Benefit-Cost Analysis

New Haven Downtown Crossing (NHDC) Benefit-Cost Analysis 8/16/2010

Introduction

A benefit-cost analysis was conducted for the New Haven Downtown Crossing (NHDC) as of August 2010. This analysis was completed for submission to the US DOT as a requirement of a discretionary grant application for the TIGER II program. The analysis was conducted in accordance with the benefit-cost methodology as recommended by the US DOT in the Federal Register (75 FR 30460).1

Project Description

The City of New Haven (the City) is requesting $21.3 million in TIGER II funding as part of the $31.7 million first phase of infrastructure improvements for Downtown Crossing. Downtown Crossing is the City's master plan to convert CT Route 34 from a limited access highway to urban boulevards from Union Avenue to the existing the Exit 3 at College Street.

In this first phase, project elements include (1) conversion of North and South Frontage Roads to urban boulevards with road, streetscape, bicycle and pedestrian enhancements; (2) reconfiguration of local street connections; and (3) reconstruction of College Street to grade level. All elements are designed to citywide Complete Streets standards and support the economic development of Connecticut's emerging health sciences industry.

The first phase will provide infrastructure improvements necessary to initiate short- and long-term job creation to proceed immediately on the first new parcel within the corridor, 100 College Street, while positioning the balance of the corridor for future development.

From a transportation perspective, these first phase infrastructure improvements have independent utility and are essential to relieve congestion, improve traffic flow and dramatically improve safety for vehicular, pedestrian and bicycle access.

Specific infrastructure improvements are described below:

1. Conversion of North Frontage Road and South Frontage Roads into urban boulevards. North and South Frontage Roads will be converted to urban boulevards by narrowing travel lanes (10-11') and adding exclusive bicycle lanes. Four traffic signals on the two urban boulevards will be upgraded at College and Church Streets. The new boulevards will be improved with landscaping, street lighting, wayfinding signs, transit shelters, curbing and utility improvements.

[1] Office of the Secretary of Transportation (2010).

2. Reconfiguration of local street connections. A series of modifications to local street connections are needed to accommodate traffic to and from the urban boulevards. CT 34 Exits 2 and 3 westbound off-ramps will be closed and replaced with streetscape enhancements. CT 34 Exits 1 and 2 will be modified and relocated in order to safely transition highway traffic to the North Frontage boulevard at slower travel speeds. Access drives to the air rights garage from Route 34 will be rebuilt. Given the high volume of pedestrians in the project area and city as a whole, pedestrian crossings will be fully upgraded and constructed to city and ADA standard.

3. Reconstruction of College Street to grade. The College Street Bridge over CT 34 will be removed. In its place, the City will reconstruct College Street at grade. A new tunnel beneath College Street will be constructed to allow for vehicular access to Yale-New Haven Hospital parking and the new 55 Park Street medical sciences building driveways to the Air Rights Garage. The next development parcel within the CT 34 right-of-way is located just east of College Street. Immediately following completion of these improvements, the site at 100 College Street will be ready for new development.

Key Analytical Assumptions

Real Discount Rate

Benefits and costs are typically valued in constant (e.g., 2010) dollars to avoid having to forecast future inflation and escalate future values for benefits and costs accordingly. Even in cases where costs are expressed in future, year of expenditure values, they tend to be built upon estimates in constant dollars, and are easily deflated. The use of constant dollar values requires the use of a real discount rate for present value discounting (as opposed to a nominal discount rate).

A real discount rate measures the risk-free interest rate that the market places on the time value of resources after accounting for inflation. Put another way, the real discount rate is the premium that one would pay to have a resource or enjoy a benefit sooner rather than defer it until later. For example, most people would prefer and thus, place a higher value on taking a vacation now instead of waiting ten years into the future, illustrating the preference for having a resource (vacation) or the choice to have it sooner rather than later. As such, the values of future resources must be discounted.

For a given evaluation period, U.S. government securities of similar maturity provide an appropriate estimate of the time value of resources reflected in a real discount rate, where the real rate is a "Treasury Inflation-Indexed" bond of the same maturity. Historically, this risk-free real interest rate has generally been within the range of 2.0 to 4.0 percent, and at present, is at historically low points (0.3 percent for 1-year notes, and 1.8 percent for 5-year).[2]

For NHDC investments, all benefits and costs are expressed in constant 2010 dollars. The cost estimates were initially expressed in constant 2008 or 2009 dollars. To calculate the dollar values of costs and benefits that are based in other (historical) years, the Bureau of Labor Statistics' Consumer Price Index

[2] U.S. Department of the Treasury (2010).

for Urban Consumers (CPI-U) was used. Because an annual 2010 CPI-U figure is not available as of the publication of this report, the April 2010 number was used as a proxy for the year 2010.

Choosing an appropriate discount rate is essential to appropriately assessing the costs and benefits of a project. The higher the discount rate, the lower the present value of future cash flows. For typical investments, with costs concentrated in early periods and benefits following in later periods, raising the discount rate tends to reduce the net present value or economic feasibility of the investment.

The real discount rate used for evaluating NHDC CIP is 7.0 percent. An alternative analysis is also conducted using a real discount rate of 3.0 percent because the project is a public expenditure and the funds are likely to have an opportunity cost as public, not private, investment. These values are consistent with US DOT guidance for TIGER II grants and OMB Circular A-4. [3]

Evaluation Period

Benefits and costs are typically evaluated for a period that includes the construction period and an operations period ranging from 20-50 years after the initial project investments are completed. Given the permanence and relatively extended design life of roads and highway investments, longer operating periods, and thus, evaluation periods are often used. However, beyond 50 years, the ability to forecast meaningful future benefits and costs is questionable, and any such values contribute increasingly less to the results, given the high degree of present value discounting this far into the future.

For the NHDC investments, the evaluation period includes the relevant (post-design) construction period during which capital expenditures are undertaken, plus 40 years of operations beyond project completion within which to accrue benefits.

For the purposes of this study, it has been assumed that construction of the NHDC investments will begin in the year 2012 and the facility will be completed in 2013. This analysis calculates all benefits and costs for 40 years beyond that point, or to 2053. As a simplifying assumption, all benefits and costs are assumed to occur at the end of each year.

Study Region Defined

The NHDC is a roadway project that will lead to further development in New Haven County, Connecticut. Traffic generation models were developed for the project boundaries, which consist of Crown Street to the North; Amistad Street to the South; Brewery Street to the East; and Park Street to the West. The trips generated for this project were calculated for this geography.

The benefits for this project extend to all of New Haven County, and other parts of Connecticut as a region. For example, livability improvements in Downtown Crossing may cause certain commuters to change to other modes. This reduces traffic, which commuters entering this area from outside of New Haven will benefit from.

[3] Office of the Secretary of Transportation (2010), p. 66.

Traffic Generation Sources

Traffic Generation Model

The City of New Haven conducted traffic generation reports based on expected future development that would occur after the NHDC improvements are made. These traffic generation reports predict the additional trips that would be generated given the type and size of a future development. The City of New Haven utilized The Highway Capacity Manual, and the following proposed development:

- 320,000 Sq. Ft. of General Office
- 107,500 Sq. Ft. of Research and Development
- 7,500 Sq. Ft. of Retail
- 5,000 Sq. Ft. of High Turnover Sit-down Restaurant

The base year for the traffic model is 2012 and reported as Average Daily Traffic. These traffic models, furthermore, do not produce a modal split. Thus, all trips appear as vehicle trips. This benefit-cost analysis subsequently applies modal split information based on existing data for the effected Census Tracts as well as assumptions about future changes in the modal split.

Forecast Years and Extrapolation Assumptions

The City of New Haven's traffic models did not include forecasts of traffic beyond year 2012. This analysis assumes that traffic will grow over time, consistent with expectations of area growth based on demographic, land use, and economic trends and expectations for the region. The City of New Haven Department of Transportation estimates that traffic will grow at approximately 1-percent per year until the end of the lifecycle analysis in 2053

Annualizing Factor Assumptions

Traffic models produce outputs on daily or sub-daily basis. For example, the New Haven Downtown Crossing model evaluates travel conditions for two three hour peak periods (a.m. and p.m. peak conditions, for a total of six hours out of the day), and an 18-hour off-peak period. The outputs represent an average weekday. Accordingly, annualizing factors are necessary to convert the travel demand outputs associated with each evaluation period to yearly values.

The highest annualizing factor would be 365, which would assume the average weekday also reflected every day of the year. The lowest annualizing factor would be 251 days, which only accounts for weekday traffic and entirely removes all 104 weekend days and ten holidays. For the NHDC corridor an annualizing factor of 300 was used.

Modal Split Assumptions

The existing modal split for commuters into the NHDC area was calculated using the Census Transportation Planning Package 2000 (CTPP).[4] The NHDC project and development was determined to

[4] U.S. Department of Transportation (2000).

occur primarily in New Haven County, Connecticut census tracts 1401, 1407, and 1403. The work-based commuting patterns for those three census tracts were derived from the CTPP and calculated to be:

Table 1. Commuting Modal Split for New Haven County, CT, Census Tracts 1401, 1407 and 1403 from CTPP 2000.

Mode	Percent
Single Occupancy Vehicles	73.7%
Carpool	9.2%
Transit	8.1%
Walk	8.0%
Bike	1.0%

Citywide, however, there is a much higher mode split favoring transit, walking and biking. According to the US Census, 2000 Diennial Census Report, only 55 percent of commuters drive alone, while 15.5 percent of commuters used non-motorized transportation (and 2.6 percent worked at home). This can be attributed to the greater accessibility to transit services and walking and biking available citywide. Under the current condition, the study area is underserved by access to alternative modes and therefore there is a corresponding increase in reliance on single occupancy vehicles for commuting. The NHDC project is expected to change commuting patterns by replacing a highway stub with an urban boulevard. It is the City's goal to implement a development plan that will reunite distressed neighborhoods with downtown while preserving corridor mobility, enhancing safety, and improving economic conditions. The NHDC integrates mixed-use development and Transit Oriented Development (TOD) in the immediate vicinity of the Route-34 corridor to take advantage of the transportation infrastructure and to create patterns of development that reflect the values and the vision of the community; complement and enhance the surrounding districts; and connect visually, physically, socially and culturally with the adjacent neighborhoods. As a result, the project expects subsequent changes to the modal split to reflect less single occupancy vehicles (SOV); more carpoolers due to traffic demand management; and more walkers and bikers due to an improved urban environment, interconnectedness, and transit oriented development.

Because a formal travel demand model was not conducted, this analysis makes certain key assumptions about changes in mode split due to the project. This was based on a comparative analysis of nearby areas of the downtown that would more closely resemble the character of the study area with the NHDC project in place. The basis of comparison was a survey conducted by the surrounding Yale University, which determined the commuting modes for its employees. This survey reveals those patterns to be as follows:[5]

[5] Yale University (2009).

Table 2. Yale University Employee Commuting Patterns, 2009.

Mode	Percent
Single Occupancy Vehicles	39%
Carpool	5%
Transit	22%
Walk	11%
Bike	22%

The figures for Yale University reflect a significant portion of commuters biking and walking (33 percent), and a very low share for those who drive alone (39 percent). These figures are a high example of a walkable university community with many who might be transit dependant or be more willing and able to walk and bike around the university. Thus, while this analysis does not consider that NHDC will reflect these patterns, they represent an extreme end to what is possible, especially given that Yale University is in the vicinity of the NHDC project.

For NHDC, this analysis assumes a reduction in the share of single occupancy vehicles commuting to the project vicinity based on the citywide and Yale University commuting patterns. This translates to the share of single occupancy vehicles dropping to 65.5 percent

The reduction in single occupancy vehicle trips result in an increase in carpool trips, transit trips, walking trips, and biking trips. This analysis assumes that because development and subsequent changes in the urban fabric and land use patterns takes time, these mode share changes will not occur immediately. Instead, this analysis allows 5 years after the completion of the NHDC infrastructure improvements in 2013 for these changes to take place. Thus, the changes in mode-shares are assumed to begin in 2018.

Below is a comparison of the CTPP existing conditions and the assumptions this analysis makes for future 2018 conditions.

Table 3.

Mode	Existing Conditions (CTPP 2000)	Future Conditions, with the NHDC project in place (Assumed, 2018)
Single Occupancy Vehicles	73.7%	65.5%
Carpool	9.2%	12.3%
Transit	8.1%	9.8%

Walk	8.0%	11.0%
Bike	1.0%	1.5%

Trip Distances

In order to calculate the changes in vehicle-miles traveled that result from the mode changes, as well as increases in walking-miles and biking-miles, certain distance factors were required.

According to the Federal Highway Administration's National Household Travel Survey[6], commuters in the Connecticut portion of the New York-Northern Jersey-Long Island-NY-NJ-CT-PA metropolitan area had an average trip length of 10.8 miles in 2009. Utilizing this data, it is assumed that all single-occupancy vehicles and carpool vehicles travel 10.8 miles per trip.

For walking and biking trips, it is assumed that persons traveling through non-motorized travel will be commuting much shorter distances. This analysis assumes that the average trip length for bicycle travelers is 1.5 miles, and the average trip length for walking commuters is 0.75 miles.

Economic Benefits Included

The following identifies and groups the benefits that are included in the BCA for the NHDC Project.

State of Good Repair

Life Cycle Cost Savings

The NHDC produces life cycle cost savings because there are annual operations and maintenance (O&M) cost savings. Annual O&M costs for the proposed fill structure facility were calculated by the City of New Haven. These O&M costs were compared against the existing highway bridge structure, and the "net costs" were calculated and used for the benefit-cost analysis. In the "build" scenario, the existing bridge structure would cease to be maintained beginning in 2012 since new construction would begin. The new fill structure's O&M costs would begin in 2014.

Net operating costs for any given year were considered as the difference between the build and the no-build scenario. The fill structure costs less to maintain than the existing bridge structure, so net O&M costs "negative costs." This means it would cost less to maintain the system after the NHDC than if the City continued to maintain the existing facility. Thus, these savings are reported as "life cycle cost savings."

Reductions in Pavement Damage

Automobiles produce damage to pavement on roads for each mile they travel, and this constitutes a marginal cost to society for each motor-vehicle VMT. Since the NHDC project is expected to cause a net

[6] Federal Highway Administration (2009).

reduction in VMT, these costs to society will be reduced. Overall, there will be less damage to highway and road pavements and the overall roadway system will remain in better repair.

This analysis utilizes the Federal Highway Administration's Federal Highway Cost Allocation Study conducted in 1997.[7] This study reports that urban automobiles have a marginal cost to pavements of 0.13 cents per vehicle-mile in 2010 CPI-U adjusted dollars. This figure was then utilized in this analysis.

Economic Competitiveness

Land Value Increases

A key component to NHDC is the development of the "First development parcel" in the project vicinity. This project will develop an existing highway stub with an approximate 101,120 sq. ft. footprint into a privately developed 400,000 sq. ft. office, laboratory, research and development facility, as well as a 600 – 800 space garage. This development is made possible by publicly funded improvements to the current roadway alignment.

It is assumed that the First development parcel in its existing state as vacant, undevelopable land zoned for right-of-way use has an economic value to society of $0 per square foot. This is the baseline upon which land value benefits are calculated from.

In order to calculate the estimated increase in the value of the First development parcel, a real-estate analysis was conducted that examined 18 comparable land sales and appraisals between 2000 and 2009. These comparable land sales and appraisals were then adjusted to current 2010 dollars utilizing the non-seasonally adjusted Case-Shiller Index for the New York Metro region.[8] According to this analysis, the average price of land was $47.00 per square foot. Accordingly, First development parcel's economic value is expected to increase by this amount due to prospective development. This benefit is assumed to be a one-time benefit occurring in 2014, or Year 1 of the project.

Reductions in Vehicle Operating Costs

The proposed NHDC investments would reduce vehicle operating and ownership costs because the changes in the infrastructure and subsequent development would cause reductions in single-occupancy vehicle travel. As a result, overall vehicle-miles traveled by motor vehicles are reduced. This causes reductions in vehicle operating and ownership costs as commuters use vehicles less.

Vehicle Operating Costs - Fuel

The first operating cost reduction this analysis calculated was the reduction in fuel costs. Energy Information Administration's (EIA) Annual Energy Outlook 2010 projections for auto fuel efficiency, as well as the price of gasoline and diesel were used.[9]

---

[7] Federal Highway Administration (1997), Table ES-6.

[8] The use of the Case-Schiller Index, which is designed to measure property value appreciation, is conservative in that the price of raw or unimproved land in the region generally increased at a greater rate than land with improvements during the analysis period. Source: Federal Reserve Bank of New York. Current Issues In Economics and Finance, Vol. 14, No. 3. April/May 2008.

[9] U.S. Energy Information Administration (2010).

The EIA only projects figures to 2035, so it was necessary to further project for years 2036 to 2055. Based on the EIA's "reference case," we projected fuel efficiency and prices based on the compound annual growth rate (CAGR) in the EIA's model for 2025 to 2035. Below is the range of estimates utilized for this analysis:

Table 4. Fuel Economy and Fuel Prices – 2010 and 2055 (Projected)

	2010	2055
Auto Fuel Economy	21.0 miles per gallon	36.7 miles per gallon
Truck Fuel Economy	6.1 miles per gallon	7.5 miles per gallon
Gasoline Price	$2.53 per gallon (2010 $)	$4.97 (2010 $)
Diesel Price	$2.65 per gallon (2010 $)	$5.26 (2010 $)

Vehicle Operating Costs – Non-Fuel

Non-fuel operating costs include the cost of operations and maintenance to vehicles, the cost of tires, and vehicle depreciation. A reduction in VMT due to project investments results in cost savings in these categories. The per-mile values of these categories were derived from a study conducted by Barnes and Langworthy at the University of Minnesota.[10] This analysis used their "baseline costs" which reflected the most conservative estimate of operating costs because they assume highway conditions and smooth pavements. The following costs were utilized (in real 2010 dollars).

Table 5. Non-fuel Operating Cost Assumptions

Operating Cost Category	Cost per Vehicle-mile Traveled
Auto - Maintenance/Repair	4.1 cents per VMT
Auto – Tires	1.1 cents per VMT
Auto – Depreciation	7.9 cents per VMT

Reductions in the Economic Cost of Oil Imports

Fuel consumption has a cost beyond the actual operating costs or the environmental costs of the consumption which is expressed as the economic cost of oil imports. This concept reflects two ideas: a monopsony component and a price shock component.

The monopsony component suggests that because the U.S. is such a large consumer of oil that an increase in U.S. oil demand will lead to higher fuel prices (based on supply and demand relationships).

[10] Barnes, G. and P. Langworthy (2003), p.22

The price shock component suggests that a reduction in oil supplies leads to higher oil prices thereby reducing the level of U.S. economic output. As a consequence, reducing oil imports by consuming less fuel reduces these costs on the U.S. economy. The National Highway Traffic and Safety Administration suggests that each gallon of fuel saved reduces total U.S. imports of refined fuel or crude oil by 0.95 gallons.[11]

The BCA uses NHTSA's estimate for the per gallon cost of oil imports for the monopsony and price shock components, which is $0.412 per gallon in real 2010 after CPI-U adjustment.[12]

Livability

Due to changes in the modal split, the NHDC project is expected to increase the number of walking miles and biking miles that occur in the project vicinity. Again, the modal split changes are expected due to subsequent changes in development patterns, transit-oriented development, and the creation of a new urban boulevard.

Active Life Health Benefits

Increases in physical activity are linked to improved health. Thus, additional walking and biking produces societal benefits in two ways. First, the individual experiences private benefits in his or her own extended life expectancy, reductions in certain diseases such as heart disease and type II diabetes, and the medical expenses the individual will pay. Furthermore, there are external benefits at large benefits from the improved health of the individual because of reduced costs in subsidized medical care, emergency room visits, and marginal reductions group health insurance rates.

The Victoria Transportation Institute has monetized these benefits accordingly.[13] The following table illustrates the walking and biking health benefits used in this analysis:

Table 6. Health Benefits from Walking and Biking

	Walking	**Biking**
Internal Health Benefit	25.25 cents/ walking-mile	10 cents / biking-mile
External Health Benefit	25.25 cents/ walking-mile	10 cents / biking-mile
Total Health Benefit	50.5 cents / walking-mile	20 cents / biking-mile

Noise Pollution

The reductions in VMT create a more livable environment by creating reductions in noise pollution. This BCA assumes a cost of noise of $0.001 per VMT as expressed in real 2010 dollars (after CPIU-adjustment), consistent with the National Traffic Highway and Safety Administration's figures.[14]

[11] National Highway Traffic and Safety Administration (2009), p. viii-22 – viii-27.

[12] Ibid., p. 60.

[13] Victoria Transportation Institute (2009).

[14] Ibid., p. viii-60

Environmental Sustainability

The NHDC will create environmental and sustainability benefits by reducing air and noise pollution associated with automobile travel. Six emissions from which to measure and monetize benefits were identified, including: carbon monoxide, nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide. The state-of-the-practice typically expresses the energy and environmental benefits in a cost per VMT.

Emissions

Per mile emissions factors differ depending on vehicle, fuel efficiency, average speed, and driving conditions. This BCA used the California Department of Transportation's emissions factors from the California Life-cycle Benefit-Cost Analysis Model (Cal B/C).[15] This model provides emissions factors for automobiles and trucks at varying speeds from 5 to 65 miles per hour. Furthermore, it uses new factors beginning in year 2027 in order to incorporate increases in fuel efficiency and changes in the vehicle fleet.

The Cal B/C model reports 2007 figures and 2027 figures only, with a most emissions factors decreasing over time due to an expected change in fuel efficiency and vehicle fleet composition. This analysis interpolates for years in between 2007 and 2027 using the combined annual growth rate. This analysis does not extrapolate beyond 2027, and instead uses the 2027 emissions rates as constant for years 2028 to 2053. This was due to the imprecision of predicting emissions rates beyond that year.

This analysis assumed a constant speed of 35 miles per hour for vehicles in order to use a consistent set of emissions factors.

Table 7. Emissions Factors From Cal B/C Model

Year	CO (g/VMT)	CO2 (g/VMT)	NO_X (g/VMT)	PM_{10} (g/VMT)	SO_X (g/VMT)	VOC (g/VMT)
	Autos @ 35 mph					
2007	4.09520	388.2	0.42910	0.03420	0.00400	0.32160
2015	2.40058	385.6	0.22799	0.03491	0.00392	0.20276
2025	1.23131	382.4	0.10342	0.03582	0.00382	0.11391
2050	1.07740	381.7	0.08830	0.03600	0.00380	0.10150

The National Highway Traffic and Safety Administration estimated the economic costs of emissions per ton.[16] These figures were converted to real 2010 dollars based on CPI-U and used to monetize any emissions benefits. Table 6 shows the per-ton cost of non-carbon dioxide emissions as reported in real 2010 dollars.

[15] California Department of Transportation (2008).
[16] National Highway Traffic and Safety Administration (2009), p. viii-60.

Table 8. Cost of Non-Carbon Dioxide Emissions - NHTSA

Emissions Category	Cost per ton (2010 $)
Carbon Monoxide	$ -
Nitrous Oxide	$ 4,310
Particulate Mater	$ 182,000
Sulfur Oxides (Sulfur Dioxide)	$ 16,000
Volatile Organic Compounds	$ 1,840

There is not a widely accepted practice for monetizing carbon dioxide's contributions to global warming. To do so, this analysis utilized the Interagency Working Group on the Social Cost of Carbon's study to estimate the per ton cost of carbon dioxide emissions.[17] Their estimates of the per ton costs of carbon dioxide in 2010 ranges from $4.7 per ton to $64.9 per ton (expressed 2007 dollars). This analysis utilized a conservative midpoint range of $35 per ton of carbon dioxide in real 2010 dollars.

Additionally, the per ton cost of carbon dioxide is expected to increase in real dollars as the impacts of global warming become greater over time. The National Highway Safety and Traffic Administration supports 2.4 percent growth rate for the cost of carbon dioxide emissions, which was utilized.[18]

Safety

Accident Cost Savings

Reductions in VMT lower the incidence of traffic accidents. The cost savings from reducing the number of accidents include direct savings (e.g., reduced personal medical expenses, lost wages, and lower individual insurance premiums) as well as significant avoided costs to society (e.g., second party medical and litigation fees, emergency response costs, incident congestion costs, and litigation costs). The value of all such benefits – both direct and societal – could also be approximated by the cost of service disruptions to other travelers, emergency response costs to the region, medical costs, litigation costs, vehicle damages, and economic productivity loss due to workers inactivity.

The state-of-the-practice in benefit-cost analyses is to estimate accident cost savings for each of three accident types (fatal accidents, injury accidents, or property damage only accidents) using the change in highway VMT. Some studies perform more disaggregate estimates of the accident cost savings, applying different accident rates to different types of roadways (e.g., interstate, highway, arterial).

This BCA estimates the benefits associated with accident cost savings using 2006 statewide accident data reported by the Connecticut Department of Transportation published in 2008.[19] The accident figures are statewide averages and represent accidents on interstate highways, state highways, county roads, and arterials. The ConnDOT reports aggregated injury accidents. This analysis disaggregated the injury accident rates into Maximum Injury Abbreviated Scale (MAIS) categories based on the share of

[17] Interagency Working Group (2010), p.2.
[18] National Traffic Highway and Safety Administration (2009), p. vii-45 – viii-54.
[19] Connecticut Department of Transpiration (2008)

nationwide accident data reported by the National Highway Traffic Safety Administration.[20] Below is the accident rate data used for this study.

Table 9. Accident Rate Assumptions From Connecticut Department of Transportation

Category	Accident Rate (per million VMT)
MAIS 6 (fatal)	0.0092
MAIS 5 (critical)	0.0015
MAIS 4 (severe)	0.0060
MAIS 3 (serious)	0.0206
MAIS 2 (moderate)	0.0714
MAIS 1 (minor)	0.7630
Property Damage Only	0.1281

The ConnDOT accident rates underestimate property damage only accidents because they do not include property accidents that occurred on local or county maintained roads. In actuality then, this rate would be much higher.

This BCA assumes constant accident rates for the "build" and "no build" scenarios. Thus, the only accident changes will result from changes in VMT. This is a limitation because the project is expected to provide safety improvements that make the facility safer.

The NHDC will reduce vehicle speeds as well as provide a "complete streets" urban boulevard with improved pedestrian and bicycle facilities. If lower accident rates were utilized for the "build" scenario versus the "no build" scenario there would be additional safety benefits. However, because the magnitude of that reduction is unknown, we maintain the conservative assumption that the rates are constant between the two scenarios.

The benefits resulting from accident reduction are converted to monetary values using the cost of fatal and injury highway accidents recommended by the US DOT.[21] The value of 'property damage only' accidents is derived from a Federal Highway Administration technical advisory.[22] The following table outlines the values used as expressed in real 2010 dollars after CPI-U adjustment.

[20] National Highway Traffic and Safety Administration (2002), p. 9.
[21] Office of the Secretary of Transportation (2009), pp. 1-8.
[22] Federal Highway Administration (1994).

Table 10. Value of a Statistical Life and of Accidents by MAIS Category

Category	Value
Value of a Statistical Life	$ 6,490,000
MAIS 6 (fatal) – cost	$ 6,490,000
MAIS 5 (critical) – cost	$ 4,948,625
MAIS 4 (severe) – cost	$ 1,216,875
MAIS 3 (serious) – cost	$ 373,175
MAIS 2 (moderate) – cost	$ 100,595
MAIS 1 (minor) – cost	$ 12,980
MAIS 0 (property only) –cost	$ 3,790

Economic Benefits Not Included

The following is a summary of other potential benefits that are excluded from the BCA. The ensuing discussion describes these possible benefits and explains the rationale for their exclusion. Fifteen percent sensitivity analyses were conducted to account for potential impacts from marginal excluded costs outlined in this section.

Regional Land Value Increases

The only increases in land values calculated in this analysis were for that of the "First development parcel." However, the NHDC project is likely to increase land values for other parcels along the corridor of the proposed urban boulevard. In particular, there are three additional parcels that would be created within the project limits of the complete Route 34 project area, but which are outside the scope of the Phase 1 improvements. The transit oriented development, as well as improved pedestrian and walkable facilities are likely to boost property values for other residential and commercial property in this vicinity. However, because those effects require detailed studies of all the parcels, they were omitted from this analysis.

Travel Time

Travel times were not included in this analysis because they require travel demand modeling not available at the time of this study. The NHDC project allows commuters greater mobility choices with enhanced transit access as well as an urban environment more conducive to bicycling and walking. These alternative modes of transportation may decrease overall system travel time by reducing automobile VMT and inducing changes in land use patterns as certain residents may choose to live closer to employment centers. Furthermore, the reduction in VMT may reduce congestion and improve travel times on the overall highway system.

Construction Delay

During the period of project construction there are expected lane closures and other disruptions as a consequence of the highway building. This would theoretically create additional delay on the system during the two year period of construction, thereby creating potential reductions in travel times. These effects were not incorporated in this analysis.

Improved Economic Productivity

Improved walking and biking access along the NHDC development, along with transit oriented development, may create shifts in employment patterns and allow workers access to more job markets that were not previously feasible. As a result, workers may seek employment in higher output work that puts their labor to the highest and best use. This has the effect of increasing overall economic productivity in the region as workers can be gainfully employed in a broader geographic job market. Such impacts, however, were excluded from this BCA as they would require detailed labor market analysis beyond the scope of the data available

Transportation Choice

A major livability benefit from projects such as this is that it facilitates and expands non-auto transportation options, In fact, increased transportation choices, even where travelers do not often take advantage of these choices on a regular basis, entail an economic benefit to users in the form of "option demand". Option demand benefits can sometimes be derived from stated preference surveys, but no attempt has been made in this analysis to conduct such a survey.

In addition, the area itself surrounding the project becomes quieter, social interactions are increased, and the general character of the area will usually become more picturesque, with retail and commercial activities enhancing streetscapes. No attempt has been made in this analysis to monetize these benefits.

Economic Costs Included and Assumptions

In the benefit-cost analysis, the term 'cost' refers to the additional resource costs or expenditures required to implement, perpetuate, and maintain the investments associated with the NHDC.

The BCA uses project costs that have been estimated for the NHDC on an annual basis. All costs were expressed in real 2010 dollars.

Initial Project Investment Costs

Initial project investment costs include engineering and design, construction, acquisition of right-of-way, vehicles, other capital investments, and contingency factors. These costs were reported by the City of New Haven and included costs beginning in 2012 and ending in 2013. The facility is expected to be operational in 2013.

The project capital investment costs are typically treated in one of two basic ways. The first, and most common, is to treat the project costs as up-front costs coinciding with the actual project expenditures on a pay-as-you go basis. This approach excludes financing costs from long-term borrowing as part of the investment expenditures subject to present value calculations.

An alternative approach would consider the proposed financial plan for the investments, when the plan involves long-term debt that is repaid over time with interest, and account for the financing costs as the debt is repaid. The two approaches yield essentially the same results for the discounted present value of the project investment costs.[23] As a result, the former pay-as-you-go assumption is usually adopted in recognition that a detailed financial plan typically would not yet be available at the time when a BCA of project alternatives is undertaken.

To understand why debt service costs over time for financed investments equate to the same present value as up-front, pay-as-you-go investments, note that debt service amounts are expressed in nominal dollars, calculated using a nominal interest rate that includes both real and inflationary components. Because BCA typically accounts for all dollar amounts in constant dollars of a single year (e.g., 2010 dollars), it is necessary to convert the stream of debt service payments into constant dollars. However, once inflation is extracted from the nominal debt service payments, the remaining debt service is simply a stream of principal repayments and real interest payments.[24] Converting this stream of real debt service payments to its present value using a real discount rate cancels out the real interest paid over time, leaving the sum of the principal payments — the original level of investment. Put another way, the long term real cost of capital for public highway investments in a relatively risk free environment is essentially equal to the real discount rate.

Annual Operating and Maintenance Costs

The annual cost of operating and maintaining the proposed fill structure facility were included in this analysis. These O&M costs were compared against the existing highway bridge structure, and the "net costs" were calculated and used for the benefit-cost analysis. In the "build" scenario, the existing bridge structure would cease to be maintained beginning in 2012 since new construction would begin. The new fill structure's O&M costs would begin in 2014.

Net operating costs for any given year were considered as the difference between the build and the no-build scenario. The fill structure costs less to maintain than the existing bridge structure, so net O&M costs "negative costs." This means it would cost less to maintain the system after the NHDC than if the City continued to maintain the existing facility.

Economic Costs Not Included

Annual Operating and Maintenance Costs

As mentioned previously, annual O&M costs produce annual and overall savings. These savings are reported as "life cycle cost savings" in the benefits section, and not included in the costs.

[23] A small difference may result from financing costs such as the underwriter's fees which would not be part of pay-as-you-go investment.

[24] Assuming the project can secure debt with a solid credit rating such that there is no material risk component also factored into the borrowing interest rate. An interest rate premium for risk could result in a higher net present value cost for the project under debt financing than pay-as-you go. However, the use of tax-exempt debt with lower nominal interest rates than taxable debt may offset the real increase attributable to credit risk.

Residual Value (Cost Offset or Negative Cost)

The City of New Haven reports that the lifecycle of the NHDC facilities for the fill structure is approximately 75 years. This benefit-cost analysis utilizes a 40 year analysis period, so it stands that the improved facility may have a residual value. However, for simplicity the benefit-cost analysis assumes that in 2053 there is no remaining economic value of the facility and the residual value is zero.

Key Benefit-Cost Evaluation Measures

There are three common benefit-cost evaluation measures, each tailored to compare benefits and costs from different perspectives.

The benefit-cost analysis converts potential gains and losses from the proposed investment into monetary units and compares them on the basis of economic efficiency, i.e., net present value (NPV). For example, NPV = PVB (present value of benefits) - PVC (present value of costs); where:

$$PVB = \sum_{t=0}^{T} B_t / (1+r)^t; \text{ and } PVC = \sum_{t=0}^{T} C_t / (1+r)^t$$

Equation 1

and the NPV of a project can be represented as:

$$NPV = \sum_{t=0}^{T} (B_t - C_t)/ (1+r)^t,$$

Equation 2

where B_t and C_t are the benefits and costs, respectively, of a project in year t; r is the real discount rate; and T is the time horizon (evaluation period). In essence, NPV gives the magnitude of the project's economic feasibility in terms of net benefits (benefits minus costs) discounted to present values using the real discount rate assumption. Under this criterion, a scenario with an NPV greater than zero may be considered "economically feasible." The NPV provides some perspective on the overall dollar magnitude of benefits not reflected by the other two measures.

Economic Rate of Return

The Economic Rate of Return (ERR) is the discount rate that makes the present value of all benefits just equal to the present value of all costs, i.e., the real discount rate at which the project's NPV is zero and it's benefit-cost is unity. The ERR measures the social or economic return on investment. As an evaluation measure, it allows comparison of the proposed investment package with other similar packages and/or alternative uses of investment funds that may have different costs, different benefit flows, and/or different timing. Note that the ERR is interpreted as a real rate of return (after accounting for inflation), since the assumption is that benefits and costs are expressed in constant dollars. As such, it should not be directly compared with investment returns calculated from inflated or nominal future year dollars. In some cases, a threshold value for the ERR may be established where exceeding that threshold results in the determination of an economically justified project.

Benefit/Cost Ratio

The evaluation also estimates the benefit-cost ratio; where the present value of incremental benefits divided by the present value of incremental costs yields the benefit-cost ratio (B/C Ratio), i.e., B/C Ratio = PVB / PVC. In essence, the B/C Ratio expresses the relation of discounted benefits to discounted costs as a measure of the extent by which a project's benefits either exceed or fall short of their associated costs. For example, a B/C ratio of 1.5 indicates that the project generates $1.5 of benefits per $1 of cost. As such, a ratio greater than 1 is necessary for the project to be economically worthwhile (feasible). The B/C Ratio can be useful when the objective is to prioritize or rank projects or portfolios of projects with the intent to decide how to best allocate an established capital budget, assuming equivalent classification of benefits and costs.

Sensitivity Analysis

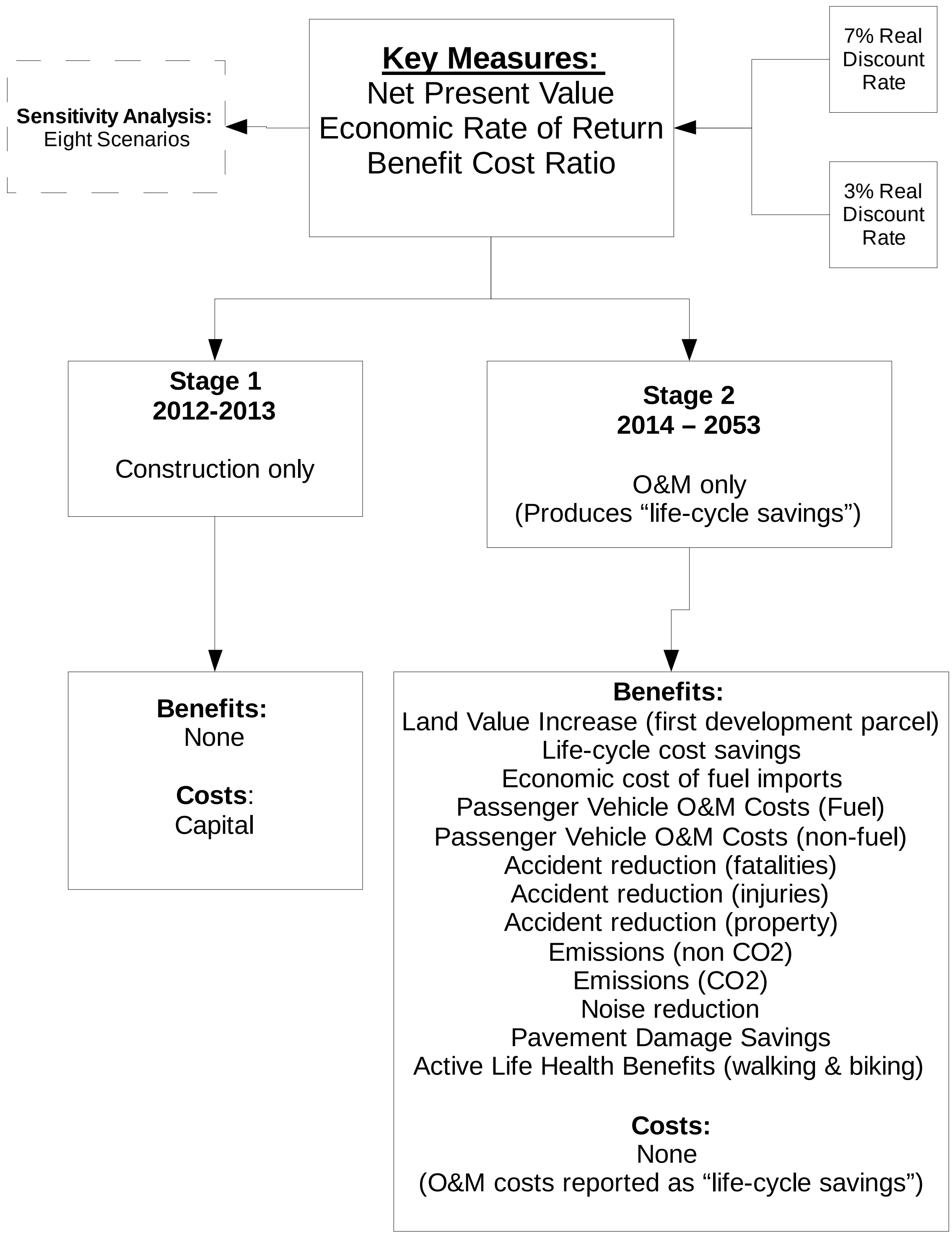
To test the robustness of the estimated NPV, ERR, and B/C Ratio, the economic analysis also conducts several sensitivity tests, where the estimated measures are re-calculated under varying scenarios (i.e. assumptions). These scenarios include:

- Scenario A1: 7% discount rate; 15% increase in all calculated benefits
- Scenario A2: 7% discount rate; 15% decrease in all calculated benefits
- Scenario A3: 7% discount rate; 15% increase in initial capital costs
- Scenario A4: 7% discount rate; 15% decrease in initial capital costs

- Scenario B1: 3% discount rate; 15% increase in all calculated benefits
- Scenario B2: 3% discount rate; 15% decrease in all calculated benefits
- Scenario B3: 3% discount rate; 15% increase in initial capital costs
- Scenario B4: 3% discount rate; 15% decrease in initial capital costs

Figure 1 below summarizes the NHDC evaluation process.

Figure 1. New Haven Downtown Crossing: Benefit-Cost Analysis Summary Graphic



New Haven Downtown Crossing Benefit-Cost Analysis Results

Results in Brief

There were two "Cases" conducted for this analysis. Case A assumes a 7 percent discount rate, and Case B assumes a 3 percent discount rate. Case A is the presumed baseline as prescribed by the US DOT.

Case B is a comparison justified because the project utilizes public funds so the opportunity cost is in public, not private, investment. Thus, there is some justification to consider a lower discount rate of 3 percent.

For the NHDC Base Case A with a 7 pecent discount rate, the proposed investments yield a net present value of $66.4 million, which provides a real economic rate of return of 18.5%. The associated benefit-cost ratio is 3.5.

When applying a 3 percent discount rate in Base Case B, the NHDC yields a net present value of $175.8 million, an economic rate of return of 18.5 percent, and a benefit-cost ratio of 7.0

Table 11 presents the evaluation results for the base case and eight sensitivity tests. All benefits and costs were estimated in constant 2010 dollars over an evaluation period extending 40 years beyond system completion in 2016.

Table 11. Benefit Cost Analysis Summary Results

Scenario	Net Present Value (NPV)	Economic Rate of Return (ERR)	Benefit Cost Ratio (B/C)
Base Case A (7% discount rate)	**$66.4 million**	**18.5%**	**3.5**
Sensitivity Tests			
A1: 15% increase in benefits	$80.3 million	20.3%	4.0
A2: 15% decrease in benefits	$52.4 million	16.5%	3.0
A3: 15% increase in costs	$62.4 million	16.8%	3.0
A4: 15% decrease in costs	$70.4 million	20.6%	4.1
Base Case B (3% discount rate)	**$175.8 million**	**18.5%**	**7.0**
Sensitivity Tests			
B1: 15% increase in benefits	$206.6 million	20.3%	8.0
B2: 15% decrease in benefits	$145.1 million	16.5%	5.9
B3: 15% increase in costs	$171.4 million	16.8%	6.1
B4: 15% decrease in costs	$180.2 million	20.6%	8.2

Travel Impacts

The NHDC analysis results are based on the City of New Haven's traffic impact models and the resulting changes in modal split from the project. The following table outlines the changes in VMT, walking trips, bicycling trips, walking miles, and bicycling miles.

Table 12. Travel Impacts from New Haven Downtown Crossing

Category	Cumulative 2014-2053	Change per year
Auto Vehicle Miles Traveled	- 960.6 million VMT	- 24.0 million VMT / year
Transit Passenger Trips	+ 33.5 million pass.-trips	+ 838,000 pass.-trips / year
Walking Trips	+ 59.6 million trips	+1.5 million trips / year
Bicycling Trips	+9.5 million trips	+237,000 trips / year
Walking Miles	+ 44.7million person-miles	+ 1.1 million person-miles / year
Bicycling Miles	+ 14.2 million person-miles	+ 355,000 miles / year

Benefits by Category

About 65.5 percent of all NHDC benefits are attributable to economic competitiveness. The (discounted) present values of all benefits that were quantified are shown in **Figure 2** and **Figure 4**.

Figure 2. Benefit Shares by US DOT Category – Discounted Present Value (2010 $)

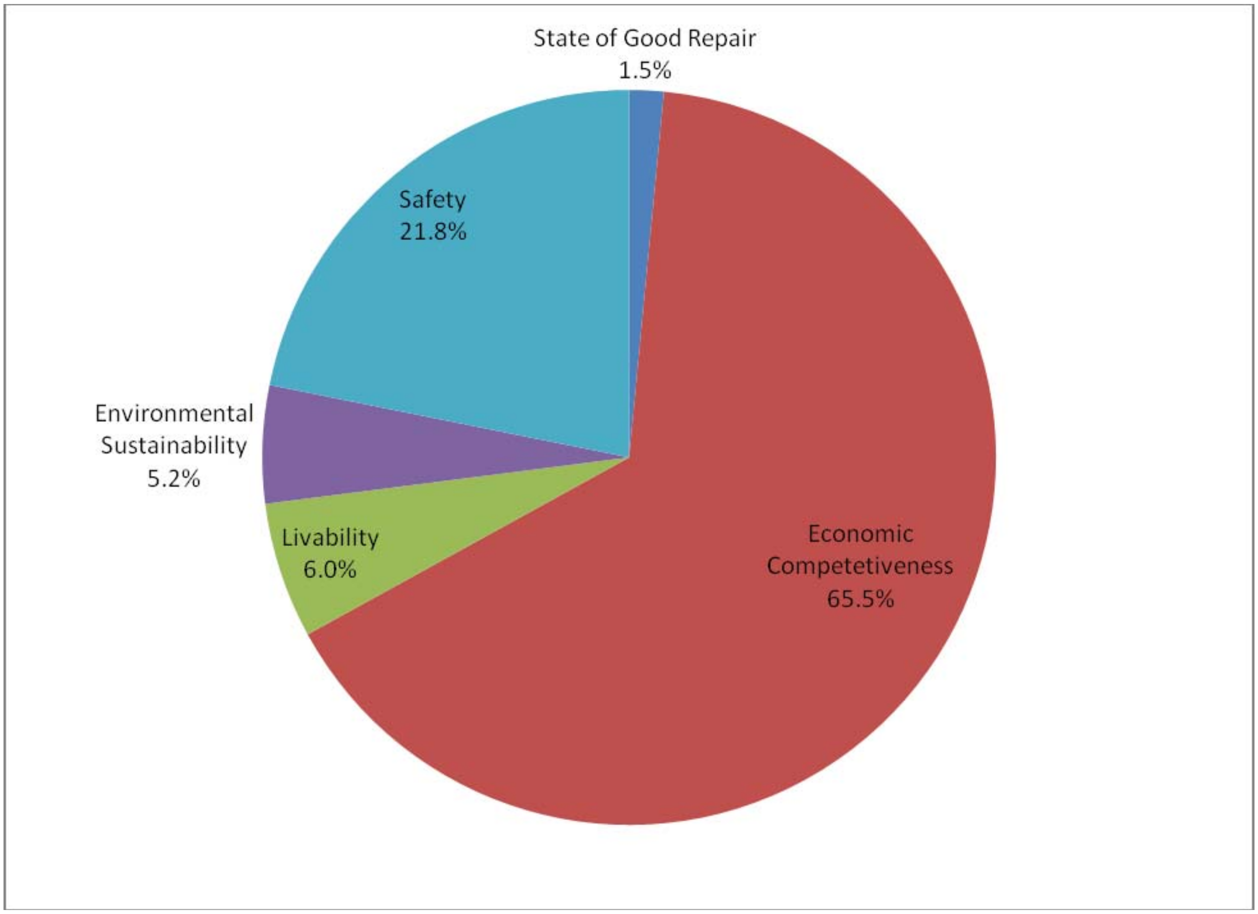


Figure 3. Benefit Shares by US DOT Category – Discounted Present Value (2010 $)

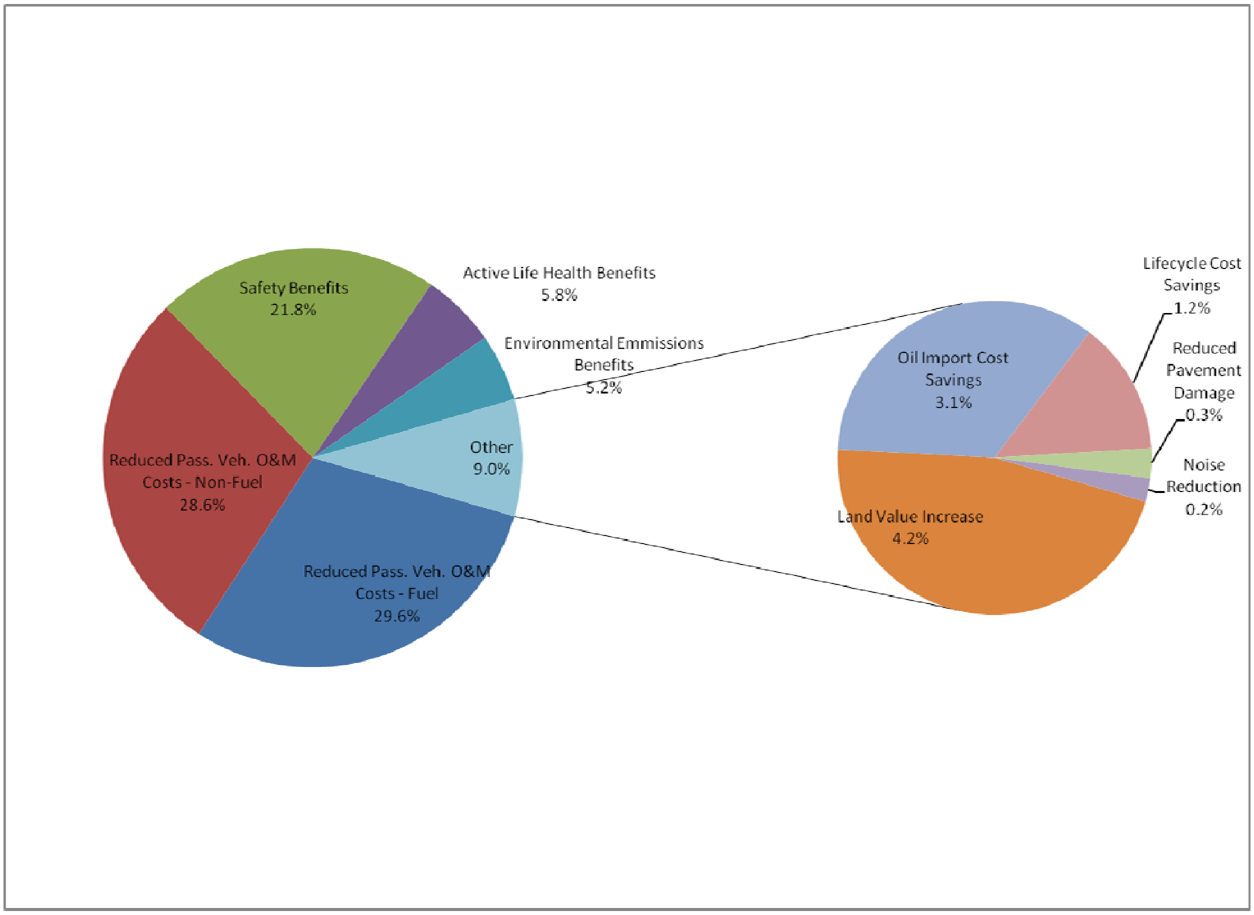
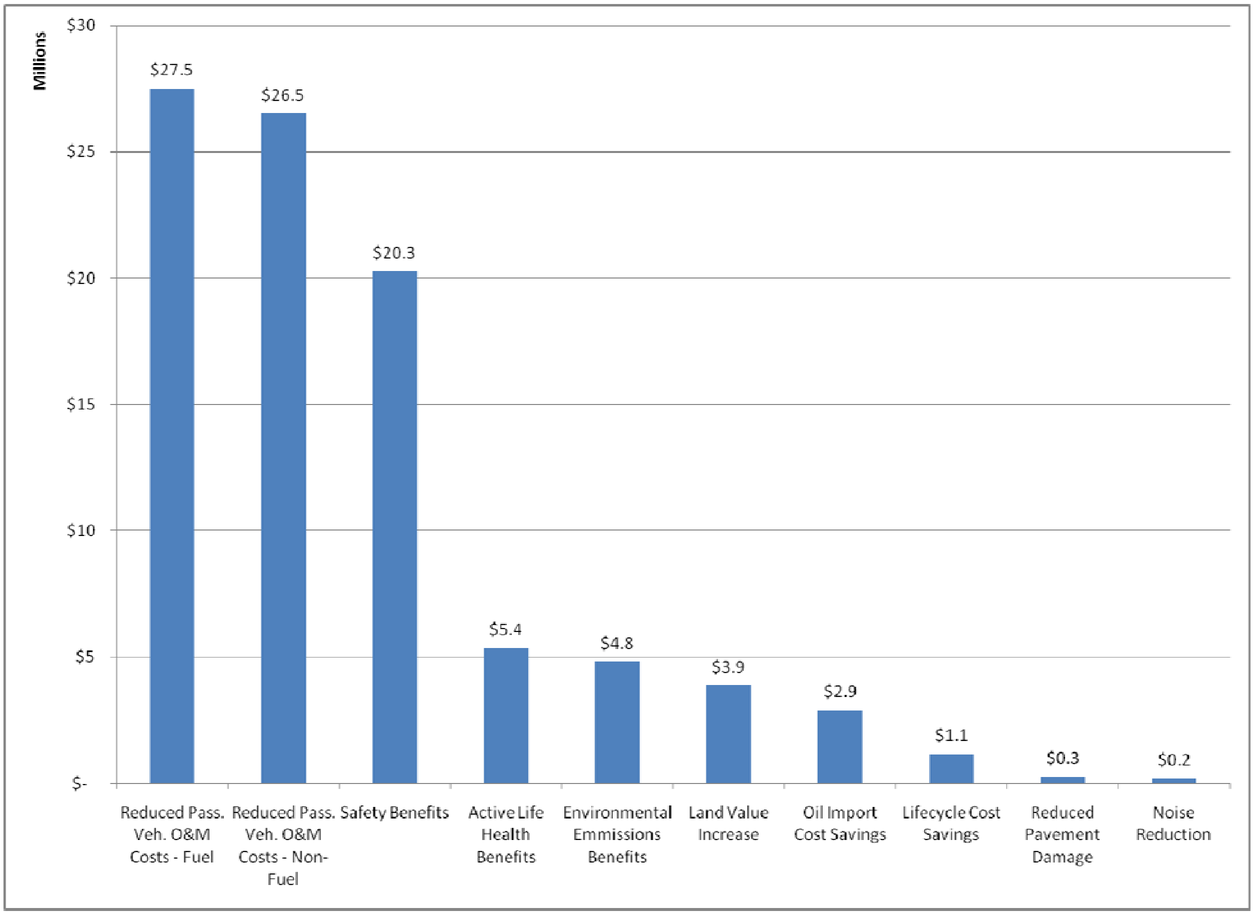


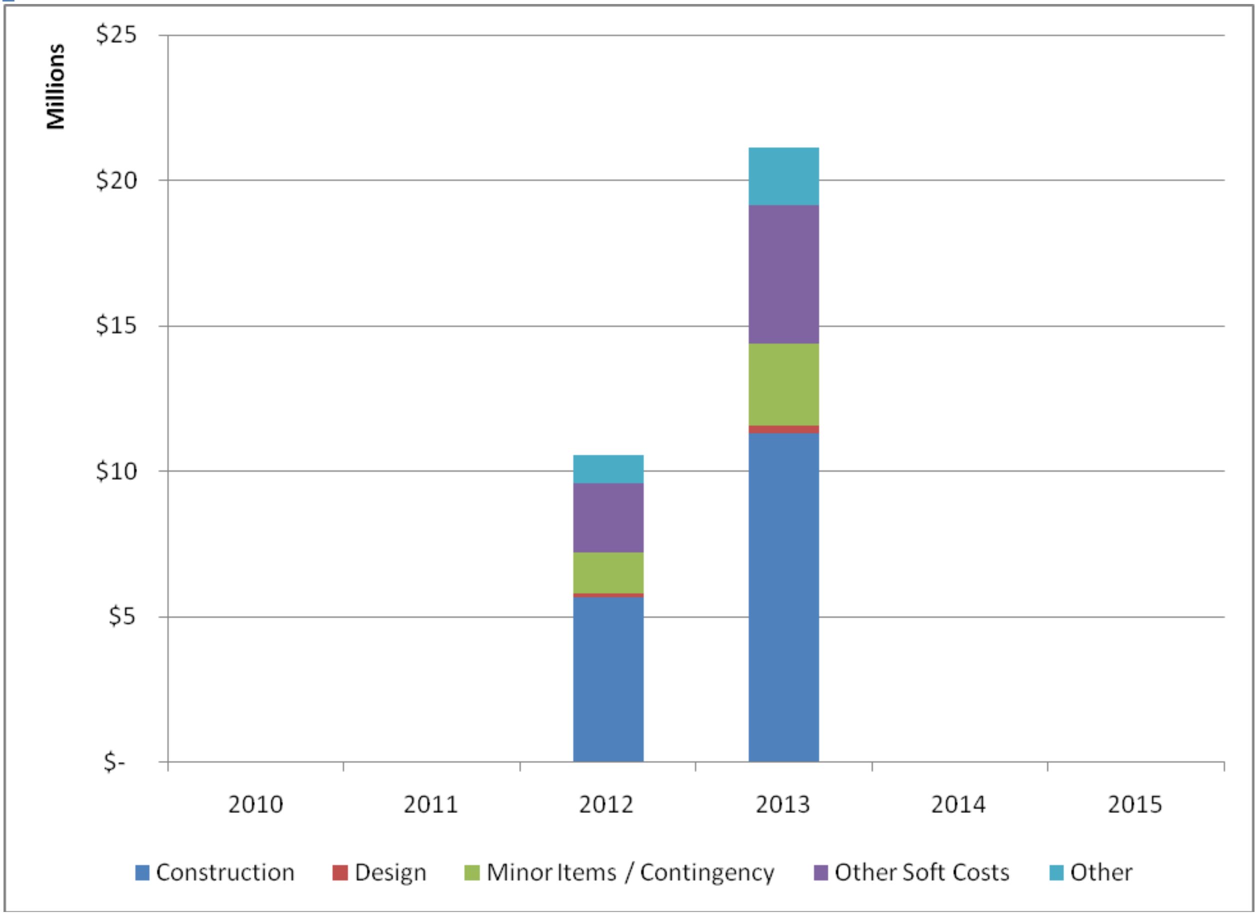
Figure 4. Benefits Amounts – Discounted Present Value (2010 $)



8.4 - Costs over Time

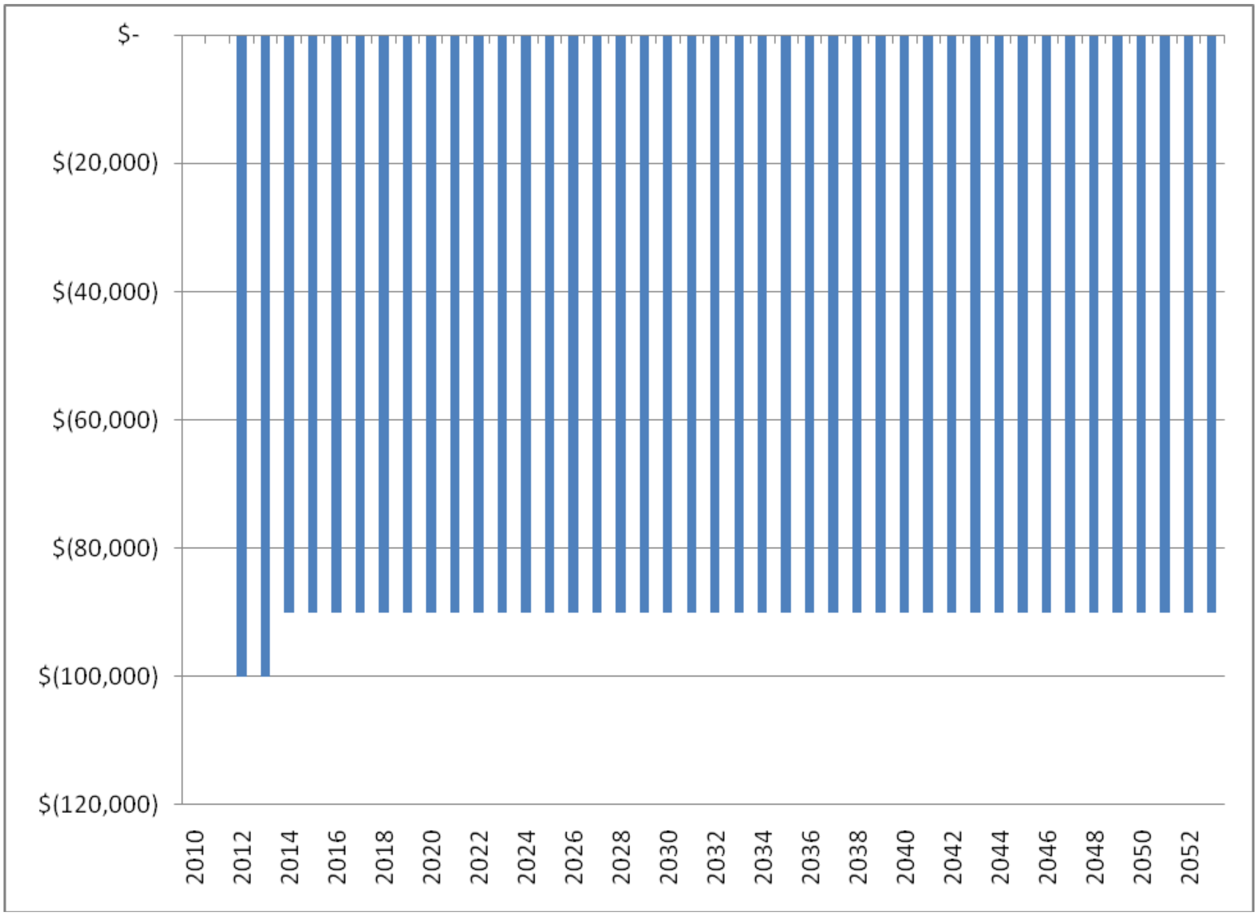
Figure 5 presents the capital expenditures over time, expressed in constant 2010 dollars before present value discounting. The capital investments ($35 million) were assumed to begin in 2012 and conclude by the end of 2013.

Figure 5. Capital Expenditures in 2010 Dollars before Present Value Discounting



Annual operating and maintenance (O&M) costs over the economic evaluation period are presented in Figure 6, expressed in constant 2010 dollars before present value discounting. The values are negative because the NHDC fill structure costs less to operate than the existing bridge facility under a "no build" scenario. Thus, they might be considered cost savings. In real dollars, the City of New Haven predicts that these costs will remain generally constant through 2053. As a result, for the purposes of calculating the benefits, costs, and the B/C ratio, these savings were reported as benefits under "life cycle cost savings."

Figure 6. Annual O&M Costs in 2010 Dollars before Present Value Discounting

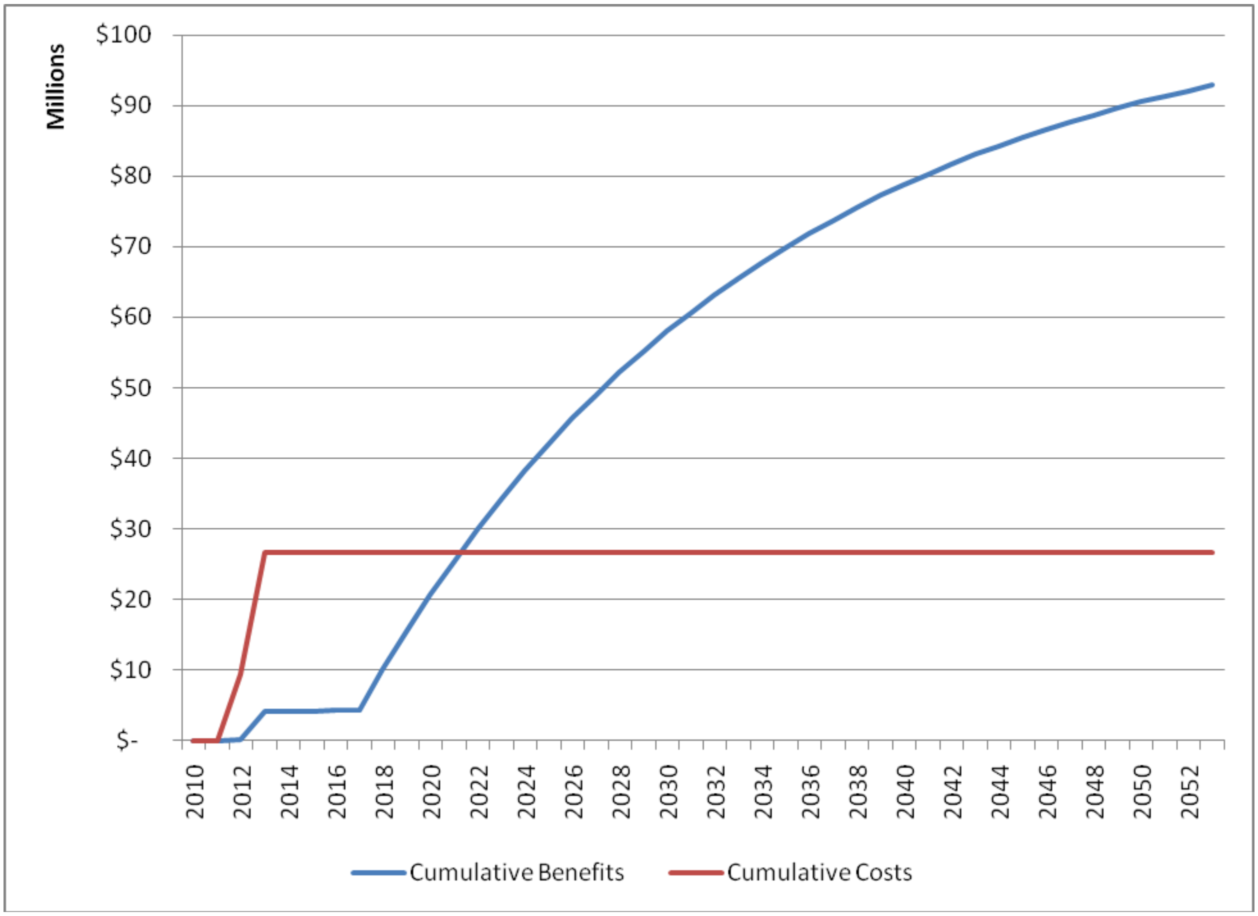


8.5 Cumulative Benefits and Costs

Figure 7 compares the cumulative present value of benefits with the cumulative present value of costs over time for Base Case A. The figure shows that the cumulative discounted benefits exceed the cumulative discounted costs by mid 2021, or approximately 8 years after the completion of the project.

The cumulative costs only reflect the capital costs in 2012 and 2013. The stepwise benefits at the beginning of the project are a consequence of the one-time land value increase in 2014. The benefits do not begin to accrue until 2018, allowing for 5 years of development and land use changes to spur new modal shifts after project completion.

Figure 7. Cumulative Benefits and Costs



9.0 Conclusion

This analysis shows that the anticipated quantifiable benefits from the New Haven Downtown Crossing exceed their anticipated costs. It is important to note this analysis does not include all of the potential benefits that highway investments will contribute to region. The value of providing a new urban boulevard that will spur economic development and reduce auto dependence is substantial. This increases the quality of life for residents and allows for continued economic growth of the region.

Sources

Barnes, G and P. Langworthy (2003). The Per-mile Costs of Operating Automobiles and Trucks. Minneapolis: University of Minnesota Press. http://www.lrrb.gen.mn.us/PDF/200319.pdf

California Department of Transportation (2007). California Life-cycle Benefit-cost Analysis Model. http://www.dot.ca.gov/hq/tpp/offices/ote/benefit.html

Connecticut Department of Transportation (2008). Connecticut Traffic Accident Facts 2006. http://www.ct.gov/dot/lib/dot/documents/dpolicy/ctaf/ctaf.pdf

Federal Highway Administration (1994). Motor vehicle accident costs. FHWA Technical Advisory T 7570.2. http://safety.fhwa.dot.gov/facts_stats/t75702.cfm

Federal Highway Administration (2009). National Household Travel Survey 2009. Average Trip Length (miles, Travel Day), distance. http://nhts.ornl.gov/tools.shtml

Interagency Working Group (2010). *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/sem_finalrule_appendix15a.pdf

National Highway Traffic and Safety Administration (2002). The Economic Impact of Motor Vehicle Crashes 2000. Report no. DOT HS 809 446. http://www.nhtsa.gov/DOT/NHTSA/Communication%20&%20Consumer%20Information/Articles/Associated%20Files/EconomicImpact2000.pdf

National Highway Traffic and Safety Administration (2009). Corporate Average Fuel Economy for MY 2011 Passenger Cars and Light Trucks. http://www.nhtsa.gov/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/CAFE_Final_Rule_MY2011_FRIA.pdf

Office of the Secretary of Transportation (2009). Guidance Memorandum: Treatment of the Economic Value of a Statistical Life in Department Analysis - 2009 Annual Revision. http://ostpxweb.dot.gov/policy/reports/VSL%20Guidance%20031809%20a.pdf

Office of the Secretary of Transportation (2010). Notice of Funding Availability for the Department of Transportation's National Infrastructure Investments under the

Transportation, Housing and Urban Development, and Related Agencies Appropriations Act for 2010. Docket Number DOT-OST-2010-0076. (75 FR 30460).

U.S. Department of Transportation (2000). Census Transportation Planning Package 2000, Part 3, Journey-to-Work Flow Tables. http://www.fhwa.dot.gov/ctpp/2000dataprod.htm.

U.S. Department of the Treasury (2010). Daily Treasury Yield Curve Rates. http://www.ustreas.gov/offices/domestic-finance/debt-management/interest-rate/yield_historical_main.shtml

U.S. Energy Information Administration. Annual Outlook 2010. Reference case, Table 7, scenario aeo2010r. http://www.eia.doe.gov/oiaf/aeo/aeoref_tab.html

Victoria Transport Policy institute (2005). *Transportation Cost Benefit Analysis.* http://www.vtpi.org/tca/

Yale University (2009). Travel Demand Management Program.

ECONSULT CORPORATION

Sixth Floor
3600 Market Street
Philadelphia, PA 19104

Voice (215) 382-1894
Fax (215) 382-1895

August 20, 2010

VIA EMAIL

Michael Piscitelli, AICP
Director
City of New Haven
Transportation, Traffic & Parking Department
200 Orange Street, G3
New Haven, CT 06510
mpiscite@newhavenct.net

Re: Peer Review: TIGER II Grant Application CBA

Dear Mr. Piscitelli:

Attached please find a memorandum from Econsult Corporation detailing our peer review of the NHDC project Benefit-Cost Analysis you plan to include in your application for TIGER II grant funding.

We examined the methodology employed, the assumptions utilized, and the data examined, as well as the conclusions reached by the authors. While we point out some specific and minor issues in our memorandum, overall we believe the cost-benefit analysis is professionally and appropriately undertaken and the results generated by the analysis are valid and reasonable, based on industry standards.

Sincerely,

Stephen P. Mullin
Senior Vice President and Principal

Richard P. Voith
Senior Vice President and Principal

MEMORANDUM TO FOLLOW

ECONSULT CORPORATION

Sixth Floor
3600 Market Street
Philadelphia, PA 19104

Voice (215) 382-1894
Fax (215) 382-1895

To: Michael Piscitelli, Director of City of New Haven, Transportation, Traffic & Parking Department

From: Richard P. Voith, Senior Vice President and Principal of Econsult Corporation
Stephen P. Mullin, Senior Vice President and Principal of Econsult Corporation

Date: August 20, 2010

RE: Independent Review of New Haven Downtown Crossing (NHDC) Benefit-Cost Analysis

The City of New Haven Transportation, Traffic & Parking Department has asked Econsult Corporation to conduct a thorough peer review of the report "New Haven Downtown Crossing (NHDC) Benefit-Cost Analysis" (the "CBA"), which was prepared as part of your TIGER II grant application[1]. The report assesses the costs and benefits of replacing a highway stub at a crucial Interstate Highway exchange with an urban boulevard in downtown New Haven, Connecticut. The following memorandum presents the steps and conclusions of Econsult's review.

This review was conducted by Dr. Richard P. Voith and Mr. Stephen P. Mullin, Senior Vice Presidents of Econsult Corporation. In addition to their extensive experiencing conducting and utilizing cost-benefit analysis at Econsult and in previous careers in government and research, both reviewers have taught courses on cost-benefit analysis for at the University of Pennsylvania's Wharton School.

[1] We initially reviewed the August 10, 2010 Draft, and then the revised August 16, 2010 Draft. The August 16, 2010 Draft adequately addressed some of the issues we had identified in our original review. Our review outlined in this memorandum should be considered a review of the August 16, 2010 Draft document.

To support New Haven's application for TIGER II funding for the proposed project, the CBA authors sought to compare the net economic effects of the "build" and "no-build" scenarios. In order to do so, they utilized a standard methodology of forecasting expected future costs and benefit streams, and then estimated the net present value (NPV), benefit-cost ratio, and internal rate of return (IRR). Their "Key Analytical Assumptions" – Real Discount Rate, Evaluation Period, and Study Region – are reasonable and appropriate. The study's overall approach is consistent with standard industry and academic practice, and we agree that the authors conducted their analysis "in accordance with the benefit cost methodology as recommended by the US DOT in the Federal Register (75 FR 30460)".

The study included the following steps which are widely recognized as necessary for properly conducting such analysis:

- Identifying and screening the alternative scenarios
- Determining standing, i.e. whose costs and benefits count
- Enumerating the impacts and selecting measurement indicators
- Quantitatively predicting the future impacts for relevant evaluation period
- Estimating a dollar value for all impacts
- Calculating discounted present values for all benefits and costs
- Estimating net present value of alternatives
- Conducting sensitivity analysis
- Making a final recommendation

We comment on these below.

Alternative Scenarios

In accordance with the above steps, the study clearly identified the alternative scenarios to be assessed as "build" and "no-build" scenarios. The authors utilized New Haven's traffic generation models and forecasts for the scenarios, with appropriate discussion about assumptions and input parameters.

Economic Benefits

The broad categories of benefit impacts included in the analysis are those required by the TIGER II grant rules: state of good repair, economic competitiveness, livability, environmental sustainability, and safety.

The study excluded several specific types of benefits including regional land value increases, travel time, improved economic productivity, and transportation choice value. Within travel time, the study discusses construction delay costs as a possible mitigating factor. If the assumptions about reduced travel demand are correct, then net impact on travel time may be positive or zero (at least not negative). These exclusions on balance appear conservative and appropriate given the level of uncertainty in any estimates of such values.

Economic Costs Included

Costs included in the analysis are: initial project investment costs, and annual operating and maintenance costs. The study lists the residual value of the project as the one economic cost (or a "Negative Cost" or "Cost Offset") which was not included in the study. This occurs because the analysis uses a 40-year horizon whereas the estimated lifecycle of the facilities is 75 years. Because the value of the project will be positive at the end of the analysis period, this will likely be a net benefit rather than a cost, therefore its exclusion is again conservative.

Overall, although potentially significant impacts are not included, the analysis appears to exclude more benefits than costs, and so the enumeration of impacts should be considered fairly conservative.

Quantifying Impacts

The quantifying of each impact is clearly enumerated and properly monetized in 2010 constant dollars, with assumptions clearly stated. Where possible, the authors have provided supporting evidence for these assumptions. The supporting evidence ranges from concrete and well-established estimates, as in the use of Federal Highway Cost Allocation Study's estimate of pavement damage per vehicle mile, to more speculative, as in the changes in commuting patterns and the development mix. However, the assumptions are appropriate given the degree of difficulty in estimating some of the particular parameter being assumed and we believe are overall conservative. For instance, providing precise statistical estimates of the changes in commuting patterns would have been difficult and ultimately speculative, and the assumed decrease in single vehicle occupancy derived from both citywide and Yale University commuting data to be reasonable given the range of possible values. The conservativeness of this assumption is reinforced by the comparison with commuting patterns of Yale University employees.

NPV & Sensitivity Analysis

The analysis concluded by reporting several indicators (net present value, economic rate of return, and benefit-cost ratio) and using a variety of alternative scenarios in order to test sensitivity of the results to different parameters. Importantly, the analysis tested different combinations of discount rates and fluctuations in calculated benefits. The high discount rate of 7% and a lower discount rate of 3% fall well within the generally accepted range[2]. As the authors argue, the lower rate is more consistent with cost-benefit for public sector spending. While it would have been informative to test the results for some other key parameters, including the percent decrease in single vehicle occupancy, a sufficiently diverse set of scenarios was modeled.

Final Recommendation

The results indicate a positive NPV, greater than 10% IRR, and benefit cost ratio greater than 1 for all scenarios. This suggests that the desirability of the investment is robust to a wide range of assumptions. Overall the report presents a clear, robust, and satisfactory analysis that considers all of the relevant issues consistent with the literature on this issue.

PEER REVIEW CONCLUSION

In summary, while we identified some specific and minor issues that could be debated and adjusted, overall we believe the cost-benefit analysis is professionally and appropriately undertaken and the results generated by the analysis are valid and reasonable, based on academic and industry standards.

[2] And, as noted above, we found the author's discussion of the real interest rate alternatives indicated a thorough understanding of the appropriateness and the implications of utilizing alternative rates.