APPENDIX A – 2023 PORT OF OAKLAND PIDP: BENEFIT-COST ANALYSIS AND METHODOLOGY REPORT

Executive Summary

This benefit-cost analysis (BCA) is conducted for the Port of Oakland **Partnering on a Resiliency Solution for Seaport Emissions: Implementing Actions in the Seaport's Pathway to Zero Emissions Plan ("Project")**, for submission to the U.S. Department of Transportation (USDOT) as a requirement of a discretionary grant application for the 2023 Port Infrastructure Development Program (PIDP).

The Port of Oakland in partnership with TraPac, LLC, is requesting Port Infrastructure Development Program (PIDP) funds to purchase 10 battery energy storage system (BESS) containers, replace 7 diesel top handlers and 26 terminal tractors (UTRs) with zero-emission electric top handlers and UTRs.

The net capital cost for this project is $44.4 million in undiscounted dollars (2025-2027). At a seven percent real discount rate, these costs are $30.3 million. At the end of 15-year operating period, the assets will retain a residual value of $14.1 million in undiscounted dollars and $3.4 million in discounted dollars.

The project will generate $47.6 million through 2042 in discounted net benefits using a seven percent discount rate (not including residual value). Including the costs of development and the residual value of long-lived assets, the project results in an overall **Net Present Value of $20.7 million** and a **Benefit Cost Ratio (BCR) of 1.7**. The overall project benefit matrix is in Table 1.

Table 1 Project Impacts and Benefits Summary

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Economic Benefit	Monetized Benefits, 2028-2042 ($millions)	Table Reference in BCA
Operating costs and efficiency of cargo handling equipment	Improved efficiency and reduced operating costs	Savings in operating costs associated with reduced peak energy use, fuel costs, and maintenance costs	$32.6	Table 3 (pp. 6/7) Table 4 (pp. 7/8) Table 5 (pp. 9)
Air pollution	Deployment of zero emissions cargo handling equipment	Reduced emissions due to avoided diesel consumption	$15.0	Table 7 (pp. 11)
Residual asset values	Value of remaining useful life on project assets	Remaining value of assets with a service life greater than 15 years	$3.4	Pg. 13

Source: Starcrest Consulting Group

1 Introduction

This benefit-cost analysis (BCA) is conducted for the Port of Oakland's **Partnering on a Resiliency Solution for Seaport Emissions: Implementing Actions in the Seaport's Pathway to Zero Emissions Plan** ("the Project"), for submission to the U.S. Department of Transportation (USDOT) as a requirement of a discretionary grant application for the 2023 Port Infrastructure Development Program (PIDP). The analysis is conducted in accordance with the benefit-cost methodology as outlined by USDOT in the Benefit-Cost Analysis Guidance for Discretionary Grant Programs, released in January 2023. The period of analysis corresponds to 18 years and includes 3 years of construction and 15 years of benefits after operations beginning in 2028. This appendix is organized as follows:

- Section 2 contains the project description.
- Section 3 documents the BCA methodology, including key methodological components, assumptions, and the study scenarios.
- Section 4 contains a detailed explanation and calculation of the project benefits.
- Section 5 contains a detailed explanation and calculation of the project costs.
- Section 6 contains the summary results of the BCA.

2 Project Description

The Port of Oakland (Port) in partnership with TraPac, LLC, is requesting Port Infrastructure Development Program (PIDP) funds to purchase 10 battery energy storage system (BESS) containers, and replace 7 diesel top handlers and 26 terminal tractors (UTRs) with zero-emission electric top handlers and UTRs. In addition to eliminating fossil-fueled cargo-handling equipment, the **Partnering on a Resiliency Solution for Seaport Emissions Project** will deploy charging infrastructure directly integrated into a state-of-the-art energy storage system to reduce energy demand on the grid at peak times, lower TraPac's future electricity costs, and provide resiliency to the terminal in the event of a power outage. Taken together, these components safeguard TraPac's ability to move cargo efficiently, safely, and with reduced emissions even during emergencies. The Port strongly supports the partnership with TraPac on this project as it not only implements its zero-emissions goals but also reduces the impacts to the Port utility grid from energy demand spikes.

This Project involves the following work components.

Table 2 Key Project Components

Component	Units	Statement of Work
Zero-emission top handlers	7	TraPac will purchase seven human-operated battery-electric top handlers The equipment will be deployed in 2027. The top handlers will be second-generation battery-electric top handlers with nearly 1MWh of onboard energy storage, which enables 16 hours of operation at about 26 lifts per hour. It will take the top handlers 5 hours to fully charge from a 10% state of charge.

Component	Units	Statement of Work
Zero-emissions yard tractors (also known as yard trucks or utility tractor rigs/UTR)	26	TraPac will purchase 26 human-operated electric UTRs. The equipment will be deployed in 2027. The performance of new generation terminal tractors models have an electric motor that is comparable with that of a diesel engine and can be equipped with large batteries (for example, 222 kWh), offering a significantly greater operating range. Additionally, new battery technology can be operated in a variety of temperature conditions due to improved onboard thermal management.
Battery energy storage system (BESS)	10	TraPac will procure ten innovative containerized battery energy storage systems (see Figure 1). The equipment provider will provide a modular "plug and play" battery system in a 20' container (stackable). There will be 5' modular attachments on either end with two pre-installed charging units at each end, each with two dispensers (for a total of 4 chargers for each BESS). Each BESS will provide 2.1 MWh, enabling the simultaneous charging of four top handlers or six UTRs plus one top handler or similar combinations. Each BESS is designed to work with any electric vehicle charger using a standard CCS1 connector. Using the standard connector will enable TraPac to deploy more electric equipment in the future without fear of compatibility issues. This project marks the first time that BESS containers have been deployed on a large scale at a container marine terminal, and will serve as an important demonstration case for other terminals as they proceed in their own electrification efforts.
Charging hardware and other infrastructure improvements	40 chargers	TraPac will install direct-current fast charger (DCFC) charging infrastructure to the BESS units (4 chargers per unit) to support the seven electric top handlers and 26 electric UTRs, as well as other supporting infrastructure improvements. This work requires utility trenching and installing new conduit, equipment pads, and related power supply equipment such as switchgear and panelboards. A detailed listing of improvements can be found in the Benefit-Cost Analysis spreadsheet in the Infrastructure Capital Costs tab in Appendix B.

3 Benefit Cost Analysis Framework

The BCA provides an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of a potential infrastructure project. Project benefits and costs are quantified in monetary terms to the extent possible. The overall goal of the project BCA is to assess whether the expected benefits of the project justify the costs. The BCA framework attempts to capture the net welfare change created by the project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off because of the proposed project.

The BCA framework involves defining a Base or "No Build" scenario, which is compared to the "Build" scenario. The BCA assesses the incremental difference between the "Build" scenario and the "No Build" scenario, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life cycle. The importance of future changes is determined through discounting, which is meant to reflect the time value of money.

Key Methodological Components

The Project BCA is conducted in accordance with the benefit-cost methodology recommended by the USDOT.[1] The methodology includes the following key components:

- Defining existing and future conditions under the “Build” scenario versus “No Build”;
- Assessing the project benefits with respect to each of the primary selection criteria defined by the USDOT over 15 years of operations beyond the project completion (the expected useful life of the CHE) when benefits accrue and using USDOT recommended values to monetize changes in emissions while relying on best practices for monetization of other benefits or disbenefits;
- Estimating the project capital costs during project construction; and
- Discounting project benefits and costs to 2021 dollars using a real discount rate of 7 percent consistent with USDOT guidance.

Key Assumptions

The assessment of the project benefits and costs associated with the Project involve the following key assumptions:

- The evaluation period includes the design and engineering, right of way acquisitions, and construction during which capital expenditures are made plus 15 years of operations beyond the project completion within which to evaluate ongoing benefits and costs.
- The construction phase of the project is expected to begin in 2025 and end in 2027.
- Zero emissions equipment will be delivered and deployed in 2027. Project benefits begin in the calendar year immediately following delivery and deployment of the zero-emissions cargo handling equipment and BESS.
- All project benefits and costs are assumed to occur at the end of each calendar year for purposes of present value discounting.
- Monetary values of project costs and benefits are in constant, year-end 2021 dollars.

“Build” and “No Build” Scenarios

The analysis of the Project considered how the balance of costs and benefits resulting from the construction of the project would result in long-term benefits by comparing the “Build” scenario relative to the “No-Build” scenario.

[1] U.S. Department of Transportation. Benefit-Cost Analysis Guidance for Discretionary Grant Programs, January 2023.

- The “No Build” (Base) scenario would consist of leaving the facilities as they currently stand, deploying and operating conventional diesel-powered cargo handling equipment.
- The “Build” scenario would consist of the components described in Section 2. Project Description above.

4 Project Benefits

The benefits of the Project are predominantly associated with Economic Competitiveness, through operating cost savings and Environmental Sustainability, through emissions reductions.

Economic Competitiveness Benefits - Operating Cost Savings

Energy Cost Savings

Energy costs savings from the implementation of the Project represent monthly demand charges avoided through the deployment and use of the BESS. Charging electrical cargo handling equipment (CHE) through the BESS will allow TraPac to avoid energy demand peaks throughout the daily work cycle (e.g., lunch breaks and shift changes). Each BESS system deployed is expected to allow TraPac to avoid demand charges associated with 720 kW per month[2].

Through an analysis of existing monthly electrical bills, it is estimated that the weighted average demand charges amount to $46.42 per kW per month. Savings are calculated by multiplying the projected monthly demand savings per BESS deployed by the average monthly demand charges. By deploying 10 BESS units, TraPac expects to save up to $334,224 per month, or $4,010,688 annually.

Table 3 Energy Cost Savings Benefits Resulting from the Project

	Energy Demand Savings	
Year	Nominal $	7% Discount ($2021)
2028	$4,010,688	$2,497,655
2029	$4,010,688	$2,334,257
2030	$4,010,688	$2,181,549
2031	$4,010,688	$2,038,830
2032	$4,010,688	$1,905,449
2033	$4,010,688	$1,780,793
2034	$4,010,688	$1,664,293
2035	$4,010,688	$1,555,414
2036	$4,010,688	$1,453,658

2 While not quantified in the BCA, the Port pays higher costs for short term energy demands. To the extent the BESS will “peak shave”, the Port will be able obtain longer term power purchase agreements at a lower rate.

	Energy Demand Savings	
Year	Nominal $	7% Discount ($2021)
2037	$4,010,688	$1,358,559
2038	$4,010,688	$1,269,681
2039	$4,010,688	$1,186,618
2040	$4,010,688	$1,108,989
2041	$4,010,688	$1,036,438
2042	$4,010,688	$968,634
Total	$60,160,320	$24,340,816

Source: Starcrest Consulting Group; Evesco

Fuel Cost Savings

Fuel cost savings represent the difference in energy costs between running conventional diesel cargo handling equipment (CHE) and battery electric zero emissions equipment. Annual fuel costs for baseline operations are calculated from current and expected operating hours, equipment fuel consumption, and an anticipated cost of fuel of $5.82 per gallon in 2021 dollars. Project energy costs for EV cargo handling equipment are estimated by the anticipated daily charging requirement for the equipment and the anticipated days of operation per year. Working hours and their related energy costs for both baseline conventional equipment and the EV alternative are increased annually, in line with the Port's anticipated cargo growth[3].

Savings are calculated as the difference between the projected baseline cost of operating diesel equipment and the projected cost of electricity required to charge EV equipment. The expected fuel costs savings are summarized in Table 4, below. Over the analysis period between 2028 and 2042, the net present value of the fuel cost savings amounts to $4.7 million when discounted to 2021 at 7%.

Table 4 Fuel Cost Savings Benefits Resulting from the Project

	Fuel Cost Savings	
Year	Nominal $	7% Discount ($2021)
2028	$725,270	$451,662
2029	$670,250	$390,092
2030	$689,592	$375,092
2031	$709,492	$360,670
2032	$729,967	$346,802

[3] SF Bay Conservation and Development Commission, 2019-2050 Bay Area Seaport Forecast, 2020.

	Fuel Cost Savings	
Year	Nominal $	7% Discount ($2021)
2033	$751,032	$333,467
2034	$772,705	$320,645
2035	$795,004	$308,316
2036	$817,946	$296,461
2037	$841,550	$285,062
2038	$865,836	$274,101
2039	$890,822	$263,562
2040	$916,529	$253,428
2041	$942,978	$243,684
2042	$970,191	$234,314
Total	$12,089,165	$4,737,359

Source: Starcrest Consulting Group

Maintenance Cost Savings

Maintenance cost savings represent the difference in maintenance costs between running conventional diesel cargo handling equipment and battery electric zero emissions equipment. Current costs associated with maintaining conventional cargo handling equipment were provided by the terminal operator and used as the basis for projected costs for conventional equipment. Battery electric vehicles typically require less maintenance than conventional vehicles because the battery, motor, and associated electronics require little to no regular maintenance. Industry studies of the maintenance cost savings for EV's indicate this reduction to be approximately 30%.[4]

Maintenance cost savings for the terminal operator is calculated as the difference between the baseline cost of maintenance for conventional cargo handling equipment and projected cost of maintaining EV replacements. The expected maintenance cost savings are summarized in Table 5, below. Over the analysis period between 2028 and 2042, the net present value of the maintenance cost savings amounts to $3.5 million when discounted to 2021 at 7%.

Table 5 Maintenance Cost Savings Benefits Resulting from the Project

	Maintenance Cost Savings	
Year	Nominal $	7% Discount ($2021)
2028	$574,315	$357,655
2029	$574,315	$334,257

[4] San Pedro Bay Zero Emissions Cargo Handling Equipment Feasibility Assessment

	Maintenance Cost Savings	
Year	Nominal $	7% Discount ($2021)
2030	$574,315	$312,390
2031	$574,315	$291,953
2032	$574,315	$272,853
2033	$574,315	$255,003
2034	$574,315	$238,320
2035	$574,315	$222,729
2036	$574,315	$208,158
2037	$574,315	$194,541
2038	$574,315	$181,814
2039	$574,315	$169,919
2040	$574,315	$158,803
2041	$574,315	$148,414
2042	$574,315	$138,705
Total	$8,614,731	$3,485,513

Source: Starcrest Consulting Group

Environmental Sustainability Benefits – Emissions Reduction

This analysis focuses on environmental sustainability as measured by reduction in cargo handling equipment emissions. Net change in environmental costs is estimated as the changes in cargo handling equipment emissions resulting from the conversion to zero emissions alternatives. This analysis estimates the emissions avoided by operating with zero emissions equipment rather than operating with conventional diesel-powered equipment. Initial emissions reductions are estimated using the EPA Diesel Emissions Quantifier tool (EPA DEQ)[5] based on the age and operating characteristics of the equipment and includes Nitrogen Oxides (NO_x), Particulate Matter ($PM_{2.5}$), Carbon Dioxide (CO_2) and Sulfur Dioxide (SO_2). Emissions reductions in subsequent years are increased annually, in line with the Port's anticipated cargo growth.[6]

The environmental cost of each pollutant was calculated by multiplying the estimated emissions reduction by the corresponding unit emission cost shown in Table 6, per USDOT guidance.

[5] EPA, Diesel Emissions Quantifier (DEQ), accessed April 2021.

[6] SF Bay Conservation and Development Commission, 2019-2050 Bay Area Seaport Forecast, 2020.

Table 6 Unit Emission Cost Used in the Monetization of the Environmental Sustainability Benefits – Cost Per Metric Ton[7]

Year	CO_2	NO_X	SO_X	$PM_{2.5}$
2027	$61	$17,900	$48,700	$865,600
2028	$62	$18,200	$49,500	$879,400
2029	$63	$18,600	$50,400	$893,400
2030	$65	$18,900	$51,300	$907,600
2031	$66	$18,900	$51,300	$907,600
2032	$67	$18,900	$51,300	$907,600
2033	$68	$18,900	$51,300	$907,600
2034	$69	$18,900	$51,300	$907,600
2035	$70	$18,900	$51,300	$907,600
2036	$72	$18,900	$51,300	$907,600
2037	$73	$18,900	$51,300	$907,600
2038	$74	$18,900	$51,300	$907,600
2039	$75	$18,900	$51,300	$907,600
2040	$76	$18,900	$51,300	$907,600
2041	$78	$18,900	$51,300	$907,600
2042	$79	$18,900	$51,300	$907,600
2043	$80	$18,900	$51,300	$907,600
2044	$81	$18,900	$51,300	$907,600
2045	$82	$18,900	$51,300	$907,600

Source: Starcrest Consulting Group

The estimated emissions reduction benefits are calculated by multiplying the annual metric tons of emissions avoided by using zero emissions CHE by the per ton values provided by USDOT and are summarized in Table 7, below. Over the analysis period between 2028 and 2042, the net present value of the emissions reductions amount to $15.0 million when discounted to 2021 at 7% (3% for CO2).

[7] U.S. Department of Transportation. Benefit-Cost Analysis Guidance for Discretionary Grant Programs, January 2023.

Table 7 Environmental Sustainability Benefits Resulting from the Project

	Emissions Benefits	
Year	Nominal $	7% Discount (3% for CO_2) ($2021)
2028	$1,945,128	$1,230,189
2029	$2,035,110	$1,205,938
2030	$2,128,892	$1,182,442
2031	$2,192,068	$1,141,419
2032	$2,257,118	$1,102,017
2033	$2,324,096	$1,064,173
2034	$2,393,060	$1,027,827
2035	$2,464,069	$992,922
2036	$2,539,191	$960,690
2037	$2,614,531	$928,501
2038	$2,692,105	$897,592
2039	$2,771,980	$867,914
2040	$2,854,222	$839,420
2041	$2,941,216	$813,345
2042	$3,028,473	$787,082
Total	$37,181,259	$15,041,471

Source: Starcrest Consulting Group

Project Benefits Summary

The analysis uses standardized factors provided by governmental and industry sources to efficiently determine the monetized value of user and social benefits resulting from the project improvements. Table 8 shows the Project's long-term benefits.

Table 8 Project Benefits by Long-Term Outcome Category, Millions of Dollars

Long-Term Outcome	Benefit (Disbenefit) Category	Benefit (Disbenefit) Description	Benefits (Millions of $)	Benefits 7% Discount (Millions of $2021)
Economic Competitiveness	Energy Cost Savings	Reduction in operating costs due to off-peak charging through BESS	$60.2	$24.3

Long-Term Outcome	Benefit (Disbenefit) Category	Benefit (Disbenefit) Description	Benefits (Millions of $)	Benefits 7% Discount (Millions of $2021)
	Fuel Cost Savings	Reduction in operating costs due to lower cost of operating equipment using electricity rather than diesel fuel	$12.1	$4.7
	Maintenance Cost Savings	Operating cost savings due to expected reduction in maintenance costs for electric cargo handling equipment (CHE)	$8.6	$3.5
Environmental Sustainability	Reduced Emissions	Elimination of emissions from cargo handling equipment (CHE)	$37.2	$15.0
Total			$118.0	$47.6

Source: Starcrest Consulting Group

5 Project Costs

Capital Costs

The schedule and capital costs associated with the Project are presented in Figure 1 and Table 9. The construction phase of the project is expected to begin in 2025 and end in 2027. Zero emissions equipment will be delivered and deployed in 2027. Project benefits begin in the calendar year immediately following delivery and deployment of the zero emissions cargo handling equipment and BESS.

Cost estimates are based on price quotes from equipment manufacturers and preliminary engineering design estimates for the charging infrastructure obtained in February and March 2023. Table 9 summarizes the net project costs, with adjustments as needed for the purposes of this analysis.

Figure 1 Project Schedule

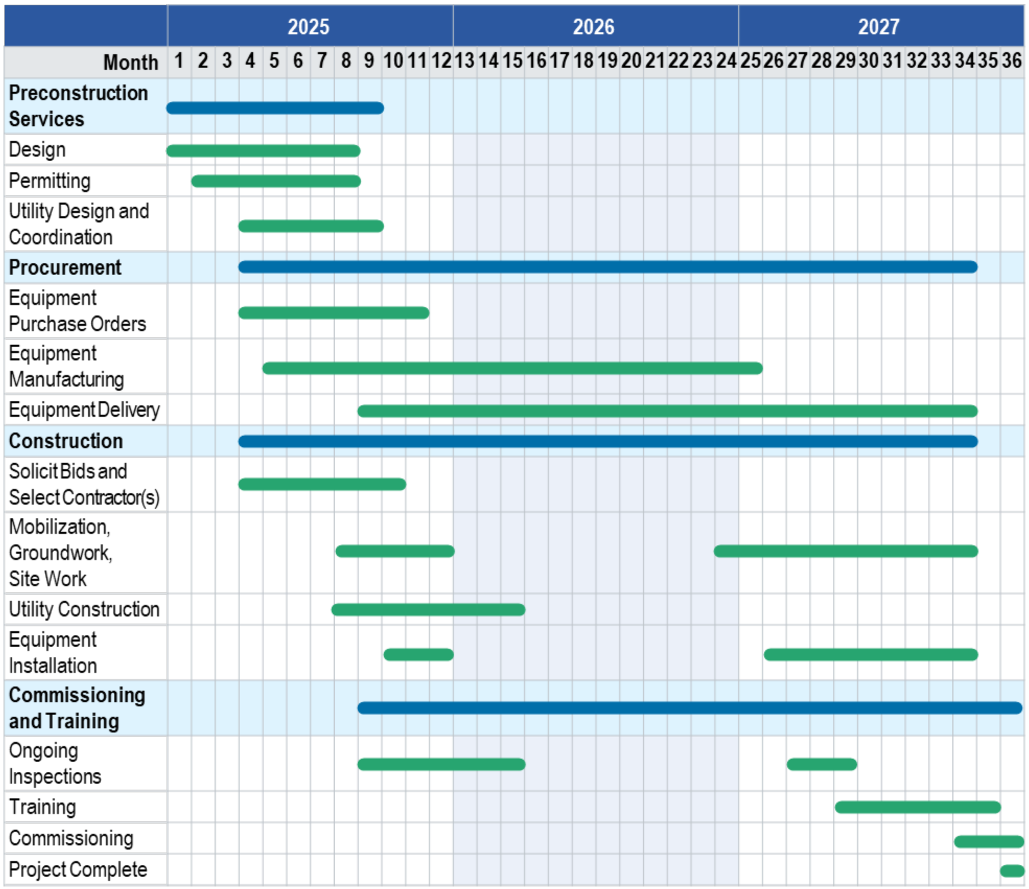

Table 9 Project Capital Costs

	Capital Costs (2021$)	
Year	Undiscounted	Discounted
2025	$4,993,860	$3,809,792
2026	$4,681,161	$3,337,603
2027	$34,773,048	$23,170,750
Total	$44,448,069	$30,318,145

Residual Value of Assets

Some of the assets built under this project will have a useful life exceeding the 15-year BCA time horizon. Therefore, per USDOT guidance, assets with useful lives beyond the BCA time-horizon are valued for the remaining useful life after 2042 and discounted back to present value. The calculated residual value of the long-lived assets such as electrical infrastructure and charging equipment is $14.1 million (undiscounted) and $3.4 million when discounted at seven percent.

6 Summary of Results

Evaluation Measures

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

- Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- Benefit Cost Ratio (BCR): The present value of incremental benefits is divided by the present value of incremental costs to yield the BCR. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.

BCA Results

Table 10 presents the evaluation results for the Project. Results are presented as undiscounted dollars and dollars discounted at seven percent. All benefits and costs are over an evaluation period extending 15 years beyond equipment delivery in 2027 (starting in 2028). The total benefits from the project improvements within the analysis period represent $51.0 million when discounted at seven percent. The total capital costs, including engineering and construction, etc. are calculated to be $30.3 million when discounted at seven percent. The difference of the discounted benefits and costs equals a NPV of $20.7 million, resulting in a BCR of 1.7:1.

Table 10 Project Benefit-Cost Analysis Summary

	Project Lifecycle	
BCA Metric	Undiscounted	7% Discount ($2021)
Benefits		
• Operating Cost Savings	$80,864,217	$32,563,688
• Environmental Sustainability	$37,181,259	$15,041,471
• Residual Asset Value	$14,119,248	$3,409,983
Total Benefits	$132,164,724	$51,015,142
Total Costs	$44,448,069	$30,318,145
Benefit/Cost Ratio	2.97	1.68
Net Present Value	$87,716,655	$20,696,997

Source: Starcrest Consulting Group

Table 10 summarizes the results of the BCA by year. The full spreadsheet model is attached with the application.

Table 11 Project Life-Cycle Costs and Benefits

	Undiscounted		Discounted 7% ($2021)	
Year	Costs	Benefits	Costs	Benefits
2025	$4,993,860	$0	$3,809,792	$0
2026	$4,681,161	$0	$3,337,603	$0
2027	$34,773,048	$0	$23,170,750	$0
2028	$0	$7,255,401	$0	$4,537,160
2029	$0	$7,290,363	$0	$4,264,543
2030	$0	$7,403,488	$0	$4,051,473
2031	$0	$7,486,564	$0	$3,832,872
2032	$0	$7,572,088	$0	$3,627,121
2033	$0	$7,660,131	$0	$3,433,436
2034	$0	$7,750,769	$0	$3,251,086
2035	$0	$7,844,077	$0	$3,079,382
2036	$0	$7,942,140	$0	$2,918,968
2037	$0	$8,041,085	$0	$2,766,662
2038	$0	$8,142,945	$0	$2,623,188
2039	$0	$8,247,805	$0	$2,488,013
2040	$0	$8,355,754	$0	$2,360,640
2041	$0	$8,469,197	$0	$2,241,880
2042	$0	$22,762,083	$0	$5,553,007
Total	$44,448,069	$132,164,724	$30,318,145	$51,015,142

Source: Starcrest Consulting Group