Routes 7/15 Interchange
Norwalk, Connecticut
State Project No. 102-358

Environmental Assessment,
Draft Section 4(F) Evaluation and
Environmental Impact Evaluation

Appendix L
Benefit Cost Analysis

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Prepared for:
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EXECUTIVE SUMMARY

A Benefit-Cost Analysis (BCA) was conducted for the proposed improvements to the Route 7/15 interchange in Norwalk. The goal of the analysis is to evaluate the societal impacts associated with the proposed investment in highway improvements, which are assessed through a present-value comparison of the monetized value of benefits from the project against projected project costs. The analysis compares the cost of constructing either Alternative 21D or Alternative 26 relative to the calculated benefits that are projected to be gained by all users as a result of a reconstructed and improved Route 7/15 interchange.

It should be noted that the BCA focuses solely on quantifiable (tangible) benefits and costs. The BCA does not measure non-quantifiable (intangible) benefits and costs such as increased transit ridership and improved multimodal connectivity by reconstructing and improving the Route 7/15 interchange. Furthermore, economic factors such as changes to business activity, retail spending, tax revenues, property values, local employment, local wages, and gross-regional product, are not evaluated in this BCA. Economic factors would be evaluated through an Economic Impact Analysis, which is a separate, independent analysis.

Calculated values of existing and/or future benefits and costs are tabulated annually for the duration of the study period, extending through the year 2047. This represents an operating period of 20 years after construction completion per USDOT guidance.

The analysis year, which represents the beginning of the benefit-cost analysis period, is 2018. This represents the latest year where dollar values for costs and benefits are available.

Anticipated benefits to be experienced over the analysis period are:

- Travel time savings with a completed interchange as alternative, shorter routes are provided for missing moves along local mainlines;
- Reductions in crashes caused by substandard acceleration and deceleration lengths, stop-controlled on-ramps, and tight ramp radii at the Main Avenue and Route 15 interchange;
- Reductions to operating costs for roadway users along key transportation corridors; and
- Reductions to emissions from vehicles within the study area.

Anticipated costs to be incurred over the analysis period are:

- Capital construction costs for Alternative 21D or Alternative 26; and
- Maintenance costs for roadways and bridges in proximity to the Route 7/15 interchange.

Results of the BCA are presented in Table 1 for each alternative. Typically, a project is considered viable if the benefit/cost ratio (B/C) is greater than 1.0; that is, the net present value of project benefits is greater than the net present value of project costs. Higher B/C ratios indicate a greater amount of project benefits when weighed against project costs. Assuming a discount rate of five percent to reflect the time value of money, Alternative 21D has a calculated benefit/cost (B/C) ratio of 2.37 while Alternative 26 has a B/C ratio of 3.89. It should be noted that the No Build Alternative, which represents conditions should the project not be completed, generates no theoretical benefits. For that reason, a B/C ratio is not prepared for the No Build Alternative.

Table 1: BCA Results for Route 7/15 Interchange Build Alternatives

Financial Indicator	Undiscounted Benefits & Costs		Discounted Benefits & Costs (5 Percent Rate)	
	Alternative 21D	Alternative 26	Alternative 21D	Alternative 26
Total Project Benefits	$701,051,709	$628,691,145	$281,586,249	$252,521,717
Total Project Costs	$97,178,697	$56,276,905	$118,980,010	$64,948,381
Net Present Value	-	-	$162,606,239	$187,573,336
B/C Ratio	**-**	**-**	**2.37**	**3.89**

Further information, including methodologies employed, pertinent analysis assumptions, and resources used, is discussed herein.

1.0 INTRODUCTION

Benefit-Cost Analysis (BCA) is an economic evaluation method which uses monetized values of total incremental benefits versus total incremental costs to compare a set of Build alternatives to a base case (No Build) alternative. This analysis evaluates incremental differences between the Build and No Build alternatives, determining additional benefits and costs associated with each. The BCA attempts to quantify infrastructure investment into financial terms to consider the fact that benefits and costs accrue over the life of a project while capital costs are incurred during the years of construction. Transportation related input variables that can be monetized are travel time costs, vehicle operating costs, safety costs, ongoing maintenance costs, and the remaining capital value at the horizon year of the analysis. Ultimately, the BCA seeks to determine whether these benefits exceed the capital and operating costs and whether a project is viable or not.

It should be noted that the BCA focuses solely on quantifiable (tangible) benefits and costs. The BCA does not measure non-quantifiable (intangible) benefits and costs such as increased rail and transit ridership, improved public spaces, and improved multimodal connectivity by reconstructing and improving the Route 7/15 interchange. Furthermore, economic factors such as changes to business activity, retail spending, tax revenues, property values, local employment, local wages, and gross regional product, are not evaluated in this BCA. Economic factors would be evaluated through an Economic Impact Analysis, which is a separate, independent analysis.

1.1 PROJECT DESCRIPTION

The Connecticut Department of Transportation (CTDOT) proposes to construct improvements (Project) at the Route 7 and Merritt Parkway (Route 15) interchange and to improve Route 7/Route 15 interconnections with local roads in the City of Norwalk (Norwalk), Connecticut. The principal elements of the Project are designed to provide a fully directional interchange with direct access between Route 7 and Route 15 and to improve traffic operations and safety at the Route 15 and Main Avenue (Route 719) interchange as well as along Main Avenue, Glover Avenue, and Creeping Hemlock Drive in the vicinity of the interchange. The BCA evaluates two alternatives – Alternative 21D and Alternative 26. Additionally, a “No Build” Alternative is evaluated for comparison purposes.

1.2 USE OF EXISTING CONDITIONS DATA IN THIS DOCUMENT

Although existing conditions traffic data are not included within a BCA, some existing conditions information is provided within this document in order for the reader to understand the projected degradation of existing conditions along affected roadways and at affected interchanges should the Project not move forward. Existing conditions refers to the Route

7/Route 15 interchange as it is currently constructed today. Further information on existing and future traffic conditions can be found within the Traffic chapter of the Environmental Assessment / Environmental Impact Evaluation (EA/EIE) document and in the associated Traffic technical memorandums.

1.3 ALTERNATIVES

Conceptual plans for each Build alternative are provided within the EA/EIE document.

No Build Alternative: This alternative assesses conditions when taking no action to meet future traffic demands. Under the No Build option, no substantial improvements to the operation, linkages, and capacity of the existing interchanges would be performed beyond routine maintenance and/or spot safety improvements currently planned by CTDOT.

Alternative 21D: This alternative proposes to complete the partial interchange (Interchange 39, 40) with traffic movements between Route 7, Route 15, and Main Avenue. The existing Route 7/Route 15 loop ramps would be retained in the easterly quadrants and the direct connections in the westerly quadrants. The four remaining Route 7/Route 15 interchange movements would be achieved with semi-direct connections involving ten new bridges. Several towers of a power line may require relocation.

The location and configuration of the Route 15 interchange with Main Avenue would enable connections between Main Avenue and Route 7 while efficiently accommodating traffic volumes there. The four tight-loop ramps would be eliminated or improved. Elimination of the existing ramps in the southwest quadrant of the Main Avenue interchange would allow for a long eastbound weaving lane between an eastbound Route 7 entry ramp and an improved exit loop ramp in the southeast quadrant of the Route 7 interchange. In the westbound direction, the tight Route 15 exit loop ramp in the northwest quadrant (to southbound Main Avenue) would be eliminated. Longer Route 15 ramp acceleration and deceleration lanes would also be provided. The westbound entrance ramp would be built between a recently constructed residential apartment building and Route 15.

Alternative 26: This alternative proposes completing the partial interchange (Interchanges 39, 40) with traffic movements between Route 7, Route 15, and Main Avenue. This concept introduces two signalized intersections along Route 7 to complete the partial interchange. A modified diamond interchange with Route 15 is proposed and retains the existing loop ramp in the northeast quadrant and the existing direct connector ramp in the southwest quadrant to optimize traffic operations at the two signalized intersections. The loop ramp in the northeast quadrant would be reduced in size from the larger existing one, a change made possible by slower speeds as Route 7 would be reclassified from a freeway to a signalized arterial. Three northbound and three southbound lanes would be necessary at the signalized Route 7/ramp intersections, with turn lanes at each Route 7 intersection approach.

Like Alternative 21D, the location and configuration of the Route 15 interchange with Main Avenue would enable connections between Main Avenue and Route 7 while efficiently accommodating traffic volumes there. Three closely-spaced signalized intersections would be provided along Main Avenue. The four tight-loop ramps would be eliminated or improved.

1.4 GUIDANCE DOCUMENTS

The following documents were used as reference documents in order to prepare the BCA:

- USDOT, "Benefit-Cost Analysis Guidance for Discretionary Grant Programs", January 2020. Available: *https://www.transportation.gov/sites/dot.gov/files/2020-01/benefit-cost-analysis-guidance-2020_0.pdf*.
- USDOT, "Life-Cycle Cost Analysis Primer", August 2002. Available: *https://www.fhwa.dot.gov/asset/lcca/010621.pdf*.
- AASHTO, "Highway Safety Manual", First Edition, 2010.
- USDOT, "The Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses", 2016.
- Texas Transportation Institute, "Performance Measure Summary – Bridgeport-Stamford CT-NY". Available: *https://static.tti.tamu.edu/tti.tamu.edu/documents/umr/congestion-data/bridg.pdf*. [Accessed March 2020].
- USDOT, "Manual of Uniform Traffic Control Devices for Streets and Highways" (MUTCD), 2009 Edition with Revision Numbers 1 and 2 incorporated, May 2012. Available: https://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm [Accessed April 2020].
- Texas A&M Transportation Institute, "2019 Urban Mobility Report and Appendices," August 2019. [Online]. Available: *https://mobility.tamu.edu/umr/report/#appx%E2%80%90c*. [Accessed April 2020].

1.5 PROJECT BENEFITS

Benefits from the Project are considered as direct and positive effects projected under either Alternative 21D or Alternative 26. For roadway infrastructure projects, benefits are first estimated in physical terms and then valued in economic terms – for example, projected crash reductions due to proposed interchange improvements must first be calculated before an economic/monetary safety benefit value can be estimated.

The USDOT has outlined five long-term outcome categories for which benefits must be analyzed: Quality of Life, Economic Competitiveness, Safety, State of Good Repair, and

Environmental Sustainability. Table 2 on the following page summarizes societal benefits associated with each long-term outcome.

While the BCA does not include all long-term outcomes listed above, the following benefits are considered: (1) crash reduction (safety), (2) travel time savings (economic competitiveness), (3) vehicle operating cost savings (economic competitiveness), and (4) reduced emissions (environmental sustainability).

Table 2: USDOT Long-Term Outcome Categories for Benefits

Long-Term Outcome	Types of Societal Benefits
Quality of Life	Land use changes that reduce VMT Increased accessibility Property value increases
Economic Competitiveness	Travel time savings Operating cost savings
Safety	Prevent crashes (Property damage, injuries, and fatalities)
State of Good Repair	Deferral of complete replacement Maintenance and repair savings Reduced VMT from not closing bridges
Environmental Sustainability	Environmental benefits from reduced emissions
Source: USDOT, "Benefit-Cost Analysis Guidance for TIGER Grant Applications", 2014. https://www.transportation.gov/sites/dot.gov/files/docs/TIGER%20BCA%20Guidance%202014.pdf	

1.5.1 Crash Reduction

Crash reduction, known herein as "Safety Benefits", are benefits resulting from transportation improvements. Benefits occur when the number of crashes and/or the severity of crashes is reduced due to a transportation improvement. The Highway Safety Manual provides guidance on determining the projected reductions in crashes due to proposed highway improvements. Crash modification factors are used to quantify the potential safety benefits.

1.5.2 Travel Time Savings

Travel time savings can generate significant benefits when comparing Build and No Build alternatives. Travel times are calculated in vehicle hours travelled by the impacted population and are estimated using VISSIM traffic models, spreadsheets, actual travel time data, or some combination of all three. The travel time savings for both drivers and occupants are included in estimates using typical vehicle occupancies for the area. Additionally, transportation mode changes could lead to different vehicle occupancy rates between alternatives. Travel time savings vary by region and are monetized as an hourly value.

1.5.3 Vehicle Operating Cost Savings

Changes in travel times also result in potential savings in vehicle operating costs due to less mileage that is incurred during a trip. Operational cost savings are calculated by multiplying traffic volumes and segment lengths from VISSIM traffic models for No Build and each Build alternative to find the difference. Subsequently, this difference is then multiplied by the recommended vehicle operating cost per mile to monetize vehicle operating cost savings.

1.5.4 Emission Savings

Changes in travel patterns also impact the amount of emissions emitted from vehicles in the Project study area as drivers no longer need to use local streets to complete the incomplete movements at the Route 7/Route 15 interchange. Emission data for two pollutants – nitrogen oxides and volatile organic compounds – are taken from the mesoscale analyses performed by KB Environmental Sciences, Inc. The analyses estimate the change in daily nitrogen oxides and volatile organic compound emissions within the study corridors that would be associated with the No Build and Build alternatives to find the differences. These are then multiplied by the typical cost per short ton of emitted nitrogen oxides and volatile organic compounds to monetize emission savings.

1.6 PROJECT COSTS

As expected, the Project also incurs costs. As mentioned in Table 2, costs are expended in order to maintain an overall state of good repair at each of the interchanges. Costs are critical to determining whether a Project is viable or not. Further information on anticipated costs is detailed below.

1.6.1 Capital Costs

In simplistic terms, capital costs account for all construction and engineering expenses required to complete the Project. This includes engineering services, major structures, grading and drainage, subbase and base, surfacing, and miscellaneous items. As the Project proceeds from planning-level cost estimates to detailed engineer estimates, capital costs should be refined as appropriate.

1.6.2 Routine Annual Maintenance Costs

Once construction is complete, the Project would still require annual maintenance. This cost accounts for expeditures such as bridge inspections, pavement repairs, street light re-illumination, and so on.

2.0 CALCULATION OF PROJECT BENEFITS AND PROJECT COSTS

Calculations are completed for each benefit and cost to monetize each respective component. In order to calculate project benefits and costs, analysis parameters needed to be developed. The following list below summarizes pertinent years that were included in the analysis:

- Analysis year: 2018 (Latest year where dollar values for costs and benefits are available)
- Estimated beginning of construction: 2024
- Estimated time of construction completion: 2027
- Horizon (design) year: 2047 (Operating period of 20 years after construction completion per USDOT guidance)

3.0 CALCULATION OF PROJECT BENEFITS

This analysis conservatively assumes that the benefits associated with the Project will begin to accrue the first year after the estimated time of construction completion, which is 2028.

3.1 SAFETY BENEFITS (CRASH REDUCTION)

The elimination of substandard ramps at the Main Avenue/Route 15 interchange that are responsible for crashes that occurred in the recent three-year crash analysis period is a significant benefit of both Alternative 21D and Alternative 26.

It should be noted that new traffic signals are proposed under either Build Alternative. Research of guidance published by FHWA (within the MUTCD) suggests that the installation of a new traffic signal, when properly designed, located, operated, and maintained will reduce the frequency and severity of certain types of crashes, among other advantages.

3.1.1 Crash Reduction

Crash Reductions due to Improvements at the Main Avenue/Route 15 Interchange (Standard Acceleration/Deceleration Lanes and Conslidated Entry/Exit Ramps)

In its current state, Route 15 at the Main Avenue interchange provides four non-standard exit ramps and two stop-controlled entry ramps, all of which have no acceleration or deceleration lanes. These would be replaced under both Alternative 21D and Alternative 26 with standard acceleration/deceleration lanes and consolidated exit and entry ramps. To account for these improvements, the AASHTO Highway Safety Manual provides methodology to calculate a crash modification factor (CMF) for each interchange ramp that projects the reduction in crashes with

the proposed improvements. Based on the guidance from the AASHTO Highway Safety Manual and from USDOT, it was projected that crashes would decrease by 42 percent at the Merritt Parkway and Main Avenue interchange under both Alternative 21D and Alternative 26. The weighted CMF for the interchange is thus 0.58 (that is, a 42 percent projected reduction in crashes), with CMF ranging between 0.47 and 0.7 for each interchange ramp depending on modification to acceleration/deceleration lane length.

3.1.2 Safety Benefits

In order to estimate the monetary benefits of safety improvements, three-year crash data for the Route 15 interchanges with Route 7 and Main Avenue were summarized for the 2015-2017 period, separated into injury and property damage only, and evaluated against the KABCO scale levels[1] listed in Table 3. The crash data did not yield further detailed information on injury severity, which in turn would have enabled a more accurate monetization of safety benefits.

Table 3: Economic Value of Statistical Life by Crash Severity

KABCO Level	Injury Severity	Unit Values Per Accident ($2018)
O	No Injury (Property Damage)	$3,200
U	Injury (Severity Unknown)	$174,000

The crash reductions between the No Build Alternative and Build alternatives, calculated using the CMFs referenced in Section 3.1.1, were multiplied by the economic unit value per accident in Table 3 to monetize the safety benefits for Alternative 21D and Alternative 26.

3.2 TRAVEL TIME BENEFITS

Travel time benefits for the Project are two pronged. First, completing the missing movements at the Route 7 and Merritt Parkway interchange provides an alternative route and improves travel time relative to using Main Avenue to complete these movements. Second, the three affected mainlines (Route 7, Route 15, and Main Avenue) all experience fluctuations in travel times throughout the study area between No Build and each Build alternative due to changes in system linkage between Route 7, Route 15, and Main Avenue.

3.2.1 Travel Times – Route 7/15 Interchange Missing Movements

Under both Alternative 21D and Alternative 26, the missing movements at the Route 7/15 interchange would be completed and additional travel routes would be provided. Using data from the VISSIM microsimulation model, peak hour travel times were generated and are presented in Table 4. In general, it typically takes five to ten minutes to complete one of the

[1] The KABCO scale, which stands for the scale levels "K – Killed, A – Incapacitated, B – Non-incapacitated, C – Possible Injury, O – No Injury", is a measure of the observed severity of a victim's functional injury at a crash scene. Law enforcement crash data is frequently reported using the KABCO scale.

incomplete movements, depending on the specific movement that is taken and the peak hour of travel.

Table 4: Peak Hour Travel Times under No Build and Build Alternatives

Travel Time (minutes)	NB Route 7 to NB Route 15		SB Route 15 to SB Route 7		SB Main Avenue to NB Route 15		SB Route 15 to NB Main Avenue	
	AM	PM	AM	PM	AM	PM	AM	PM
No Build	6.7	11.9	16.0	14.6	3.1	10.6	8.4	6.5
Alt 21D	3.4	9.6	10.7	5.6	2.8	9.0	9.2	4.3
Alt 26	4.2	10.2	12.4	5.3	3.7	9.7	11.3	4.7

Under the No Build Alternative, motorists are forced to use Main Avenue to travel between northbound Route 7 and northbound Route 15. Under the Build alternatives, motorists can use the new direct connector ramps in both Alternative 21D and Alternative 26 to travel from northbound Route 7 to northbound Route 15. The projected difference in travel times are shown in Table 5 below. In most cases, both Alternative 21D and Alternative 26 provide faster travel times, however there are three instances where the travel time increases under the Build alternatives.

Table 5: Peak Hour Travel Time Savings – Alternative 21D and Alternative 26 vs. No Build

Travel Time Savings (minutes)	NB Route 7 to NB Route15		SB Route 15 to SB Route 7		SB Main Avenue to NB Route 15		SB Route 15 to NB Main Avenue	
	AM	PM	AM	PM	AM	PM	AM	PM
No Build	-	-	-	-	-	-	-	-
Alt 21D	3.3	2.3	5.3	9.0	0.3	1.6	(0.8)	2.2
Alt 26	2.5	1.7	3.6	9.3	(0.6)	0.9	(2.9)	1.8
Note: Text in parentheses indicates an increase in travel time.								

3.2.2 Peak Hour Vehicle Hours of Travel – Route 7, Route 15, and Main Avenue Corridors

Route 7, Route 15, and Main Avenue travel times fluctuate between No Build and each Build alternative. A commonly used metric to compare travel times is vehicle hours of travel, generated by multiplying each segment's peak hour traffic volume by the time taken to travel along the segment. For this analysis, each segment's volume and travel time were taken from the VISSIM microsimulation models to calculate vehicle hours of travel, which are listed in Table 6. In general, the vehicle hours of travel increase between existing and no build conditions. There are varying differences in vehicle hours of travel when comparing No Build and each Build alternative for each roadway segment.

Table 6: Mainline Peak Hour Vehicle Hours of Travel – Existing, No Build, and Build Alternatives (Hours)

Corridor	From	To	AM Peak Hour				PM Peak Hour			
			Existing	No Build	Alt 21D	Alt 26	Existing	No Build	Alt 21D	Alt 26
NB Route 15	Main Ave	East Rocks Road	22	22	21	23	217	230	258	278
	Route 7	Main Avenue	11	20	6	6	68	81	98	72
	Silvermine River	Route 7	22	25	14	21	70	78	81	52
	Route 123	Silvermine River	168	196	198	174	190	199	238	188
SB Route 15	East Rocks Road	Main Ave	240	260	259	295	29	180	78	58
	Main Avenue	Route 7	92	94	104	100	12	79	69	54
	Route 7	Silvermine River	147	146	167	162	29	109	150	129
	Silvermine River	Route 123	195	189	171	192	59	64	62	61
NB Main Ave	Route 123	Route 15	53	90	63	72	42	64	62	80
	Route 15	Grist Mill Road	18	19	23	16	19	37	11	13
SB Main Ave	Grist Mill Road	Route 15	15	15	8	8	66	55	52	50
	Route 15	Route 123	37	95	36	36	69	119	81	87
NB Route 7	Route 123	NB Route 7 C-D Rd S	72	116	92	92	69	96	89	97
	NB Route 7 C-D Rd S	NB Route 7 C-D Rd N	28	184	43	33	25	44	46	38
	NB Route 7 C-D Rd N	Grist Mill Road	99	231	41	81	48	197	61	122
SB Route 7	Grist Mill Road	NB US 7 Svc Rd N	38	38	29	39	39	44	35	48
	NB Route 7 C-D Rd S	Route 123	55	58	62	68	54	57	65	86

3.2.3 Daily Travel Time Benefits

To extrapolate peak hour vehicle hours of travel to a daily value, time of day factors were applied to traffic data for Route 15, Route 7, and Main Avenue. Ratios between peak hour and daily traffic along specific roadways were used to factor traffic into daily values from peak hour values.

Subsequent daily vehicle hours of travel are listed in Table 7. Daily, motorists spend over 13,800 hours in vehicle hours traveled along main corridors within the study area. If the Project is not completed (i.e., the No Build Alternative), it is projected that motorists would spend over 21,900 hours per day in vehicle hours traveled. This represents a 59 percent increase over current vehicle hours traveled. However, if the Project is completed it is anticipated that overall vehicle hours of travel could decrease by up to 20 percent (depending on the chosen Build Alternative) compared to if the Project is not completed.

Table 7: Total Daily Vehicle Hours of Travel (VHT) for Mainlines – Existing, No Build, and Build Alternatives

Corridor	Existing	No Build	Alternative 21D	Alternative 26
NB Route 15	4,405	4,975	5,091	4,595
SB Route 15	3,938	7,074	6,398	6,013
NB Main Ave	892	1,435	1,070	1,293
SB Main Ave	1,064	1,801	966	998
NB Route 7	2,167	5,292	2,682	3,450
SB Route 7	1,300	1,359	1,316	1,605
Total Daily VHT	13,811	21,936	17,523	17,955
Daily VHT Difference Relative to No Build	n/a	n/a	4,413	3,981

3.2.4 Annualization Factors and Estimation of Annual Travel Time Savings

In order to monetize the annual savings in travel time, an annualization factor had to be developed to convert daily VHT to an annual value. Since the Route 7, Route 15, and Main Avenue corridors have different traffic patterns throughout the year, separate annualization factors were used to annualize VHT. A review of permanent count station data along Route 15 and Route 124 (applicable to Route 7 and Main Avenue) indicated that annualization factors of 343 and 308 should be applied to daily VHT on Route 15, and Route 7 and Main Avenue, respectively, to project annual VHT.

Travel time savings were monetized using the daily differences in VHT relative to the No Build Alternative for both Alternative 21D and Alternative 26. These differences were then multiplied by the annualization factors discussed above to generate annual VHT and by the value of time

for the study area[2] to generate annual savings in travel time costs. The projected savings for each alternative are summarized in Table 8. Travel time savings projected for Alternative 21D and Alternative 26 would respectively amount to over $30.9 million dollars and $28.6 million dollars to the local and regional economy.

Table 8: Projected Annual Travel Time Savings – Build Alternatives Relative to No Build Alternative

Projected Annual Travel Time Savings Relative to No Build Alternative ($2018)	Alternative 21D	Alternative 26
	$30,911,314	$28,623,065

3.3 VEHICLE OPERATING COSTS

Vehicle operating cost savings for the Project are realized on three mainlines: Route 15, Route 7, and Main Avenue. Vehicle miles of travel estimates from the VISSIM model were used to determine the savings in vehicle operating costs. Table 9 lists peak hour vehicle miles of travel by segment for the No Build and Build alternatives. Again, existing conditions data are provided for further context.

Table 9: Peak Hour Vehicle Miles of Travel by Segment – Existing, No Build, and Build Alternatives

Corridor	From	To	AM Peak Hour				PM Peak Hour			
			Existing	No Build	Alt 21D	Alt 26	Existing	No Build	Alt 21D	Alt 26
NB Route 15	Main Ave	East Rocks Road	1,345	1,352	1,270	1,388	2,197	2,213	1,973	2,203
	Route 7	Main Avenue	610	552	380	352	569	550	516	503
	Silvermine River	Route 7	1,296	1,273	869	1,058	1,144	1,132	1,039	1,035
	Route 123	Silvermine River	3,016	2,964	2,938	2,963	2,648	2,618	2,611	2,761
SB Route 15	East Rocks Road	Main Ave	1,970	1,812	1,874	1,821	1,731	1,776	1,861	2,008
	Main Avenue	Route 7	481	470	470	395	619	621	485	449
	Route 7	Silvermine River	1,264	1,293	1,249	1,185	1,589	1,667	1,321	1,354
	Silvermine River	Route 123	2,776	2,828	2,836	2,805	3,372	3,529	3,482	3,522

[2] The value of time (VOT) was determined to be $18.68 per hour, is based on a 2017 VOT estimate for the Bridgeport-Stamford CT-NY area and adjusted to 2018 dollars as per USDOT guidance.

Corridor	From	To	AM Peak Hour				PM Peak Hour			
			Existing	No Build	Alt 21D	Alt 26	Existing	No Build	Alt 21D	Alt 26
NB Main Ave	Route 123	Merritt Parkway	1,209	1,472	1,257	1,010	993	1,332	931	667
	Route 15	Grist Mill Road	575	583	702	521	443	647	289	341
SB Main Ave	Grist Mill Road	Route 15	453	451	213	224	703	666	683	566
	Route 15	Route 123	839	929	778	766	1,434	1,371	1,314	1,332
NB Route 7	Route 123	NB Route 7 C-D Rd S	4,220	4,682	5,079	5,393	4,059	4,702	5,041	5,356
	NB Route 7 C-D Rd S	NB Route 7 C-D Rd N	1,445	1,459	2,214	845	1,306	1,457	2,294	831
	NB Route 7 C-D Rd N	Grist Mill Road	1,564	1,573	706	2,021	1,334	1,358	738	1,910
SB Route 7	Grist Mill Road	NB Route 7 C-D Rd N	2,070	2,095	1,625	1,724	2,217	2,348	1,895	1,996
	NB Route 7 C-D Rd S	Route 123	3,296	3,448	3,724	4,025	3,336	3,382	3,857	4,157

Peak hour vehicle miles of travel were converted to daily vehicle miles of travel using the time of day factors discussed in Section 3.2.3. The differences in daily vehicle miles of travel between the No Build Alternative and both Alternative 21D and Alternative 26 were calculated, converted into annual figures based on daily peaking data and corridor specific annualization factors previously discussed in Section 3.2.4, and then multiplied by the USDOT recommended passenger vehicle operating cost of 41 cents per mile. The results are listed by corridor in Table 10. It should be noted that some corridors experience an increase in operating costs due to the increased mobility that is provided by either Alternative 21D or Alternative 26.

Table 10: Projected Annual Operating Cost Savings by Corridor

Corridor	Alternative 21D	Alternative 26
NB Route 15	$1,403,321	$647,623
SB Route 15	$732,167	$572,320
NB Main Ave	$1,310,555	$1,857,010
SB Main Ave	$614,068	$675,219
NB Route 7	($1,056,495)	($1,215,440)
SB Route 7	$280,562	($567,964)
Note: Text in parentheses indicates an increase in annual operating cost.		

The projected total annual operational savings relative to the No Build Alternative are the summed and listed in Table 11.

Table 11: Projected Annual Operating Cost Savings – Alternative 21D and Alternative 26

Projected Annual Operating Cost Savings Relative to No Build Alternative ($2018)	Alternative 21D	Alternative 26
	$3,284,180	$1,968,768

3.4 VEHICLE EMISSION COSTS

Vehicle emission reductions are projected to change at existing intersections along each corridor and within the Route 7/Route 15 and Main Avenue/Route 15 interchanges under the Build alternatives. Table 12 lists the estimated and projected emissions (in short tons per day) by alternative that were extracted from KB Environmental Sciences, Inc.'s air quality assessment.

Table 12: Projected Daily Vehicle Emissions by Alternative

Alternative	Volatile Organic Compounds (VOC)			Nitrogen Oxides (NO_x)		
	Daily Emissions (Short Tons/Day)	Difference from No Build (Short Tons/Day)	Difference from No Build (%)	Daily Emissions (Short Tons/Day)	Difference from No Build (Short Tons/Day)	Difference from No Build (%)
No Build	0.234	-	-	0.158	-	-
Alt 21D	0.226	-0.008	-3.3	0.152	-0.006	-3.3
Alt 26	0.231	-0.003	-1.2	0.156	-0.002	-1.2
Source: KB Environmental Sciences, Inc., 2019.						

Projected daily vehicle emission values were annualized and then monetized using USDOT recommended emission costs to determine yearly emissions savings. These savings are presented in Table 13.

Table 13: Projected Annual Vehicle Emissions Savings for Alternative 21D and Alternative 26

Quantity	Alternative 21D		Alternative 26	
	Volatile Organic Compounds (VOC)	Nitrogen Oxides (NO_x)	Volatile Organic Compounds (VOC)	Nitrogen Oxides (NO_x)
Daily Reduction in Emissions Relative to No Build Alternative (Short Tons per day)	-0.008	-0.006	-0.003	-0.002
Daily Cost per Short Ton	$2,100	$8,600	$2,100	$8,600
Annualization Factor	320	320	320	320
Annual Savings ($2018)	$5,376	$16,512	$2,016	$5,504
Total Annual Savings ($2018)	$21,888 per year		$7,520 per year	

4.0 CALCULATION OF PROJECT COSTS

The BCA assumes that capital costs of the Project would be spread over four years of construction, commencing in 2024 and ending in 2027. Maintenance costs of the Project would commence from the first year of construction and continue through the horizon year of 2047.

4.1 NET CAPITAL COSTS

Capital costs are equivalent to the difference between the projected capital construction cost and the residual value of the reconstructed interchange (asset) at the end of the analysis period. Both capital costs and residual values for both Alternative 21D and Alternative 26 were developed based upon a review of prior preliminary cost estimates prepared for the Project as well as using guidance from the USDOT. These costs are summarized in Table 14. The service life of the interchange was assumed to be an average of 50 years, which is conservative given the service life of interchanges in southwestern Connecticut and considering that the typical life cycles for pavement is 35 years and up to 75 to 100 years for new superstructures.

Table 14: Capital Construction Costs for Alternative 21D and Alternative 26 (Undiscounted)

Costs ($2018)	Alternative 21D	Alternative 26
Capital Construction Cost	$206,691,134	$109,049,615
Residual Value (Asset Value at 20 years of service life)	$120,053,781	$63,340,010
Net Capital Cost at the End of the Analysis Period	$86,637,354	$45,709,605

4.2 MAINTENANCE COSTS

Structure maintenance costs were provided by CTDOT for existing structures in the study area. In the maintenance management system, thirty-three maintenance activities are scheduled on structures in the study area between 2024 and 2047, totaling approximately $5.5M in 2018 dollars. These maintenance activities assume funding levels as of March 10, 2020 and are applicable to the No Build Alternative, Alternative 21D, and Alternative 26. Projected costs are summarized in Table 15.

Table 15: Projected Maintenance Costs on Structures in the Study Area

Year of Maintenance	Bridge Number	Structure Location	Maintenance Work	Cost ($2018)
2028	00530A	Route 15 over Main Ave	Superstructure Repair	$82,899
2028	00530A	Route 15 over Main Ave	Wearing Surface Replacement	$36,844
2028	00720	Route 15 over MNR	Substructure Repair	$242,875
2028	00720	Route 15 over MNR	Superstructure Repair	$169,711
2028	00720	Route 15 over MNR	Wearing Surface Replacement	$75,427

Year of Maintenance	Bridge Number	Structure Location	Maintenance Work	Cost ($2018)
2029	06066	Route 7 over Perry Ave	Bearings Replacement	$162,563
2030	04155	Glover Ave over Norwalk River	Substructure Repair	$194,288
2030	04155	Glover Ave over Norwalk River	Superstructure Repair	$135,760
2030	04155	Glover Ave over Norwalk River	Wearing Surface Replacement	$60,338
2030	06068	SB Route 15 on-ramp from SB Route 7	Bearings Replacement	$46,446
2030	06068	SB Route 15 on-ramp from SB Route 7	Wearing Surface Replacement	$52,165
2030	06069	Route 15 over Route 7	Bearings Replacement	$278,679
2030	06069	Route 15 over Route 7	Joint Replacement	$108,604
2031	06067	NB Route 15 off-ramp to SB Route 7	Bearings Replacement	$46,446
2031	06067	NB Route 15 off-ramp to SB Route 7	Joint Replacement	$24,707
2031	06067	NB Route 15 off-ramp to SB Route 7	Superstructure Repair	$117,372
2031	06067	NB Route 15 off-ramp to SB Route 7	Wearing Surface Replacement	$52,165
2032	00719	Route 15 over Perry Ave	Superstructure Repair	$95,984
2032	00719	Route 15 over Perry Ave	Wearing Surface Replacement	$42,660
2033	00530B	Route 15 over Main Ave	Superstructure Repair	$82,899
2033	00530B	Route 15 over Main Ave	Wearing Surface Replacement	$36,844
2039	06066	Route 7 over Perry Ave	Bearings Replacement	$162,563
2039	06066	Route 7 over Perry Ave	Deck Repair	$937,198
2039	06066	Route 7 over Perry Ave	Superstructure Repair	$527,174
2039	06066	Route 7 over Perry Ave	Wearing Surface Replacement	$234,299
2041	06069	Route 15 over Route 7	Bearings Replacement	$278,679
2041	06069	Route 15 over Route 7	Joint Replacement	$108,604
2041	06069	Route 15 over Route 7	Wearing Surface Replacement	$509,636
2042	00530A	Route 15 over Main Ave	Substructure Repair	$118,638
2042	00530A	Route 15 over Main Ave	Superstructure Repair	$82,899
2042	00720	Route 15 over MNR	Superstructure Repair	$169,711
2046	00719	Route 15 over Perry Ave	Superstructure Repair	$95,984
2047	00530B	Route 15 over Main Ave	Superstructure Repair	$82,899
			Total	**$5,453,963**
Source: CTDOT				

In addition to structures, CTDOT also estimates the cost to maintain one lane mile of roadway on an annual basis to be $14,300 in 2019 dollars, which amounts to approximately $14,100 when deflated to 2018 dollars given Gross Domestic Product (GDP) inflation factors. Lane miles for the No Build Alternative, Alternative 21D, and Alternative 26 were summarized and then multiplied by the per lane mile maintenance cost in 2018 dollars to generate an annual pavement maintenance cost. Results are presented in Table 16.

Table 16: Projected Annual Pavement Maintenance Costs in the Study Area, 2018 Dollars

Alternative	No Build	Alternative 21D	Alternative 26
Lane Miles	12.54 mi	15.53 mi	15.62 mi
Cost per Lane Mile	$14,100	$14,100	$14,100
Annual Pavement Maintenance Cost	$176,847	$219,000	$220,298

The estimates from Table 15 and Table 16 were then used to project the total maintenance costs for the No Build Alternative, Alternative 21D, and Alternative 26 for the years of 2024 (when construction begins) through 2047. Results are shown in Table 17.

Table 17: Total Projected Maintenance Costs, 2024-2047, 2018 Dollars (Undiscounted)

Year	No Build	Alternative 21D	Alternative 26	Year	No Build	Alternative 21D	Alternative 26
2024	$176,847	$176,847	$176,847	**2036**	$176,847	$219,000	$220,298
2025	$176,847	$176,847	$176,847	**2037**	$176,847	$219,000	$220,298
2026	$176,847	$176,847	$176,847	**2038**	$176,847	$219,000	$220,298
2027	$176,847	$176,847	$176,847	**2039**	$2,038,080	$2,080,234	$2,081,531
2028	$784,604	$826,757	$828,055	**2040**	$176,847	$219,000	$220,298
2029	$339,409	$381,562	$382,860	**2041**	$1,073,765	$1,115,918	$1,117,216
2030	$1,053,127	$1,095,280	$1,096,578	**2042**	$548,095	$590,248	$591,546
2031	$417,537	$459,690	$460,988	**2043**	$176,847	$219,000	$220,298
2032	$315,490	$357,643	$358,941	**2044**	$176,847	$219,000	$220,298
2033	$296,590	$338,743	$340,041	**2045**	$176,847	$219,000	$220,298
2034	$176,847	$219,000	$220,298	**2046**	$272,831	$314,984	$316,282
2035	$176,847	$219,000	$220,298	**2047**	$259,746	$301,899	$303,197

Total Projected Maintenance Costs (2024-2047, $2018)	No Build	Alternative 21D	Alternative 26
	$9,698,281	$10,541,344	$10,567,301

5.0 BENEFIT-COST ANALYSIS FINDINGS

Table 18 provides an executive level summary of the BCA for Alternative 21D and Alternative 26. Two sets of benefit-cost analyses are presented – undiscounted and discounted. To reflect the time value of money, both benefits and costs were discounted at a 5 percent rate per USDOT guidance for life cycle analyses. It should also be noted that no analysis is performed for the No Build Alternative since it does not provide any benefits (a theoretical B/C of 0.00).

Typically, a project is considered viable if the B/C ratio is greater than 1.0; that is, the net present value of project benefits is greater than the net present value of project costs. Higher B/C ratios indicate a greater amount of project benefits when weighed against project costs. Alternative 21D has a B/C ratio of 2.37 while Alternative 26 has a B/C ratio of 3.89.

Comparing discounted dollar amounts, although Alternative 21D provides $29.1M more in discounted project benefits when compared to Alternative 26 it also costs $54.0M more to construct and maintain.

Table 18: BCA Summary – Alternative 21D & Alternative 26

Financial Indicator	Undiscounted Benefits & Costs		Discounted Benefits & Costs (5 Percent Rate)	
	Alternate 21D	Alternate 26	Alternate 21D	Alternate 26
Total Project Benefits	$701,051,709	$628,691,145	$281,586,249	$252,521,717
Total Project Costs	$97,178,697	$56,276,905	$118,980,010	$64,948,381
Net Present Value	-	-	$162,606,239	$187,573,336
B/C Ratio	**-**	**-**	**2.37**	**3.89**

Detailed annual summaries of each project benefit and project cost are presented for Alternative 21D in Table 19 and Alternative 26 in Table 20 for years 2024 (the first year of construction) through 2047 (horizon year). Both undiscounted and discounted benefits and costs are provided.

Table 19: Calculated Project Benefits and Costs for Alternative 21D, 2024-2047

Year	Project Benefits (Undiscounted)					Project Costs (Undiscounted)			Discounted Benefits and Costs		
	Travel Time Savings	Safety Cost Savings	Operating Cost Savings	Emissions Cost Savings	Total Cost Savings (Benefits)	Maintenance Costs	Capital Costs	Total Costs	Discount Factor (5%)	Discounted Benefits	Discounted Costs
2024						$176,847	$51,672,784	$51,849,630	0.75	$0	$38,690,992
2025						$176,847	$51,672,784	$51,849,630	0.71	$0	$36,848,564
2026						$176,847	$51,672,784	$51,849,630	0.68	$0	$35,093,871
2027						$176,847	$51,672,784	$51,849,630	0.64	$0	$33,422,734
2028	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$826,757	$0	$826,757	0.61	$21,519,247	$507,557
2029	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$381,562	$0	$381,562	0.58	$20,494,521	$223,092
2030	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$1,095,280	$0	$1,095,280	0.56	$19,518,591	$609,893
2031	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$459,690	$0	$459,690	0.53	$18,589,134	$243,784
2032	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$357,643	$0	$357,643	0.51	$17,703,938	$180,634
2033	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$338,743	$0	$338,743	0.48	$16,860,893	$162,941
2034	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$219,000	$0	$219,000	0.46	$16,057,993	$100,326
2035	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$219,000	$0	$219,000	0.44	$15,293,327	$95,549
2036	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$219,000	$0	$219,000	0.42	$14,565,073	$90,999
2037	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$219,000	$0	$219,000	0.40	$13,871,498	$86,666
2038	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$219,000	$0	$219,000	0.38	$13,210,951	$82,539
2039	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$2,080,234	$0	$2,080,234	0.36	$12,581,858	$746,684
2040	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$219,000	$0	$219,000	0.34	$11,982,722	$74,865
2041	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$1,115,918	$0	$1,115,918	0.33	$11,412,116	$363,311
2042	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$590,248	$0	$590,248	0.31	$10,868,682	$183,017
2043	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$219,000	$0	$219,000	0.30	$10,351,126	$64,671
2044	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$219,000	$0	$219,000	0.28	$9,858,215	$61,592
2045	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$219,000	$0	$219,000	0.27	$9,388,776	$58,659
2046	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$314,984	$0	$314,984	0.26	$8,941,692	$80,350
2047	$30,911,314	$835,204	$3,284,180	$21,888	$35,052,585	$301,899	($120,053,781)	($119,751,881)	0.24	$8,515,897	($29,093,279)
Total	$618,226,273	$16,704,085	$65,683,591	$437,760	$701,051,709	$10,541,344	$86,637,354	$97,178,697	-	$281,586,249	$118,980,010
										Benefit / Cost (B/C) Ratio	**2.37**

Note: Negative costs are in parentheses. Under "Capital Costs", negative costs indicate the remaining value of the asset at the end of the analysis period.

Table 20: Calculated Project Benefits and Costs for Alternative 26, 2024-2047

Year	Project Benefits (Undiscounted)					Project Costs (Undiscounted)			Discounted Benefits and Costs		
	Travel Time Savings	Safety Cost Savings	Operating Cost Savings	Emissions Cost Savings	Total Cost Savings (Benefits)	Maintenance Costs	Capital Costs	Total Costs	Discount Factor (5%)	Discounted Benefits	Discounted Costs
2024						$176,847	$27,262,404	$27,439,250	0.75	$0	$20,475,591
2025						$176,847	$27,262,404	$27,439,250	0.71	$0	$19,500,563
2026						$176,847	$27,262,404	$27,439,250	0.68	$0	$18,571,965
2027						$176,847	$27,262,404	$27,439,250	0.64	$0	$17,687,585
2028	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$828,055	$0	$828,055	0.61	$19,298,091	$508,354
2029	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$382,860	$0	$382,860	0.58	$18,379,135	$223,850
2030	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$1,096,578	$0	$1,096,578	0.56	$17,503,938	$610,616
2031	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$460,988	$0	$460,988	0.53	$16,670,417	$244,472
2032	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$358,941	$0	$358,941	0.51	$15,876,587	$181,290
2033	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$340,041	$0	$340,041	0.48	$15,120,560	$163,566
2034	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$220,298	$0	$220,298	0.46	$14,400,533	$100,921
2035	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$220,298	$0	$220,298	0.44	$13,714,793	$96,115
2036	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$220,298	$0	$220,298	0.42	$13,061,708	$91,538
2037	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$220,298	$0	$220,298	0.40	$12,439,722	$87,179
2038	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$220,298	$0	$220,298	0.38	$11,847,354	$83,028
2039	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$2,081,531	$0	$2,081,531	0.36	$11,283,194	$747,150
2040	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$220,298	$0	$220,298	0.34	$10,745,899	$75,309
2041	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$1,117,216	$0	$1,117,216	0.33	$10,234,190	$363,734
2042	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$591,546	$0	$591,546	0.31	$9,746,847	$183,420
2043	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$220,298	$0	$220,298	0.30	$9,282,712	$65,054
2044	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$220,298	$0	$220,298	0.28	$8,840,678	$61,957
2045	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$220,298	$0	$220,298	0.27	$8,419,693	$59,006
2046	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$316,282	$0	$316,282	0.26	$8,018,756	$80,681
2047	$28,623,065	$835,204	$1,968,768	$7,520	$31,434,557	$303,197	($63,340,010)	($63,036,813)	0.24	$7,636,910	($15,314,562)
Total	$572,461,299	$16,704,085	$39,375,362	$150,400	$628,691,145	$10,567,301	$45,709,605	$56,276,905	-	$252,521,717	$64,948,381
										Benefit / Cost (B/C) Ratio	**3.89**

Note: Negative costs are in parentheses. Under "Capital Costs", negative costs indicate the remaining value of the asset at the end of the analysis period**.**