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**Improvements to PR-2 Intersections with PR-102, PR-3108, Mayagüez Terrace, PR-239 (PR-2R) and Luis Llorens Torres St. (San Juan St.), Mayagüez (AC-200241)**

May 22, 2022

**Benefit Cost Analysis Report**

**FY 2020**

**Presented To:**

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# Acronym List

AAA American Automotive Association

AASHTO American Association of State Highway and Transportation Officials

ASTM American Society of Testing and Materials

ATRI American Truck Research Institute

BCA Benefit Cost Analysis

BCR Benefit Cost Ratio

CB Census Bureau

CFR Code of Federal Regulations

CMF Crash Modification Factors

CO2 Carbon Dioxide

COE Corps of Engineers

dBA Decibels

DNER Department of Natural and Environmental Resources

DOT Department of Transportation

EQB Environmental Quality Board

ESA Environmental Site Assessment

FEMA Federal Emergency Management Agency

FHWA Federal Highway Administration

FY Fiscal Year

GHG Greenhouse gas

INFRA Multimodal Freight and Highways Projects

JD Jurisdictional Determination

Km. Kilometer

M Millions

Mega National Infrastructure Project Assistance Grants Program

MPDG Multimodal Project Discretionary Grant

NAAQS National Air Ambient Quality Standards

NEPA National Environmental Policy Act

NHFN National Highway Freight Network

NHPP National Highway Performance Program

NHS National Highway System

NOx Nitrogen Oxides

NOFA Notice of Funds Availability

NOFO Notice of Funds Opportunity

NPV Net Present Value

O&M Operating and Maintenance

OMB Office of Management and Budget

PCMS Portable Changeable Message Signs

PM Particulate Matter

PRASA Puerto Rico Aqueduct and Sewer Authority

PREPA Puerto Rico Electric Power Authority

PRHTA Puerto Rico Highway and Transportation Authority

RCRA Resources Conservation and Recovery Act

ROW Right-of-Way

Rural Rural Surface Transportation Grant Program

SF Standard Form

SOX Sulfur Oxide

STIP Statewide Transportation Improvement Program

UA Urbanized Area

UPR-RUM University of Puerto Rico, Mayagüez Campus

Urb. Urbanization

USC United States Code

USDOT United States Department of Transportation

USEPA United States Environmental Protection Agency

USFWS Fish and Wildlife Service

USGS United States Geological Survey

VOC Volatile Organic Compounds

VSL Value of a Statistical Life

VTTS Value of Travel Time Savings

# Executive Summary

The Puerto Rico Highway and Transportation Authority (PRHTA)’s mission is to lead Puerto Rico towards economic development through an efficient transportation system, safely and in accord with the environment, while procuring the delivery of excellent service. The PR-2 is classified as a principal arterial that runs parallel to the north, west and south coast of the Island. With 143 miles, it is the longest singled signed highway in Puerto Rico. It connects the major and largest municipalities generating and impacting positively the national and regional economic benefits. PRHTA received a Notice of Funding Opportunity (NOFO), issued on March 25, 2022, by DOT through Grants.gov. Therefore, PRHTA thought ATKINS Caribe, hired José A. Batlle and Associates, PSC (JABA) to assist with a multidisciplinary team to achieve the submittal of this grant opportunity application due on May 23, 2022 @ 11:59 PM.

JABA hired Pedro Panzardi and Associates, LLC (PPA) to develop the BCA analysis for this project. Therefore, a benefit-cost analysis (BCA) which evaluates the improvements to multiple PR-2 Intersections in the western Municipality of Mayagüez including the access to one of the most important campuses of the University of Puerto Rico (UPR). This project is identified by the Puerto Rico Highway and Transportation Authority (PRHTA) as AC-200241. The document is part of the application for submission to the U.S. Department of Transportation (U.S. DOT) to solicit applications for three funding opportunities: the National Infrastructure Project Assistance grant program (Mega), the Nationally Significant Multimodal Freight and Highways Projects grant program (INFRA), and the Rural Surface Transportation Grant program (Rural). The analysis was conducted in accordance with the benefit-cost methodology as outlined by U.S. DOT in the Benefit-Cost Analysis (BCA) Guidance for Discretionary Grant Programs, released in March 2022 (revised). The guidance requires to perform the analysis based on year FY 2020 dollars.

Therefore, PPA prepared an analysis following the above-mentioned guidance thus, an analysis corresponding to the period of 30 years including 3 years of construction and 30 years of benefits after operations beginning in 2026. The total benefits at 7% discount (with a sensitivity analysis of 3% discount rate), is approximately $227 million dollars with approximately $151 million in costs for a BCR of 1.50 with a Net Present Value (NPV) of approximately $76 million.

Following the Mega selection criteria, BCR of 1.50 qualifies this project to obtain an Economic Analysis Rating of “High” obtained by projects with benefits exceeding its costs, with a benefit-cost ratio of at least 1.5.

Reviewing the programs requirements, the project contributes to all seven (7) National Goals (23 USC 150) i.e., safety, infrastructure condition, congestion reduction, system reliability, freight movement and economic vitality, environmental sustainability, and reduced project delivery delays.

The project will be issued for bidding in December 2022. The construction is expected to start several months later for a duration of three (3) years, reasonably expected to begin construction 18 months from obligation.

# Introduction

A benefit-cost analysis (BCA) was conducted for the Project for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement for discretionary grants applications. The following sections describe the BCA framework, evaluation metrics, and report findings based on the U.S. DOT’s Benefit-Cost Analysis Guidance for Discretionary Grant Programs as of March 2022.

## BCA Framework

The benefit-cost analysis (BCA) is a systematic process for identifying, quantifying, and comparing expected benefits and costs of a potential infrastructure project. A BCA provides estimates of the anticipated benefits that are expected to accrue from a project over a specified period and compares them to the anticipated costs of the project. As described in the respective sections below, costs would include both the resources required to develop the project and the costs of maintaining the new or improved asset over time. Estimated benefits would be based on the projected impacts of the project on both users of the facility and non-users, valued in monetary terms.

The BCA analysis requires the definition of a baseline or “No Build Alternative” which is compared to the “Build Alternative” of the improvement that will be built as proposed if the grant is awarded.

The preparation of this BCA was conducted in accordance with the U.S. DOT’s Benefit-Cost Analysis Guidance for Discretionary Grant Programs as of March 2022. This methodology includes the following assumptions:

* Defining existing and future conditions under a “No Build Alternative” as baseline as well as under “Build Case”.
* Estimating benefits and costs during project construction and operation, including 30 years of operations beyond the Project completion when benefits accrue.
* Using U.S. DOT recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits.
* Presenting dollar values in real 2020 dollars. In instances where cost estimates and benefits valuations are expressed in historical dollar years, using appropriate Consumer Price Index (CPI) to adjust the values.

## Report Contents

This report is organized as follows:

* Section II provides the project background and analytical assumptions;
* Section III summarizes the project costs;
* Section IV summarizes the project benefits by benefit category; and
* Section V discusses the BCA results.

# Project Overview

## Project’s Description

The Puerto Rico Highway and Transportation Authority (PRHTA)’s mission is to lead Puerto Rico towards economic development through an efficient transportation system, safely and in accord with the environment, while procuring the delivery of excellent service. The PR-2 is classified as a principal arterial that runs parallel to the north, west and south coast of the Island. With 143 miles, it is the longest singled signed highway in Puerto Rico. It connects the major and largest municipalities generating and impacting positively the national and regional economic benefits.

The project AC-200241 consists of the improvements to multiple PR-2 Intersections in the western Municipality of Mayagüez including the access to one of the most important campuses of the University of Puerto Rico (UPR). As shown in Figure 1, at the project location, the PR-2 intersects with PR-102, PR-3108, Chardón St. (Mayagüez Terrace and University Plaza), PR-239 (PR-2R) and Luis Llorens Torres St. (San Juan St.). PR-2 also provides access to the main commercial, industrial, residential, hotel, university, and vocational areas of the Municipality of Mayagüez. However, this highway currently operates with excessive travel times and poor service levels, which negatively impacts the economy and development of the municipality, as well as economic initiatives, such as the development of the Port of Mayagüez, the Port of the Americas in Ponce and the Rafael Hernández Airport in Aguadilla, among others.

Map

Description automatically generated with low confidenceThe proposed project consists in the development of two (2) overpass bridges to be located over the existing PR-2, to eliminate traffic signals in two (2) of the mayor intersections at existing intersection of PR-2 and San Juan Street, just at the entrance of the UPR Campus (La Vita) and at existing intersection of PR-2 and PR-3108. PR-2 service area includes Añasco and Homigueros. This road serves a total locally of 89,080 residents, according to 2010 Bureau of the Census data.

Figure 1. Project Area

Based on the results of preliminary engineering, project AC-200241 consists of improvements of 2.2468 kilometers (1.3960 miles), addressing following objectives:

* Solve the traffic’s congestion and improve the service levels throughout the identified area of the PR-2;
* Considers the elimination of the traffic lights in the six (6) intersections;
* Considers the elimination of the direct accesses to the PR-2;
* Considers the possible intersections unevenness in the substitution of the traffic lights;
* Considers the construction of the marginals on both sides of the PR-2, for the local transit, pedestrians, cyclists that would access the PR-2, using controlled access, and;
* Minimize the environmental impact in the construction of the proposed project.

The project also considers aspects related to mobility such as; vehicular operation, pedestrian access, and cycling facilities. Safety benefit aspects were assessed in the traffic plan and traffic management plan. Geotechnical, geometry, construction costs, constructability and traffic maintenance during construction, acquisitions, utility, future collective transportation, and urban architecture. Due to the result of the studies and stakeholders’ comments, the proposed project has added additional construction activities to maximize level of service, thus requiring amending field studies to accommodate for agreed changes. These changes have been discussed already with FHWA. Currently, a revised Categorical Exclusion to incorporate all changes will be submitted by October 2022. A detailed description of the project is included in the application appendixes.

The approximate construction cost of the project in FY2022 is $185,046,285.60, to be funded by MPDG (60%), State (20%) and Federal funds (20%) from other programs. To comply with one or more stable and dependable funding or financing sources, PRHTA has identified state and federal matching funds for the project. Based on the funding distribution considered for this critical project, it is evident that it cannot be completed in a timely and efficient manner without federal funding. Nevertheless, the PRHTA, as applicant has the sufficient legal, financial, technical capacity to carry out the project.

The project’s cost effectiveness was assessed, using a Benefit Cost Analysis (BCA), which provided a Best Cost Ratio (BCR) of over 1.50, thus qualifying for a High-Performance punctuation in this category for the Mega funds in the application. The project will be issued for bidding in December 2022. The construction is expected to start several months later for a duration of three (3) years, reasonably expected to begin construction 18 months from obligation.

Reviewing the programs requirements, the project contributes to all seven (7) National Goals (23 USC 150) i.e., safety, infrastructure condition, congestion reduction, system reliability, freight movement and economic vitality, environmental sustainability, and reduced project delivery delays.

## General Assumptions

The project construction period is 2023 - 2026, starting operations in year 2026. The BCA is developed for the evaluation of a 30-year period covering the years 2026 to 2056. The discount rate is 7%. A sensitivity analysis is conducted with a 3% discount rate. All figures are expressed in 2020 dollars.

# Project Costs

## Capital Costs

Table 1 summarizes the project costs, expressed in 2020 dollars using Consumer Price Index cumulative factor of -10.48%.

**Table 1. Project Schedule and Costs, Millions of 2020 Dollars**

|  |  |  |
| --- | --- | --- |
| **Variable** | **Unit** | **Value** |
| Construction Start | year | 2023 |
| Construction Ends | year | 2026 |
| Construction Duration | years | 3 |
| Project Opening | year | 2026 |
| Capital Cost – Construction | $M | $150,531,543.70 |
| Capital Cost – Soft Costs | $M | $15,121,891.17 |
| Capital Expenditures (CAPEX) | $M | $165,653,434.87 |
| Analysis period | 30 years | 2026-2056 |

**Source: Puerto Rico Highway and Transportation Authority, JABA, and PPA**

## Operations and Maintenance Costs

Transportation facilities require ongoing operating and maintenance (O&M) to provide service and keep the assets in operating condition. The O&M costs of the new or improved facility throughout the entire analysis period should be included in the BCA and should be directly related to the proposed service plans for the project.

O&M costs were estimated at $36,883.72 per year. This was calculated using the U.S. average annual cost for road maintenance of $26,421.00, multiplied by the project’s distance of 1.3960 miles. The Table 2 summarizes the project’s costs to be included in the BCA as a disbenefits.

***Table 2. Operations and Maintenance Costs***

|  |  |  |
| --- | --- | --- |
| **Variable** | **Unit** | **Value** |
| **CAPEX** | 2020 Dollars | $ 165,653,434.87 |
| **Annual Maintenance** | Dollars per Year | $36,883.72 |
| **Miles** | Miles | 1.3960 |
| **Cost per Mile** | Dollars per Mile | $26,421 |
| **Years of maintenance** | Years | 30 |

**Source: Average Annual Cost for Road Maintenance by Operational Maintenance Level**

# Project Benefits

The purpose of the proposed improvements to PR-2 is as follows:

* 1. Improve regional mobility.
  2. Alleviate local system congestion due to signalized intersection along the corridor and improve local mobility by separation of turning movements from thru traffic.
  3. Provide for efficient movement of freight.
  4. Provide an efficient and safety traffic flow at entrance to UPR Mayagüez. Campus, Vocational School at San Juan Street, and Chardón Street (Mayaguez Terrace) and University Plaza Commercial.

The proposal for the development of Project AC-200241 has gone through a rigorous evaluation of alternatives, including stakeholders from the public and private sectors, as well as a broad process of citizen participation. Therefore, the disbenefits of the project have been significantly reduced and are outweighed by the benefits shown in the BCA.

For the foundation of the BCA, a comprehensive effort to develop the best monetization model possible was made based on the consultation with subject matter experts, technical studies, and reference manuals available. The project purposes were described and broken down into categories of long-term outcomes.

**Table 3. Project Benefits by Long-Term Outcome Category**

| **Long-Term Outcome** | **Benefit (Disbenefit)** | **Description** | **Monetized** | **Quantified** | **Qualitative** |
| --- | --- | --- | --- | --- | --- |
| **Economic Competitiveness** | Travel Time Savings | Based on travel saved hours | x |  |  |
| Flood Savings Benefits | HMP 2019 Mayaguez, 2019, PPA Calcs | x |  |  |
| Vehicle Operating Costs | Based on travel saved hours | x |  |  |
| Fuel Savings | Based on gasoline savings estimates | x |  |  |
| **Safety** | Reduced Incidents | Based on historical data | x |  |  |
| Property damages | Based on historical data | x |  |  |
| Personal Injuries | Based on historical data | x |  |  |
| **Environmental Sustainability** | Emissions Reduction | CO2, SOx, NOx values | x |  |  |
| Environmental Damage | N/A |  |  |  |
| Noise Reduction | N/A |  |  |  |
| **System Reliability** | Service Reliability | Project purpose |  |  | x |
| Project Delivery | N/A |  |  |  |
| Program Management | N/A |  |  |  |
| **Infrastructure Condition** | Hazard Resilience | N/A |  |  |  |
| Facility Damage | N/A |  |  |  |
| Road Condition | Project purpose |  |  | x |

Based on the limitations of the studies carried out, the results obtained for travel time savings, fuel consumption and emissions corresponded to two hours of a typical school. Therefore, the sum of the totals of these performance measures were presented to calculate an annual projection. The number of 182 days comes from the calendar published by the Department of Education that establishes this number of school days. Consequently, this BCA must be considered conservative for the estimate of project’s benefits.

## Demand Projections

### Traffic Growth

This highway is currently operating with excessive travel times and deficient levels of service thus negatively impacting the economy and the development of the municipality as well as the economic initiatives. According to traffic data obtained from the Puerto Rico Highway and Transportation Authority (PRHTA), Traffic Analysis Office, the annual growth on Highway PR-2 corridor under study shows a growth factor of 1.31 in twenty years which is 1.5% growth per year.

## Economic Competitiveness

### Travel Time Savings

Land use along the project area included: commercial, industrial, residential, university, access to hotel facilities and other land uses intermixed in the area that can be defined as local trip generators. Added to this traffic demand, is the condition of this highway as a regional traffic commuter for the area connecting the Municipality of Mayagüez with the rest of towns along this corridor.

This project would contribute to rise the economic competitiveness through improvements in the mobility of people and goods in the study area, resulting in reduced travel time. For modelling those benefits, data inputs from project’s traffic study, volume and distribution assumptions, and the hourly values recommended to monetized savings from the Benefit Cost Analysis Guidance for Discretionary Grant Programs of March 2022 were utilized, resulting in $5.9M of travel savings per year.

**Table 4. Travel Time Savings Data Inputs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table A-3 values** | | **Mode distribution** | **Annual hours saved** | **Distribution per mode** | **Value** |
| **Personal** | $ 16.20 | 30% | $ 229,000.96 | $ 68,700.29 | $ 1,112,944.66 |
| **Business** | $ 29.40 | 50% | $ 229,000.96 | $ 114,500.48 | $ 3,366,314.10 |
| **Truck Drivers** | $ 32.00 | 20% | $ 229,000.96 | $ 45,800.19 | $ 1,465,606.14 |
| **Total per year** | | | | | **$ 5,944,864.90** |

Source: DOT Benefit Cost Analysis Guidance for Discretionary Grant Programs of March 2022, Traffic Study AC-200241, PPA Calculations

The Travel Time Savings costs were estimated, as summarized in Table 5, for the project’s life returning in $178.3M in Undiscounted 2020 Dollars, $62.7M with a 7% Discount and, $108.5M at 3% Discount Rate.

**Table 5. Travel Time Savings**

|  |  |  |  |
| --- | --- | --- | --- |
| **Benefit** | **Project life 2026-2056** | | |
| **Undiscounted** | **Discounted 7%** | **Discounted 3%** |
| **Value of travel time savings** | $178,345,946.87 | $62,677,270.36 | $108,500,211.21 |

**Source: PPA Calculations**

### Flood Savings

Another element of economic competitiveness included in this BCA was the modelling of floods in the project area. PPA photo-interpreted the flood areas in the project footprint by using post-disaster imagery provided by NOAA for Hurricane María (2017). The average loss values were obtained from the Hazard Mitigation Plan (2019) which established the average loss costs per residential and non-residential structures as: $19,089.00 per residential unit and, $1,327,000.00 for non-residential, including commercial self-standing stores and related expenses due to loss of services. Parking lots compensation was obtained from the FEMA Standard Values Guide (Appendix C, COM 10). This value is defined as $0.36 dollars/SF/month. PPA identified at least two (2) flood events in the project area from the HMP document list. In addition, a National Weather Service flood probability calculator was used to estimate the percentage of 100-year flood chance with a return of 26%, as presented on Table 6.

***Table 6. Flood Savings Data Input***

| **Impacted Area** | **Units** | **Average Lost** | **Total** | **Reference** |
| --- | --- | --- | --- | --- |
| Mayagüez Terrace | 42 | $19,089.00 | $801,738.00 | HMP 2019 Mayagüez, 2019 |
| Urb Ensanche Ramírez | 20 | $19,089.00 | $381,780.00 | HMP 2019 Mayagüez, 2019 |
| Commercial self-standing stores | 18 | $1,327,000.00 | $3,886,000.00 | HMP 2019 Mayagüez, 2019 |
| UPR General Studies Parking Lot (738 Parking spaces in 234,000 SF Lot) | 1 | $8,424.00 | $8,424.00 | 2008 FEMA Std Values App C (COM 10) 0.36 dollars/p2/month |
| **Total per Event based on HMP values and FEMA 2008 Std values** | | | **$25,077,942.00** | per event (2 events: Sept 2010, Sept 2017) |
| **Probability of Annual Occurrence** | | **26%** | **$6,520,264.92** | <https://www.weather.gov/epz/wxcalc_floodperiod>, PPA Calculations |

The Flood Savings costs were estimated, as summarized in Table 7, for the project’s life returning in $195.6M in Undiscounted 2020 Dollars, $68.7M with a 7% Discount and, $119.0M at 3% Discount Rate.

***Table 7. Flood Savings***

|  |  |  |  |
| --- | --- | --- | --- |
| **Benefit** | **Project life 2026-2056** | | |
| **Undiscounted** | **Discounted 7%** | **Discounted 3%** |
| **Flood Savings** | $195,607,947.60 | $68,743,767.00 | $119,001,883.70 |

**Source: PPA Calculations**

Vehicle Operation Cost – Trucks and Fuel Savings - Cars (80%)

For the Vehicle Operating Costs, a mixed approach was developed since the data available from the traffic study presented the accumulated delay of the studied intersections during the peak hours. Assuming that traffic proportion is 80% cars and 20% trucks, the Average Marginal Cost Per Hour 2011-2020 developed by American Truck Research Institute (ATRI) was applied to only 20% of the peak hour savings. Savings from this calculation were estimated in $ 3.1 M annually as summarized in Table 8.

**Table 8. Savings from Vehicle Operating Costs**

|  |  |  |
| --- | --- | --- |
| **Motor Carrier** | **Marginal Cost** | **Savings** |
| **Vehicle based** | | |
| Fuel cost | $12.52 | $573,416.00 |
| Truck/Trailer Lease or Purchase Payments | $11.00 | $503,800.00 |
| Repair & maintenance | $6.00 | $274,800.00 |
| Truck Insurance Premiums | $3.55 | $162,590.00 |
| Permits & Licenses | $0.67 | $30,686.00 |
| Tires | $1.73 | $79,234.00 |
| Tolls | $1.49 | $68,242.00 |
| **Driver based** | | |
| Driver wages | $22.97 | $1,052,026.00 |
| Driver benefits | $6.94 | $317,852.00 |
| **Total:** | **$66.87** | **$3,062,646.00** |

**Source: (**[**https://truckingresearch.org/**](https://truckingresearch.org/)**), PPA Calculations**

In the case of car operating costs, due to the lack of more comprehensive data, the most feasible approach was to calculate the annual savings in gasoline consumption only. Using the U.S. Energy Information Administration, the current average gasoline price in 2022 is $3.84, deflated to 2020 Dollars returns $3.35 per gallon. Calculations using this methodology returned an annual savings value of $23,055.70, as presented on Table 9.

**Table 9. Annual Gas Savings Value**

|  |  |
| --- | --- |
| **Cars** | **Values** |
| Gasoline Cost (2020) | $3.35 |
| Annual Gasoline Savings Cars | $6,874.08 |
| Annual Gas Savings | **$23,055.70** |

**Source:** [**https://www.eia.gov/**](https://www.eia.gov/)**, PPA Calculations**

Over 30 years, the summarized value of Vehicle Operating Cost Savings, for trucks and cars, is about $92.5M in undiscounted 2020 dollars, with a present value of about $32.5M using a 7% discount rate, and $56M when present value is calculated at 3% discount rate.

**Table 10. Vehicle Operation Cost – Trucks and Fuel Savings – Cars**

|  |  |  |  |
| --- | --- | --- | --- |
| **Benefit** | **Project life 2026-2056** | | |
| **Undiscounted** | **Discounted 7%** | **Discounted 3%** |
| Trucks (20%) | $91,879,380.00 | $32,289,765.15 | $55,896,600.46 |
| Cars (80%) | $691,670.90 | $243,078.38 | $420,791.39 |
| **Totals:** | **$92,571,050.90** | **$32,532,843.54** | **$56,317,391.85** |

## System reliability

This project will not have any system reliability benefits estimated.

## Safety

The safety benefits assessed in this analysis include a reduction in fatalities and injuries, as well as a reduction in other property damage crash costs resulting directly from the project. Closing intersections and the provision of grade separator, the number of access points within the functional areas of intersection reduces the potential of crashes. Also, restricting access to commercial properties near intersections by closing access on major road reduces conflicts between through and turning movements. The reduction of conflict will reduce the rear-end crashes related to speed changes near cross-street and angle crashes related to vehicles turning in and out of cross-street.

To quantify the number of reduced incidents, several of Crash Modification Factors (CMF) were considered based on each counter-measure included in the project. For example, the CMF for removing unwarranted signals, or converting at-grade intersections into grade-separated intersections was found to be 0.73 according to data in the CMF Clearinghouse, <https://www.cmfclearinghouse.org/>. The CMF for installing a pedestrian countdown timer is 0.91, providing a raised median is .78, installing raised median with marked crosswalk is 0.54, and adding a continuous auxiliary lane for weaving between entrance and exit ramp is 0.77 for fatal and injury crashes. Since it was not possible to connect the historical crash data to each counter-measure and associated CMF, a general CMF 0.73 was used. Based on the USDOT guidance on using CMF to quantify safety benefits, the number of reduced crashes was calculated as:

N x (1-CMF), where N is the number of annual crashes.

Table 11 shows safety data inputs used to calculate benefits based on the average frequency of the historical incidents from years 2013, 2014 and 2015 for the study area.

**Table 11. Safety Data Inputs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Type of Damage** | **Total Annual incidents** | **KABCO Value** | **Reduced incidents (0.73 CMF)** | **Incident Reduction Value** |
| Fatal crash | 1 | $12,837,400.00 | 0.27 | $3,466,098.00 |
| Injury crash | 29.3 | $302,600.00 | 7.92 | $2,396,592.00 |
| Property damage | 95 | $4,600.00 | 25.65 | $117,990.00 |
| **Totals** |  |  |  | **$5,980,680.00** |

**Source: Puerto Rico Highway and Transportation Authority, CMF Clearinghouse, PPA Calculations**

Based on this calculation, about 25.65 property damage instances, 7.92 injuries, and 0.27 fatalities are estimated to be reduced every year. The injuries are converted using the KABCO Scale which measures the observed severity of the victim’s functional injury at the crash scene, as outlined in the 2022 USDOT BCA guidelines. The value of overall safety benefits is about $179.4M in undiscounted 2020 dollars, or $54.5M when discounted at 7% or $109.2M at 3% discount rate, as presented in Table 12.

**Table 12. Safety Benefits**

|  |  |  |  |
| --- | --- | --- | --- |
| **Safety Benefits** | **Total 30 Years** | | |
| **Undiscounted** | **Discounted (7%)** | **Discounted (3%)** |
| **$179,420,400.00** | **$54,567,994.03** | **$109,153,875.58** |

**Source: PPA Calculations**

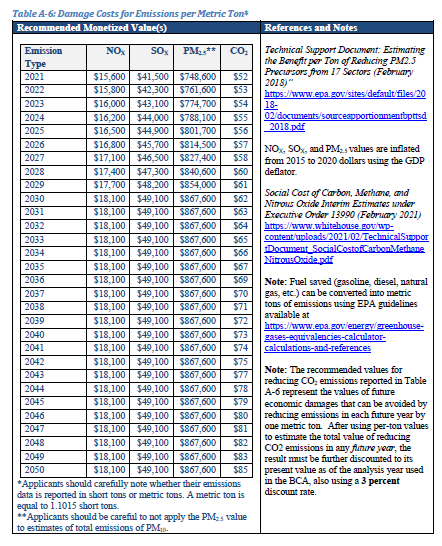
## Infrastructure Condition

This project will not have any infrastructure condition benefits estimated.

## Environmental Sustainability

Transportation infrastructure projects may also reduce the transportation system’s impact on the environment by lowering emissions of air pollutants that result from production and combustion of transportation fuels. The economic damages caused by exposure to air pollution represent externalities because their impacts are borne by society, rather than by the travelers and operators whose activities generate those emissions. Transportation projects that reduce overall fuel consumption, either due to improved fuel economy or reduction in vehicle miles traveled, will typically also lower emissions, and may thus produce climate and other environmental benefits.

The most common local air pollutants generated by transportation activities include sulfur oxides (SOX), nitrogen oxides (NOX), and fine particulate matter (PM2.5). Another important type of emissions from the combustion of transportation fuels is greenhouse gases (GHGs), specifically carbon dioxide (CO2). Recommended monetized values by year for reducing emissions of these pollutants are listed in the following figure obtained from Table A-6 of the DOT BCA Guidelines 2022. Those values were applied for three of the four main pollutants listed.



Based on the Traffic Study data, the emission values on Table 13 were calculated for CO2, NOx and SOx emissions.

**Table 13. Emissions Data Inputs**

|  |  |
| --- | --- |
| **Data Input** | **Value** |
| CO2 Emission (ton) | 77.9 |
| NOx Emission (ton) | 0.9 |
| SOx Emission (ton) | 0.04 |

**Source: Traffic Study**

Table 14 presents total emission benefits for the project life totalizing undiscounted $716,811.30, $211,460.61 discounted at 7% and, $432,041.87 discounted at 3% rate.

**Table 14. Emissions Benefits**

|  |  |  |  |
| --- | --- | --- | --- |
| **Emissions Benefits** | **Project life 2026-2056** | | |
| **Undiscounted** | **Discounted (7%)** | **Discounted (3%)** |
| **$716,811.30** | **$211,460.61** | **$432,041.87** |

**Source: Table A-6 Damage Costs for Emissions per Metric Ton DOT Guidelines 2022, PPA Calculations**

## 

## Residual Value

The analysis period used in the BCA is tied to the expected useful life of the infrastructure asset constructed or improved by the project. However, some transportation assets are designed for very long-term use, and thus have an expected life that would exceed the maximum analysis period recommended by USDOT.

Residual value should be estimated using the total project cost and the remaining service life at the end of the analysis period. For this BCA the analysis period is 30 years of operation, but the project has a useful service life of 60 years. The total project cost, in real dollars, is $151,214,974.56 M. The residual value of the project would thus be $8,107,746.13.

**Table 15: Residual Value**

|  |  |
| --- | --- |
| **Analysis period** | 30 years |
| **Total Service Life** | 60 years |
| **Total cost 7% Discount** | $151,214,974.56 |
| **Residual value 7%** | $8,107,746.13 |

**Source: PPA Calculations**

# Summary of Results

## Evaluation measures

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following common benefit-cost evaluation measures are 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 evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. 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

The table below presents the evaluation results for the project. Results are presented in undiscounted, discounted at 7 percent and discounted at 3 percent (sensitivity) as prescribed by the U.S. DOT. All benefits and costs were estimated in constant 2020 dollars over an evaluation period extending 30 years beyond system completion in 2026.

The total benefits are about $722,269,643.95 in undiscounted 2020 dollars. Discounted at 7%, the present value of total benefits is about $226,841,081.66. Discounted at 3%, the present value of total benefits is about 423,491,385.54.

The total costs are about $166,759,946.47million in undiscounted 2020 dollars. Discounted at 7%, the present value of total costs is about $151,214,974.56. Discounted at 3%, the present value of total costs is about 159,596,216.97.

With a 7% discount rate, the project NPV is about $75,626,107.10, with a BCR of 1.50. With a 3% discount rate, the project NPV is about $263,895,168.58, with a BCR of 2.65.

**Table 16: Benefit Cost Analysis Results, Million of 2020 Dollars**

| **Benefits** | **Undiscounted** | **7% Discount** | **3% Discount** |
| --- | --- | --- | --- |
| **Value of Travel Time Savings** | $178,345,946.87 | $62,677,270.36 | $108,500,211.21 |
| **Safety** | $179,420,400.00 | $54,567,994.03 | $109,153,875.58 |
| **Vehicle Operation Cost - Trucks (20%)** | $91,879,380.00 | $32,289,765.15 | $55,896,600.46 |
| **Fuel Savings - Cars (80%)** | $691,670.90 | $243,078.38 | $420,791.39 |
| **Emission Reduction CO2, NOx, SOx** | $716,811.30 | $211,460.61 | $432,041.87 |
| **Residual Value** | $75,607,487.28 | $8,107,746.13 | $30,085,981.34 |
| **Flood Savings** | $195,607,947.60 | $68,743,767.00 | $119,001,883.70 |
| **Total:** | **$722,269,643.95** | **$226,841,081.66** | **$423,491,385.54** |
|  |  |  | |
| **Costs** | **Undiscounted** | **7% Discount** | **3% Discount** |
| **Total Costs (CAPEX and O&M)** | $166,759,946.47 | $151,214,974.56 | $159,596,216.97 |
|  |  |  |  |
| **Totals** | **Undiscounted** | **7% Discount** | **3% Discount** |
| **Cumulative Benefits (2020 Dollars)** | $722,269,643.95 | $226,841,081.66 | $423,491,385.54 |
| **Cumulative Costs (2020 Dollars)** | $166,759,946.47 | $151,214,974.56 | $159,596,216.97 |
| **BCA Ratio** | **4.33** | **1.50** | **2.65** |
|  |  |  |  |
| **NPV** | **$555,509,697.48** | **$75,626,107.10** | **$263,895,168.58** |