,711
2023	600,162	378,926	168,732	267,071,995	163,695,964	66,311,619
2024	618,393	390,437	169,576	275,184,977	168,668,640	66,643,177
2025	640,364	404,309	170,423	284,962,133	174,661,335	66,976,393
2026	666,432	420,767	171,276	296,562,099	181,771,281	67,311,275
2027	697,028	440,085	172,132	310,177,437	190,116,506	67,647,831
2028	732,674	462,590	172,993	326,039,952	199,839,089	67,986,071
2029	773,994	488,679	173,858	344,427,247	211,109,181	68,326,001
2030	821,732	518,819	174,727	365,670,765	224,129,934	68,667,631
2031	876,777	553,573	175,600	390,165,661	239,143,546	69,010,969
2032	940,186	593,608	176,478	418,382,883	256,438,678	69,356,024
2033	1,013,222	639,721	177,361	450,884,011	276,359,537	69,702,804
2034	1,097,392	692,864	178,248	488,339,465	299,317,042	70,051,318
2035	1,194,496	754,173	179,139	531,550,918	325,802,561	70,401,575
2036	1,306,694	825,011	180,035	581,478,932	356,404,850	70,753,583
2037	1,436,578	907,016	180,935	639,277,115	391,830,988	71,107,350
2038	1,587,268	1,002,158	181,839	706,334,457	432,932,325	71,462,887
2039	1,762,535	1,112,817	182,749	784,327,946	480,736,737	71,820,202
2040	1,966,940	1,241,872	183,662	875,288,149	536,488,812	72,179,303
2041	2,206,025	1,392,824	184,581	981,681,188	601,700,109	72,540,199
2042	2,486,543	1,569,936	185,504	1,106,511,548	678,212,160	72,902,900
2043	2,816,745	1,778,416	186,431	1,253,451,385	768,275,734	73,267,415

TABLE 4: WATERWAY DIVERSION INCREASED CRASH COSTS - PART 2

Year	Flood Waterway Diversion							
	Diverted Ton-Miles		Base		Diversion		Increased Crash Cost	NPV
	Rail	Truck	Fatalitiies	Inuries	Fatalitiies	Inuries		
2018	170,419,781	20,634,805	0.01	0.01	0.19	10.46		
2019	171,271,880	20,737,979	0.01	0.01	0.19	10.51		
2020	172,868,824	20,931,416	0.01	0.01	0.19	10.61		
2021	175,232,926	21,217,819	0.01	0.01	0.19	10.75		
2022	178,398,354	21,601,329	0.01	0.01	0.20	10.95		
2023	182,412,002	22,087,629	0.01	0.01	0.20	11.19		
2024	187,334,690	22,684,090	0.01	0.01	0.21	11.49	$ 4,390,055	$ 3,130,049
2025	193,242,755	23,399,961	0.01	0.01	0.21	11.86	$ 4,528,576	$ 3,017,582
2026	200,230,073	24,246,620	0.01	0.01	0.22	12.29	$ 4,692,404	$ 2,922,193
2027	208,410,593	25,237,875	0.01	0.01	0.23	12.79	$ 4,884,210	$ 2,842,655
2028	217,921,490	26,390,349	0.01	0.01	0.24	13.37	$ 5,107,211	$ 2,777,984
2029	228,927,035	27,723,950	0.01	0.01	0.25	14.05	$ 5,365,259	$ 2,727,426
2030	241,623,363	29,262,445	0.02	0.02	0.27	14.83	$ 5,662,953	$ 2,690,428
2031	256,244,306	31,034,172	0.02	0.02	0.28	15.73	$ 6,005,776	$ 2,666,636
2032	273,068,552	33,072,902	0.02	0.02	0.30	16.76	$ 6,400,262	$ 2,655,881
2033	292,428,413	35,418,907	0.02	0.02	0.32	17.95	$ 6,854,204	$ 2,658,179
2034	314,720,613	38,120,263	0.02	0.02	0.35	19.32	$ 7,376,905	$ 2,673,730
2035	340,419,541	41,234,458	0.02	0.02	0.37	20.89	$ 7,979,487	$ 2,702,928
2036	370,093,608	44,830,373	0.02	0.02	0.41	22.72	$ 8,675,280	$ 2,746,371
2037	404,425,460	48,990,736	0.03	0.03	0.45	24.82	$ 9,480,289	$ 2,804,876
2038	444,237,029	53,815,150	0.03	0.03	0.49	27.27	$ 10,413,789	$ 2,879,499
2039	490,520,669	59,423,872	0.03	0.03	0.54	30.11	$ 11,499,048	$ 2,971,572
2040	544,477,962	65,962,514	0.03	0.03	0.60	33.42	$ 12,764,240	$ 3,082,731
2041	607,568,228	73,607,923	0.04	0.04	0.67	37.30	$ 14,243,586	$ 3,214,965
2042	681,569,361	82,575,549	0.04	0.04	0.75	41.84	$ 15,978,772	$ 3,370,672
2043	768,654,347	93,128,723	0.05	0.05	0.85	47.19	$ 18,020,753	$ 3,552,730
						Total	$ 170,323,057	$ 58,089,087

Environmental Flood Damage Savings

The total **environmental flood damage savings, $10.5 million (NPV)**, are based on anecdotal evidence from port directors that 75 percent of cargo would be diverted to rail and truck. Of this 75 percent, a total of 90 percent of this value would diverted to rail while the remaining 10 percent would be diverted to truck. Damage costs for pollutant emissions were based on the Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis from the BCA Guidelines 2021, TSD by quantifying carbon dioxide (CO2), volatile organic compounds (VOCs), nitrogen oxide (NOx), particulate matter, and sulfur dioxide emission damage costs. Average CO2 and nitrous oxide emissions for barge, rail, and truck were based on the Waterways: Working for America, February 2017 from the National Waterways Foundation.

Pollutant emission reduction was then converted to emission amounts (in short tons) for each pollutant – CO2 and NOx - by its emission production factor (tons per million ton – miles for CO2 and pounds per thousand ton-miles for NOx). This is then converted to an environmental damage cost. ***Table 5*** shows the value of environmental damage reduction savings.

TABLE 5: ENVIRONMENTAL COST SAVINGS - FLOOD

	Loss of Use Diversion										
	Waterway Ton-	Diverted Ton-Miles		Metric Tons				Cost		NPV	
Year	Miles	Rail	Truck	Co2	NoX	So2	PM2.5	Polutants	CO2	Polutants	CO2
2024	510,496,794	187,334,690	22,684,090	-2,882	137	17	-2	$ 1,067,574	$ (158,533)	$ 761,165	$ (136,752)
2025	526,599,861	193,242,755	23,399,961	-2,973	142	17	-3	$ 1,111,199	$ (166,507)	$ 740,439	$ (139,447)
2026	545,644,656	200,230,073	24,246,620	-3,081	147	18	-3	$ 1,162,485	$ (175,610)	$ 723,937	$ (142,787)
2027	567,941,774	208,410,593	25,237,875	-3,207	153	19	-3	$ 1,238,150	$ (185,994)	$ 720,615	$ (146,825)
2028	593,865,112	217,921,490	26,390,349	-3,353	160	20	-3	$ 1,307,834	$ (197,837)	$ 711,375	$ (151,626)
2029	623,862,429	228,927,035	27,723,950	-3,523	168	21	-3	$ 1,387,119	$ (211,354)	$ 705,141	$ (157,267)
2030	658,468,330	241,623,363	29,262,445	-3,718	177	22	-3	$ 1,493,245	$ (226,797)	$ 709,430	$ (163,843)
2031	698,320,176	256,244,306	31,034,172	-3,943	188	23	-3	$ 1,583,604	$ (244,467)	$ 703,139	$ (171,464)
2032	744,177,585	273,068,552	33,072,902	-4,202	200	25	-4	$ 1,687,580	$ (264,724)	$ 700,286	$ (180,264)
2033	796,946,352	292,428,413	35,418,907	-4,500	215	26	-4	$ 1,807,226	$ (287,996)	$ 700,873	$ (190,400)
2034	857,707,824	314,720,613	38,120,263	-4,843	231	28	-4	$ 1,944,995	$ (319,642)	$ 704,956	$ (205,166)
2035	927,755,054	340,419,541	41,234,458	-5,239	250	31	-5	$ 2,103,817	$ (350,986)	$ 712,636	$ (218,723)
2036	1,008,637,365	370,093,608	44,830,373	-5,695	272	33	-5	$ 2,287,206	$ (387,283)	$ 724,071	$ (234,312)
2037	1,102,215,453	404,425,460	48,990,736	-6,224	297	36	-5	$ 2,499,381	$ (429,439)	$ 739,477	$ (252,250)
2038	1,210,729,669	444,237,029	53,815,150	-6,837	326	40	-6	$ 2,745,422	$ (478,557)	$ 759,132	$ (272,914)
2039	1,336,884,885	490,520,669	59,423,872	-7,549	360	44	-7	$ 3,031,460	$ (535,972)	$ 783,387	$ (296,755)
2040	1,483,956,264	544,477,962	65,962,514	-8,379	399	49	-7	$ 3,364,923	$ (603,317)	$ 812,673	$ (324,312)
2041	1,655,921,496	607,568,228	73,607,923	-9,350	446	55	-8	$ 3,754,828	$ (682,584)	$ 847,514	$ (356,235)
2042	1,857,626,608	681,569,361	82,575,549	-10,489	500	61	-9	$ 4,212,164	$ (786,710)	$ 888,543	$ (398,620)
2043	2,094,994,534	768,654,347	93,128,723	-11,830	564	69	-10	$ 4,750,360	$ (899,069)	$ 936,517	$ (442,282)
							Total	$ 44,540,572	$(7,593,377)	$15,085,305	$(4,582,245)

Flood Event Travel Time Savings

Travel time savings were calculated to compare whether or not the US-62 bridge over the Arkansas River was open to traffic for trucks and passenger cars. In the event of a barge collision with the bridge, ultimately resulting in a bridge closure, a detour route for traffic would be needed. The assumed distance of this detour route, 14.8 miles, was informed by ODOT and Google Maps. The existing bridge route is 4.4 miles in length which was used as the corridor length assuming the bridge was operable. These calculations provide the total vehicle miles traveled and vehicle hours traveled via the US-62 bridge or the assumed detour route from Fort Gibsonto Muskogee.

The 2021 BCA Guidance includes cost factors for the Truck value of time and the Passenger Vehicle Value of Time as well as a per-mile truck and passenger car operating cost. The average daily traffic (ADT) for the US-62 bridge over the Arkansas river for years 2015 and 2019 was used to identify traffic levels on this route. The growth rate and truck percent values for this route were provided by ODOT. The vehicle miles and hours traveled were calculated by applying the truck and vehicle factors to the ADT to determine the split of cars and trucks traveling the route. The vehicle miles and hours traveled were then calculated based on the corridor lengths for the detour route and operable bridge route. The vehicles were then subtracted from one another based on their given route of detour or bridge to determine the overall reduction in vehicle miles traveled. The vehicle miles traveled produced a **negative benefit of $2.2 million (NPV), which highlights how a detour route would negatively impact operational**.

A similar approach was used to determine the vehicle hours traveled based on either the detour or the operable bridge route. The passenger and truck values were subtracted based on either scenario to determine the reduction in vehicle hours traveled. **The vehicle hours traveled calculation produced a negative savings of $2.7 million**. This identifies the **negative impact to travel time** if a detour route were needed because the bridge was closed. The travel time and operational costs for the detour route and bridge are shown in ***Tables 6 and 7***.

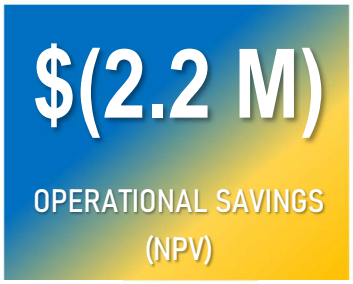


TABLE 6: TRAVEL TIME SAVINGS

Year	Traffic Volumes		Vehicle Hours Traveled				Reduction in VHT		VHT Benefit
			Detour		Bridge				
	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks	
2024	22,138	685	8,487	262	1,845	57	-6,642	-205	$ (125,204)
2025	22,281	689	8,541	264	1,857	57	-6,684	-207	$ (126,019)
2026	22,425	694	8,596	266	1,869	58	-6,728	-208	$ (126,832)
2027	22,570	698	8,651	268	1,881	58	-6,770	-210	$ (127,658)
2028	22,715	703	8,708	269	1,893	59	-6,815	-210	$ (128,464)
2029	22,862	707	8,764	271	1,905	59	-6,859	-212	$ (129,300)
2030	23,010	712	8,820	273	1,918	59	-6,903	-214	$ (130,148)
2031	23,159	716	8,877	275	1,930	60	-6,948	-215	$ (130,982)
2032	23,308	721	8,935	276	1,942	60	-6,993	-216	$ (131,822)
2033	23,458	726	8,993	278	1,955	60	-7,037	-218	$ (132,680)
2034	23,610	730	9,050	280	1,967	61	-7,083	-219	$ (133,531)
2035	23,763	735	9,109	282	1,981	61	-7,128	-221	$ (134,405)
2036	23,916	740	9,167	284	1,993	62	-7,175	-222	$ (135,267)
2037	24,071	744	9,227	285	2,006	62	-7,222	-223	$ (136,133)
2038	24,226	749	9,287	287	2,019	62	-7,268	-225	$ (137,018)
2039	24,383	754	9,347	289	2,032	63	-7,315	-226	$ (137,901)
2040	24,540	759	9,407	291	2,045	63	-7,362	-228	$ (138,797)
2041	24,698	764	9,467	293	2,058	64	-7,410	-229	$ (139,685)
2042	24,858	769	9,529	295	2,072	64	-7,457	-231	$ (140,597)
2043	25,018	774	9,590	297	2,085	64	-7,505	-233	$ (141,509)
								Total	$ (2,663,953)

TABLE 7: OPERATIONAL SAVINGS

Year	Traffic Volumes		Vehicle Miles Traveled				Reduction in VMT		VMT Benefit
			Detour		Bridge				
	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks	
2024	22,138	685	327,647	10,133	97,409	3,013	-230,238	-7,121	$ (105,625)
2025	22,281	689	329,757	10,199	98,036	3,032	-231,721	-7,167	$ (106,305)
2026	22,425	694	331,896	10,265	98,672	3,052	-233,224	-7,213	$ (106,995)
2027	22,570	698	334,035	10,331	99,308	3,071	-234,728	-7,260	$ (107,684)
2028	22,715	703	336,189	10,398	99,948	3,091	-236,241	-7,306	$ (108,379)
2029	22,862	707	338,357	10,465	100,592	3,111	-237,764	-7,354	$ (109,077)
2030	23,010	712	340,553	10,533	101,245	3,131	-239,308	-7,401	$ (109,785)
2031	23,159	716	342,750	10,601	101,899	3,152	-240,851	-7,449	$ (110,494)
2032	23,308	721	344,960	10,669	102,556	3,172	-242,405	-7,497	$ (111,206)
2033	23,458	726	347,186	10,738	103,217	3,192	-243,968	-7,545	$ (111,924)
2034	23,610	730	349,425	10,807	103,883	3,213	-245,542	-7,594	$ (112,646)
2035	23,763	735	351,693	10,877	104,557	3,234	-247,136	-7,643	$ (113,377)
2036	23,916	740	353,962	10,947	105,232	3,255	-248,730	-7,693	$ (114,108)
2037	24,071	744	356,244	11,018	105,910	3,276	-250,334	-7,742	$ (114,844)
2038	24,226	749	358,541	11,089	106,593	3,297	-251,948	-7,792	$ (115,584)
2039	24,383	754	360,867	11,161	107,285	3,318	-253,582	-7,843	$ (116,334)
2040	24,540	759	363,192	11,233	107,976	3,339	-255,216	-7,893	$ (117,084)
2041	24,698	764	365,532	11,305	108,672	3,361	-256,861	-7,944	$ (117,838)
2042	24,858	769	367,901	11,378	109,376	3,383	-258,525	-7,996	$ (118,602)
2043	25,018	774	370,270	11,452	110,080	3,405	-260,190	-8,047	$ (119,365)
								Total	$ (2,247,255)

LOSS OF USE SAVINGS

The Loss of Use portion of this BCA deals with the end of the life of service for existing structures associated with the Tulsa Port of Catoosa liquid dolphins and the Muskogee dolphin line. The structures at the Tulsa Port of Catoosa that support liquid cargo shipment will lose 100 percent of their capacity and the Muskogee dolphin line will lose 30 percent of its capacity at the start of 2025. The savings calculated for the Loss of Use savings section accounts for the environmental, safety, and economic costs that will be discussed in the following sections. The Project will produce **a total of $75.4 million NPV in Loss of Use savings.**

The tons associated with the Tulsa Port of Catoosa and Muskogee dolphin line were informed by each port location. The tonnage values for these existing structures were utilized to determine the value lost when capacity is reduced without improvement in year 2025. The following sections will describe in more detail the assumptions used to determine loss of use savings for environmental, safety, and the economy.

Loss of Use Safety

The loss of use safety savings for this BCA were calculated by assuming cargo that is unable to be ship via the MKARNS due to lost capacity from deteriorating mooring structures would result in 25 percent goods not moved, while 90 percent of the remaining tons would be diverted to rail and 10 percent diverted to truck. The large percentage diverted to rail versus truck is simply because of the volume of cargo that can be handled via rail. Additional assumptions include safety rates per ton-mile for rail, truck, and waterway that report fatalities and injuries per ton-mile for each of these modes of transportation.[4]

The diversion distance assumed was from Mississippi to Muskogee, however, to be conservative Little Rock was used as the starting distance. These assumptions were compiled to determine the total ton-miles diverted from the waterway to rail and truck associated with the ton-miles supported by the 22 structures that will by unusable by 2025. These ton-miles were then applied to the assumed fatality and injury factors to calculate the amount of fatalities and injuries that occur from the diversion. The expected annual fatalities and injuries were calculated for both the no-build and build conditions. **The final value for the increased crash cost as a result of the tonnage diversion** due to waterway closure **produced $66.5 million NPV. The flood waterway diversion increased crash costs are shown in *Tables 8 and 9*.**

TABLE 8: LOSS OF USE SAFETY SAVINGS – PART 1

Year	Loss of Use - Safety					
	Waterway Tons Diverted		Waterway Ton-Miles Diverted		Diverted Ton-Miles	
	Catoosa	Muskogee	Catoosa	Muskogee	Rail	Truck
2018	1,027,433	197,491	457,207,685	77,614,090	205,374,527	24,935,385
2019	1,032,570	198,479	459,493,723	78,002,160	206,401,399	25,060,061
2020	1,042,922	199,471	464,100,148	78,392,171	208,326,505	25,293,935
2021	1,058,644	200,469	471,096,516	78,784,132	211,176,753	25,640,275
2022	1,079,976	201,471	480,589,346	79,178,053	214,993,347	26,104,092
2023	1,107,247	202,478	492,724,830	79,573,943	219,832,837	26,692,261
2024	1,140,882	203,491	507,692,583	79,971,813	225,768,570	27,413,697
2025	1,181,417	204,508	525,730,594	80,371,672	232,892,603	28,279,593
2026	1,229,509	205,531	547,131,532	80,773,530	241,318,144	29,303,710
2027	1,285,957	206,558	572,250,658	81,177,398	251,182,610	30,502,754
2028	1,351,721	207,591	601,515,632	81,583,285	262,651,423	31,896,836
2029	1,427,952	208,629	635,438,607	81,991,201	275,922,686	33,510,039
2030	1,516,025	209,672	674,631,070	82,401,157	291,232,925	35,371,116
2031	1,617,578	210,721	719,822,042	82,813,163	308,864,127	37,514,349
2032	1,734,563	211,774	771,880,387	83,227,229	329,152,371	39,980,594
2033	1,869,308	212,833	831,842,169	83,643,365	352,498,407	42,818,569
2034	2,024,594	213,897	900,944,256	84,061,582	379,380,657	46,086,436
2035	2,203,743	214,967	980,665,666	84,481,890	410,371,207	49,853,743
2036	2,410,738	216,041	1,072,778,552	84,904,299	446,155,524	54,203,821
2037	2,650,362	217,122	1,179,411,221	85,328,821	487,556,837	59,236,748
2038	2,928,374	218,207	1,303,126,242	85,755,465	535,566,345	65,073,024
2039	3,251,725	219,298	1,447,017,513	86,184,242	591,380,766	71,858,131
2040	3,628,834	220,395	1,614,831,253	86,615,163	656,449,131	79,768,227
2041	4,069,926	221,497	1,811,117,248	87,048,239	732,531,293	89,017,254
2042	4,587,457	222,604	2,041,418,511	87,483,480	821,771,280	99,865,859
2043	5,196,651	223,717	2,312,509,857	87,920,898	926,789,579	112,632,611

[4] Bureau of Transportation Statistics

TABLE 9: LOSS OF USE SAFETY SAVINGS – PART 2

Year	Loss of Use - Safety					
	Base		Diversion		Increased Crash Cost	NPV
	Fatalitiies	Inuries	Fatalitiies	Inuries		
2018	0.01	0.01	0.23	12.63		
2019	0.01	0.01	0.23	12.70		
2020	0.01	0.01	0.23	12.81		
2021	0.01	0.01	0.23	12.99		
2022	0.01	0.01	0.24	13.22		
2023	0.01	0.01	0.24	13.52		
2024	0.01	0.01	0.25	13.89		
2025	0.01	0.01	0.26	14.33	$ 5,476,711	$ 3,649,364
2026	0.01	0.01	0.27	14.85	$ 5,675,031	$ 3,534,124
2027	0.01	0.01	0.28	15.45	$ 5,907,225	$ 3,438,058
2028	0.02	0.02	0.29	16.16	$ 6,177,187	$ 3,359,980
2029	0.02	0.02	0.30	16.98	$ 6,489,582	$ 3,298,974
2030	0.02	0.02	0.32	17.92	$ 6,849,977	$ 3,254,375
2031	0.02	0.02	0.34	19.00	$ 7,265,010	$ 3,225,751
2032	0.02	0.02	0.36	20.25	$ 7,742,594	$ 3,212,901
2033	0.02	0.02	0.39	21.69	$ 8,292,163	$ 3,215,844
2034	0.02	0.02	0.42	23.35	$ 8,924,979	$ 3,234,823
2035	0.02	0.02	0.45	25.26	$ 9,654,510	$ 3,270,317
2036	0.03	0.03	0.49	27.46	$ 10,496,894	$ 3,323,048
2037	0.03	0.03	0.54	30.01	$ 11,471,509	$ 3,394,006
2038	0.03	0.03	0.59	32.97	$ 12,601,691	$ 3,484,473
2039	0.04	0.04	0.65	36.40	$ 13,915,611	$ 3,596,058
2040	0.04	0.04	0.72	40.41	$ 15,447,383	$ 3,730,745
2041	0.04	0.04	0.81	45.09	$ 17,238,435	$ 3,890,942
2042	0.05	0.05	0.91	50.59	$ 19,339,241	$ 4,079,553
2043	0.05	0.05	1.02	57.06	$ 21,811,491	$ 4,300,062
				Total	$ 200,777,223	$ 66,493,397

Loss of Use Environmental

The total **environmental savings produces a benefit of $18.9 million (NPV)** for the loss of use in ton-miles associated with the end of life and usabiilty of the 22 structures at the Port of Catoosa, Muskogee, and Oakley's Terminal Muskogee by 2025. The calculation in savings is based on anecdotal evidence from port directors that 75 percent of cargo would be diverted to rail and truck. Of this 75 percent, a total of 90 percent of this value would diverted to rail while the remaining 10 percent would be diverted to truck. Damage costs for pollutant emissions were based on the Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis from the BCA Guidelines 2021, TSD by quantifying carbon dioxide (CO2), volatile organic compounds (VOCs), nitrogen oxide (NOx), particulate matter, and sulfur dioxide emission damage costs. Average CO2 and nitrous oxide emissions for barge, rail, and truck were based on the Waterways: Working for America, February 2017 from the National Waterways Foundation.

Pollutant emission reduction was then converted to emission amounts (in short tons) for each pollutant – CO2 and NOx - by its emission production factor (tons per million ton – miles for

CO2 and pounds per thousand ton-miles for NOx). This is then converted to an environmental damage cost. ***Table 10*** shows the value of environmental damage reduction savings.

TABLE 10: LOSS OF USE ENVIRONMENTAL SAVINGS

	Loss of Use Diversion - Environmental										
		Diverted Ton-Miles		Metric Tons				Cost		NPV	
Year	Waterway Ton-Miles	Rail	Truck	Co2	NoX	So2	PM2.5	Polutants	CO2	Polutants	CO2
2024	587,664,395	225,768,570	27,413,697	-2,987	173	22	-3				
2025	606,102,266	232,892,603	28,279,593	-3,079	178	22	-3	$ 1,793,236	$ (172,440)	$ 1,194,909	$ (144,416)
2026	627,905,063	241,318,144	29,303,710	-3,188	185	23	-3	$ 1,879,773	$ (181,742)	$ 1,170,628	$ (147,773)
2027	653,428,056	251,182,610	30,502,754	-3,316	192	24	-3	$ 2,000,501	$ (192,339)	$ 1,164,310	$ (151,834)
2028	683,098,917	262,651,423	31,896,836	-3,465	201	25	-3	$ 2,117,636	$ (204,414)	$ 1,151,854	$ (156,666)
2029	717,429,808	275,922,686	33,510,039	-3,636	211	27	-3	$ 2,251,370	$ (218,183)	$ 1,144,482	$ (162,348)
2030	757,032,227	291,232,925	35,371,116	-3,834	223	28	-3	$ 2,423,922	$ (233,901)	$ 1,151,588	$ (168,975)
2031	802,635,205	308,864,127	37,514,349	-4,062	236	30	-4	$ 2,574,690	$ (251,874)	$ 1,143,193	$ (176,659)
2032	855,107,616	329,152,371	39,980,594	-4,325	252	32	-4	$ 2,748,232	$ (272,464)	$ 1,140,419	$ (185,535)
2033	915,485,534	352,498,407	42,818,569	-4,627	270	34	-4	$ 2,947,983	$ (296,106)	$ 1,143,279	$ (195,761)
2034	985,005,837	379,380,657	46,086,436	-4,974	291	37	-4	$ 3,178,043	$ (328,294)	$ 1,151,869	$ (210,720)
2035	1,065,147,555	410,371,207	49,853,743	-5,375	315	40	-5	$ 3,443,317	$ (360,105)	$ 1,166,371	$ (224,406)
2036	1,157,682,851	446,155,524	54,203,821	-5,837	342	43	-5	$ 3,749,680	$ (396,926)	$ 1,187,053	$ (240,147)
2037	1,264,740,042	487,556,837	59,236,748	-6,372	374	47	-6	$ 4,104,189	$ (439,677)	$ 1,214,281	$ (258,264)
2038	1,388,881,707	535,566,345	65,073,024	-6,992	411	52	-6	$ 4,515,340	$ (489,472)	$ 1,248,529	$ (279,139)
2039	1,533,201,755	591,380,766	71,858,131	-7,714	454	57	-7	$ 4,993,391	$ (547,662)	$ 1,290,387	$ (303,227)
2040	1,701,446,416	656,449,131	79,768,227	-8,554	504	64	-8	$ 5,550,762	$ (615,898)	$ 1,340,582	$ (331,076)
2041	1,898,165,487	732,531,293	89,017,254	-9,537	562	71	-9	$ 6,202,539	$ (696,198)	$ 1,399,995	$ (363,340)
2042	2,128,901,992	821,771,280	99,865,859	-10,690	631	80	-10	$ 6,967,100	$ (801,726)	$ 1,469,688	$ (406,228)
2043	2,400,430,754	926,789,579	112,632,611	-12,046	712	90	-11	$ 7,866,907	$ (915,506)	$ 1,550,934	$ (450,368)
							Total	$ 71,308,611	$ (7,614,927)	$23,424,350	$(4,556,882)

Loss of Use Economic

The Project **will save approximately $6,272 NPV by 2043**, providing economic competitiveness by decreasing the risk of cargo spillage. This was calculated assuming that the 22 structures mentioned in previous sections were no longer be able to support storage and all associated tonnage would be diverted to truck and rail. Assuming that the cargo weighs the same as water (8.34 pounds), spillage rates associated with barge, truck and rail were utilized to determine the ton spillage that would occur if the cargo was diverted. Spillage tables for barge, rail, and truck were sourced from Waterways: Working for America, February 2017 by the National Waterways Foundation. The economic savings associated with loss of use are displayed in ***Table 11***.

TABLE 11: LOSS OF USE ECONOMIC SAVINGS

Year	Diversion Spillage						
	Waterway Ton-Miles	Diverted Ton-Miles		Spillage (Gallons)	Spillage (Tons)	Lost Good	
		Rail	Truck			Value	NPV
2024	587,664,395	225,768,570	27,413,697	263	1.1		
2025	606,102,266	232,892,603	28,279,593	272	1.1	$ 511	$ 340
2026	627,905,063	241,318,144	29,303,710	282	1.2	$ 530	$ 330
2027	653,428,056	251,182,610	30,502,754	294	1.2	$ 552	$ 321
2028	683,098,917	262,651,423	31,896,836	307	1.3	$ 578	$ 314
2029	717,429,808	275,922,686	33,510,039	323	1.3	$ 608	$ 309
2030	757,032,227	291,232,925	35,371,116	342	1.4	$ 642	$ 305
2031	802,635,205	308,864,127	37,514,349	363	1.5	$ 682	$ 303
2032	855,107,616	329,152,371	39,980,594	387	1.6	$ 728	$ 302
2033	915,485,534	352,498,407	42,818,569	415	1.7	$ 781	$ 303
2034	985,005,837	379,380,657	46,086,436	447	1.9	$ 842	$ 305
2035	1,065,147,555	410,371,207	49,853,743	485	2.0	$ 912	$ 309
2036	1,157,682,851	446,155,524	54,203,821	528	2.2	$ 992	$ 314
2037	1,264,740,042	487,556,837	59,236,748	578	2.4	$ 1,086	$ 321
2038	1,388,881,707	535,566,345	65,073,024	635	2.6	$ 1,195	$ 330
2039	1,533,201,755	591,380,766	71,858,131	702	2.9	$ 1,321	$ 341
2040	1,701,446,416	656,449,131	79,768,227	781	3.3	$ 1,468	$ 355
2041	1,898,165,487	732,531,293	89,017,254	872	3.6	$ 1,640	$ 370
2042	2,128,901,992	821,771,280	99,865,859	979	4.1	$ 1,842	$ 389
2043	2,400,430,754	926,789,579	112,632,611	1,106	4.6	$ 2,080	$ 410
					Total	**$ 18,989**	**$ 6,272**

Project Cost

The capital cost is **$21.9 million** in 2019 dollars per guidance. It covers design and construction based on the moorings being built in 2023-2024

Annual project costs (***Table 12***) include the Net Present Value (NPV) based on a seven-percent discount rate. At the end of the 20-year analysis period, the facility will have a discounted residual value of $16.1 million. This was calculated using the FHWA-recommended 20-year analysis period, then dividing by the time before the moorings will need to be replaced (75-year lifespan). The number is then multiplied by the project cost in today's dollars.

TABLE 12: PROJECT COSTS

20 Year Costs			
Year	Percent Project Cost Paid	Project Cost	Project Cost (NPV)
2021	6%	$ 1,393,100	$ 1,216,787
2022	30%	$ 6,571,170	$ 5,364,032
2023	64%	$ 13,939,630	$10,634,477
2024		$ -	$ -
2025		$ -	$ -
2026		$ -	$ -
2027		$ -	$ -
2028		$ -	$ -
2029		$ -	$ -
2030		$ -	$ -
2031		$ -	$ -
2032		$ -	$ -
2033		$ -	$ -
2034		$ -	$ -
2035		$ -	$ -
2036		$ -	$ -
2037		$ -	$ -
2038		$ -	$ -
2039		$ -	$ -
2040		$ -	$ -
2041		$ -	$ -
2042		$ -	$ -
2043		$(16,062,860)	$ (3,166,739)
Total	**100%**	**$ 5,841,040**	**$14,048,557**

BENEFITS SUMMARY

The McClellan-Kerr Arkansas River Navigation (MKARNS) Project **offers a Benefit-Cost Ratio of 5.38**. This ratio was derived by dividing total discounted benefits by total discounted costs over a 20-year period. It and other figures shown below in ***Table 13*** and throughout this methodology memo were derived based on FHWA 2021 BCA Guidance.

TABLE 13: BENEFITS SUMMARY TABLE

Project	Capital Costs	Project Costs (NPV)	Total Net Benefit	Total Net Benefit (NPV)	Benefit-Cost Ratio
2021 BCA SUMMARY - MKARNS Waterway Project	$ 21,903,900	$ 14,048,558	$ 224,742,959	$ 61,583,173	5.38