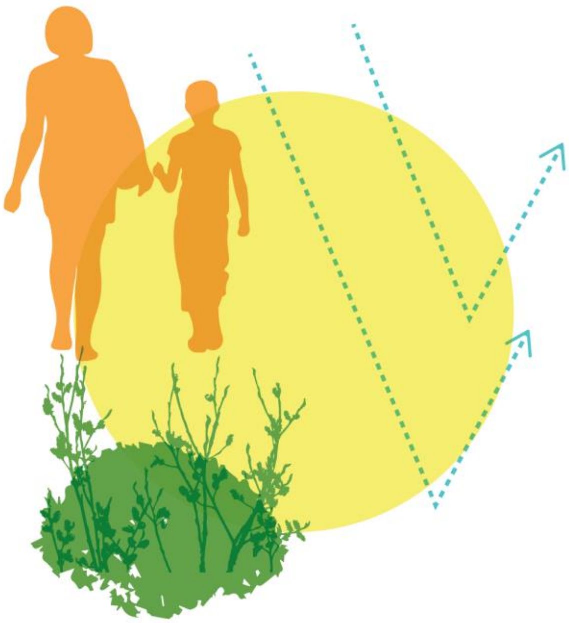
Living Streets Economic Feasibility Project

Final Report



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Executive Summary

Our streets are arterials that touch and connect every neighborhood in Los Angeles. They span the length of the city and are utilized by everyone. Because of this there are arguably no other infrastructure projects that can have a greater impact on the health and environment of an urban area like L.A. For most of the city's history our streets have been built largely with the sole purpose of servicing the automobile. "By 1925, Southern California had a density of 1 car per 1.6 people [which] the rest of the nation would not reach until 1950." (Davis, 1990) In 2000, this ratio was approximately the same, 1 car per 1.85 people. With close to 4 million people living in the City of Los Angeles, building or maintaining infrastructure the way we did in 1950's is no longer feasible. It's time for a new perspective. We must start building the infrastructure of 2050, which is multi-purposeful, functional, and beneficial to all Angelenos. Beyond multi-modal, any new transit that requires streets should be carried out on *Living Streets.*

Modern and post-modern municipal planning strategies have been automobile-centric. In the City of Los Angeles, for example, 28% (86.5 square miles) of the 468.7 square miles of land area is occupied by streets, with another 800 miles of alleys and 181 miles of freeways (City of Los Angeles Mobility Plan 2035). These figures do not include the amount of land area devoted to idle cars, like parking lots, garages, or driveways. The hard infrastructure of streets and parking lots exacerbates issues such as flooding, increased street temperatures, and elevated exhaust emissions (carbon, pm, NOx and Sox).

The lack of green infrastructure makes the City's 4 million residents highly vulnerable to the effects of heat impacts. Asphalt streets, parking lots and playgrounds, with their dark, heat-absorbing materials, add upwards of 1.8-5.4 °F (1-3 °C) to the surrounding environment, warming nearby homes, schools and office buildings (Oke, 1997).

In addition to heat impacts, municipal streets and sidewalks act as a conveyance mechanism for carrying water runoff into streams, creeks, rivers, and oceans. It is estimated that every time it rains an inch in the City of LA, 3.8 billion gallons of runoff pollute our waterways and ocean (City of Los Angeles Integrated Resource Plan for Water). This runoff is often contaminated with pollutants such as metals, pathogens, toxins, nutrients, and trash. The impacts can be a missed opportunity to enhance our local water supply, unsafe beach water quality, contaminated fish, and impaired ecosystems.

The current "Business as Usual" (BAU) models for street and sidewalk maintenance --the simple re-paving / re-sealing a street, and the outright reconstruction of the street and sidewalk -- fail to address, if not worsen, a litany of issues confronting cities including: the lack of groundwater infiltration or recharge, large heat islands, and poor air quality. Poorly designed streets and sidewalks can be aesthetically disempowering and socially destructive for generating health capital, economic development, and public engagement.

Across the nation, city planning is adopting new strategies to address climate change. Cities must adapt and become more resilient in order to thrive in the face of climate change. Cities must promote public right-of-ways and spaces that generate multiple social benefits with environmental services built into them. Adaptation provides an opportunity to rethink the role of city streets and sidewalks. To this end, cities have recently investigated different street paradigms such as *Complete, Green, and Cool Streets* to capture rainwater, promote pedestrian usage, or reduce city temperatures.

This report proposes a more inclusive street paradigm, *Living Streets*, as an all-encompassing method to street and sidewalk construction for the City of Los Angeles. Living Streets combines all three alternative street strategies—complete, green, and Cool Streets -- under the banner of *Living Streets*.

Living Streets are more equitable. They allow different populations to fairly use and share public resources. Living Streets are walkable, bikeable streets that:

- improve air quality by using vegetation to facilitate the removal of air pollutants and GHGs.
- improve water quality and quantity by capturing, storing, and cleaning stormwater, helping to retain valuable water resources in drought stricken areas and prevent flooding and soil erosion.
- improve human health and general wellbeing by lowering air temperatures, making streets cooler, cleaner, safer, walkable, and aesthetically pleasing.

This results in decreased medical expenses and increased livability. Living Streets develop clean and safe open spaces and recreation. They provide a public greenway that can provide active and passive recreational opportunities for the surrounding neighborhoods.

This report details the costs and benefits associated with investing in Green, Cool, and Complete Streets in the City of Los Angeles compared to two "business as usual" or traditional approaches. It also investigates and discusses the enhanced or increased benefits of incorporating all three design elements into one Living Street.

According to this study, the Living Street paradigm generates the highest total benefits and the highest net present value of all street approaches. In Table 1, all four non-traditional approaches (Green, Cool, Complete, and Living) are compared to a simple re-paving of the existing subgrade street infrastructure — called "BAU1-only". In this analysis, the Living Street (Living-BAU1) produces an additional $5.35 billion in total benefits to society when compared to BAU1-only approach and more than $3.04 billion to the next highest non-traditional street design (Complete-BAU1). In addition, Living Streets (Living-BAU1) produces $2.78 billion more in net present value over the lifetime of the project as compared to BAU1.

This analysis is meant to provide a high-level economic comparison of different street paradigms that could be implemented in the City of Los Angeles. The scenarios have been created using several assumptions to design 1,000 center-line miles of road for each scenario. The analysis uses averages for Los Angeles' road, weather, and population conditions. In addition, the analysis uses a discount rate of 4% as instructed by the Caltrans for Life-Cycle Cost Analysis of pavement structures (State of California, Department of Transportation, Pavement Standards Team & Division of Design, 2010). Finally, the results are presented in 2015 US Dollars.

The results, therefore, are meant to give a comparison of the costs and benefits associated with these elements. They are not meant to provide an estimate to the actual costs and benefits of a particular project implemented within the city.

TABLE 1: COST-BENEFIT SUMMARY COMPARING GREEN, COOL, COMPLETE, AND LIVING STREETS TO A SCENARIO WHERE THE STREETS ARE SIMPLY RE-PAVED (KNOWN AS BAU1)

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (Years)	Benefit-Cost Ratio
BAU1-only	$738,677,265	$7,088,603,848	$6,349,926,582	3.0	9.6
Green-BAU1	$1,021,685,627	$7,602,417,470	$6,580,731,843	3.5	7.4
Cool-BAU1	$1,905,102,187	$8,190,384,713	$6,285,282,526	4.2	4.3
Complete-BAU1	$2,118,314,678	$9,395,271,662	$7,276,956,985	5.7	4.4
Living-BAU1	$3,301,975,358	$12,434,311,761	$9,132,336,403	4.6	3.8

Even though the BAU1-only approach (simply repaving) has a slightly faster pay-back period than the four other scenarios, it is not significant considering that average pay back period any other alternative is 4.5 years, with the longest pay-back period (Complete-BAU1) taking less than six years.

In addition, the BAU1-only case has the highest benefit-cost ratio (BCR)--meaning that for every dollar invested a little more than $9 of benefits is generated. The Green Street approach has the next highest BCR value with $7-plus in benefits produced. The remaining three alternatives all have considerably lower BCR values.

However, when comparing 'net present value', the Living Street approach had the highest dollar value with over $9 billion generated. In contrast to the other economic indicators, BAU1-only was only slightly better ($6.35 billion) in terms of net present value than the lowest spot occupied by Cool Streets ($6.29 billion).

When there are conflicting rankings, the net present value is the more ideal, better criterion to consider because it measures the economic contribution of each project in absolute terms. The benefit-cost ratio is limited in that it conceals absolute magnitudes. For example, a project may have a high benefit-cost ratio but is small in terms of the absolute dollar amounts. In this scenario, an alternative street paradigm could appear less desirable than the BAU1 street paradigm because it has a lower benefit-cost ratio; yet, the alternative street paradigm would likely be the more economically prudent investment because of its larger scale and impact on the overall economy. As proven here, the Living Streets BAU1 has the highest net present value, and therefore makes it the best project to invest in from an economic perspective.

When looking at a complete street and sidewalk reconstruction, Table 2 shows all four alternative approaches compared to the business-as-usual or "BAU2-only". Again, the Living Street approach (Living-BAU2) provides similar benefits as witnessed in the repaving scenario, with $5.28 billion in total benefits accruing to society compared to the BAU2-only case. In addition, Living Streets produced in an additional $2.62 billion more in net present value over the lifetime of the project as compared to the BAU2-only case.

TABLE 2: COST-BENEFIT SUMMARY COMPARING GREEN, COOL, COMPLETE, AND LIVING STREETS TO A SCENARIO WHERE THE STREETS AND SIDEWALKS ARE RECONSTRUCTED (KNOWN AS BAU2)

Action code	Total cost	Total benefit	Net present value	Pay back (years)	Benefit-Cost Ratio
BAU2-only	$1,086,995,688	$7,144,352,396	$6,057,356,708	4.3	6.6
Green-BAU2	$1,285,372,720	$7,652,323,491	$6,366,950,771	4.5	6.0
Cool-BAU2	$2,250,851,059	$8,246,133,262	$5,995,282,202	5.4	3.7
Complete-BAU2	$2,034,655,649	$9,303,142,393	$7,268,486,744	6.1	4.6
Living-BAU2	$3,741,949,842	$12,419,670,386	$8,677,720,544	6.2	3.3

Looking at the overall costs and benefits of the entire project, the BAU2-only case has the lowest payback period. However, despite the higher initial cost by all the alternative scenarios, each one breaks-even within two-years of the BAU2-only approach.

Again, the BAU2-only case demonstrates the highest benefit-cost ratio, while Living-BAU2 has the highest net present value. When there are conflicting rankings, the net present value is the better criterion to consider as it measures the economic contribution of each project in absolute terms. Therefore, a BAU2 project could be less desirable than an alternative street paradigm that has a lower benefit-cost ratio, due to the lack of scale and or impact on the overall economy. Investment in Living Streets BAU2 street design makes economic sense because of the higher net present value.

Investments in Living Streets can produce immense benefits to municipalities and their residents. Investing in Living Streets is more important now than ever before to help cities adapt to a new climate reality. This report is intended to provide city planners, policy makers, and elected officials the economic arguments and justifications for alternative street paradigms. The future of Los Angeles' street and sidewalk infrastructures can play an important role in city design, especially one that enables its residents to not merely survive, but thrive.

When City of Los Angeles electeds and transit experts state that "31% to 38% of the city streets…are so damaged that they can no longer be maintained" and the longer a roadway is allowed to deteriorate the more expensive it costs to repair them, then the time is now to begin embarking on a different street paradigm. The City of Los Angeles city council forwarded a bond idea in 2014 with the intent of addressing the city's failing street infrastructure. The bond would solve the poor street conditions, which were major impacts to the environment, goods-movement, damage done to vehicles, and public safety. The political will existed to place a measure on the ballot, but there was uncertainty if community support existed to ensure the bond would pass in an election.

Community groups wanted more in terms of multi-modal forms of transit, increased green infrastructure, and streets that worked for communities. As a Los Angeles Times editorial noted in April 2014, "All great amenities, but ones that could increase the project's cost and complexity." The editorial poignantly noted "Is [the bond] to fix crumbling asphalt? Or remake L.A.'s urban landscape? Can both be done affordably?" This report suggests that investing in both through Living Streets is the economically superior approach because of the tremendous societal benefits to be gained. Will it be affordable? Likely not, but simply doing business as usual with transit infrastructure is like paying the interest-only on a mounting credit card debt, eventually you go bankrupt.

This report was prepared by Heal the Bay in collaboration with Climate Resolve and Green LA Coalition in fulfillment of a California Coastal Conservancy grant.

Background

The following section details how this project started, its goals, definitions of street paradigms, the methodology for conducting the analysis, and understanding what this cost-benefit analysis includes.

How the project started

In the spring 2014, the City of Los Angeles intended to place a street repair revenue bond for the November ballot. In response, local NGOs, including the principals of the *Living Streets* effort, formed a broad coalition of environmental and community organizations to ensure that the multi-billion-dollar investment included a comprehensive range of street and sidewalk infrastructure improvements that would provide multiple-benefits, beyond the singular automotive benefit, to Angelenos for decades to come.

There was much discourse between City officials, public agencies, and the coalition on the various street paradigms (business as usual (BAU), Green, Complete, and Cool). Policy and Programmatic implementation related issues, such as developing criteria on when and where to implement a particular street approach; or how anticipated funds would be distributed—based on district or street grade — indefinitely delayed the public process. As such, the proposed funding mechanism never made it to council for a vote. Despite the funding measure never making it to council, one constant issue in this dialogue was the dearth of any economic analysis on the costs and benefits associated with non-traditional street and sidewalk designs. As the City of Los Angeles continues to pursue policy ideas on revamping standard street designs, officials have maintained their desire to have greater economic information on the various proposed street alternative paradigms so that they can make more informed decision.

Green LA Coalition (GLA) was formed in 2007 to advance Los Angeles toward a just and sustainable future. Five years ago GLA's Living Street Initiative hired Holly Harper, an architect, who had worked on Los Angeles' first green street. With funding from the County of Los Angeles Department of Public Health, she created concept plans with community residents for four Living Street prototypes in Boyle Heights. While not part of this report, those case studies are evaluated in an accompanying document entitled *Living Street for Boyle Heights*, which assesses two of the four prototypes. This report addresses a number of economic questions about various street paradigms in both qualitative and quantitative detail.

Goals of the project, cost-benefit report

The goal of this report is to provide economic evidence on a variety of potential alternative street paradigms that could be implemented within the City of Los Angeles. Historically, city streets were planned and built to support the automobile. A singular benefit without consideration of any externalized costs and lost social benefits, the cost-benefits associated with standard street design has often been limited in economic scope. This report attempts to quantify elements from standard and alternative street designs, like walkability, bike-ability, managing rainwater, greenery, air quality, and urban heat, in an attempt to compare street paradigms within the same context.

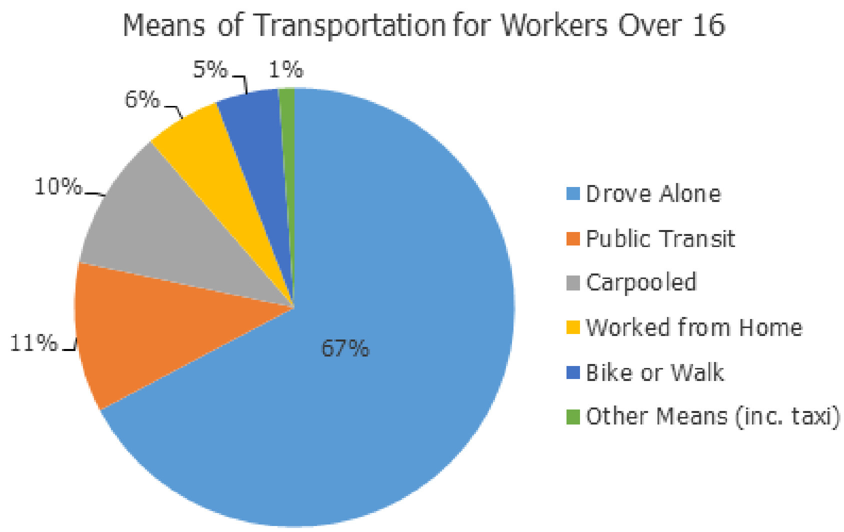
Heal the Bay, and its partners the California Coastal Commission, Climate Resolve and Green LA, are working with the city to implement a different approach to street design. Policies and practices must be updated, including new standards, performance metrics, and regulations associated with streets. Good demonstration projects exist, and more are needed. Coupled with up-to-date City and regionally applicable cost/benefit data, the report demonstrates how LA’s streets can be an essential and cost effective response to the impacts of climate change, while providing environmental, health and job benefits.

The Economic Feasibility of Living Streets report is intended for city planners, policy makers, and elected officials in Los Angeles. The document should be used as a tool to identify the quantifiable benefits and costs associated with a variety of street designs. In particular, when considered in combination with the two other accompanying components, the *Living Streets Policy Recommendations* and *Evaluative Tools for Alternative Street Designs*, it is hoped that it will facilitate better street planning, design, and decision-making. TRIP, a Washington, D.C.-based nonprofit that studies transportation data and issues, conducted an analysis in 2014 that showed 65% of Los Angeles streets are in poor condition, 24% are mediocre, 6% fair and only 5% good (TRIP, 2014). With the pressing need to redo the majority of Los Angeles streets, this cost benefit report will help make the financial case for creating Living Streets.

Defining Street Paradigms

In Los Angeles, in 2015, the main mode of transportation for working adults was driving solo. Figure 1 shows the distribution of different means of transportation for workers over 16 for the City of Los Angeles as of year 2015.

FIGURE 1: MEANS OF TRANSPORATION FOR WORKERS OVER 16 (CITY OF LOS ANGELES PERFORMANCE DATA, 2015)



A main reason for a sizeable portion of the pie attributed to the 'driving alone' category stems from how streets were historically designed to focus on a singular mode of transit--the automobile. However, recently there has been a growing awareness about mobility for all types of transport (walking, biking, public transportation) that has led to street and sidewalk designs encouraging alternative modes of travel. These alternative street and sidewalk design elements are briefly described below.

Complete Streets **as defined by The National Complete Streets Coalition are:**

... designed and operated to enable safe access for all users. Pedestrians, bicyclists, motorists and bus riders of all ages and abilities are able to safely move along and across a Complete Street ***(Smart Growth America, 2015).***

In design terms, this can mean wider, walk-able sidewalks, narrower streets, inclusion of bike lanes, speed reducing elements, etc. Whereas Complete Streets looks to increase mobility for all users, *Green Streets* focuses on using our streets and sidewalks to reduce pollution, softening the hardscape, and preserve water sources via Green Street design elements.

Green Streets **as defined by the U.S. Environmental Protection Agency are:**

...streets that use a natural systems approach to reduce stormwater flow, improve water quality, reduce urban heating, enhance pedestrian safety, reduce carbon footprints, and beautify neighborhoods (U.S. EPA, 2009).

This is often translated as utilizing spaces to increase vegetative cover and/or designing areas to capture water.

Furthermore, with increasing temperatures, cooling our cities has become a major concern. Urban areas are usually warmer than their rural surroundings, a phenomenon known as the "Heat Island Effect." As cities develop, more vegetation is lost and more surfaces are paved with heat absorbing material. The change in ground cover results in less shade and moisture to keep urban areas cool and use of heat absorbing material that increases the surrounding temperature.

Cool Streets **as defined by Climate Resolve are:**

...streets designed to reduce heat island effect.

Cool Streets use reflective and/or permeable pavement material and/or increase vegetative cover.

These three alternative approaches to BAU street design are all guided by different goals: mobility, preserving water resources and protecting the environment, or cooling our cities. In addition, they can have very different design elements to achieve those goals.

Living Streets is an approach that combines Complete Streets, Green Streets, and Cool Streets' elements and goals. Living Streets enable safe access for all users while preserving and protecting the environment and its resources and reducing the Urban Heat Island Effect.
The Model Design Manual for Living Streets (2011) defines Living streets as the following:

- Integrate income, racial, and social equity into their design and function
- Are designed for people of all ages and physical abilities whether they walk, bicycle, ride transit, or drive
- Integrate connectivity and traffic calming with pedestrian- oriented site and building design to create safe and inviting places
- Connect people through everyday interaction
- Involve local people to share the responsibility for designing their streets
- Are inviting places with engaging architecture, street furniture, landscaping, and public art that reflect the diversity and cultures of the neighborhood
- Foster healthy commerce

- Strengthen and enhance neighborhoods as envisioned by community members without displacing current residents
- Encourage active and healthy lifestyles
- Integrate environmental stewardship, water management, energy conservation, and preservation of plant life
- Vary in character by neighborhood, density, and function

The goals of designing living streets are to:

- Serve the land uses that are adjacent to the street; mobility is a means, not an end
- Encourage people to travel by walking, bicycling, and transit, and to drive less
- Provide transportation options for people of all ages, physical abilities, and income levels
- Enhance the safety and security of streets, from both a traffic and personal perspective
- Improve peoples' health
- Create livable neighborhoods
- Reduce the total amount of paved area
- Reduce Urban Heat Island Effect
- Reduce street water runoff into watersheds
- Maximize infiltration and reuse of stormwater
- Reduce greenhouse gas emissions and other air pollution
- Reduce energy consumption
- Promote the economic well-being of both businesses and residents
- Increase civic space and encourage human interaction

To learn more about design guidelines for Living Streets, see the Model Street Design Manual for Living Streets (2011). The section below discusses the methodology for generating this analysis.

Methodology

This economic analysis of various street designs is intended for the Los Angeles region. Thus the analysis focuses on those elements that are practical and feasible for the area. As such, not every design element of Complete, Green, and Cool Streets is included. Elements that have the combinatory goals of mobility, water preservation, and cooling have been prioritized.

The development of the Living Streets Economic Feasibility Report followed a process that involved:

1. A literature review of Complete, Green, Cool and Living Street design elements
2. Prioritization of the elements based on:
    a. Living Street goals – Prioritize the elements that enhance mobility for pedestrians and bikers, preserve water and enhance water quality, and reduce the Urban Heat Island Effects.
    b. Practicality – Must be applicable and useful to the Los Angeles region.
    c. Feasibility – The element could be implemented easily when the City updates a street.
    d. Quantitative data – There are quantifiable benefits and costs for the element. Elements with only qualitative information on costs and benefits were included in the discussion section.
    e. Feedback from partnering organizations (Heal the Bay, The California Coastal Conservancy, Climate Resolve, Green LA).
3. Collecting data on the costs and benefits associated with prioritized elements.
4. Quantifying and monetizing the cost and benefits for prioritized elements for the Los Angeles region.
5. Documenting cost efficiencies in coordinating traditional street repair with Living Street elements implementation.
6. Identifying research and data gaps.
7. Peer Review

The following subsections detail the economic analysis methodology, including the scenarios chosen for the economic evaluation, the type of analysis undertaken, and the discount rate applied.

The Scenarios Chosen for Economic Evaluation

The Report analyzed Green, Cool, Complete, and Living Street elements against to two different *Business as Usual* (BAU) scenarios: **BAU1** and **BAU2**. The BAU1 street paradigm is simply a “rehabilitation” or "repaving" of an existing street. In contrast, the BAU2 approach is a more involved, "reconstruction" of the entire street, including the sidewalk. The two BAU scenarios are approaches the City of Los Angeles currently uses when redoing a street. These two scenarios were first analyzed to determine a baseline value. Once these values were determined, then the two BAU scenarios could be compared to the other four alternative street designs.

This approach was taken in order to understand the relative change in the total benefits and costs when these elements are included in street construction. Our methodology was to apply estimated costs and benefits for each scenario to 1,000 center-lane miles to be constructed between 2015 and 2050. This calculation gave us the total costs and benefits of the different infrastructure projects over the life cycle of the project. The time-period of 35 years was chosen in order to provide a relatively long assessment period, reflecting the long life-cycle of the infrastructure being studied, without choosing a period too long in which levels of uncertainty about future conditions would be high.

The table below shows the ten different scenarios that were evaluated in this study. Five of the scenarios were evaluated under the BAU1 (repaving of the street only) specifications: BAU1 only (BAU1-only); BAU1 with Green Street elements (Green-BAU1); BAU1 with Cool Street elements (Cool-BAU1); BAU1 with Complete Street elements (Complete-BAU1); and BAU1 with Living Street elements (Living-BAU1).

The other five scenarios were evaluated under the BAU2 (reconstruction of street and sidewalk) specifications: BAU2 only (BAU2-only); BAU2 with Green Street elements (Green-BAU2); BAU2 with Cool Street elements (Cool-BAU2); BAU2 with Complete Street elements (Complete-BAU2); and BAU2 with Living Street elements (Living-BAU2).

TABLE 3: SUMMARY OF THE SCENARIOS EVALUATED IN THE ECONOMIC ANALYSIS

		Two Scenarios:	
		BAU1: Repaving of the streets	**BAU2: Reconstruction of the street and sidewalks**
Elements being evaluated	**BAU-Only**	BAU1-only	BAU2-only
	Green Street Elements	Green-BAU1	Green-BAU2
	Cool Street Elements	Cool-BAU1	Cool-BAU2
	Complete Street Elements	Complete-BAU1	Complete-BAU2
	Living Street Elements	Living-BAU1	Living-BAU2

The table below describes the basic construction assumptions used for each analysis of the 10 scenarios.

TABLE 4: DETAILED SUMMARY OF THE SCENARIOS EVALUATED IN THE ECONOMIC ANALYSIS

	BAU1: Repaving of the Streets	**BAU2: Reconstruction of the Street and Sidewalks**
BAU-Only	• Removal of 100% of current top course layer of asphalt or concrete and asphalt replacement. (See Table 6 for complete details of each street design)	• Removal of 100% of current top course layer of asphalt or concrete • Removal of 20% of sub-base layer where it is structurally damaged. • Replacement of subgrade and asphalt top course. (See Table 7 for complete details of each street design)
Green Street Elements	4% Green Street elements built into existing sidewalks	4% Green Street elements in reconstructed sidewalks
Cool Street Elements	Slurry Seal, 100% of all street surface (See Table 20 for complete details of each street design)	Slurry Seal, 100% of all street surface (See Table 20 for complete details of each street design)
Complete Street Elements	Assumed: 25% of roads considered "Arterial" 75% of roads considered "Residential" Sidewalk construction (since it is not constructed as part of the BAU scenario)	Assumed: 25% of roads considered "Arterial" 75% of roads considered "Residential" (See Table 26 for complete details of each street design)

Living Street Elements	• 7.5% Green Street Elements • Slurry Seal, 100% of all street surface • Complete Street Elements incorporated Assumed: 25% of roads considered "Arterial" 75% of roads considered "Residential" Sidewalk Construction (since it is not constructed as part of the BAU scenario) (See Table 29 for complete details of each street design)	• 7.5% Green Street Elements • Slurry Seal, 100% of all street surface • Complete Street Elements incorporated Assumed: 25% of roads considered "Arterial" 75% of roads considered "Residential" (See Table 29 for complete details of each street design)

It is important to note that this analysis is meant to provide a high-level economic comparison of different street paradigms that could be implemented in the City of Los Angeles. The scenarios have been created using several assumptions to design 1,000 center-line miles of road for each scenario. The analysis uses averages for Los Angeles' road, weather, and population conditions. The results, therefore, are meant to give a comparison of the costs and benefits associated with these elements. They are not meant to provide an estimate to the actual costs and benefits of a particular project implemented within the city.

Explanation of the Economic Analysis Undertaken

For this economic analysis, several fiscal metrics were used to analyze each of the 10 scenarios evaluated in this study:

Net Present Value: The sum of the benefits minus costs of each year of the project, discounted into the present:

$$Net\ Present\ Value = \sum_{t=1}^{T} \frac{(B_t - C_{t)}}{(1+r)^t}$$

Where:

C = the costs incurred in implementing the measure

B = the benefits that come from implementing the measure, in economic terms

r = the discount rate

t = the time period

T = the last period in the series

Benefit-Cost Ratio: The net present value of the benefits, divided by the net present value of the costs. The result provides the total benefits per dollar of cost over the lifecycle of the study. For example, if the benefit-cost ratio were 3.5, for every dollar of cost incurred, $3.5 of benefits are felt by society.

$$BCR = \frac{\sum_{t=1}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{C_t}{(1+r)^t}}$$

Where:

C = the costs incurred in implementing the measure

B = the benefits that come from implementing the measure, in economic terms

r = the discount rate

t = the time period

T = the last period in the series

Payback Period: The year when the benefits have covered the costs of implementation.

Net Present Value per Mile: For each element, the net present value per mile has been calculated to show a marginal cost/benefit per mile of road constructed. Note: this does not provide a cost per mile of construction.

*All results are in 2015 U.S. dollars.

Discount Rate

This analysis uses a discount rate of 4% as instructed by the Caltrans for Life-Cycle Cost Analysis of pavement structures (State of California, Department of Transportation, Pavement Standards Team & Division of Design, 2010). In order to determine the effect the discount rate has on the results, a sensitivity analysis was done using two additional discount rates: 2% and 7%. The 2% rate was selected because it is recommended by the Congressional Budget Office (Bazelon and Smetters, 1999, p. 221-222) as the time preference of consumption. The 7% rate was chosen because it is recommended by the Office of Management and Budget (OMB, 1992) as it “approximates the marginal pretax rate of return on an average investment in the private sector in recent years”. The full sensitivity analysis on the various discount rates can be found in Appendix 5.

Valuing the Costs and Benefits of Living Street Elements

The Feasibility Study analyzes the economic, social, and environmental impacts incurred under each of the proposed street design paradigms. Economic valuations for each of these impacts have been taken from the literature, and referenced noting where each data point in the calculation was taken from. However, several impacts were unable to be included in the economic analysis due to either a lack of numeric data or incomplete information. This may have been due to a difficulty in estimating the level of impact to the City of Los Angeles or a lack of data regarding an economic valuation for the impact. For example, increasing the amount of pervious surface area with Green Street elements will improve the quality of the marine habitat typically affected by runoff. Currently, there is a lack of evidence to determine 1) how much an increase in pervious surface area will improve this environmental impact and 2) what the economic value is for the biological improvements. For those impacts without a quantification, a list of the impacts is provided in each street paradigm section with a qualitative description.

The following sections will detail each street design paradigm, including an economic analysis for the different cases (BAU-only cases, Green Streets, Cool Streets, Complete Streets and Living Streets). Details of the included elements, as well as their qualitative and quantitative costs and benefits are outlined in Appendix 3. A sensitivity analysis on several of the key assumptions and variables used in this study can be found in Appendix 5.

Business as Usual - Only

Two BAU scenarios were chosen for this economic feasibility analysis: BAU1 (rehabilitation) and BAU2 (reconstruction). The two BAU scenarios are standard street designs currently used by the City of Los Angeles. As such, the two scenarios used in this study represent two economic end points, the low (BAU1) and high (BAU2) cost scenarios for improving street conditions. Since certain elements associated with each street design require different starting conditions (e.g. Green Street elements need a complete demolition of portions of the street and sidewalk in order to include the element), implementing them maybe more costly if the city is simply planning on simply re-paving or re-sealing a street. However, if the City of Los Angeles is planning to completely reconstruct the street from the subgrade up, then the relative cost of certain elements are lowered. The table below describes the type of maintenance required for roads depending on their condition.

TABLE 5: SUMMARY OF STREET MAINTENANCE REQUIREMENTS BASED ON ROAD CONDITION (CITY OF LOS ANGELES, DEPT. OF PUBLIC WORKS, 2008)

Street Maintenance Requirements for Based on Road Condition
Streets in **Condition A** (Good) have the following characteristics:
Type of Maintenance Required: none Physical Condition: no cracking, no oxidation, and no base failure PCI[1] Range: 86 to 100
Streets in **Condition B** (Satisfactory) have the following characteristics:
Type of Maintenance Required: Slurry Seal (residential streets only) Physical Condition: minimal cracking, no oxidation, and no base failure PCI Range: 71 to 85
Streets in **Condition C** (Fair) have the following characteristics:
Type of Maintenance Required: maintenance overlay (1.5 to 2.0 in. of A.C.) Physical Condition: minimal cracking, no base failure to 5% of base failure PCI Range: 56 to 70
Streets in **Condition D** (Poor) have the following characteristics:
Type of Maintenance Required: resurfacing (2.0 to 2.5 in. of A.C.) Physical Condition: some cracking, 6% of base failure to 35% of base failure PCI Range: 41 to 55
Streets in **Condition F** (Very Poor) have the following characteristics:
Type of Maintenance Required: resurfacing and/or reconstruction (6.0 to 12.0 in. of A.C.) Physical Condition: major or unsafe cracking, 36% to over 50% of base failure PCI Range: 0 to 40

[1] Pavement Condition Index (PCI) "a scale that rates the physical condition of the street by considering the pavement's structural and surface operational condition. This numerical rating index ranges from 0 for a failed pavement to 100 for a pavement in perfect condition". (City of Los Angeles, Dept. of Public Works, 2008)

The descriptions below provide an explanation of assumptions included for each BAU scenario. For more detailed information about each street scenario is available in Appendix 3.

Business as Usual 1 Only (BAU1-only)

Table 6 shows the assumptions considered for the BAU1 scenario. This scenario assumes that the streets are repaved with an asphalt top layer, without a complete reconstruction of the street subgrade and base course. Sidewalk re-paving or reconstruction are not included in this evaluation.

TABLE 6: BAU1-ONLY TREATMENT DETAILS

BAU1 Treatment		
Treatment	**Percentage of Treated Area**	**Treatment Depth**
Engineering and Planning (Percentage of Total Capital Cost)	20% of Capital Costs	
Demolish and Remove Existing Asphalt or Concrete Road	100%	5 inches
Hauling	100% of Asphalt/Concrete	
Traditional Asphalt Top Course	100%	6 inches
Contingency (Percentage of Total Capital Cost)	20% of Capital Costs	

Business as Usual 2 Only (BAU1-only)

The Business as Usual (BAU) 2 scenario in Table 7 assumes that the entire street is reconstructed, including the sidewalks. This scenario assumes that 20% of subgrade and base course is removed and reconstructed. It also assumes that 100% of the sidewalks along both sides of the street are removed and reconstructed.

Table 7: BAU2-Only Treatment Details

BAU2 Treatment		
Treatment	**Percentage of Treated Area**	**Treatment Depth**
Engineering and Planning (Percentage of Total Capital Cost)	20% of Capital Costs	
Demolish and Remove Existing Asphalt or Concrete: Roads	100%	2 inches
Percentage of Road Where Subgrade Will Need to be Replaced	20%	
Demolish and Remove Existing Asphalt or Concrete: Subgrade	20%	5 inches
Demolish and Remove Existing Concrete in Sidewalks	100% of Sidewalks	5 inches
Hauling	100% of Asphalt/Concrete	
Paving, Traditional Asphalt Subgrade and Base Course	20%	2 inches
Traditional Asphalt Top Course	100%	6 inches
Concrete Slab on Grade, 6"	92% of Space Along Roads (taking out intersections)	
CIP Concrete Curb and Gutter	Along All Sidewalks (92% of sidewalk LF)	
Contingency (Percentage of Total Capital Cost)	20% of Capital Costs	

The specific costs and benefits included in the economic analysis for the BAU-only cases are briefly described in Appendix 3 Section 1. The valuations detailed in this section are based on previous research and were used as the basis for the assumptions and calculations undertaken in this study.

Results of the Economic Analysis

Table 8 provides a summary of the economic indicators for both the BAU1-only (repaving) and BAU2-only (reconstruction) cases:

TABLE 8: SUMMARY OF BAU-ONLY RESULTS

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (years)	Benefit-Cost Ratio
BAU1-only	$738,677,265	$7,088,603,848	$6,349,926,582	3.0	9.6
BAU2-only	$1,086,995,688	$7,144,352,396	$6,057,356,708	4.3	6.6

In the BAU1-only case, the benefit-cost ratio is 9.6, meaning for every dollar invested there is more than nine dollars of benefit created for society. In the BAU2-only case, the benefit-cost ratio is 6.6. The value is lower in the BAU2-only case because the costs of construction are significantly higher (about $350 million more). The net present value of BAU1-only is slightly higher than BAU2-only, due to the significant construction cost differences between BAU1-only and BAU2-only. The total benefit for the BAU2-only case is slightly higher than the BAU1-only case given the fact that the sidewalk's improvements are addressed in the BAU2 scenario. For example, sidewalk improvements reduce the liability to the City from pedestrians who injure themselves while walking on unimproved sidewalks. Sidewalk improvements are also required for Americans with Disabilities (ADA) Act of 1990 compliance. Figures 2 and 3 show the costs and benefit data for the two BAU-only cases.

FIGURE 2: BREAKDOWN OF THE COSTS AND BENEFITS FOR BAU1-ONLY (STREET REPAVING ONLY)

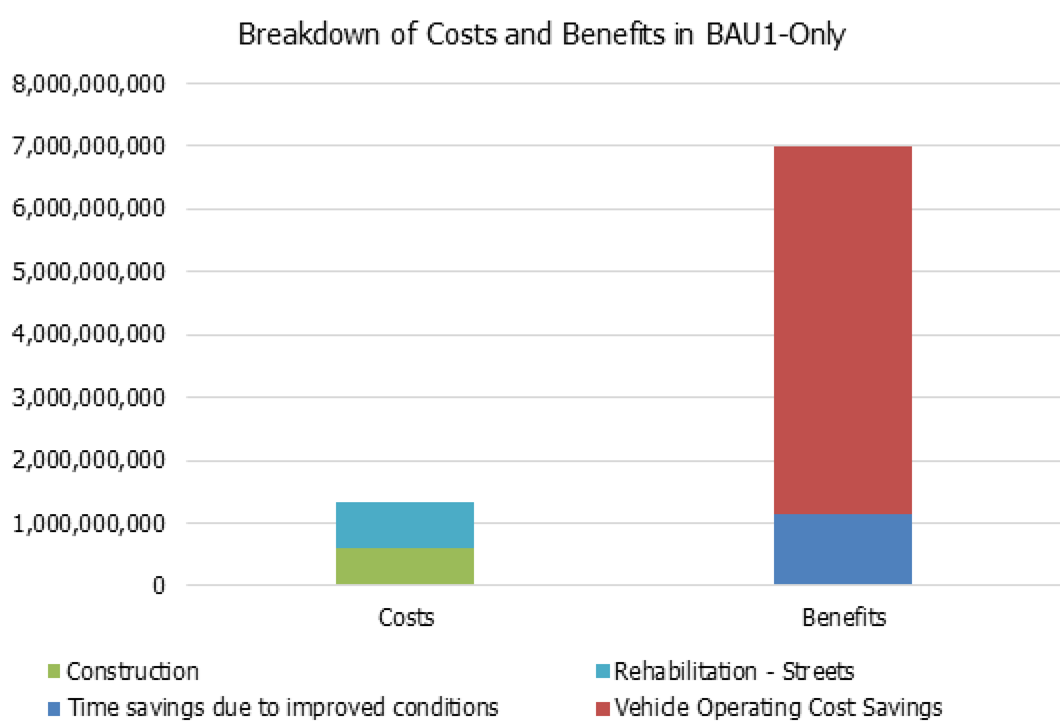
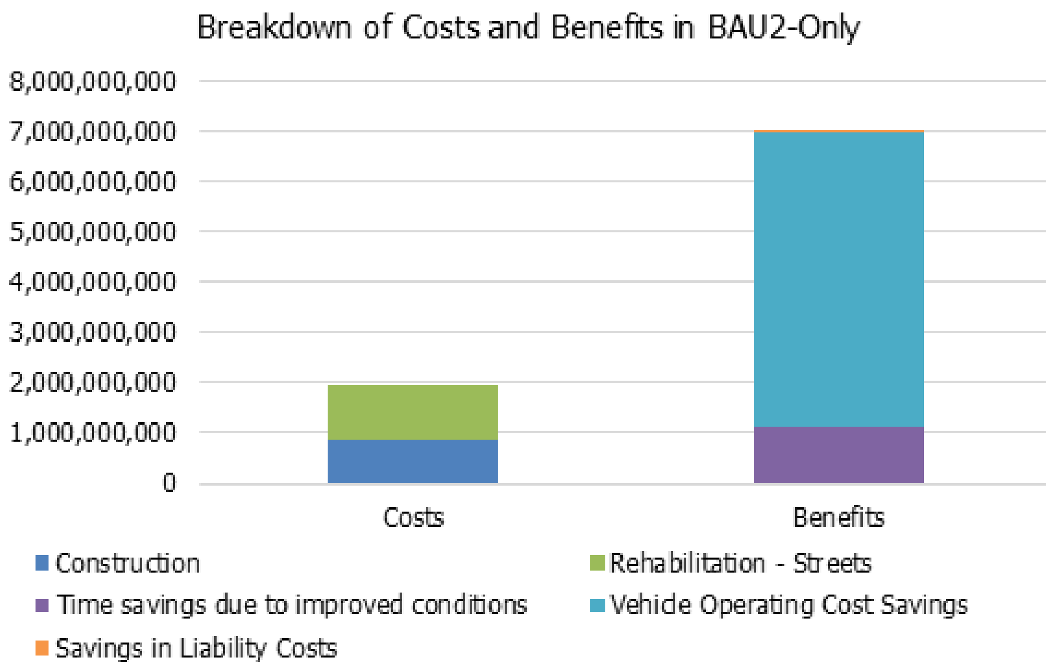


FIGURE 3: BREAKDOWN OF THE COSTS AND BENEFITS FOR BAU2-ONLY (FULL RECONSTRUCTION OF STREETS AND SIDEWALKS)



As can be seen in the figures above, the benefits of improving the street conditions outweigh the costs of construction in both the BAU1-only (repaved/rehabilitated) and BAU2-only (complete reconstruction) scenario. The largest contributor to the benefits is the reduction in vehicle operating costs, accounting for 84% of the benefits calculated in this study in both the BAU1-only and BAU2-only cases.

For a complete analysis of the economic results and comparisons between all street design approaches, please see Section 7 of this report.

Green Streets

Description of Green Street Elements

Urban streets and sidewalks have historically been made of impervious material that carry stormwater filled with trash, bacteria, heavy metals, and other pollutants from the urban landscape out to receiving waters. Not only do we lose fresh water this way, but we also degrade the receiving waters. Once again, California is experiencing an intense drought, and is forecasted to continue to experience significant periods of dry weather in the changing climate. Therefore, capturing as much rain water as possible is imperative so that it can either be treated and reused or infiltrated back into the ground for future use. This can happen if we change our planning strategies for streets and sidewalks.

Green Streets use an environmental services approach to reduce stormwater flow, improve water quality, reduce urban heating, enhance pedestrian safety, reduce carbon footprints, and beautify neighborhoods. Green Streets use vegetation, soils, and natural processes to manage water and create healthier urban environments. Green Streets can incorporate a wide variety of design elements, yet their functional goals are the same: provide source control of stormwater, increase infiltration by limiting its transport, reduce pollutant conveyance to the collection system, and provide environmentally enhanced roads.
The main features of Green Streets are listed in the Table 9. Those that are included in the economic analysis are indicated with a check mark.

TABLE 9: DESCRIPTION OF GREEN STREET ELEMENTS

Green Street Element	Description/Impact	Included in Economic Analysis
Trees and Vegetative Cover	Trees and vegetative cover are the main feature of Green Streets and can be part of a water management system, like planter boxes or bioswales.	✓
Mulch	Mulch refers to any substance used to cover and protect soil. The primary function of mulch is to reduce evaporation of moisture from the soil.	✓
Planter Boxes	Planter boxes are urban rain gardens with vertical walls and open or closed bottoms that collect and absorb runoff from sidewalks, parking lots, and streets.	✓
Bioswales	Bioswales are vegetated, mulched, or xeriscaped channels that provide treatment and retention as they move stormwater from one place to another.	✓
Curb-Cuts	Curb cuts are openings created in the curb to allow stormwater from the street (or any adjacent impervious surface, like a parking lot) to flow into a depressed infiltration and planting area.	✓
Sediment Traps	Sediment traps capture and collect sediment at the entrance to bioretention areas, facilitating periodic sediment removal and extending the functional life of these features.	✓

Green Street Element	Description/Impact	Included in Economic Analysis
Permeable Pavement	Permeable pavements are paved surfaces that infiltrate, treat, and/or store rainwater where it falls.	

Trees and Vegetative Cover

Native plants (trees, shrubs, and/or ground cover) are the main feature of Green Streets. Tree and vegetative cover can be part of a water management system, like an at-grade tree well, below-grade vegetated bioswale, or above-grade planter box. Trees can also be planted as a standalone unit where there is no room for water collection. In the latter case some of the water quality and water management benefits are lost, but benefits like carbon sequestration, reduction in local temperatures, and aesthetic value remain.

Mulch

Mulch refers to any substance used to cover and protect soil. Organic mulch is made up of dry, shredded plant pieces. Rock mulch is made of gravel or stone.
The primary function of mulch is to reduce evaporation of moisture from the soil. This function is crucial in desert areas, where potential evaporation far exceeds rainfall. The general rule for choosing mulch is:

1. Use organic mulch in areas where water pools/eddies are deposited, such as in a basin attached to a curb cut. The area right next to the curb cut however should be rock mulch so that it doesn’t get disturbed and washed away.
2. Use rock mulch in areas where water is being transported or where flooding is a concern, such as in a swale or in-street practices.

Planter Boxes

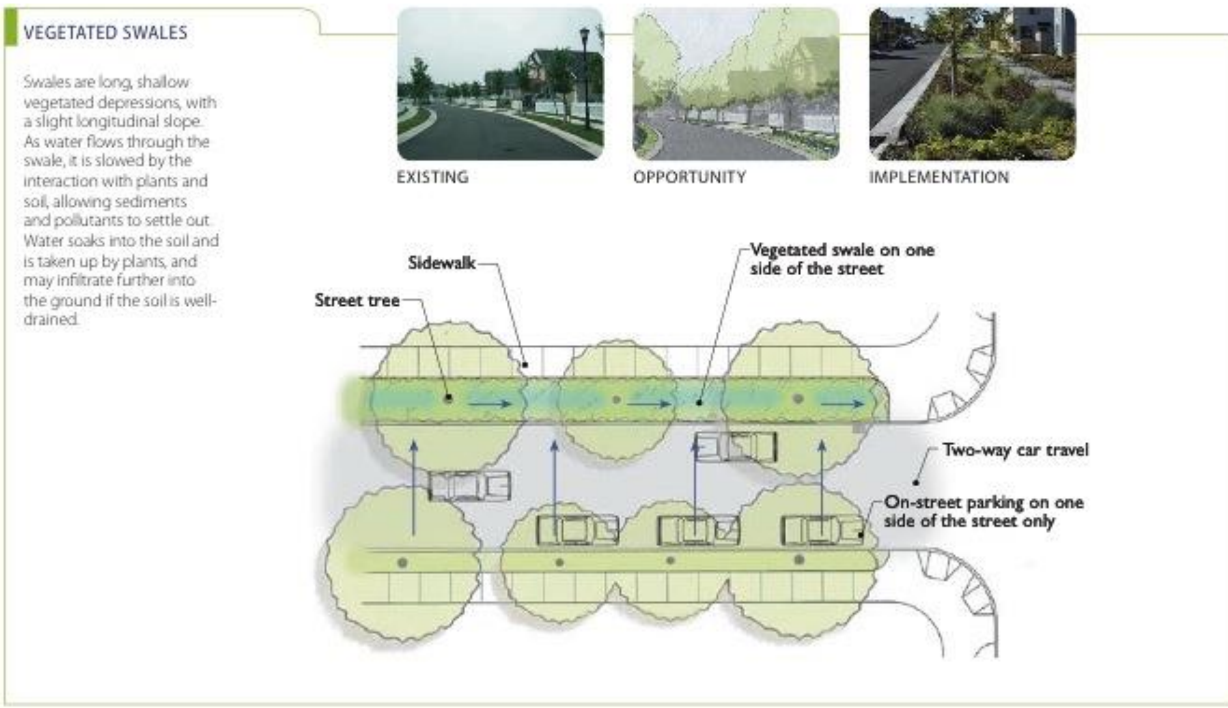
Planter boxes are urban rain gardens with vertical walls and open or closed bottoms that collect and absorb runoff from sidewalks, parking lots, and streets. Planter boxes are ideal for space-limited sites in dense urban areas, and as a streetscaping element. Figure 4 demonstrates a schematic of a stormwater planter box from the US Environmental Protection Agency (EPA) manual on Green Streets.

FIGURE 4: SCHEMATIC OF STORMWATER PLANTERS (EPA, 2009)

Bioswales

Bioswales are vegetated, mulched, and or xeriscaped channels that provide treatment and retention as they move stormwater from one place to another. Vegetated swales slow, infiltrate, and filter stormwater flows. As linear features, vegetated swales are particularly suitable along streets and parking lots. Figure 5 shows two schematics of vegetative swales from the US EPA manual on Green Streets.

FIGURE 5: SCHEMATICS OF VEGETATIVE SWALES (EPA, 2009, GREEN STREETS)

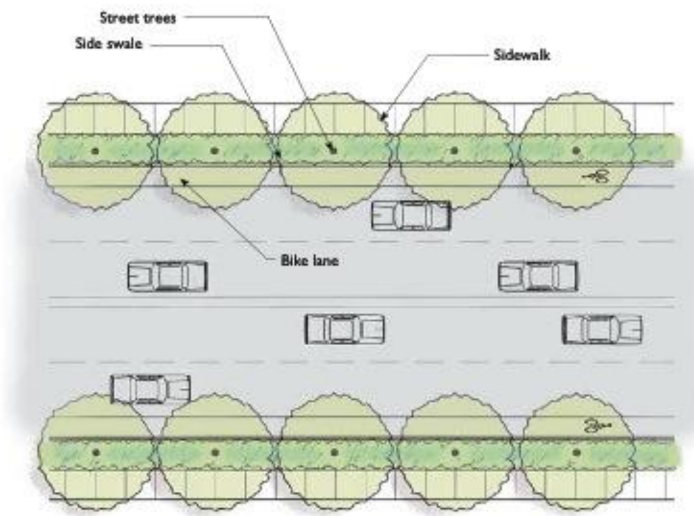


VEGETATED SWALES

Like residential streets, arterial roadways are good street types for swales because they typically have long, linear stretches of uninterrupted space that can be used to manage stormwater.

Some arterials may not have landscape space in place but do have travel lanes or paved shoulders that can be narrowed to create space for swales.

TYPICAL STREET OPPORTUNITY IMPLEMENTATION



Curb-cuts

Curb-cuts are openings created in the curb to allow stormwater from the street (or any adjacent impervious surface, like a parking lot) to flow into a depressed infiltration and planting area. Since curb-cut openings are perpendicular to the flow of stormwater on the street, they will usually collect only a portion of the water flowing along the gutter. Figure 6 highlights a couple of curb-cut designs found in city streets.

FIGURE 6: CURB-CUTS (WATERSHED MANAGEMENT GROUP, 2010)

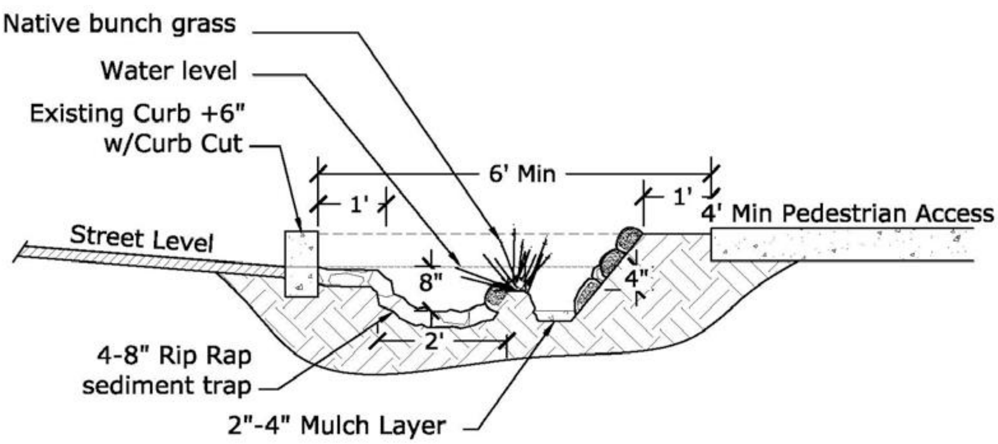
A curb cut draws stormwater from the street into a bioretention basin in the right-of-way.

A rock apron protects against soil erosion where curb cuts draw stormwater into bioretention areas.

Sediment Traps

As demonstrated in Figure 7, sediment traps capture and collect sediment at the entrance to bioretention areas, facilitating periodic sediment removal and extending the functional life of these features (Watershed Management Group, 2010).

FIGURE 7: TYPICAL CROSS SECTION OF SEDIMENT TRAP FOR CURB CUT WITH ROCK-LINED BASIN (WATERSHED MANAGEMENT GROUP, 2010)



Permeable Pavement

Permeable pavement has been excluded from this economic analysis due in part to the lack of appropriate street conditions for applicability. For permeable pavement to effectively function, the street criteria should be met: low traffic and low speed. Unfortunately, many of Los Angeles streets do not meet either of these baseline criteria, and as such permeable pavement was not evaluated. In addition, permeable pavement is also very costly to maintain. It is more effective where land values are high and where flooding or icing is a problem.

Benefits and Costs Associated with Green Streets

Benefits

Green Street features are designed to produce a number of community and environmental benefits. Based on a literature review of Green Streets, we summarized these benefits in Table 10. In this section, those benefits that were quantified are indicated with a checkmark and are briefly described. Reference and citations for each of these identified benefits are provided in Appendix 3 Section 2.

Due to insufficient or non-applicable data, some of the identified benefits are not included in the economic analysis--those without a checkmark. Information on non-quantified benefits can be found in Appendix 3.

TABLE 10: BENEFITS OF GREEN STREETS

Impact Category	Description	Included in Economic Analysis
Urban Heat Island Effect Mitigation	**Reduce Temperatures** Green Streets shade hardscape and provide cooling evapotranspiration that can reduce urban temperatures and make the city more pleasant.	
	Reduce Incidence of Heat-Related Illnesses Cool temperatures reduce the risk of heat-related illnesses and deaths.	
	Reduce Energy Consumption and Green House Gas (GHG) Emissions Cooler temperatures reduce air conditioning use and thus reduce energy consumption and associated GHG emissions.	✓
	Increase Pavement Life Lower surface temperatures increase the longevity of pavement, thus reducing maintenance or resurfacing of the pavement.	
Sequester Carbon/ Reduce Greenhouse Gas (GHG) Emissions	Planting vegetation helps reduce the amount of atmospheric CO_2 through direct carbon sequestration, reductions in water and wastewater pumping, and treatment and the associated energy demands.	✓
Remove Air Pollutants	Planting trees and employing bioretention and infiltration practices can help reduce air pollutants through direct up-take and absorption, reduced electricity generation, and reduced ozone and smog formation.	✓
Recharge Groundwater/Improve Storm Water Management	Green Street practices help to reduce the volume and rate of runoff entering storm drain systems. These practices infiltrate runoff to recharge ground water. This reduces both the capital and operational costs of gray infrastructure systems such as storage tanks and pumping stations.	✓
Reduce Stormwater Treatment/ Filtration Costs	Increasing water infiltration and reducing pollutant loads can decrease stormwater and drinking water treatment costs by decreasing the need for regional stormwater management systems and expansions in drinking water treatment systems.	✓

Impact Category	Description	Included in Economic Analysis
Reduce Flooding and Soil Erosion	Green Street elements reduce downstream flooding through the reduction of peak flows and the total amount of runoff. Infiltrating stormwater, particularly the first flush of larger storms, reduces peak flows and erosive potential of stormwater released.	✓
Reduce Spending on Stormwater and Street Infrastructure.	Flood prevention reduces property damage. It also can reduce the initial capital costs, and the operation and maintenance costs of stormwater and street infrastructure. Less money is spent on replacing curbs, gutters, storm drains and associated best management practices, pipe infrastructures.	
Improve Water Quality	Green Street infiltration practices result in pollutant removal through settling, filtration, adsorption, and biological uptake.	
Avoid Regulatory Fines	By reducing the amount of stormwater runoff and improving water quality, regulatory costs associated with water quality impacts such as threats to sensitive species, Total Maximum Daily Load (TMDL) compliance, etc. are avoided.	✓
Create/Improve Habitats	Vegetation in the urban environment provides habitat for birds, mammals, amphibians, reptiles, and insects. By reducing erosion and sedimentation, green infrastructure also improves habitat in small streams and washes.	✓
Create Open/Recreation Spaces	Commercial Green Streets provide a public greenway that can provide recreational opportunities for the surrounding neighborhoods. Many of the candidate sites include disadvantaged communities (per California Public Resources Code Section 75005) with limited access to existing green space and recreation.	
Reduce Noise Levels	Green Streets have the potential to reduce road traffic noise in the urban environment by absorbing sound. Trees also reduce noise transmission. Certain hard, manmade, surfaces tend to amplify traffic noise.	

Impact Category	Description	Included in Economic Analysis
Improve Human Well-being and Reduce Associated Medical Costs	**From Improved Access to Green Space** Green spaces are aesthetically pleasing and more inviting. People are more likely to get outside and stay active. People with access to green spaces are less stressed and prone to anxiety, have lower blood pressure and cholesterol, lower rates of obesity, have faster recovery from surgery and heart attacks, and show more improvement managing attention and behavioral disorders.	✓
	From Improved Water Quality Green Street elements are used to protect water resources that are downstream in the watershed, this can reduce incidence of illness and associated medical costs from contact with polluted water contaminated seafood living in it.	
	From Improved Air Quality Trees and vegetative cover improve air quality, which decreases the incidence of respiratory illnesses.	✓
Improve Safety	Green spaces increase public presence. More implied or actual surveillance decreases criminal activity.	
Increase Property Values	Green spaces increase adjacent property values. Property owners are willing to pay a premium to be located next to or near aesthetically pleasing amenities like water features and green spaces.	✓
Improve Economy	Green infrastructure can reduce a community's infrastructure costs, promote economic growth, and create construction and maintenance jobs.	

Urban Heat Island

The benefits of Green Streets are widespread environmentally; air, water, land, and living organisms. As mentioned, the main feature of Green Streets is tree and vegetative cover. Trees and vegetative cover have the ability to mitigate the Urban Heat Island Effect. Green Streets shade hardscape and provide cooling evapotranspiration that can reduce urban temperatures. Akbari (2002) and Taha (1996) show that increasing the canopy cover may reduce air temperature by 1–3°C in Los Angeles. These cooler temperatures reduce the risk of heat-related illnesses and death. The Centers for Disease Control and Prevention calculated that the premature deaths in the US that occur as a result of exposure to extreme heat outnumber total deaths from hurricanes, lightning, tornadoes, flooding, and earthquakes combined. Not only do higher temperatures put sensitive populations at risk, but they also increase the formation of ground level ozone. A study in Los Angeles found that every increase in 1°F above 70°F results in a 3% increase in ozone levels, triggering asthma attacks and may even lead to the development of asthma in children (Detwiler, 2012). Cooler temperatures also reduce the use of air conditioning, which means less energy consumption and associated GHG emissions. Research shows that peak urban electricity demand rises by 2– 4% for each 1°C rise in daily maximum temperature above a threshold of 15–20°C. Thus, the additional air-conditioning use caused by this urban air temperature increase is responsible for 5–10% of urban peak electric demand (Akbari, 2005).

Sequester Carbon

Planting vegetation also helps reduce the amount of atmospheric CO_2 through direct carbon sequestration, reductions in water and wastewater pumping and treatment, and the associated energy demands. One of the most comprehensive studies of atmospheric CO_2 reductions by an urban forest found that Sacramento's six million trees remove approximately 304,000 t (1.2 t/ha) of atmospheric CO_2 every year, with a value of $3.3 million (McPherson 1998). Avoided power plant emissions (75,600 t) accounted for 32% of the amount sequestered (238,000 t). The amount of CO_2 reduction by Sacramento's urban forest offsets 1.8% of total CO_2 emitted annually as a byproduct of human consumption. This savings could be substantially increased through strategic planting and long-term stewardship that maximizes future energy savings from new tree plantings (McPherson 1994, ICLEI 1997).

Remove Air Pollutants

Planting trees and employing bioretention and infiltration practices can help reduce air pollutants through direct up-take and absorption, reduced electricity generation, and reduced ozone and smog formation. Urban trees provide air quality benefits by (1) absorbing pollutants such as ozone and nitrogen oxides through leaf surfaces, (2) intercepting particulate matter (e.g., dust, ash, pollen, smoke), (3) releasing oxygen through photosynthesis, and (4) transpiring water and shading surfaces, which lowers local air temperatures, thereby reducing ozone levels. In the absence of the cooling effects of trees, higher air temperatures contribute to ozone formation. Plumb and Seggos (2007) cite one study that found that a single tree can remove 0.44 pounds of air pollution per year. One study for the entire Los Angeles region found that 20 years after planting, 11 million trees would save $180 million due to ozone reductions (Rosenfeld et al. 1998).

Recharge Groundwater/Improve Storm Water Management

Some of the major benefits from Green Streets deal with stormwater management and water quality. Greater stormwater capture and infiltration could reduce stormwater management costs, by localizing groundwater infiltration practices that help to reduce the volume and rate of runoff entering storm drain systems. A study of the Los Angeles Region showed that implementation of distributed best management practices (BMPs) in all of the 49 identified candidate catchments has the potential to augment groundwater supplies by 17,000 acre feet/year. This represents nearly 10% of the 180,000 acre feet/year of runoff that is estimated to be available for capture (Council for

Watershed Health, 2012). In Modesto each street and park tree is estimated to reduce stormwater runoff by 845 gal (3.2 m^3) annually, and the value of this benefit is $6.76 (McPherson et al. 1999b).

Reduce Stormwater Treatment/ Filtration Costs

As for water treatment savings, The Trust for Public Lands conducted a study of 27 water suppliers and found a direct relationship between tree cover in a watershed and water supply treatment costs. Communities with higher percentages of tree cover had lower treatment costs. According to the study, approximately 50% to 55% of the variation in treatment costs can be explained by the percentage of tree cover in the source area. The researchers also found that for every 10% increase in tree cover in the source area, treatment and chemical costs decreased approximately 20% (up to about 60%) (Reducing Stormwater Costs through Low Impact Development, 2007).

Reduce Spending on Stormwater and Street Infrastructure

By reducing runoff Green Streets also reduce downstream flooding and associated infrastructure costs. Infiltrating stormwater, particularly the first flush of larger storms, reduces peak flows and erosive potential of stormwater released. In Southern California, a 25-year winter event deposits 5.3 inches (134 mm) of rainfall during 57 hours. Approximately $0.0054/gal ($1.44/m3) is spent annually for controlling flooding caused by such an event (McPherson et al, 2000). Flood prevention reduces property damage. Less money is spent on replacing curbs, gutters, storm drains and associated best management practices, and pipe infrastructure. It also can reduce the initial capital costs, and the operation and maintenance costs of stormwater and street infrastructure.

Improve Water Quality

In addition to increasing our supply of groundwater, Green Street infiltration practices result in pollutant removal through settling, filtration, adsorption, and biological uptake. Practices like rain gardens and green roofs can filter out biological and chemical pollutants. Some pollutants, such as heavy metals and hydrocarbons, attach to soil or vegetation in a process known as adsorption. Suspended solids, phosphorous, and organic matter can be filtered out as runoff infiltrates into the ground. In addition, some plants and microorganisms remove nutrients like nitrogen.

A 2007 study of Washington, DC found that implementing urban trees and green roofs to manage stormwater runoff would keep 1.2 billion gallons of stormwater out of the City's combined sewer system. As a result of the lower stormwater volumes, combined sewage overflow (CSO) frequencies would be reduced by approximately 7 percent and 120 pounds of copper, 180 pounds of lead, 340 pounds of phosphorous, and 530,000 pounds of total solids would be kept out of the Potomac and Anacostia Rivers annually (The Green Build Out Model, 2007). A study of the Southern California Region shows that if 49 identified priority catchments had best management practices (BMP) the total pollutant loading for the region would be greatly reduced (Council for Watershed Health, 2012).

Avoid Regulatory Fines

Finally, by reducing the amount of stormwater runoff and improving water quality, regulatory costs associated with water quality impacts such as threats to sensitive species, Total Maximum Daily Load (TMDL) compliance, etc. can be reduced.

Create and Improve Habitats

Green Streets also create and improve habitats by making spaces in the urban environment available to flora and fauna. Green infrastructure also improves habitat in small streams and washes by reducing erosion and sedimentation. In addition, commercial Greet Streets provide a public greenway that can provide recreational opportunities for the surrounding neighborhood. Many of the candidate catchments include disadvantaged communities (per California Public Resources Code Section 75005) with limited access to existing green space and recreation.

Access to Green Space

All the aforementioned benefits make Green Streets a more aesthetically pleasing and inviting space. Landscaped green public spaces are not only used more, but also attract a wide variety of users from children to the elderly. Children are twice as likely to be supervised by adults when playing in green urban neighborhood spaces compared to public spaces without vegetation (Taylor et al, 1998). A considerable body of studies indicates that vegetation aids in the recovery from mental fatigue. Contact with nature in a variety of forms—wilderness areas, prairie, community parks, window views, and interior plants—is systematically linked with enhanced cognitive functioning as measured by both self-report and performance on objective tests (e.g., Canin, 1991; Cimprich, 1993; Hartig, Mang, & Evans, 1991; R. Kaplan, 1984; Lohr, Pearson-Mimms, & Goodwin, 1996; Miles, Sullivan, & Kuo, 1998; Ovitt, 1996; Tennessen & Cimprich, 1995). Studies have demonstrated that people with access to parks and green space are less stressed and prone to anxiety, have lower blood pressure and cholesterol, lower rates of obesity, have faster recovery from surgery and heart attacks, and show more improvement managing attention and behavioral disorders (Kuo, 2012; How Cities Use Parks, 2012; Salois, 2012).

Improve Human Health

Green Streets are likely to reduce incidence of illness and associated medical costs from waters polluted by dirty runoff. Four in ten of California's most polluted beaches are in Los Angeles County. 48% of beaches in LA County received an F grade for wet weather water quality (2008 - 2012 average) (LA Mobility Plan 2035). A study of over 13,000 swimmers in Santa Monica Bay found that those swimmers who swam within 100 yards of a storm drain experiences increased incidences of gastrointestinal illness, with rates highest for those who swam nearest the storm drain outlet (Haile et al, 1996). A 2004 study of Huntington Beach and Newport Beach in California determined that the cost of illness from water-borne gastrointestinal illness was $36.58 per person in lost work days and medical costs, not including lost recreational values or willingness to pay of individuals to avoid getting sick (Given et al, 2006). For another two beaches in California, illness associated with swimming in water contaminated by polluted runoff at those beaches cost the public over $3 million every year (All Stormwater is Local, 2008).

In addition to swimming in polluted waters, eating seafood from rivers and lakes contaminated by polluted runoff can also pose a risk to health. Gastrointestinal illness and infection can occur when people eat shellfish from waters contaminated by bacteria, sewage, or excess nutrients that cause toxic algal blooms (Testing the Waters, 2011; Effects of Nitrogen and Phosphorous Pollution). Illness and death caused by eating contaminated seafood is estimated to cost local economies an average of $22 million per year from missed work days, medical expenses, and investigation of the contamination (NOAA Economic Statistics, 2002).

Green Streets reduce the incidence of respiratory illness from poor air quality. In one study of a metropolitan area of Barcelona, the annual mean health benefits of reducing the mean PM10 were estimated to be 3,500 fewer deaths (representing an average increase in life expectancy of 14 months), 1,800 fewer hospitalizations for cardio-respiratory diseases, 5,100 fewer cases of chronic bronchitis among adults, 31,100 fewer cases of acute bronchitis among children, and 54,000 fewer asthma attacks among children and adults (Perez et al., 2008).

Improve Safety

Green Streets can also enhance safety. With increased public presence in well maintained green areas, criminal activity is reduced with implied or actual surveillance. A study of 2,813 single-family homes in Portland, Oregon found that large trees in lots and in the public right-of-way decreased the occurrence of crime (Donovan and Prestemon, 2010). Another study of 98 apartment buildings in the Ida B. Wells public housing development in Chicago found a significant correlation between the amount of greenery and the number of reported property crimes and violent crime. Buildings that had the most greenery also had the lowest levels of reported crime (Kuo and Sulilivan, 2001). There is also some evidence to suggest that residential vegetation can act as a territorial marker. Well-maintained vegetation outside a home serves as one of the cues to care (Nassauer, 1988), suggesting that the inhabitants actively care about their home territory and potentially implying that an intruder would be noticed and confronted.

Another mechanism by which vegetation might inhibit crime is through mitigating mental fatigue. S. Kaplan (1987) suggested that one of the costs of mental fatigue may be a heightened propensity for “outbursts of anger and potentially . . . violence” and three proposed symptoms of mental fatigue—irritability, inattentiveness, and decreased control over impulses—are each well-established psychological precursors to violence. Irritability is linked with aggression in numerous studies (e.g., Caprara & Renzi, 1981; Coccaro, Bergeman, Kavoussi, & Seroczynski, 1997; Kant, Smith-Seemiller, & Zeiler, 1998; Kavoussi & Coccaro, 1998; Stanford, Greve, & Dickens, 1995). Inattentiveness has been closely tied to aggression in both children (Stewart, 1985) and adolescents (Scholte, van Aken, & van Leishout, 1997). And, impulsivity is associated with aggression and violence in a variety of populations (for reviews, see Brady, Myrick & McElroy, 1998; Markovitz, 1995; Tuinier, Verhoeven, & Van Praag, 1996).

Increase in Property Values

Green Streets increase neighboring property values. Property owners are willing to pay a premium to be located next to or near aesthetically pleasing amenities like water features and green spaces. Several studies including Lacy (1990), Mohamed (2006), U.S. Department of Defense (2004), and Bisco Werner et al. (2001) report that the natural features and vegetative cover of LID can enhance an area's aesthetics, and increase adjacent property values.

Improve Economy

Finally Green Streets improve the economy. Green infrastructure can reduce a community's infrastructure costs, promote economic growth, and create construction and maintenance jobs. As demand for green infrastructure skills increases, a range of new training and certification programs has emerged. In a study that examined the job impact of a $188.4 billion investment on greening water infrastructure in the US equally over the next five years shows that this investment would generate $265.6 billion in economic activity (i.e., growth in GDP) and create close to 1.9 million jobs. These figures are in job-years, which is equivalent to one job for one year. In California this means 80,000 more jobs (Gordon et al, 2011).

Costs

Table 11 summarizes the costs associated with implementing Green Street design elements. Those included in the economic analysis are indicated with a check mark.

Table 11: Costs of Green Streets

Cost	Description	Included in Economic Analysis
Construction	Construction costs include demolition of existing concrete, asphalt, existing structures, and the replacement of fill material with planting soil and infrastructure.	✓
Landscaping	Landscaping costs are required at a development regardless of the installation. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.	✓
Maintenance	Maintenance costs include ongoing maintenance activities such as pruning, pest and disease control, and irrigation (can be reduced or eliminated if native plants are used).	✓
Street Rehabilitation	Every 15-20 years streets have to be rehabilitated, which includes grinding off old roadway surfaces, resurfacing the pavement with new asphalt, and repairing/replacing curbs where necessary.	✓
Increased Liability	There are more trips and falls with trees planted on sidewalks. Liability from injuries and the costs of trip and fall claims and legal staff salaries for tree-related cases increases.	✓
Gentrification	Green infrastructure increases property values, which can displace low-income families and small businesses if the health and economic stability of current residents is not considered.	

In addition to the construction and maintenance costs of Green Streets, trees increase liability costs from trips and falls. According to a report by McPherson et al. (2000) "annual payments for trip and fall claims and legal staff salaries for tree-related cases averaged $1.81/tree" (McPherson, G. et al., 2000). This is considered an added cost to tree implementation.

Another important social cost to consider is the gentrification that occurs when property values increase from proximity to greener spaces. If the health and economic stability of current residents is not considered, low-income families and small business can be displaced. However, this doesn't necessarily have to be the case. Green spaces have the ability to make all the aforementioned benefits more pronounced in low-income areas that often are lacking any green infrastructure.

Green Street Design Used in the Economic Analysis

The Green Street scenario assumes that 4% of the total impervious space is converted to green space. It also assumes that 1% of green space was already existing in the street. In the Green Street scenario, it is assumed that all of this green space is implemented in the sidewalks, accounting for 23% (17% new green space and 6% already existing) of sidewalk space. This equates to over 12 million square feet of green space added to the 1,000 center-lane miles of Los Angeles streets projected in this study. It was also assumed that 85% of the green space would be covered by vegetative cover, 3% by gravel, 7% by rip-rap inlets, and 5% by trees. Table 12 summarizes the assumptions used in the Green Streets scenario.

TABLE 12: SUMMARY OF GREEN STREET TREATMENT

Treatment	Percentage of Treated Area
Rip-rap at Inlets for Energy Dissipation	7%
Mixed BMP Vegetation	85%
Washed Pea Gravel Forebay	3%
Trees	5% (86,568 trees)

The treatment details are listed in the Table 13.

TABLE 13: GREEN STREET TREATMENT DETAILS

Green Street Treatment		
Treatment	Percentage of Treated Area	Treatment Depth
Engineering and Planning (Percentage of Total Capital Cost)	20% of Capital Costs	
Demolish and Remove existing Asphalt or Concrete	75%	5"
Excavation, Small Scale to 250CY	100%	42"
Hauling and Disposal	25% of Excavation	
Finish Grading	100%	2"
Curb Inlet and/or Area Drain	24 inlets per mile	
Rip-rap at Inlets for Energy Dissipation	7%	12"
Mulch	85%	3"
Surface Treatments / Finishing - Soil preparation	90%	6"
Surface Treatments / Finishing - Mixed BMP Vegetation	85%	N/A
Washed Pea Gravel Filter Layer	100%	2"
Washed Pea Gravel Forebay	3%	12"
Drainage/Storage Rock	100%	4"
Trees	5%	N/A
Contingency (Percentage of Total Capital Cost)	20% of Capital Costs	

Results of the Economic Analysis

BAU-only compared to Green Streets

Table 14 summarizes the economic indicators for the two street designs, BAU and Green Streets, and compares their specific costs and benefits. The valuations detailed in this section are based on previous research and were used as the basis for the assumptions and calculations undertaken in this study.

TABLE 14: SUMMARY OF GREEN STREET RESULTS

Action code	Total cost	Total benefit	Net Present Value	Pay Back (years)	Benefit-Cost Ratio
BAU1-Only (repaving)	$738,677,265	$7,088,603,848	$6,349,926,582	3.0	9.6
BAU2-Only (reconstruction)	$1,086,995,688	$7,144,352,396	$6,057,356,708	4.3	6.6
Green Street - BAU1 (Green-BAU1)	$1,021,685,627	$7,602,417,470	$6,580,731,843	3.5	7.4
Green Street - BAU2 (Green-BAU2)	$1,285,372,720	$7,652,323,491	$6,366,950,771	4.5	6.0

The Green Street case has significantly lower relative costs under the BAU2 scenario than the BAU1. In the BAU1 scenario, the cost of construction for Green-BAU1 is 38% ($283 Million) higher than simply repaving the street (BAU1-only). The total benefits for the Green-BAU1 were 7% ($514 Million) greater than BAU1-only. The net present value for the Green-BAU1 was 4% ($230 million) greater than BAU1-only.

In the BAU2 scenario, Green-BAU2 is only 18% ($198 Million) more costly than reconstructing the streets and sidewalks (BAU2-only). This is due to the fact that in BAU2-only, the sidewalks are already being taken out and some of the sidewalk no longer needs to be constructed because green elements are going in their place. In the BAU1 scenario, however, the sidewalks are not being replaced; therefore, sidewalk removal costs for the Green Street elements are an added cost beyond the Business as Usual treatment. The total benefits for the Green-BAU2 were 7% ($508 million) greater than BAU2-only. The net present value for the Green-BAU1 was 5% ($310 million) greater than BAU1-only.

The net present value for the Green-BAU1 scenario is higher than the net present value of Green-BAU2. This is due mainly to the fact that the increase in construction costs in the BAU2 scenario still outweigh the increase benefits of the Green Street elements and the efficiencies of incorporating the construction of the Green Street elements within sidewalk reconstruction. The difference between BAU1 and BAU2, however, has decreased with the inclusion of the Green Street elements. BAU2-only costs were $348 million (47%) higher than BAU1-only. With the addition of the Green Street Elements, this difference drops to $264 million (26%).

The total benefit for Green-BAU2 is slightly higher than Green-BAU1 given the fact that the sidewalks were also addressed in the BAU2 scenario, reducing the liability that pedestrians injure themselves while walking on the improved sidewalk conditions.
Figures 8 and 9 show the cost and benefit data for each of the two Green Street designs: Green-BAU1 and Green-BAU2.

FIGURE 8: BREAKDOWN OF THE COSTS AND BENEFITS FOR GREEN-BAU1

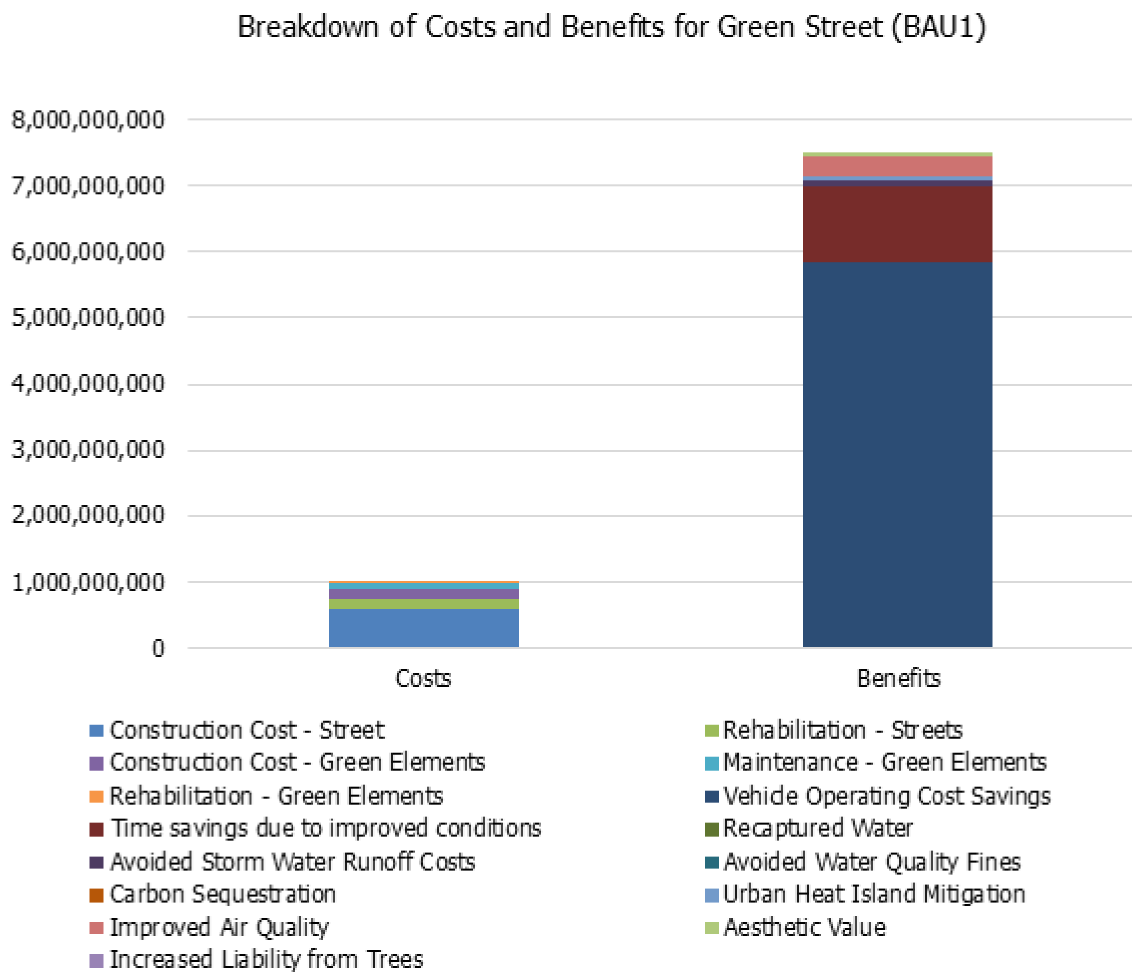
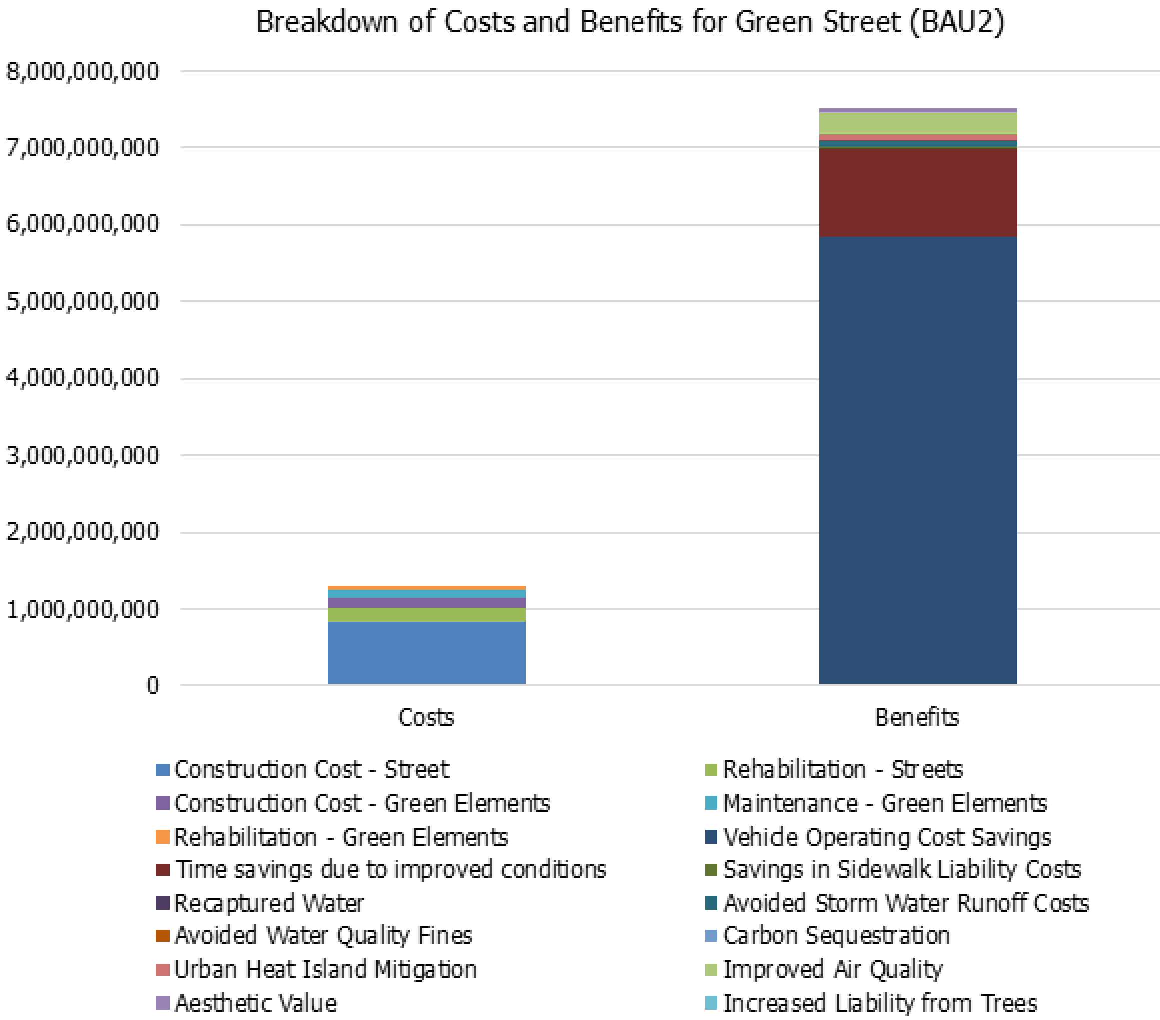


Figure 9: Breakdown of the Costs and Benefits for Green-BAU2



The two figures demonstrate the benefits of improving the street conditions significantly outweigh the costs of construction. This is true regardless of if they require repaving (BAU1-only) or a more extensive and costly reconstruction (BAU2-only). The largest contributor to the benefits is the reduction in vehicle operating costs, accounting for 78% of the benefits calculated in this study in both the Green-BAU1 and Green-BAU2 scenarios. The benefits from the Green Street elements are about 7% of the total benefits calculated.

Green Street Element Only (EO) Analysis

The economic data presented in this section shows the cost and benefit data for the only Green Street elements. This analysis shows the added costs and benefits associated with implementing the Green Street Elements. In other words, these are the costs and benefits above and beyond the original street construction costs.

Table 15 provides a summary of the economic indicators for both Green Street designs (Green-BAU1 and Green-BAU2) without any of the BAU construction costs and benefits:

TABLE 15: SUMMARY OF GREEN STREET – ELEMENT ONLY RESULTS

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (years)	Benefit-Cost Ratio
Green Street - BAU1, Element Only (Green-BAU1-EO)	$288,457,597	$513,813,622	$225,356,026	11.3	1.8
Green Street - BAU2, Element Only (Green-BAU2-EO)	$274,860,840	$513,103,832	$238,242,992	10.9	1.9

The costs of constructing the Green Street elements is lower in the BAU2 scenario due to the fact that the costs associated with demolition of the sidewalks and hauling of the old sidewalk concrete were absorbed by the BAU2 scenario. In the BAU2 street design, the sidewalks were already being demolished and replaced, so these costs are not considered as additional costs for including Green Street elements in the street. This saving demonstrates the efficiencies of incorporating these elements in the already planned street reconstruction, rather than trying to implement green elements later on. Given this efficiency savings, the net present value of the Green Street elements is higher in the BAU2 scenario than BAU1. It also causes the payback period to decrease and the benefit-cost ratio to increase.

Figures 10 and 11 show the cost and benefit data for the Green Street Element Only – taking out the construction of the BAU elements and their associated costs and benefits.

FIGURE 10: BREAKDOWN OF THE COSTS AND BENEFITS FOR GREEN-BAU1-EO

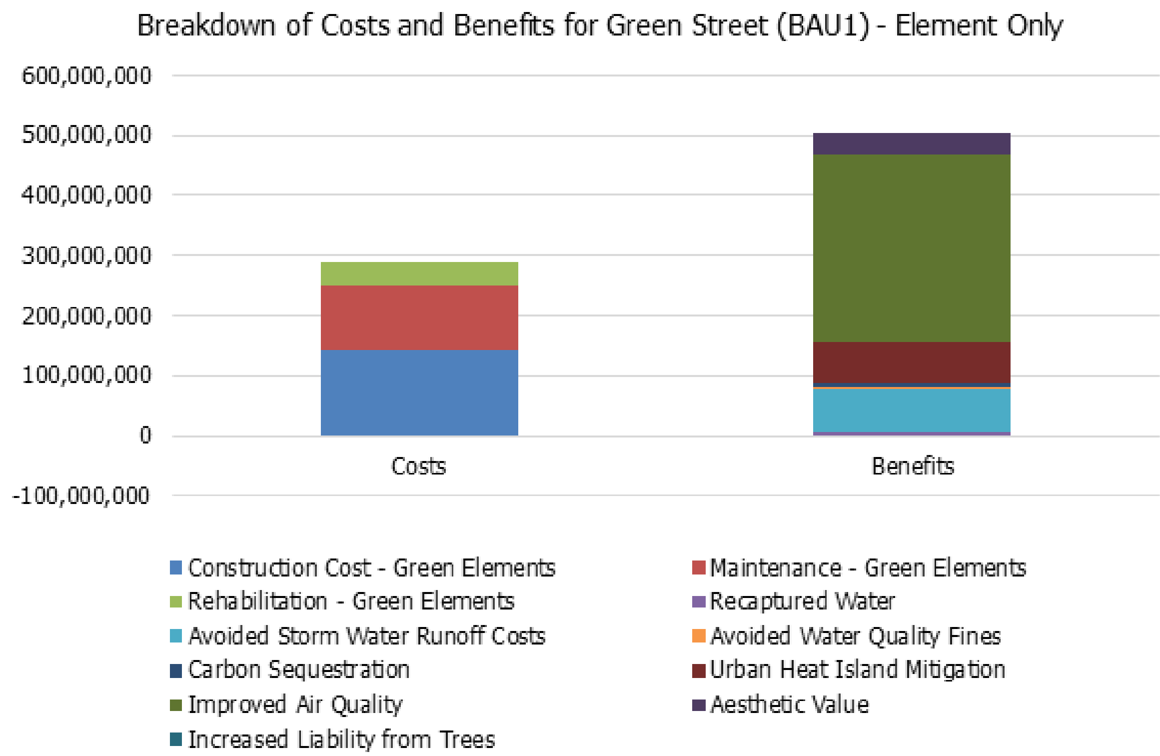
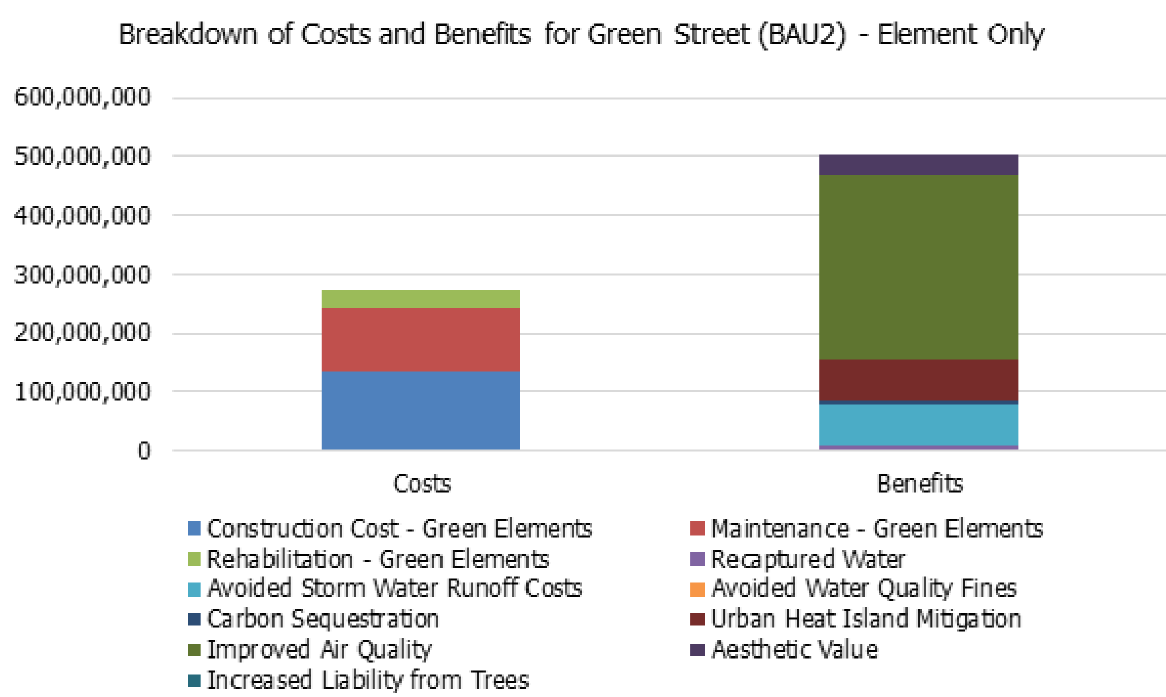


FIGURE 11: BREAKDOWN OF THE COSTS AND BENEFITS FOR GREEN-BAU2-EO



These two figures highlight the largest benefit calculated was from improved air quality, which was 62% of the total benefits in both Green-BAU1-Element Only and Green-BAU2-Element Only. Additionally, the benefits from just improved air quality alone are about 13% higher than the costs associated with implementing the Green Street elements in the BAU2 scenario. In the BAU1 scenario, the benefits from just improved air quality alone are about 8% higher. The benefit-cost ratio shows that, in total, Green Street elements bring in about $1.80 in benefits for every $1 invested.

For a complete analysis of the economics results and comparisons between treatment options, please see Section 7 of this report.

Cool Streets

Description of Cool Street Elements

Cool Streets are streets designed to cool our cities and reduce the Urban Heat Island Effect (UHIE). The main cause of the Urban Heat Island Effect has been the modification of land surfaces, which use materials, like asphalt, that effectively store short-wave radiation (Solecki et al., 2005; EPA, 2005). This surface modification usually entails removal of canopy cover or soft scape that shade and provide cooling evapotranspiration that further exacerbates the UHIE. Waste heat generated by energy use, like air conditioning use in cars, is a secondary contributor (Zhao, 2012).
The main features of Cool Streets are listed in Table 16. Those elements with a checkmark are included in the economic analysis. The analysis of tree and vegetative cover is only included once in the individual street paradigms for simplicity and calculation purposes. As such, this element is not thoroughly detailed in this chapter.

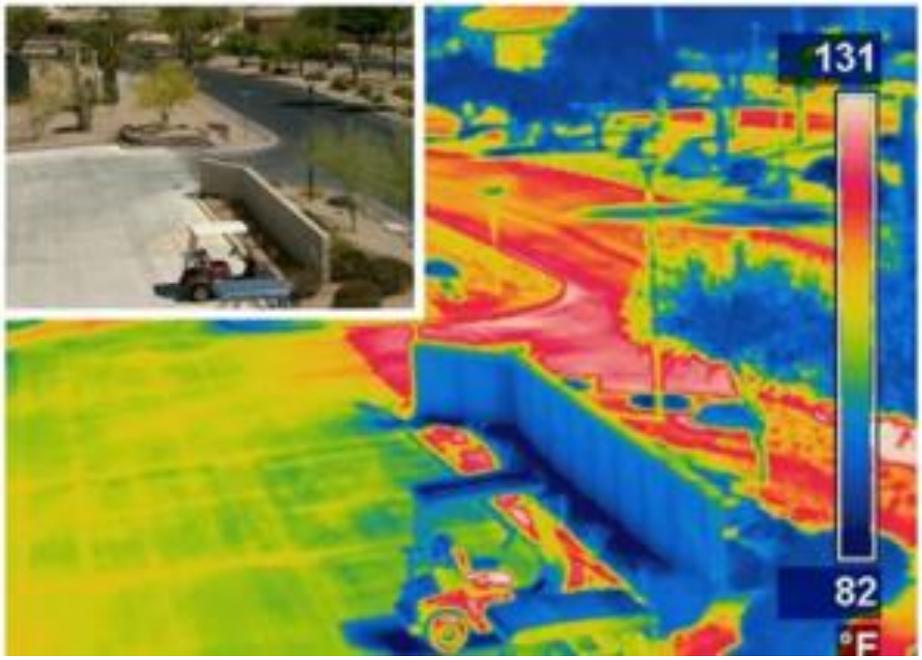
Table 16: Cool Street Elements

Cool Street Element	Impact	Included in Economic Analysis
Tree and Vegetative Cover	Tree and vegetative cover reduce local temperatures by shading hardscape and providing cooling evapotranspiration.	Covered in Green Streets Section[2]
Cool Pavement	Cool pavements reflect more solar radiation reducing surface temperature and/or cool pavement through evaporation.	✓

Tree and vegetative cover is the installation of native plants (trees, shrubs, and/or ground cover), whether at-grade such as trees wells, below-grade such as vegetated bioswales, above-grade such as planter boxes, or any combination of these soft-scape elements in lieu of hardscapes like asphalt, cement, or concrete. Including mulch in any landscaped design also facilitates soil protection and reduction of evapotranspiration from the ground. Implementing these soft-scape elements provide shading or canopy cover, which prevent short-wave radiation from reaching hard surfaces that are capable of storing solar radiation. For a more thorough description of the quantitative or qualitative details of tree and vegetative cover, please see Green Streets Section 3.
The other main feature of Cool Streets is cool pavements. There are various types of cool pavements that reduce surrounding temperatures either by reflecting radiation or evaporating water such as reflective Slurry Seal, conventional, chip seals, resin, whitetopping, vegetated permeable, etc. Figure 12 shows an example of a reflective lighter colored pavement and its resulting cooler surface temperature.

[2] It is important to note that in order to provide a clear analysis between the different scenarios, tree and vegetative cover was not included in the Cool Street Scenario. Given that these costs and benefits are major part of the Green Street Scenario, they were not included in the Cool Street so that the scenarios could be clearly compared.

Figure 12: Lighter colored pavement is more reflective, resulting in a cooler surface temperature



Currently, reflective Slurry Seal is the only cool pavement being developed for use in California due to cost and feasibility. As such, it is the only cool pavement considered in this report. While not included in the economic analysis, these other cool pavement approaches and their application are described in Appendix 1 Section 1.

Slurry Seal is a preventative, maintenance process designed to prolong the life of the asphalt surface. Slurry Seal extends the life of the existing street surface by approximately 5-7 years. It also provides several benefits for streets including: minimizing oxidation/ageing; reducing water infiltration; providing skid resistance; improving aesthetics; and correcting raveling and weathering (Delatte, 2008).
Table 17 highlights three types of Slurry Seals currently applied to city streets.

TABLE 17: TYPE OF SLURRY SEALS (INTERSTATE PAVEMENT RESURFACING, 2015)

Slurry Seal Type	Composition	Application
Type I	"Fine" aggregate (1/8")	Low wear, low-density traffic areas
Type II	"General" aggregates (1/4")	Streets with moderate-to heavy traffic; collector and arterial roads, as well as residential streets
Type III	"Coarse" aggregate (3/8")	Roads with heavy traffic, including truck routes, highways and interstates. Type III Slurry Seal correct severe surface conditions, and provide improved skid resistance, which helps to prevent vehicles from hydroplaning.

Benefits and Costs Associated with Cool Streets

Benefits

When fully implemented, Cool Street features are designed to produce a number of benefits. In this section, those benefits are identified (with a checkmark) and briefly described. Reference and citations for each of the benefits identified are provided in Appendix 3 Section 3. The benefits shown in Table 18 are based on a literature review of Cool Streets.

Those benefits without a checkmark are not included in the economic analysis because there was insufficient or non-applicable data.

TABLE 18: COOL STREET BENEFITS SUMMARY

Impact Category	Description	Included in Economic Analysis
Urban Heat Island Mitigation	**Reduce Temperatures** Cool Streets reflect radiation which can lower temperatures making the city more pleasant.	
	Reduce Energy Consumption Cool Streets indirectly reduce energy consumption from reduced air-conditioning use.	✓
	Reduce Greenhouse Gas Emissions Cool Streets indirectly reduce greenhouse gas emissions by reducing energy consumption from air conditioning use.	✓
	Reduce Smog Exceedance Levels Cool Streets reduce ambient temperatures which reduce the photochemical reaction rate of pollutants that create smog. This reduction in smog also means reduced health related costs from smog.	✓
	Reduce Heat-Related Illnesses Cooler streets result in fewer heat–related illnesses including, general discomfort, respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality.	
	Increase Pavement Performance Cool Streets reduce the risk of pavement deformation and pavement weathering with lower ambient temperatures.	
Reduce Thermal Shock To Aquatic Life	Cool Streets' cool pavements reduce runoff temperature, which may result in less thermal shock to aquatic life meeting with runoff water.	
Enhance Complete Streets By Establishing Visible Spaces For Bicycles And Pedestrians	Cool Streets' reflective pavement (different than the streetscape pavement) create visually distinctive bicycle lanes and pedestrian walkways.	
Better Nighttime Visibility	Cool Streets' reflective pavements improve visibility at night, potentially reducing lighting requirements	

Urban Heat Island Mitigation: Reduce Temperature

Cool Streets have the ability to lower the temperatures of our urban cities. According to simulations, with a reasonable change in the albedo of Los Angeles – assuming that all roads and roofs are improved – we could expect a 1.5°C decrease in temperature of the downtown area (Akbari, H., 2005). The decrease in temperature, especially during summer months, can indirectly result in lower energy consumption from decreased air-conditioning use. Less energy consumption results in less greenhouse gas emissions. Lower temperatures also reduce the photochemical reaction rate of pollutants that create smog. For example, in Los Angeles, for every 1°C the temperature rises above 22°C, incident of smog increases by 5% (Akbari, 2005).

Urban Heat Island Mitigation: Reduce Heat related Illness

Increased daytime surface temperatures, reduced nighttime cooling, and higher air pollution levels increases the risk of heat-related illnesses, particularly for low income populations, the elderly, and young children with no or limited access to air-conditioning and poor ventilation. Cooler temperatures result in general wellbeing and fewer heat-related illnesses like respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality. Some studies suggest that the lack of nighttime relief from hotter temperatures is highly correlated to increased mortality and may be even more significant than maximum day temperatures (U.S. Environmental Protection Agency, 2008).

Urban Heat Island Mitigation: Increase Pavement Performance

Cooler temperatures also reduce the risk of pavement deformation and pavement weathering. At early ages, high temperatures make asphalt softer, increasing the risk for permanent deformation (rutting) (McPherson, 2005). Over time, the increase in pavement temperature causes volatilization of the asphalt binder and oxidization, which results in hardening of the binder, making it more susceptible to raveling and weathering as well as fatigue cracking (Chula Vista, 2012).

Reduce Thermal Shock

By using cool pavements Cool Streets can reduce thermal shock to aquatic life. Cool pavements absorb less heat and thus runoff temperature is reduced, which may result in less thermal shock to aquatic life meeting with runoff water.

Better Night-time Visibility

Cool reflective pavements can enhance the safety of an area. Reflective pavements can create visually distinctive bicycle lanes and pedestrian walkways making it safer and easier for end users. Furthermore, reflective pavement enhances nighttime visibility. It takes about 30% more lighting fixtures to have the same amount of lighting on low albedo pavements than high albedo pavements (Riley). The lighter pavement creates a brighter area and a safer environment.

Costs

Table 19 lists the costs associated with cool pavements, in particular reflective pavement. Reference and citations for the costs identified are provided in Appendix 3 Section 3.

TABLE 19: COOL STREET COSTS SUMMARY

Cost	Description	Included in Economic Analysis
Construction	The planning and construction cost of using reflective pavement.	✓
Maintenance	The cost of re-applying the reflective pavement every 7 years.	✓

Cool Street Design used in the Economic Analysis

In the Cool Street scenario, all of the street area is covered in a reflective Slurry Seal increasing the albedo of the street by roughly 0.25. While Slurry Seals are normally not applied until the maintenance phase of road construction, for the purposes of this study, it is assumed that the reflective seal is also applied in both the BAU1 (repaving) and BAU2 (reconstruction) scenarios after the streets are completed in order to gain the benefits of the increased albedo from year 1. Note that tree and vegetative cover are not covered in the Cool Street economic analysis, but rather once in the individual street paradigm scenarios (Green Street section) and then in the Living Street economic analysis.

TABLE 20: COOL STREET TREATMENT DETAILS

Cool Street Treatment	
Treatment	**Treatment Design**
Slurry Seal	100% of all Street Surface

Results of the Economic Analysis

BAU-only compared to Cool Street Elements

Table 21 provides a summary of the economic indicators for the two Cool Street designs under the two BAU scenarios:

TABLE 21: SUMMARY OF COOL STREET RESULTS

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (years)	Benefit-Cost Ratio
BAU1-only (repaving)	$738,677,265	$7,088,603,848	$6,349,926,582	3.0	9.6
BAU2-only (reconstruction)	$1,086,995,688	$7,144,352,396	$6,057,356,708	4.3	6.6
Cool Street - BAU1 (Cool-BAU1)	$1,905,102,187	$8,190,384,713	$6,285,282,526	4.2	4.3
Cool Street – BAU2 (Cool-BAU2)	$2,250,851,059	$8,246,133,262	$5,995,282,202	5.4	3.7

The Cool Street element changes both the BAU1 and BAU2 cases by the same amount since it is an added Slurry Seal treatment on top of the finished street. In both Cool-BAU1 and Cool-BAU2, the amount of street treated is the same, creating the same added costs and benefits in both scenarios. This report found that including a reflective slurry in either of the BAU scenarios increases costs by $1.17 Billion. The reflective slurry increases the overall total benefit by $1.10 billion. Given that the total costs associated with the Cool Street treatment are higher than the total benefits, the benefit-cost ratio for the Cool Street cases are slightly lower than the BAU-only cases.

It is important to note that in order to provide a clear analysis between the different scenarios, tree and vegetative cover was not included in the Cool Street Scenario. Given that these costs and benefits are major part of the Green Street Scenario, they were not included in the Cool Street so that the scenarios could be clearly compared. However, the benefit-costs analysis would be different if tree and vegetative cover were included, adding both costs and benefits to the results. The inclusion of tree cover with cool pavement may augment the Urban Heat Island Mitigation benefits, thus improving the quality of life of the community, reducing greenhouse gas emissions, reducing smog exceedance, reducing the number of heat related illnesses, etc.

Figures 13 and 14 show the costs and benefits for each Cool Street design element implemented under the two BAU scenarios:

FIGURE 13: BREAKDOWN OF THE COSTS AND BENEFITS FOR COOL-BAU1

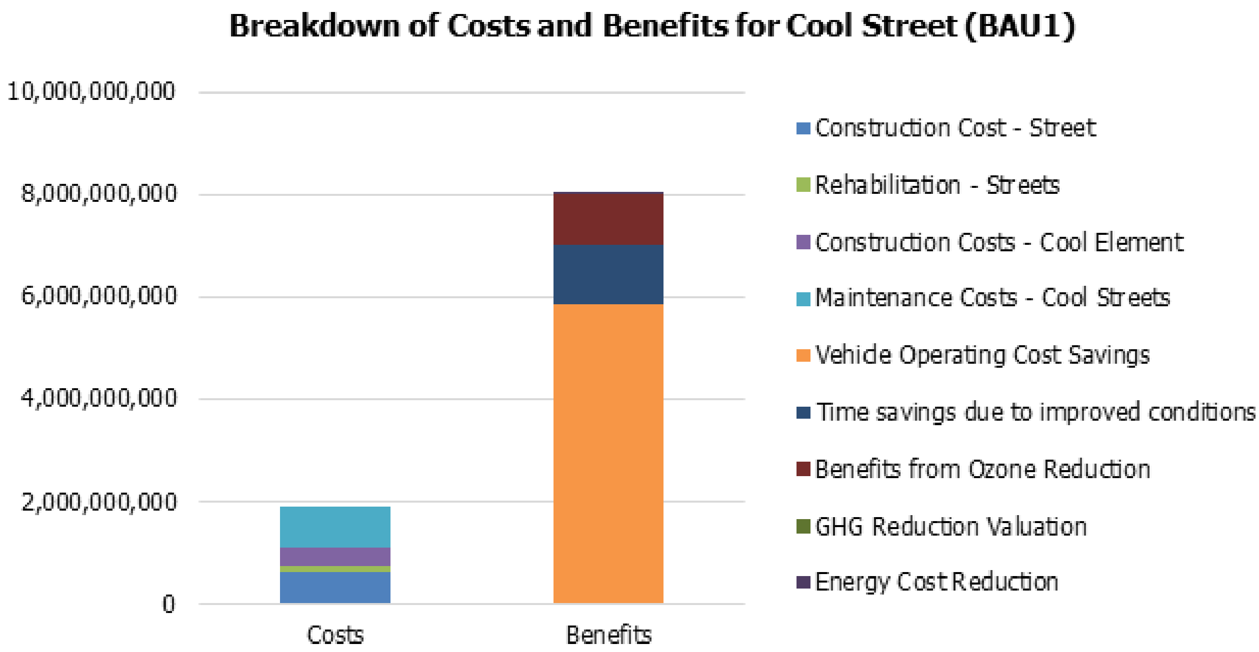
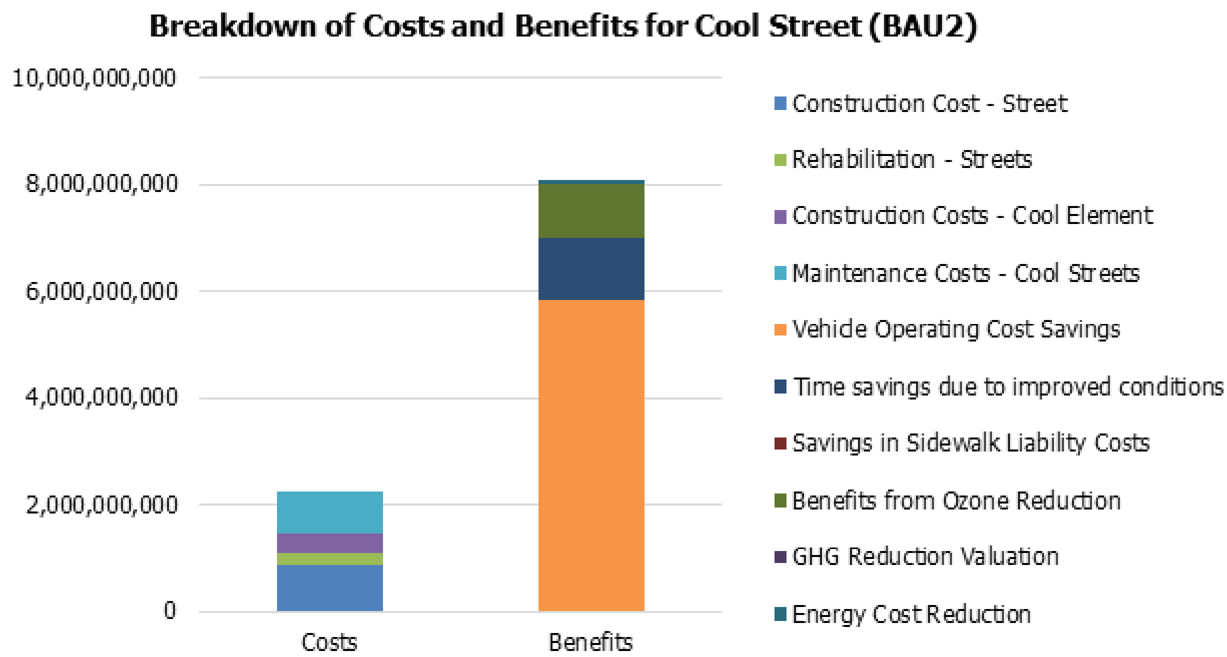


FIGURE 14: BREAKDOWN OF THE COSTS AND BENEFITS FOR COOL-BAU2



As can be seen in the two figures 13 and 14, the largest contributor to the benefits is the reduction in vehicle operating costs, accounting for 73% of the benefits calculated in both Cool-BAU1 and Cool-BAU2 cases. The benefits attributed to cool pavements are 13% of the total benefits calculated in the scenario.

Cool Street Element Only (EO) Analysis

The economic data presented in this section shows the cost and benefit data for the Cool Street elements themselves. . This analysis shows the added costs and benefits associated with implementing the Green Street Elements. In other words, these are the costs and benefits above and beyond the original street construction costs.

Table 22 shows the costs and benefits for the Cool Street - Element Only – taking out the construction of the BAU1 and BAU2 elements and their associated costs and benefits.

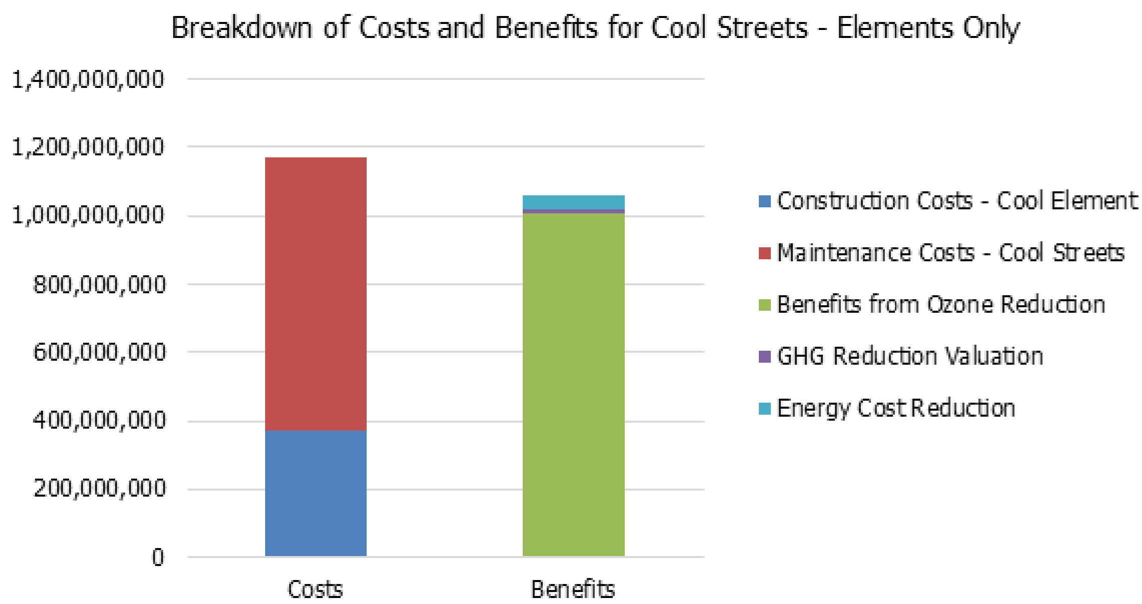
TABLE 22: SUMMARY OF COOL STREET – ELEMENT ONLY RESULTS

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (years)	Benefit-Cost Ratio
Cool Street - BAU1, Element Only (Cool-BAU1-EO)	$1,171,874,156	$1,101,780,865	-$70,093,290	34.2	0.94
Cool Street – BAU2, Element Only (Cool-BAU2-EO)	$1,171,874,156	$1,101,780,865	-$70,093,290	34.2	0.94

As shown in Table 22, the total costs are higher than the total benefits for the implementation of Cool Street treatment. The net present value associated with implementing a reflective Slurry Seal is negative; this investment is not appealing from an economic perspective. The benefit-cost ratio is about 0.94 meaning that for every dollar invested, $0.94 of benefits are received. It should be noted that many of the identified benefits for cool pavements were not quantified due to the lack of suitable data. In addition, cool street elements should be paired with other alternative street design features in order to augment the benefits and improve the results. For example, the benefit-costs analysis would be different if tree and vegetative cover were included. The inclusion of tree cover with cool pavement may augment the Urban Heat Island Mitigation benefits, thus improving the quality of life of the community, reducing greenhouse gas emissions, reducing smog exceedance, reducing the number of heat related illnesses, etc.

Figures 15 and 16 present the costs and benefit data for the Cool Street Element Only – again taking out the construction of the BAU elements and their associated costs and benefits.

FIGURE 15: BREAKDOWN OF THE COSTS AND BENEFITS FOR COOL-BAU1-EO AND COOL-BAU2-EO



As can be seen in the figure above, the largest benefit calculated was from ozone reduction, which was 95% of the total benefits in both the BAU1 and BAU2 cases. As previously noted, the total benefits are slightly lower than the total costs associated with implementing the Cool Street element.

For a complete analysis of the economics results and comparisons between treatment options, please see Section 8 of this report.

Complete Streets

Description of Complete Street Elements

Complete Streets are designed and operated to enable safe access for all users. Pedestrians, bicyclists, motorists, and public transportation users of all ages and abilities are able to safely move along and across a Complete Street.

There is no *one size fits all* design for Complete Streets. While the ultimate goal is to design a street that is convenient and safe for all users, every Complete Street design evolves from a process of evaluating a number of factors (some possibly competing) that influence the ultimate design of the street. These factors include, but are not limited to:

- Number and types of users
- Available and planned right-of-way
- Existing improvements
- Existing and planned land use context
- Community desires
- Available budget
- Parking needs
- Utilities

Complete Streets give solo drivers options to easily shift toward other modes of transport. In Los Angeles 47% of all trips are less than 3 miles (within walking/ biking distance) and 84% of these trips are currently made by car. Furthermore, 87% of all roads in Los Angeles are relatively flat (less than 5% grade) and 300 days/year there is favorable weather conditions for active transportation (sunshine, moderate temperatures) (LA Draft Mobility Plan 2035).

Figures 16, 17, and 18 display the 2015 Walk, Bike, and Transport Scores taken from City of Los Angeles Performance Data. These figures show that Los Angeles comes out in the middle of ranking compared to other US cities, with a walk score of 70/100, bike score 55/100, and a transit score of 50/100.

FIGURE 16: WALK SCORES FOR SELECTED CITIES (WALK SCORE, 2015)

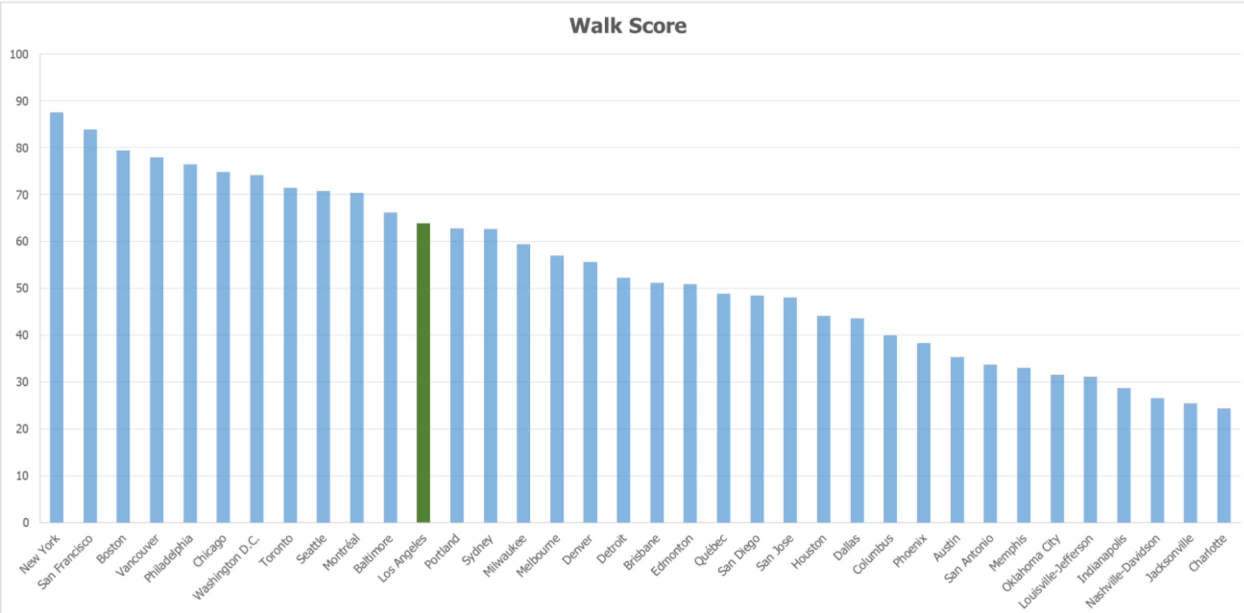


FIGURE 17: BIKE SCORES FOR SELECTED CITIES (WALK SCORE, 2015)

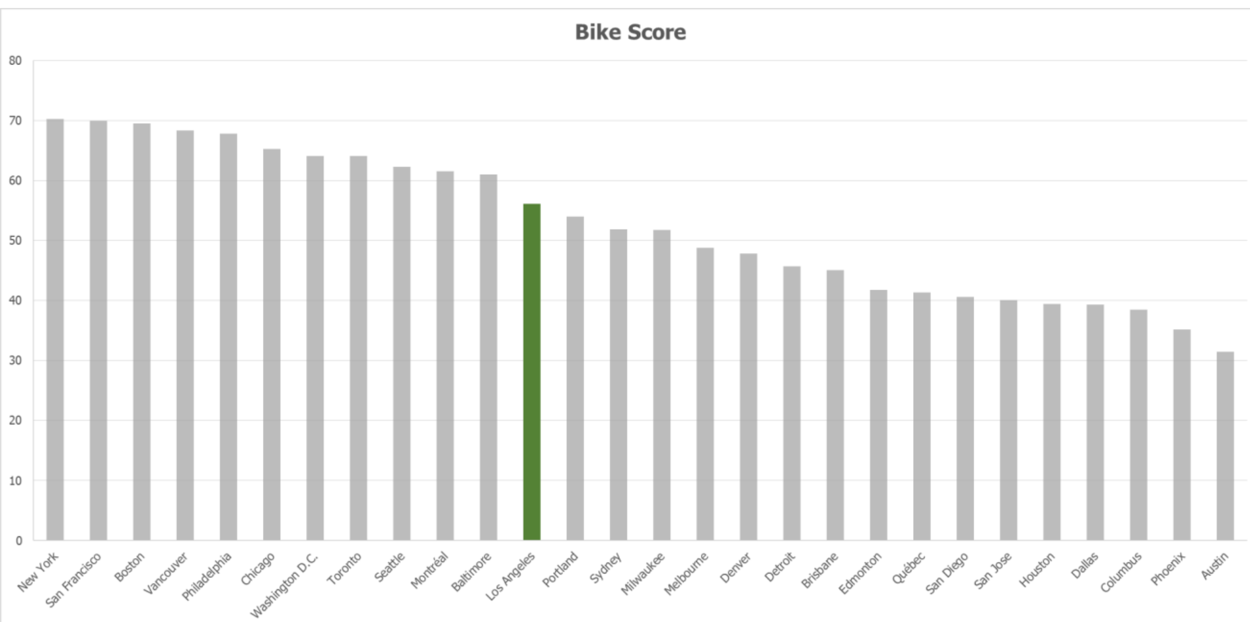
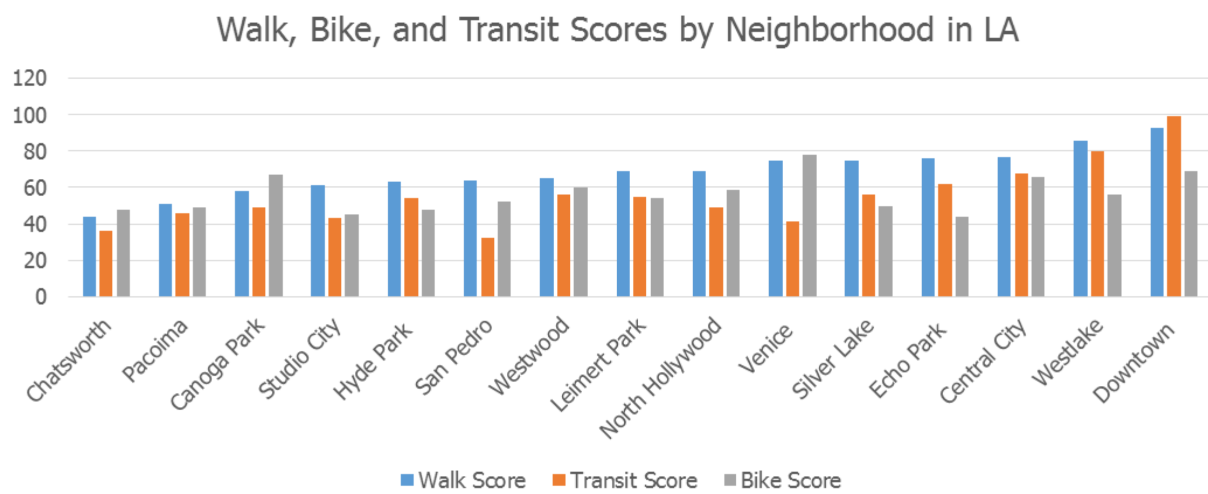


Figure 18: Transit Scores for Selected Cities (Walk Score, 2015)

Figure 19 shows neighborhoods within the City of Los Angeles and their respective scores for the three categories, with some communities scoring quite low. Different Complete Street elements can help make Los Angeles a more walk-able, bike-able, and transit friendly city. In-Complete Streets make it dangerous or unpleasant to walk, bicycle, or take transit. Complete Streets would help convert many of these short automobile trips to multi-modal travel. If there is safe and convenient infrastructure, it is expected that more people will choose bicycling or walking for short trips, in combination with public transportation for longer trips. The LA Mobility Plan 2035 outlines ways in which the City of Los Angeles plans to achieve getting people out of their cars for trips under three miles. One way the City of Los Angeles is currently doing this is, is by investing 20% of road reconstruction budgets and capital improvement funds toward Complete Street improvements.

FIGURE 19: WALK, BIKE, AND TRANSIT SCORES BY NEIGHBORHOOD IN LA (CITY OF LOS ANGELES PERFORMANCE DATA, 2015)



The main features of Complete Streets are listed in Table 23. Those that are included in the economic analysis are indicated with a check mark. These included elements are also ones that can be combined with Green and/or Cool Street elements. Those elements not included in this evaluation are either outside of the scope of this report or the analysis is considering a similar element.

TABLE 23: COMPLETE STREET ELEMENTS

Complete Street Element	Description	Included in Economic Analysis
Lane Reductions	Reducing the number of travel lanes on a multi-lane street can shift the balance of right-of-way (ROW) from motor vehicle to other users (pedestrians, bicyclists, etc.).	
Lane Width Reduction	This feature reduces the width of individual travel lanes, but keeping the total number of lanes constant. Lane width reductions are a good strategy for reclaiming street ROW for non-motor vehicle uses and for encouraging appropriate motor vehicle operating speeds	
Median/Island	A median is the portion of the roadway separating opposing directions of the roadway, or local lanes from through travel lanes. They are used to control traffic movements.	✓

Complete Street Element	Description	Included in Economic Analysis
Traffic Calming Circle	A traffic-calming circle is a raised island located in the center of an intersection around which traffic must circulate. Traffic calming circles are generally used at low volume neighborhood intersections.	
Curb Extension/Gateway	Curb extensions visually and physically narrow the roadway, creating safer and shorter crossings for pedestrians while increasing the available space for street furniture, benches, plantings, and street trees.	✓
Chicane	A chicane is a series of alternating mid-block curb extensions or islands that narrow the roadway and require vehicles to follow a curving, S-shaped path.	
Midblock Pedestrian Crossing	This is a pedestrian crosswalk that is located mid-block. As a rule of thumb, pedestrians will not walk more than 200 feet laterally in order to cross a street, and pedestrians will begin to seek out mid-block crossing opportunities when intersection spacing exceeds 400 feet.	✓
Raised Crosswalk	Raised pedestrian crosswalks serve as traffic calming measures by extending the sidewalk across the road and bringing motor vehicles to the pedestrian level.	
Corner Radii Design	Corner radii, when designed appropriately, result in smaller, more pedestrian-scaled intersections, reduce pedestrian cross times, encourage appropriate vehicular speeds and allow for proper placement of marked crosswalks.	
Vertical Speed Control (speed hump, speed cushion, speed table)	Vertical speed control elements manage traffic speeds and reinforce pedestrian-friendly, safe speeds. These devices may be appropriate on a range of street types, but are most widely applied along neighborhood, residential, or low-speed streets where freight traffic is discouraged	
On Street Parking	On-street parking provides an additional buffer between the sidewalk and travel lanes. Additionally, on-street parking encourages lower motor vehicle operating speeds (consistent with the target speed).	

Complete Street Element	Description	Included in Economic Analysis
Public Transit	Well-planned and designed transit facilities provide safe, comfortable and intentional locations for riders to access transit. People walking to the transit stop should find their path safe and inviting. Dedicated transit lanes, appropriate base signal timings, and operational traffic improvements ensure that the transit vehicle experiences minimal wait time at intersections and can move freely regardless of traffic congestion, providing a passenger experience competitive with driving.	
Bicycle Lanes	Having a space for bicyclists to use encourages bicycling. There are various types of bicycle lanes.	✓
Safe, Accessible, and Well-Maintained Sidewalks	Having a safe, accessible, and well-maintained sidewalk encourages walking.	✓
Traffic Signal Treatments	Signal timing is an essential tool, not just for the movement of traffic, but also for a safer environment that supports walking, bicycling, and public transportation.	
Lighting	Studies have shown that the presence of lighting not only reduces the risk of traffic crashes, but also their severity. In most cases, roadway street lighting can be designed to illuminate the sidewalk area as well.	
Smart Features	With all the current technology improvements streets can employ different features (smart meters, digital tag, information panels) to make transit easier and safer for all user.	

Median/Island

A median is the portion of the roadway separating opposing directions of the roadway, or local lanes from through travel lanes. Medians may be depressed, raised, or flush with the road surface—see Figure 20. Medians are generally linear and continuous through a block. An island is defined as an area between traffic lanes used for control of traffic movements.
Where no median is present, raised islands can be used as traffic-calming features to briefly narrow the traveled way, either in mid-block locations, or to create gateways at entrances to residential streets. Green and Cool Street features can be used on medians and islands.

FIGURE 20: EXAMPLE OF A MEDIAN/ISLAND (CITY OF PERRIS)

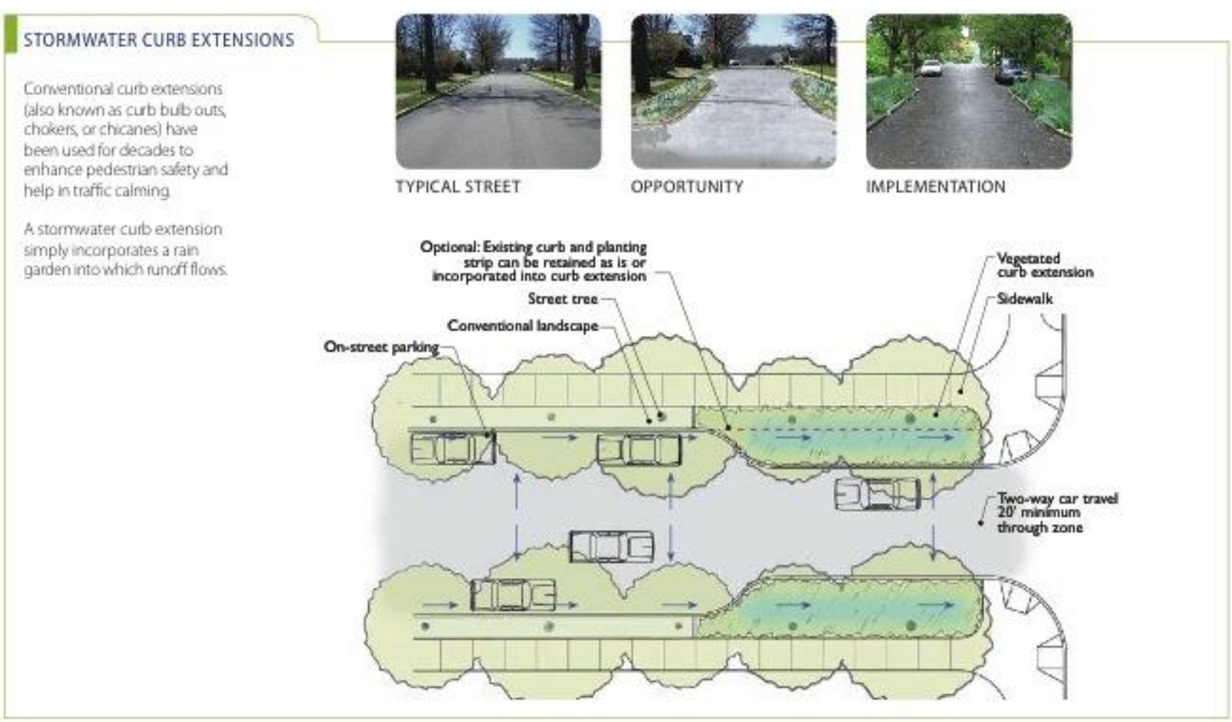
Curb Extension/Gateway

Curb extensions visually and physically narrow the roadway, creating safer and shorter crossings for pedestrians while increasing the available space for street furniture, benches, plantings, and street trees. They may be implemented on downtown, neighborhood, and residential streets.
Where on-street parking and/or shoulders are present, curb extensions should be considered for intersections. When located along a transit route, curb extensions should consider the inclusion of transit stops at the near side of an intersection. The curb extension allows transit vehicles to pick up passengers without leaving the travel lane, rapidly decreasing dwell times and eliminating operational conflicts.

Curb extensions are often applied at the mouth of an intersection. When installed at the entrance to a residential or low speed street, a curb extension is referred to as a "gateway" treatment and is intended to mark the transition to a slower speed street.

Curb extensions may be applied at midblock to slow traffic speeds and add public space. When utilized within a Green Street design, curb extensions can help collect stormwater by implementing a bioretention green area that allows stormwater to be collected. Figure 21 shows an example of a curb extension used to capture stormwater.

FIGURE 21: SCHEMATIC FOR STORMWATER CURB EXTENSIONS (EPA, 2009, GREEN STREETS)



Mid-block Pedestrian Crossing

As a rule of thumb, pedestrians will not walk more than 200 feet laterally in order to cross a street, and pedestrians will begin to seek out mid-block crossing opportunities when intersection spacing exceeds 400 feet. The distance can be even less when two high- volume, complementary uses are located directly across the street from each other. It is at these locations that mid-block crossing treatments should be considered. Figure 22 demonstrates an example of a mid-block pedestrian crossing. Reflective pavement can be used to make a visually separate walkway for pedestrians.

FIGURE 22: EXAMPLE OF A MID-BLOCK PEDESTRIAN CROSSING (HILLSBOROUGH COUNTY, 2014)

Bicycle Lanes

There are a variety of different bicycle lane designs to consider. The type of design chosen depends on a number of contextual factors including the type of user, available right of way (ROW), pavement width and street volume/ character. Figure 23 provides examples of the different types of bicycle lanes.

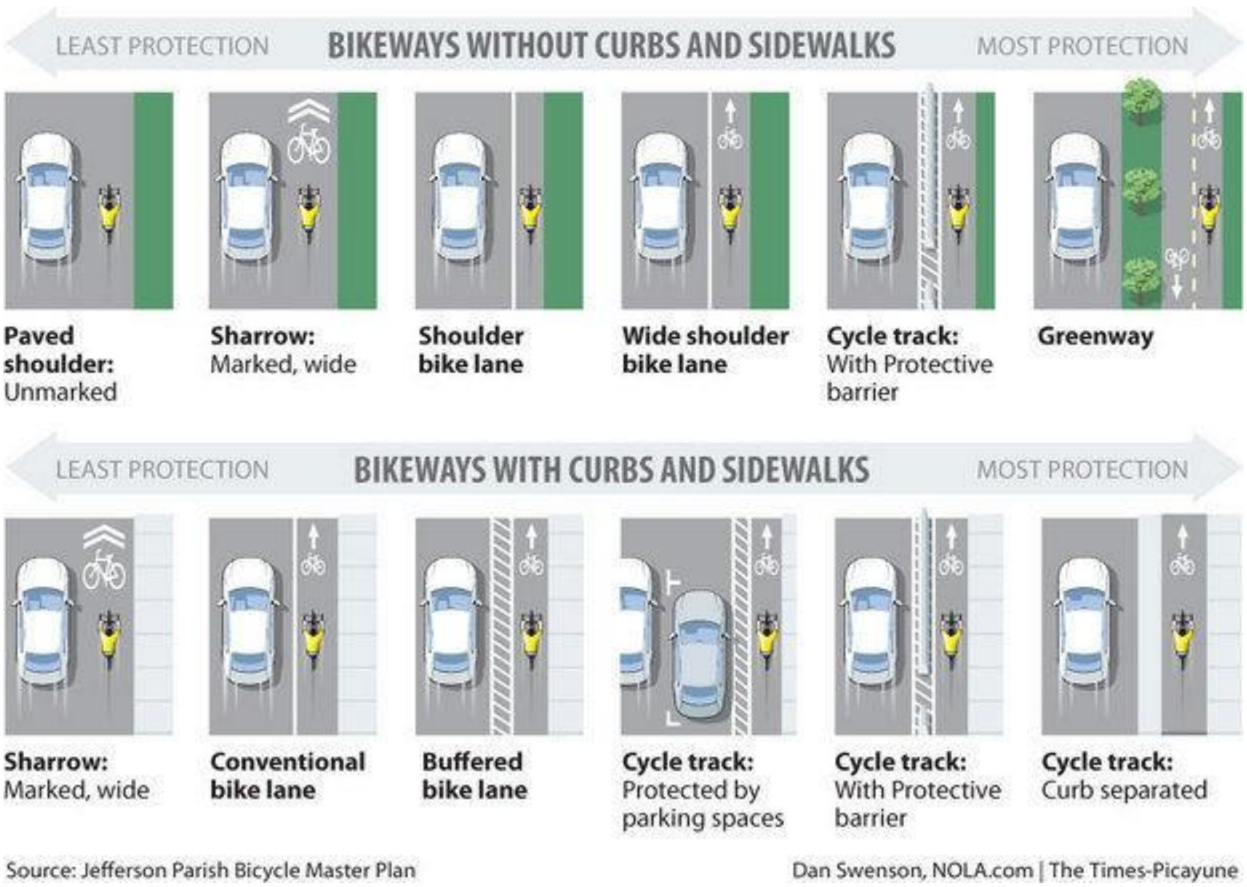


FIGURE 23: EXAMPLES OF BIKE-LANES (JEFFERSON PARISH BICYCLE MASTER PLAN)

Safe, accessible, and well-maintained sidewalks

Safe, accessible, and well-maintained sidewalks encourage walking. Sidewalks consist of different use zones. For example, the street furniture/curb zone should contain proper amenities like lighting, benches, bicycle parking, and green elements like rain gardens or flow-through planters. The buffer zone right next to the sidewalk can include curb extensions, parklets, stormwater management features, parking, bike racks, bike share stations, and curbside bike lanes or cycle tracks.

Details about the excluded Complete Street elements can be found in Appendix 1 Section 2.

Benefits and Costs associated with Complete Streets

Benefits

Complete Street features are designed to produce a number of benefits. In this section, those benefits are identified and briefly described. Reference and citations for each of the benefits identified are provided in Appendix 3 Section 4 (A.3.4).

Based on a literature review of Complete Streets, the benefits are summarized Table 24. Those benefits that we were quantifiable are indicated with a checkmark. Those elements without a checkmark were not included in the analysis due to insufficient or non-applicable data.

TABLE 24: COMPLETE STREET BENEFITS

Impact Category	Description	Included in Economic Analysis
Reduce Energy Consumption	Complete Streets help shift to modes of travel other than the automobile thus reducing energy consumption.	✓
Reduce Pollution	Complete Streets encourage active transport thus reducing air (including Greenhouse Gas emissions), noise and water pollution.	✓
Improve Safety	Complete Streets makes all types of transit safe, convenient, and comfortable thus reducing traffic injuries and fatalities.	✓
Increase Transportation Capacity	Complete Streets reduce short-distance car trips thereby increasing the street's overall capacity to accommodate more travelers.	
Reduce Congestion	Complete Streets provide travel choices – walking, bicycling, and public transportation – which can reduce the demand for peak-hour travel in cars, the principal cause of daily congestion.	✓
Reduce Roadway Costs	Complete Streets reduce infrastructure costs by requiring far less pavement per user; this saves money at the onset of the project and reduces maintenance costs over the long-term.	✓
Reduce Parking Cost	Complete streets encourage less automobile use meaning fewer parking spots are needed.	✓
Provide Option Value	Complete Streets give people different travel options that they currently do not use. Option value refers to the value people may place on having an option available.	✓
Reduce Transportation costs	Complete Streets encourage active transportation, which helps families replace car trips with bicycling, walking, or taking public transit, reducing transportation expenses.	✓

Impact Category	Description	Included in Economic Analysis
More equitable	Complete Streets allow different populations (children, elderly, low-income persons, and socially or physically disadvantaged people) to fairly use and share in public resources by increasing accessibility, connectivity, and affordability.	✓
Reduce Chauffeuring Burdens	Complete Streets increase independent travel reducing chauffeuring burdens.	✓
Improve User Travel Experience	Complete Streets increase convenience, comfort, safety, accessibility and enjoyment of travel.	✓
Create more "liveable" communities	Complete Streets create walkable/bikeable communities, where people are more likely to be socially engaged and trusting, and they report being in good health and happy more often. These areas tend to be more secure because many strategies for improving walking and cycling conditions can increase security.	
Improve Health and Fitness	Complete Streets improve peoples' health and fitness levels with active transport options.	✓
Improve Economy (increased employment, income, productivity, property values and tax revenues)	**Increase regional economic growth** Complete streets can decrease automobile use, shifting spending from vehicles and fuel to goods with increased regional value	
	Increase retail and tourism Complete streets increase pedestrian, bicycle, and public transit traffic which is beneficial to store fronts. Tourism also increases in pedestrian, bicycle, public transit friendly areas.	
	Increase property values Complete Streets create transit rich areas, thus increasing the property values of surrounding areas.	

Impact Category	Description	Included in Economic Analysis
	Increase jobs Complete streets create a more tourist friendly environment. With increased tourism more jobs are created. Furthermore, bicycle lane and pedestrian only projects create more jobs per spending than roadway projects.	

The goal of Complete Streets is to create access and safe mobility for all users. As mentioned the historical focus of streets have been the automobile, but by making this paradigm shift to encourage other modes of transport many benefits are reaped.

Reduce Energy Consumption

Complete Streets encourage active transport. Driving less means less fuel consumption, less GHG emissions, and less air pollution. In a study looking at the annual fuel savings in the US, shifting more short trips to bicycling or walking could amount to 2.4 billion gallons to five billion gallons of fuel. The total savings that would result from improving public transportation by bicycling or walking would result in 100 million to 1.6 billion gallons of fuel a year in the US. (Gotschi and Mills, 2008). Active transport can provide relatively large energy savings because it tends to substitute for short urban trips that have high emission rates per mile due to cold starts (engines are inefficient during the first few minutes of operation) and congestion. As a result, each 1% shift from automobile to active travel typically reduces fuel consumption 2-4% (Komanoff and Roelofs, 1993).

Reduce Pollution

In California cars account for 160 million tons of greenhouse emissions, this represent 30% of California's greenhouse gas emissions (Air Resources Board, 2010). If each resident of an American community of 100,000 replaced one car trip with one bike trip just once a month, it would cut carbon dioxide (CO) emissions by 3,764 tons per year in the community. Complete Streets make switching to active transport more possible. Boulder, Colorado is working to create a Complete Streets network with over 350 miles of dedicated bike facilities, paved shoulders and a comprehensive transit network. Between 1990 and 2003, fewer people in the city drove alone, more people bicycled, and transit trips grew by a staggering 500 percent. The reduction in car trips cut annual CO_2 emissions by half a million pounds (National Research Center, 2004).

In addition to GHG emission reductions, Complete Streets reduce air pollution. In 2012 there were 57 days when air pollution levels exceeded federal standards. Researchers estimate that air pollution is responsible for more than 7,500 premature deaths per year in the Los Angeles metro area, of which more than 2,000 can be attributed to vehicle emissions alone (Fabio, 2005). Statewide, vehicle emissions result in more than twice as many premature deaths as car crashes. The economic impact of this public health burden is estimated at $22 billion per year in the South Coast Air Basin (in lost days at work, lost days at school, health care, and premature death) (SCAG, 2012). A study from Washington State found that people who work in the most concentrated jobs center – that is, the middle of the city – emit 30% less nitrogen oxides and 20% less carbon dioxide than people who work in areas with lower concentrations of jobs (Lawrence Frank and Co., 2005) because they use more active transport.

Increase Safety

Complete Streets make streets safer for everyone. It is estimated that roadway features are likely a contributing factor in approximately one-third of fatal traffic crashes. Roadway features that impact safety include the number of lanes, lane widths, lighting, lane markings, rumble strips, shoulders, guard rails, other shielding devices, median barriers and intersection design. The severity of serious traffic crashes are reduced through various Complete Street elements.

Every year, over 36,000 Angelinos are injured or killed in motor vehicle collisions. That amounts to 100 people every day. Forty eight percent of traffic fatalities are pedestrian and bicyclists (LA Mobility Plan 2035). Road incidents analysis by Lovegrove and Litman (2008) using community based, macro level collision prediction models suggests that improving transportation options (better walking and cycling conditions, and improved ridesharing and public transit services) could reduce collision frequency by 14% (total) and 15% (severe). One study found that designing for pedestrian travel by installing raised medians and redesigning intersections and sidewalks reduced pedestrian risk by 28 percent. Speed reduction has a dramatic impact on pedestrian fatalities. Eighty percent of pedestrians struck by a car going 40 mph will die; at 30 mph the likelihood of death is 40 percent. At 20 mph, the fatality rate drops to just 5 percent (Leaf and Preusser, 1999).

A recent review of bicyclist safety studies found that the addition of well-designed bicycle-specific infrastructure tends to reduce injury and crash risk. On-road bicycle lanes reduced these rates by about 50% (Conner et al., 2009). One project, in Seattle, Washington, to create Complete Streets along a major arterial included the installation of new crossings, bus plazas, and redesign of the street. Total crashes dropped by 21 percent. On another street, the city redesigned to better accommodate both freight vehicles and bicycles. After the redesign, speeding dropped by 75 percent; bicycle traffic increased by 35 percent, the collision rate for bicyclists declined, and collisions involving pedestrians dropped 80 percent. Peak traffic volumes remained consistent with citywide levels, and no traffic diversion to parallel streets occurred (National Complete Streets Coalition).

Reduce Congestion

Complete Streets also increase transportation capacity and reduce congestion by reducing short-distance car trips thereby increasing the street's overall capacity to accommodate more travelers. Decades of investment in expanding automobile capacity have not succeeded in keeping congestion in check in the United States. Sixty to seventy percent of increased road capacity (additional lane-miles) on state highways in California counties was filled with new automobile traffic within just five years; at the municipal level, 90% was filled over the same period (Hansen and Huang, 1997). Providing travel choices – walking, bicycling, and public transportation – can reduce the demand for peak-hour travel in cars, the principal cause of daily congestion. About 44% of all vehicle trips in both congested areas and other areas made during the morning peak are not to work or related to a work trip. Instead, they are for shopping, going to school or the gym, or running errands. Many such trips are short and could be made by walking, bicycling, or taking transit – if the streets are complete.

Parents cite traffic as a primary reason for driving children to school, yet in doing so, they account for 7 to 11% of non-commuting vehicle traffic during morning rush hour (US Department of Transportation, 2007). Boulder Colorado invested in making its major arterials into Complete Streets that accommodate all transportation modes. While Boulder had grown over the prior 10 years, the level of congestion on its streets has stayed steady while bicycling, walking, and transit use had increased. Over 20 years, the city has seen a 7 percent drop in trips taken by single-occupancy vehicles; a bicycle commuting rate that is about 20 times the national average; transit use at twice the national average; and the number of trips made on foot at three times the national average (National Complete Streets Coalition).

Reduce Roadway Costs

With a less car-centered focus Complete Streets also reduce infrastructure costs by requiring far less pavement per user; this saves money at the onset of the project and reduces maintenance costs over the long-term. Money is also saved on construction and fees of parking spots.

Reduce Transportation Costs

Another way Complete Streets help households save money spent on transportation is reducing the costs of owning an automobile. In the US 15-20% of household income is typically spent on transportation and $9,122 is the average annual cost of vehicle ownership (Surface Transportation Project, 2003). Complete Streets reduces transportation costs by encouraging and allowing people to replace car trips with bicycling, walking, or taking public transit. Households that locate near public transportation drive an average of 16 fewer miles per day compared to a similar household without access to public transportation, which results in hundreds of dollars in savings each year. In fact, a two-person adult household that uses public transportation saves an average of $6,251 annually compared to a household with two cars and no public transportation accessibility (Litman, 2006).

Improving access to transit also reduces dependence on more costly alternatives, such as paratransit or private transportation services. A calculation by the Maryland Transit Administration found that providing paratransit for a daily commuter costs about $38,500 a year. Basic improvements to a transit stop costs $7,000, the equivalent of just two months' worth of that service for a single rider. More extensive improvements, such as adding a lighted shelter and bench and replacing the sidewalk leading to the stop, costs about $58,000 – just 33% more than providing a single year of paratransit service for one person (Schnider, 2005).

More Equitable

Improving active travel conditions through Complete Streets can also help achieve equity objectives by providing a fair share of resources to non-drivers and providing basic mobility for low-come, and physically and socially disadvantaged people. In most communities, 20-40% of the population cannot or should not drive due to disability, low incomes, or age. Walking and cycling facility improvements benefit existing users (people who currently walk and bicycle), plus new users (people who walk and bike more due to improvements) (Litman 2004c).

Studies show that core riders of public transit have relatively low incomes. A comprehensive review of literature finds that low-income people, along with people of color and renters, ride public transit at much greater rates than others (Pollack). Households earning less than $25,000 annually are represented disproportionately among public transit riders (American Public Transportation Association, 2007), and account for over 75% of workers who commute by transit in Los Angeles (LA Housing Dept). Complete Streets can allow for a fairer share of street resources for this population. Furthermore it can increase assess to those who use it or would use it most. However for this to happen the health and economic stability of current residents around new transit stops, etc. must be protected.

In addition to creating more travel opportunities for low-income people, Complete Streets provide children with opportunities to walk, bike and play in a safe environment. More children are likely to walk or bike to school when sidewalks or footpaths are present, when there are safe street crossings, and when school zones enforce a reduced vehicle speed. Streets that provide dedicated space for bicycling and walking help kids get physical activity and gain independence. As for the elderly, more than 50% of older Americans who do not drive stay home on a given day because they lack transportation options. Older Americans make just 6% of their trips on foot or bike – far less than in some European countries, where adults over the age of 65 use these active modes for about half of all trips. Non-driving seniors make 65% fewer trips to visit family, friends or go to church; many report they do not like to ask for rides (Pucher, and Dijkstra, 2005).

Reduce Chauffer Burdens

Another benefit of Complete Streets is that it reduces chauffeuring burdens. Chauffeuring is particularly inefficient because it often requires empty return trips, so transporting a passenger 5 miles generates 10 vehicle-miles. Improving alternative modes can reduce chauffeuring burdens, saving driver travel time, vehicle operating costs, external costs, and increasing non-drivers' independence.

Increase Livability

Complete Streets create more "liveable" communities. Residents of walkable/bikeable communities are more likely to be socially engaged and trusting, and they report being in good health and happy more often. These areas tend to be more secure because many strategies for improving walking and cycling conditions can increase security. In San Diego, where a number of Complete Streets policies are in place, the La Jolla neighborhood saw its namesake boulevard become vibrant and alive, with pedestrians, bicyclists, and shoppers. Despite the economic decline during that time, the street outperformed on every factor, from numbers of bicyclists and pedestrians to general wellbeing (Mason, 2007). Contrary to popular assumptions, per capita crime rates tend to decline in more compact, mixed, walkable communities, probably due to a combination of improved surveillance, better policing and emergency response, and improved economic opportunity for at-risk residents (Litman, 2013).

Improve Health and Fitness

Complete Streets also improve human health. Complete Streets provide opportunities for increased physical activity by incorporating features that promote regular walking, cycling and transit use. A report prepared by the National Conference of State Legislators found that the most effective policy avenue for encouraging bicycling and walking is incorporating sidewalks and bike lanes into community design – essentially, creating Complete Streets. The continuous network of safe sidewalks and bikeways provided by a Complete Streets policy is important for encouraging active travel. Residents of multi-modal communities exercise more and are less likely to be overweight than in automobile-oriented communities (Ewing, Schieber and Zegeer 2003; Frank 2004). A comprehensive study of walkability has found that people in walkable neighborhoods did about 35-45 more minutes of moderate intensity physical activity per week and were substantially less likely to be overweight or obese than similar people living in low-walkable neighborhoods (Sallis et al., 2009).

Improve Economy

Complete Streets improve the economy by shifting spending on fuel to spending on regional goods, increasing tourism and retail sales, increasing property values and tax revenues, and increasing employment. Local businesses see many benefits in improving travel by foot or bicycle. When a bike lane was added along Valencia Street in San Francisco's Mission district, nearby businesses saw sales increase by 60 percent, which merchants attributed to increased pedestrian and bicycle activity (National Complete Streets Coalition, 2012). Lancaster, California added pedestrian safety features as part of a downtown revitalization effort, including a pedestrian-only plaza, wider sidewalks, landscaping and traffic calming. The project spurred $125 million in private investment, a 26% increase in sales tax revenue, and 800 new jobs, after a public investment of $10.6 million (National Complete Streets Coalition, 2012).

In some areas, such as the northern Outer Banks of North Carolina, bicycle facilities partly drive tourism. A 2003 economic impact analysis of a bicycle trail system in this area focused on economic benefits such as tourist spending on food, lodging, and entertainment. Data were gathered through user surveys and bicycle traffic counts to estimate the amount of money that tourists spent during a visit, the total number of tourists, and the proportion of tourists for whom bicycling was an important reason for the visit. The researchers found that, annually, approximately 68,000 tourists visited the area at least partly to cycle. This led to an estimate that $60 million in tourism spending and multiplier effects came to the area in relation to the bikeways, and supported approximately 1,400 jobs (Lawrie et al., 2006).

Complete Streets also tend to increase property values. Tu (2000) found 11% higher property values in such neighborhoods compared with otherwise similar homes in conventional, automobile-dependent communities. In a survey of 15 real estate markets from Jacksonville, Florida to Stockton, California a one-point increase in the walkability of a neighborhood as measured by WalkScore.com increased home values by $700 to $3,000 (CEOs for Cities, 2009). This increase is amplified when walkable neighborhoods are near each other, demonstrating the value of networks of Complete Streets connected throughout a community (The Brookings Institution, 2012).

Of course, the positive correlation between WalkScore and property values also reflect other factors such as land use density, transit accessibility, and employment access. It's important to note that with increasing property values we often see gentrification, or the displacement of low-income residents. Increasing housing costs can price out poor and working-class people and people of color to make way for wealthier residents. Displacing a group of people in favor of newcomers dilutes the political power of working-class communities and communities of color by breaking up families, communities, and voting blocs. To ensure that this doesn't happen development in these communities needs to be based on the needs of existing residents. Land use planning and development processes should not only involve input from affected community residents, but also happen in partnership with communities on an ongoing basis.

Costs

Table 25 outlines the costs associated with Complete Streets. Those included in the economic analysis are indicated with a check mark.

Table 25: Complete Street Costs

Cost	Description	Included in Economic Analysis
Construction Costs	The planning and construction cost associated with implementing Complete Street elements.	✓
Maintenance Costs	The cost of maintaining the Complete Street elements.	✓
Rehabilitation Costs	Every 15-20 years streets have to be rehabilitated, which includes grinding off old roadway surfaces, resurfacing the pavement with new asphalt, and repairing/replacing curbs where necessary.	✓
Equipment Costs	The cost of bike ownership and appropriate bike and walking shoes.	✓
Vehicle Traffic Impacts	Incremental delays to motor vehicle traffic or parking.	✓ Was taken into consideration in the overall benefits calculated for "reduced congestion".
Gentrification	The social cost of possibly displacing low-income families and small businesses. Complete Streets increases property values, which can displace low-income families and small businesses if the health and economic stability of current residents is not considered.	

Construction Cost

The construction and maintenance costs associated with different Complete Street elements vary by location, topography, and geography as well as by year, and even by season. In some jurisdictions, materials costs vary by as much as 15–20 percent every year. Regardless of the element though, if included early in the life of a project costs can be greatly minimized. However even as add-on features there are many Complete Street elements whose cost is dwarfed by the economic benefits. On a recent reconstruction project, in Redding California, the city invested in low-cost treatments to improve pedestrian safety and comfort: six curb extensions and two refuge islands. The total cost of these elements, $40,000, represented just 13 percent of the overall project budget (National Complete Streets Coalition).

Equipment Cost

In addition to the cost of Complete Street elements on a community level is the individual additional cost of bike ownership, appropriate walking shoes or public transportation costs if one switches to that mode of travel. Public transportation costs are not included in this analysis because public transit as a Complete Street element is out of the scope of this report.

Vehicle Traffic Impacts

A negative impact for automobile users is the incremental delay from traffic and parking. For example, traffic calming and speed reductions, converting traffic lanes to bike lanes or wider sidewalks, and more pedestrians and bicyclists crossing roadways, can reduce vehicle travel speeds. Similarly, converting parking lanes to bike lanes or wider sidewalks can reduce the ease of finding a parking space. Travel time is one of the largest transportation costs. In this scenario automobile drivers are slightly negatively impacted. Often it's thought that walking and cycling are inefficient and costly because they tend to be slower than motorized modes, however this is not necessarily true. Measured door-to-door, active travel is often time competitive for short trips: for walking up to a half-mile, which represents about 14% of total personal trips, and for cycling up to three miles, which represents about half of total trips (Dill and Gliebe 2008; Litman 2010). Transport planning that improves pedestrian and cycling connectivity, and land use planning that creates more compact, mixed development increases the portion of trips for which active modes are time-competitive.

Gentrification

Another important social cost to consider is the gentrification that could occur when property values increase from Complete Streets. To ensure that this doesn't happen development in these communities needs to be based on the needs of existing residents. Land use planning and development processes should not only involve input from affected community residents, but also happen in partnership with communities on an ongoing basis. If the health and economic stability of current residents is considered, Complete Streets have the ability to make all the aforementioned benefits more pronounced in low-income areas. Those that are most likely to use the infrastructure would be encouraged to do so.

Complete Street Design Used in the Economic Analysis

In the Complete Street scenario, it is assumed that bike lanes, bike parking, sidewalks, mid-block pedestrian crossings, and center medians are implemented in order to promote active modes of transportation including biking and walking along the streets. Table 26 details the assumptions used for assessing the Complete Street treatment.

TABLE 26: COMPLETE STREET TREATMENT DETAILS

Complete Street Treatment	
Treatment	**Treatment Design**
Percentage of Roads Considered "Arterial" Roads	**25%**
Bike Lanes	95% of road (taking out intersections)
Bike Parking	10 per mile (about every 500ft)
Sidewalks (in the case of BAU1 when they are not constructed)	95% on both sides of the road (taking out intersections)
Number of Intersections per Mile with Curb Extensions	4 intersections per mile
Number of Curb Extensions per Intersection	4 curb extensions per intersection
Mid-Bloc Crossings per Intersection	4 mid-block crossings per mile
Feet of Center Median per Mile (used as pedestrian refuge medians at intersections)	1,000 lf per mile
Percentage of Roads Considered "Residential" (lower speed, more locally important streets)	**75%**
Bike Lanes	95% of road (taking out intersections)
Bike Parking	10 per mile (about every 500ft)
Sidewalks (in the case of BAU1 when they are not constructed)	95% on both sides of the road (taking out intersections)
Number of Intersections per Mile with Curb Extensions	6 intersections per mile
Number of Curb Extensions per Intersection	4 curb extensions per intersection

It is important to note: In the BAU1 scenario, the benefits for the sidewalks are included in the Complete Street element costs and benefits, given that they are not a part of the BAU1-Only case. However, in the BAU2 Scenario, the costs of the sidewalks and their direct benefits considered part of the BAU2 case and are not included in the Complete Street element costs and benefits. This is done for continuity in the analysis across the five scenarios.

Results of the Economic Analysis

BAU-only compared to Complete Streets

Table 27 summarizes the economic results for Complete Street design under the two BAU scenarios:

TABLE 27: SUMMARY OF COMPLETE STREET RESULTS

Action Code	Total Cost	Total Benefit	Net Present Value	Break Even (Years)	Benefit-Cost Ratio
BAU1-only (repaving)	$738,677,265	$7,088,603,848	$6,349,926,582	3.0	9.6
BAU2-only (reconstruction)	$1,086,995,688	$7,144,352,396	$6,057,356,708	4.3	6.6
Complete Street - BAU1 (Complete-BAU1)	$2,118,314,678	$9,395,271,662	$7,276,956,985	5.7	4.4
Complete Street - BAU2 (Complete-BAU2)	$2,034,655,649	$9,303,142,393	$7,268,486,744	6.1	4.6

In the Complete-BAU1 case, the total cost is 187% ($1.38 Billion) higher than simply repaving the street (BAU1-only). The total benefits under the Complete-BAU1 case generate approximately $2.31 billion in additional benefits, which is a 33% increase compared to BAU1-only. The net present value is 15% ($930 Million) greater in the Complete-BAU1 scenario compared to BAU1-only. Finally, it would take almost 6 years to break even on the Complete-BAU1.

In the BAU2 scenario, the Complete Street (Complete-BAU2) is only 87% ($948 Million) more costly than reconstructing the streets and sidewalks (BAU2-only). The reduction in total cost in the Complete-BAU2 case compared to the Complete-BAU1 is due to the fact that the sidewalk construction costs are already incorporated into the BAU2 scenario. The bulk of the construction costs are already incorporated in the BAU2-only design; however, the Complete Street design calls for more strategic design of the streets and sidewalks. Total benefits from Complete-BAU2 are very similar to the Complete-BAU1 approach, with $2.16 Billion in additional benefits above BAU2-only (30% increase). The net present value in the Complete-BAU2 scenario is 20% ($1.21 Billion) greater than BAU2-only.

Given that, under Complete Street design, both scenarios now incorporate sidewalk reconstruction, the difference in total costs between BAU1 and BAU2 has reversed. BAU2-only costs were $348 million (47%) higher than BAU1-only. With the addition of the Complete Street elements, Complete-BAU2 is slightly less costly than Complete-BAU1 (4%). This is likely attributed to the fact the efficiencies attributed to the complete demolition of the street and sidewalk beds in BAU2, and their reconstruction to accommodate the complete street elements, rather than a piecemeal approach taken to adding improved sidewalks, median, and curb extensions in Complete-BAU1. The benefit-cost ratio for both scenarios shows that for every dollar invested in the Complete Street scenario, about $4.5 in benefits is received.

Figures 24 and 25 show the costs and benefit data for Complete Street design under the two BAU scenarios:

FIGURE 24: BREAKDOWN OF THE COSTS AND BENEFITS FOR COMPLETE-BAU1

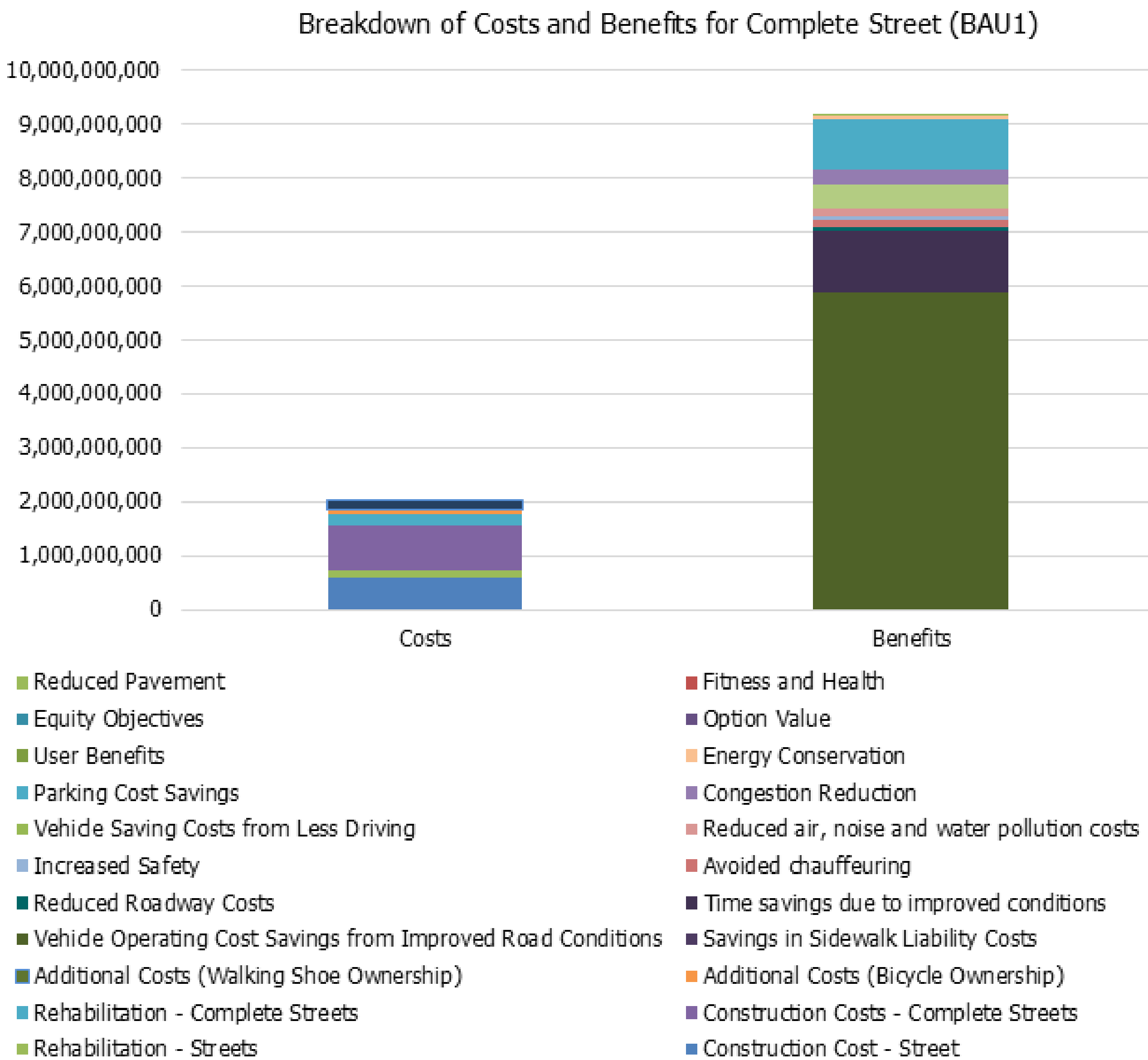
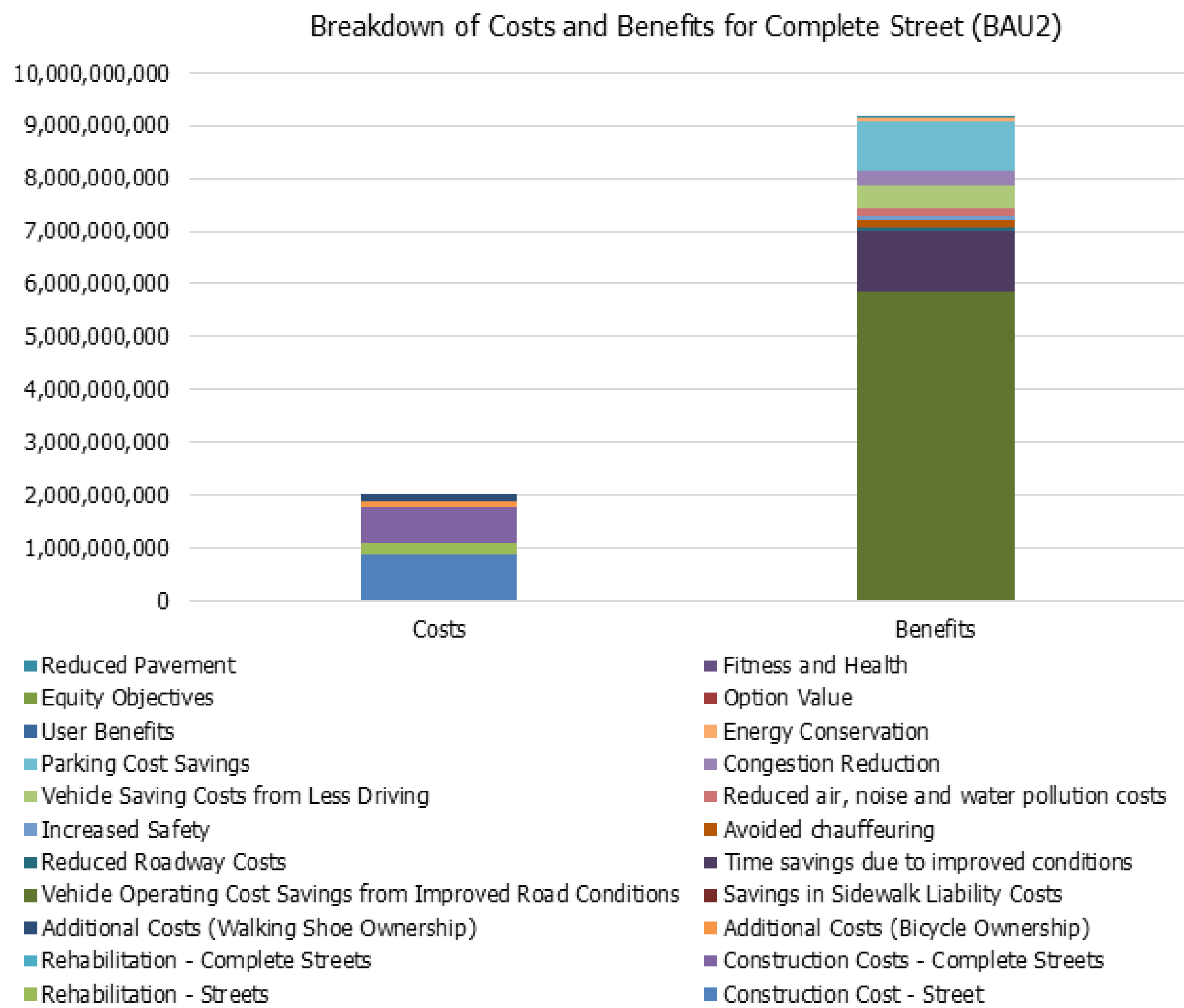


FIGURE 25: BREAKDOWN OF THE COSTS AND BENEFITS FOR COMPLETE-BAU2



As can be seen in the two figures above, the benefits of improving the street conditions significantly outweigh the costs of construction. This is true regardless of if they require repaving (BAU1-only) or a more extensive and costly reconstruction (BAU2-only). The largest contributor to the benefits is the reduction in vehicle operating costs, accounting for 64% of the benefits calculated in this study in both the Complete-BAU1 and Complete-BAU2 scenarios. The Complete Street Element benefits account for 23% of the total calculated benefits.

Complete Street Element Only (EO) Analysis

The economic data presented in this section shows the cost and benefit data for the Complete Street elements themselves. This analysis shows the added costs and benefits associated with implementing the Green Street Elements. In other words, these are the costs and benefits above and beyond the original street construction costs.

Table 28 provides a summary of the economic results for the Complete Street design elements without the construction of the BAU elements and their associated costs and benefits:

TABLE 28: SUMMARY OF COMPLETE STREET – ELEMENT ONLY RESULTS

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (Years)	Benefit-Cost Ratio
Complete Street - BAU1, Element Only (Complete-BAU1-EO)	$1,385,086,647	$2,306,667,815	$921,581,168	12.4	1.7
Complete Street – BAU2, Element Only (Complete-BAU2-EO)	$955,678,746	$2,158,789,997	$1,203,111,251	10.8	2.3

The costs of constructing the Complete Street elements is significantly lower (31%) in the Complete-BAU2-EO case compared to Complete-BAU1-EO due to the fact that the costs associated with demolition of the sidewalks and hauling of the old sidewalk concrete are absorbed in the BAU2 scenario. In the Complete-BAU2 street design, the sidewalks were already being demolished and replaced, so these costs are not considered additional costs in the Complete-BAU2 case. The sidewalks will are assumed to be designed strategically in the Complete Street to include more pedestrian friendly attributes, including curb extensions. This saving demonstrates the efficiencies of incorporating these elements in the design of projects rather than trying to implement these elements after the fact. The net present value of the Complete Street elements is 31% higher in Complete-BAU2 compared to Complete-BAU1. It also causes the payback period to decrease and the benefit-cost ratio to increase in Complete-BAU2.

Figures 26 and 27 show the costs and benefit data for the Complete Street Element Only – taking out the construction of the BAU elements and their associated costs and benefits:

FIGURE 26: BREAKDOWN OF THE COSTS AND BENEFITS FOR COMPLETE-BAU1, ELEMENT ONLY

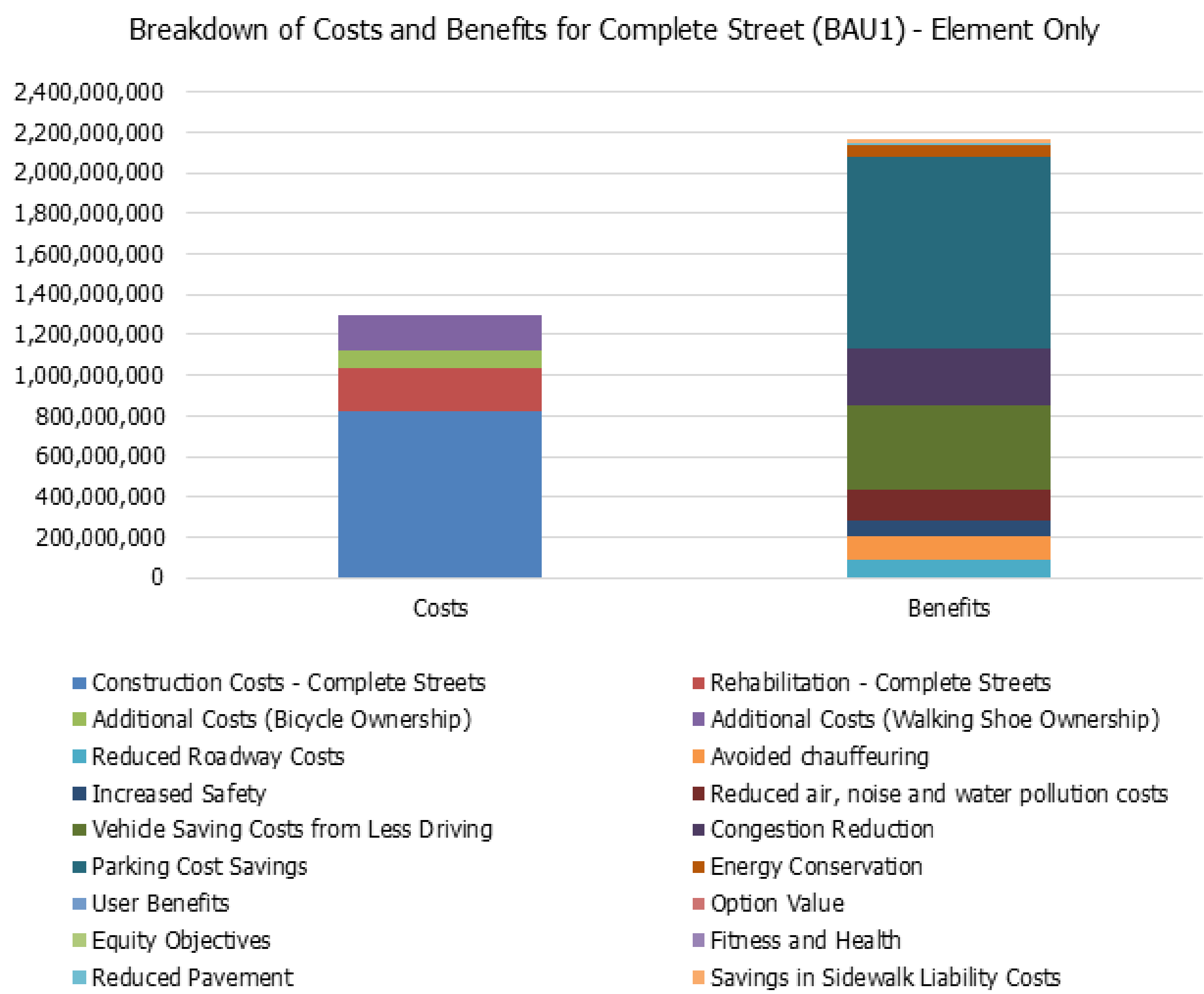
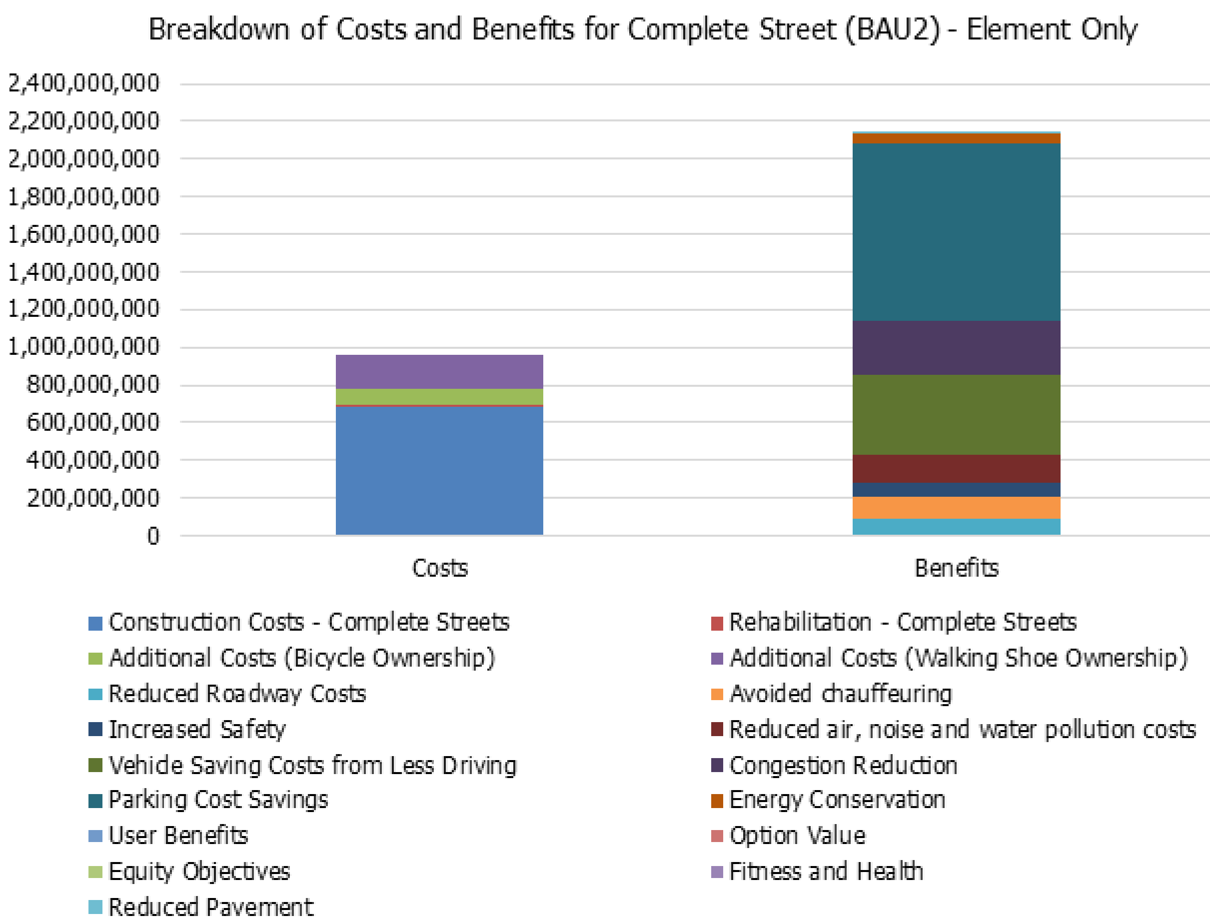


FIGURE 27: BREAKDOWN OF THE COSTS AND BENEFITS FOR COMPLETE-BAU2, ELEMENT ONLY



As can be seen in the figures above, the largest benefit calculated was from parking cost savings, which was 44% of the total benefits in both the BAU1-EO and BAU2-EO cases. Notably, the benefits from parking cost savings are 99% the total costs associated with implementing the Complete Street elements in Complete-BAU2-EO and 73% of the total costs associated with implementing the Complete Street elements in Complete-BAU1-EO.

For a complete analysis of the economics results and comparisons between treatment options, please see Section 7 of this report.

Living Streets

Benefits of a Well-Designed Street

Living Streets incorporate street and sidewalk design elements discussed in prior sections within an integrated framework. The inter-connectedness of elements throughout the network can enhance or increase benefits achieved through Green, Cool, and Complete Streets. They can help improve the aesthetics, water quality, air quality, energy consumption, walk and bikeability, health, and wellbeing of the communities where they are constructed. Living Streets have the ability to improve the economic, social, and environmental attributes of the community, impacting all residents living and working in the area.

Some of the benefits derived from implementing Green, Cool, or Complete Street design elements may be enhanced or reinforced when combined into a Living Street approach - through the incorporation of multiple elements together, their benefits are augmented. For example, the combinatory effects of Green and Complete Street elements make the environments both aesthetically pleasing and accessible for walkers and bicyclists. Implemented together, these two elements will likely increase the substitution rates of VMT by car to active modes of transportation, thereby increasing the benefits above those found from either element when implemented independently.

Additionally, Living Street benefits associated with property values, local economic development, and a well-being are likely to be higher than the sum of their (Green, Cool, and Complete Streets) individual benefits. The inclusion of tree cover with cool pavement may also augment the Urban Heat Island Mitigation benefits, thus improving the quality of life of the community, reducing greenhouse gas emissions, reducing smog exceedance, reducing the number of heat related illnesses, etc.

Finally, there are also benefits that come with strategically implementing the Green, Cool, and Complete Street elements into a well-designed Living Street. As an example, if curb extensions are chosen to improve pedestrian safety and reduce traffic speeds – as part of the Complete Street – and these are strategically designed to incorporate curb-cuts that allow storm water runoff to run into tree wells, planter boxes, or bioswales, this design could improve the capture of stormwater through theses Green Street elements. It provides a strategic use of both spaces, improving the functionality of the street environment. The next subsections detail the economic analysis of Living Streets.

Living Street Design Used in the Economic Analysis

It is important to note that some of these results may be reinforcing, meaning that by incorporating multiple elements together, their benefits are augmented. For example, the joint implementation of Green and Complete Street elements can switch automobile riders to active transport by making the area beautiful and inviting while also making it accessible for walkers and bicyclists. These two elements implemented together will likely increase the substitution rates of VMT by car to active modes of transportation, increasing the benefits above those found from either element when implemented independently. In the Living Street Case, the assumption for the amount of VMT transferred from vehicle travel to active travel has been increased from 5% to 7.5% to take this into account.

In addition, this analysis assumes that the amount of green space increases from 4% to 7.5% of the total street and sidewalk area –4% was assumed in the Green Street case. The additional 3.5% of green space is assumed to be implemented in the Complete Street elements within the street area that would otherwise have been hardscape.
Table 29 details the assumptions used in this economic analysis for the Living Streets treatment design:

TABLE 29: LIVING STREET TREATMENT

Living Street Treatment	
Treatment	**Treatment Design**
Green Street Elements	7.5% of Street and Sidewalk Space (4% in Sidewalks and 3.5% in Complete Street Elements) 85% of the green space would be covered by vegetative cover, 3% by gravel, 7" by rip-rap inlets, and 5% by trees (162,316 trees)
Cool Street Elements	Slurry Seal, 100% of all street surface
Complete Street Elements	Assumed: 25% of roads considered "Arterial" 75% of roads considered "Residential" (lower speed, more locally important streets) Sidewalk Construction (in the case of BAU1 when they are not constructed) (See Table 26 for the details on the "Arterial and Residential" Street Designs)

Results of the Economic Analysis

BAU-only compared to Living Streets

Table 30 and 31 provide a summary of the economic indicators for the two street designs under the two BAU cases including Living Street elements:

Table 30: Summary of Living Street Results

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (Years)	Benefit-Cost Ratio
BAU1-only (repaving)	$738,677,265	$7,088,603,848	$6,349,926,582	3.0	9.6
BAU2-only (reconstruction)	$1,086,995,688	$7,144,352,396	$6,057,356,708	4.3	6.6
Living Street -BAU1 (Living-BAU1)	$3,301,975,358	$12,434,311,761	$9,132,336,403	4.6	3.8
Living Street –BAU2 (Living-BAU2)	$3,741,949,842	$12,419,670,386	$8,677,720,544	6.2	3.3

The Living Street has lower total costs (13%) under Living-BAU1 than Living-BAU2. In Living-BAU1, the total cost of construction is 347% ($2.56 Billion) higher than simply repaving the street (BAU1-only). In Living-BAU2, the Living Street is 244% ($2.65 Billion) more costly than reconstructing the streets and sidewalks (BAU2-only). This reduction in overall cost is due to the fact that in the BAU2 scenario, the sidewalks area already being reconstructed; therefore, the bulk of their construction costs are already incorporated in the BAU2 design.

In both Living-BAU1 and Living-BAU2 cases, the total benefits are extremely high, compared to other street cases considered in the report. Specifically, Living-BAU1 and Living-BAU2 both have more than $5.2 Billion in additional total benefits, compared to their BAU-only counterparts. This amounts to roughly a 75% increase in benefits.

The net present value of the Living-BAU1 is $2.78 billion (44%) higher than BAU1-only. The Living-BAU2 scenario was $2.62 billion (43%) higher than BAU2-only. This increase is noteworthy given that the total costs for the Living Street cases are significantly above the BAU-only cases. Finally, the benefit-cost ratio shows that every $1 invested in Living-BAU1 brings about a $3.8 in benefits returned; in Living-BAU2, every $1 invested equates to $3.3 in benefits.

Figures 28 and 29 show the costs and benefit data for Living Street design under the two BAU scenarios:

FIGURE 28: BREAKDOWN OF THE COSTS AND BENEFITS FOR LIVING-BAU1

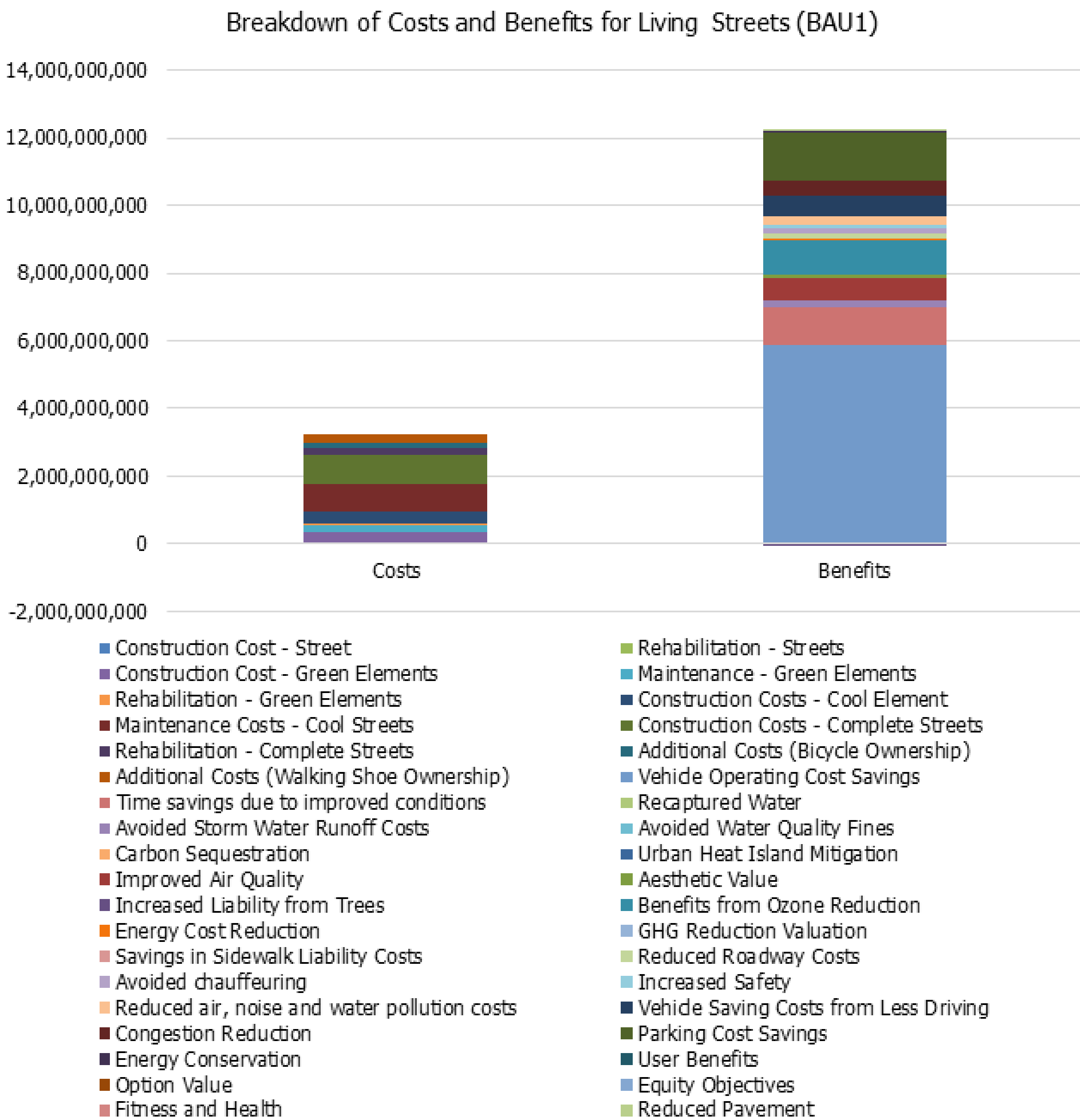
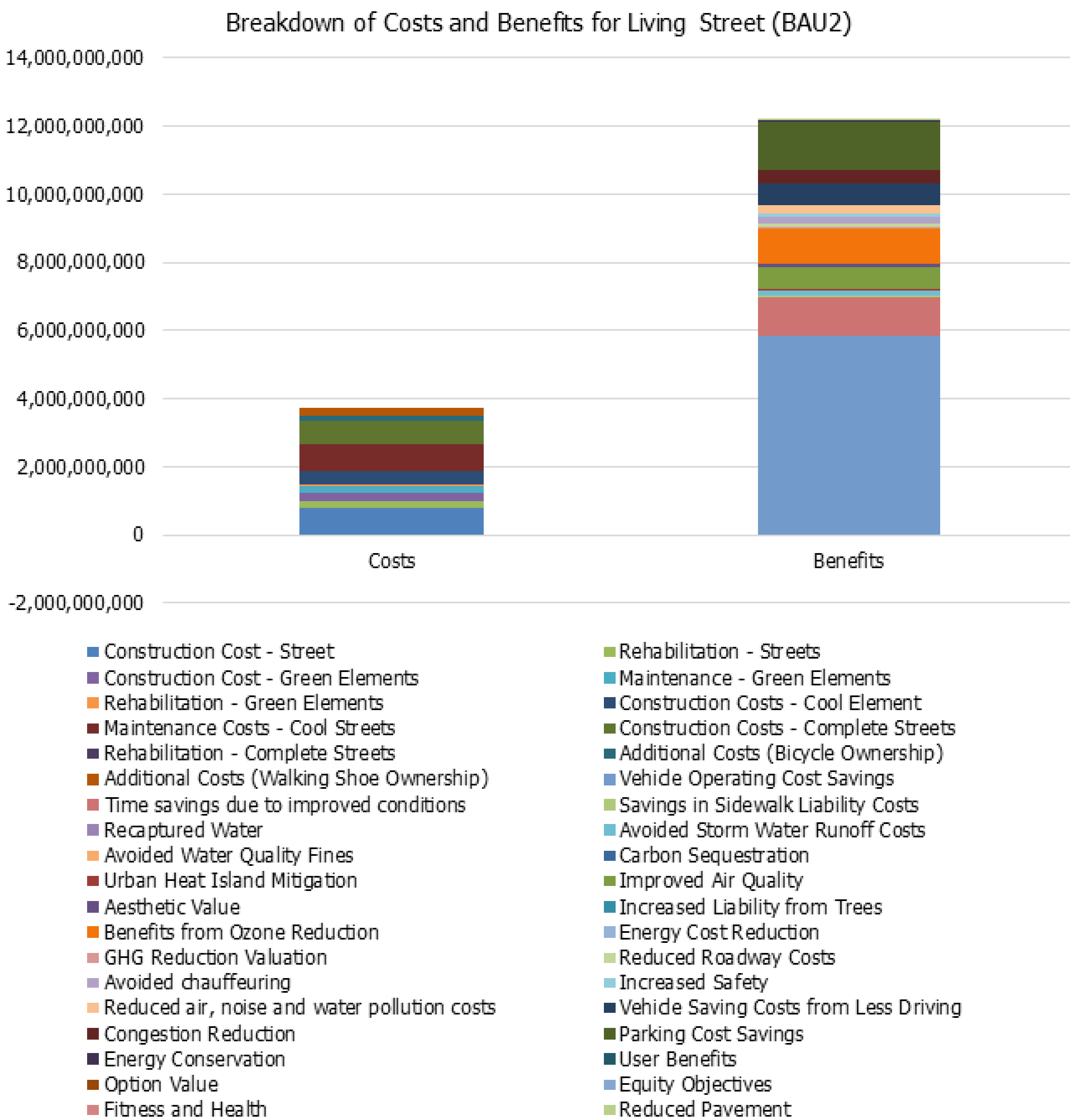


FIGURE 29: BREAKDOWN OF THE COSTS AND BENEFITS FOR LIVING-BAU2



As can be seen in these two figures, the benefits of improving the street conditions significantly outweigh the costs of construction in either Living-BAU case. The largest contributor to the benefits is the reduction in vehicle operating costs, accounting for 48% of the benefits calculated in this study in both the BAU1 and BAU2 scenarios. The benefits from the Living Street elements are about 43% of the total benefits calculated.

Living Street Element Only Analysis

The economic data presented in this section shows the cost and benefit data for the Living Street elements themselves. This analysis shows the added costs and benefits associated with implementing the Green Street Elements. In other words, these are the costs and benefits above and beyond the original street construction costs.

Table 31 summarizes the economic results for scenarios where only Living Street elements are considered - taking out the construction of the BAU elements and their associated costs and benefits:

TABLE 31: SUMMARY OF LIVING STREET – ELEMENT ONLY RESULTS

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (Years)	Benefit-Cost Ratio
Living Street - BAU1, Element Only (Living-BAU1-EO)	$3,229,563,592	$5,430,568,144	$2,201,004,552	10.9	1.7
Living Street - BAU2, Element Only (Living-BAU2-EO)	$2,755,956,855	$5,287,258,731	$2,531,301,877	9.8	1.9

The costs of incorporating Living Street Element Only is 15% higher in the Living-BAU1 case compared to the Living-BAU1. Similar to Complete Streets, this is due to the fact that the costs associated with demolition of the sidewalks and hauling of the old sidewalk concrete are absorbed in the BAU2 scenario. In the BAU2 street design, the sidewalks were already being demolished and replaced, so these costs are not considered added costs for including Living Street elements in the street. However, the sidewalks will be designed differently in the Living Street to include more pedestrian friendly attributes, including curb extensions. There are efficiencies of incorporating these elements in the already planned sidewalk reconstruction, rather than trying to implement these elements later on.

In addition, the ability to increase the green space - by placing additional Green elements in center medians, mid-bloc crossings, and curb extensions - increased the benefits from the Green Street elements for the Living Street case by an additional $452 Million (90%). Benefits from active transport also increased from $2.15 Billion in the Complete Street to $3.21 Billion (49% increase) in the Living Street since the assumed VMT travelled that switch from vehicle to active transport was increased from 5% to 7.5%.

Figures 30 and 31 show the costs and benefit data for the Complete Street Element Only – taking out the construction of the BAU elements and their associated costs and benefits:

FIGURE 30: BREAKDOWN OF THE COSTS AND BENEFITS FOR LIVING-BAU1 ELEMENT ONLY

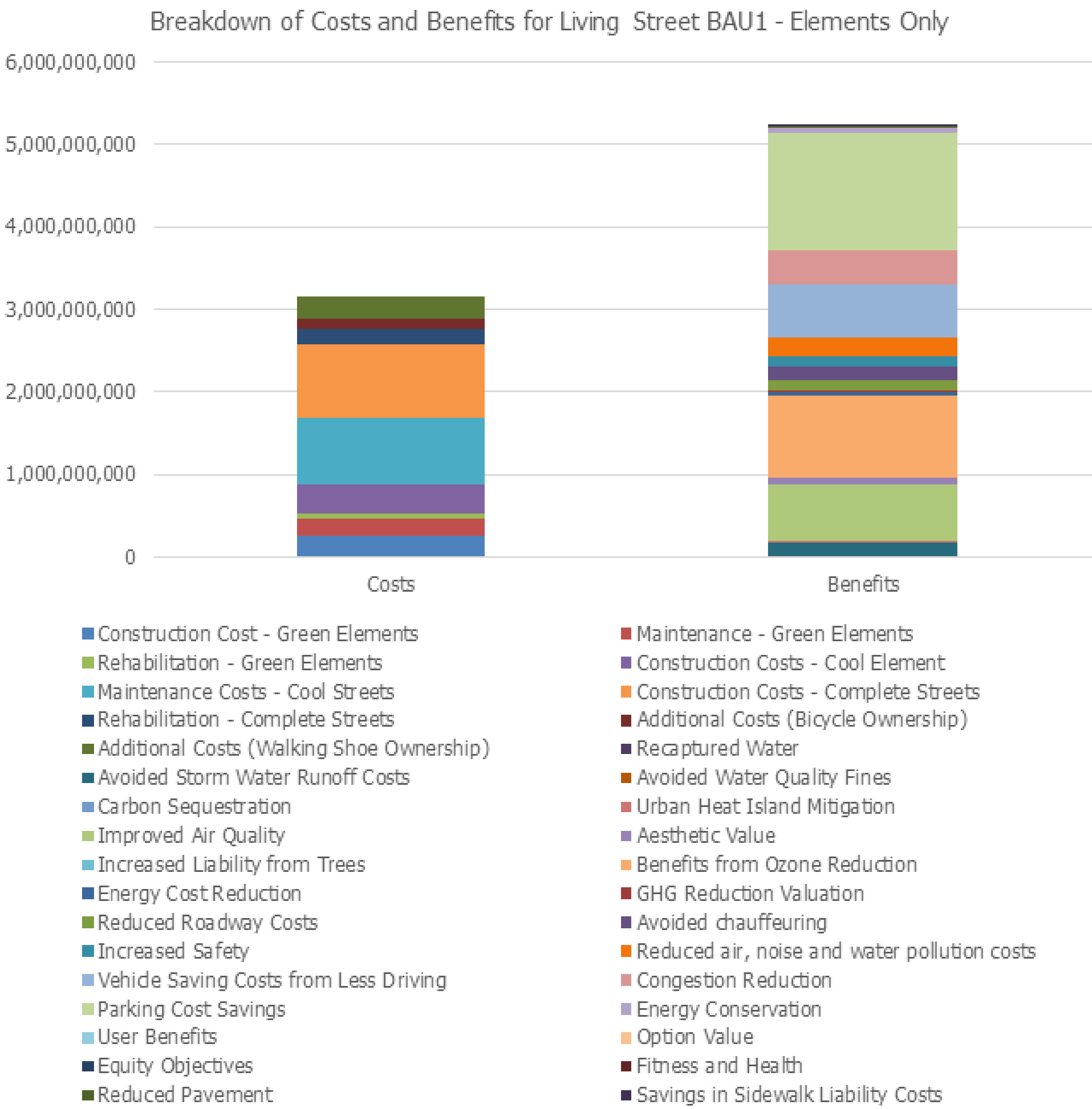
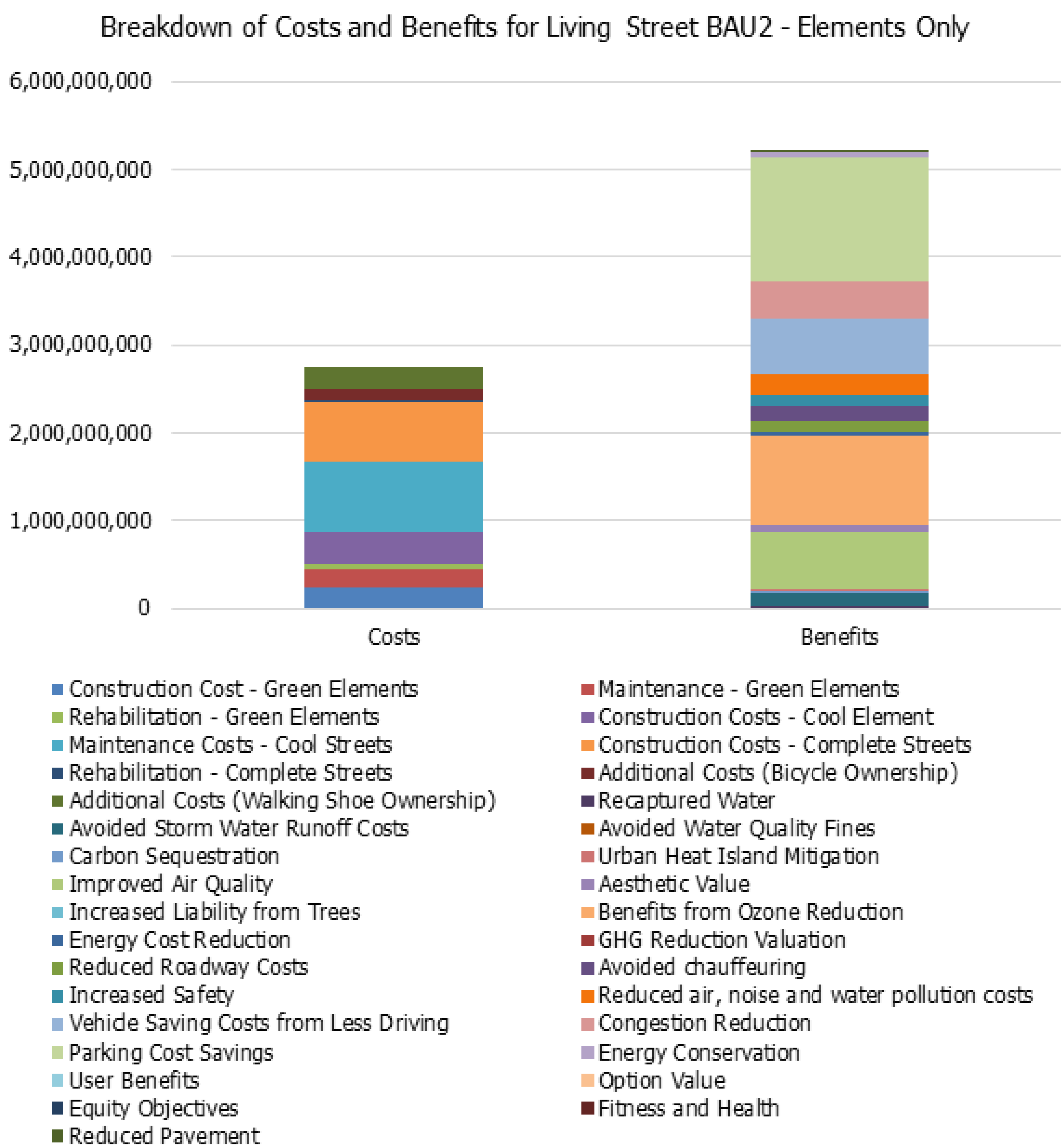


FIGURE 31: BREAKDOWN OF THE COSTS AND BENEFITS FOR LIVING-BAU2, ELEMENT ONLY



As can be seen in the figures above, the largest benefit calculated was from parking cost savings, which was 27% of the total benefits in both the BAU1 and BAU2 cases. The benefits from ozone reduction and air quality improvement were also high, accounting for 19% and 13% of the total benefits respectively. The benefit-cost ratio shows that, in Complete-BAU1, the benefits accrued are about $1.7 for every $1 invested; in Complete-BAU2, every $1 invested equates to $1.9 in benefits. For a complete analysis of the economics results and comparisons between treatment options, please see Section 7 of this report.

Economic Analysis: Results

Business as Usual 1 (BAU1)

BAU1 Analysis Compared to Different Street Paradigms

T Table 32 shows a comparison of the various street design elements under the BAU 1 scenario—simply repaving the street, but the subgrade and sidewalks are left alone:

TABLE 32: COMPARISON OF THE COSTS AND BENEFITS ASSOCIATED WITH THE BAU1 CASE

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (Years)	Benefit-Cost Ratio
BAU1-only	$738,677,265	$7,088,603,848	$6,349,926,582	3.0	9.6
Green-BAU1	$1,021,685,627	$7,602,417,470	$6,580,731,843	3.5	7.4
Cool-BAU1	$1,905,102,187	$8,190,384,713	$6,285,282,526	4.2	4.3
Complete-BAU1	$2,118,314,678	$9,395,271,662	$7,276,956,985	5.7	4.4
Living-BAU1	$3,301,975,358	$12,434,311,761	$9,132,336,403	4.6	3.8

When looking at the overall costs and benefits of the entire project - repaving the streets and constructing the respective design elements, the BAU1-only case (street repaving only) has the lowest payback period - meaning that its initial investment is recovered quicker that in the other case. This is principally due to the lower initial total cost invested in the project. Despite the quicker pay-back period for BAU1-only, the other four scenarios themselves do not require many more years to break even, with the longest pay-back period (Complete-BAU1) taking less than six years.

The BAU1-only case also has the highest benefit-cost ratio, meaning that for every dollar invested, it has a higher return in benefits. In this case, BAU1-only has the highest benefit-cost ratio, yet the Living Street has the highest net present value. When there are conflicting rankings, the net present value is the better criterion to consider as it measures the economic contribution of each project in absolute terms. The benefit-cost ratio is limited in that it conceals absolute magnitudes; a project may have a high benefit-cost ratio but is small in terms of the absolute dollar amounts, as in the case of BAU1-only. Therefore, this project could be less desirable than another that has a lower benefit-cost ratio, but is larger in scale and impact.

Of the three elements constructed independently, Complete-BAU1 has the highest total cost, total benefit, and net present value. Cool-BAU1 has the lowest net present value, although the total benefits are higher than the BAU-only and Green-BAU1.

Living-BAU1 has the highest total benefits and total costs. It also has the highest net present value, making it the best project to invest in from an economic perspective. These results are represented in figures 32, 33, and 34:

FIGURE 32: BAU1 COST-BENEFIT SUMMARY

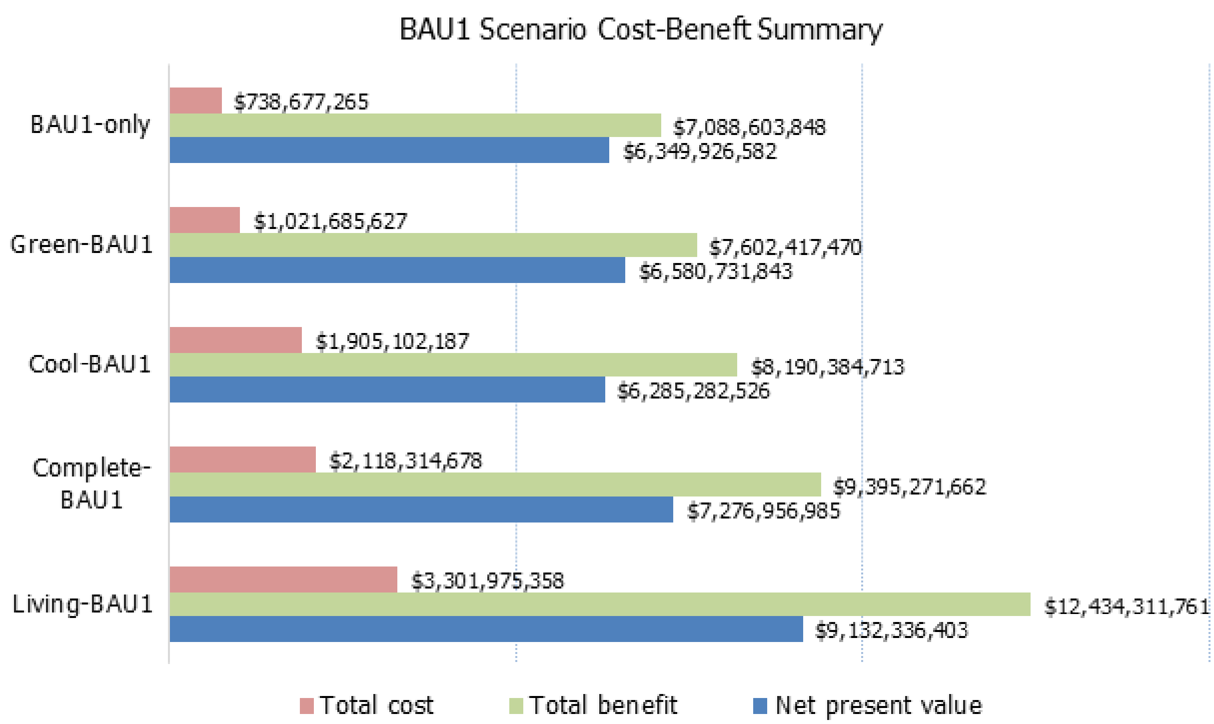


FIGURE 33: BAU1 COST-BENEFIT PER MILE CONSTRUCTED

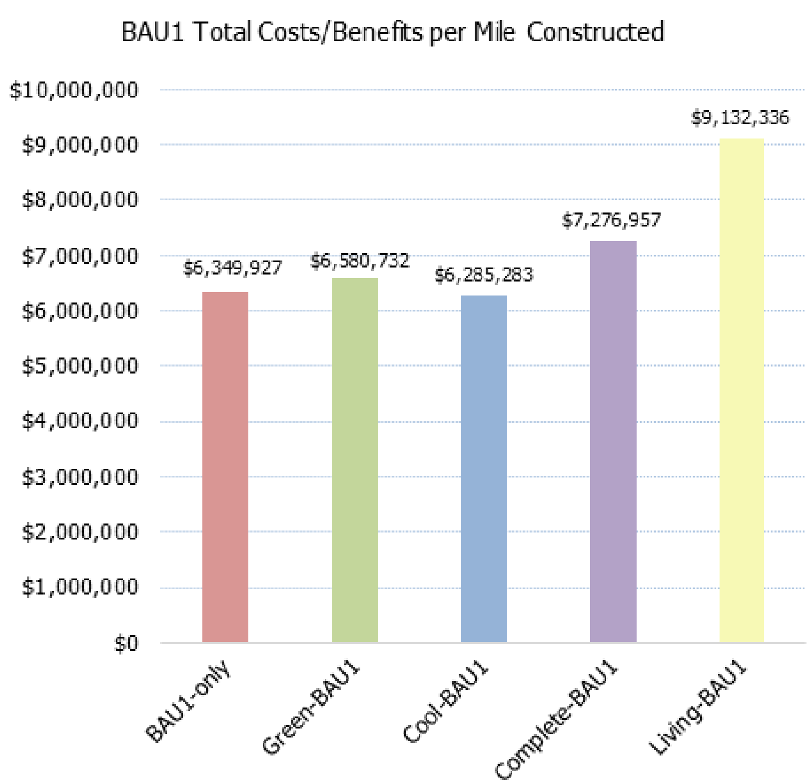
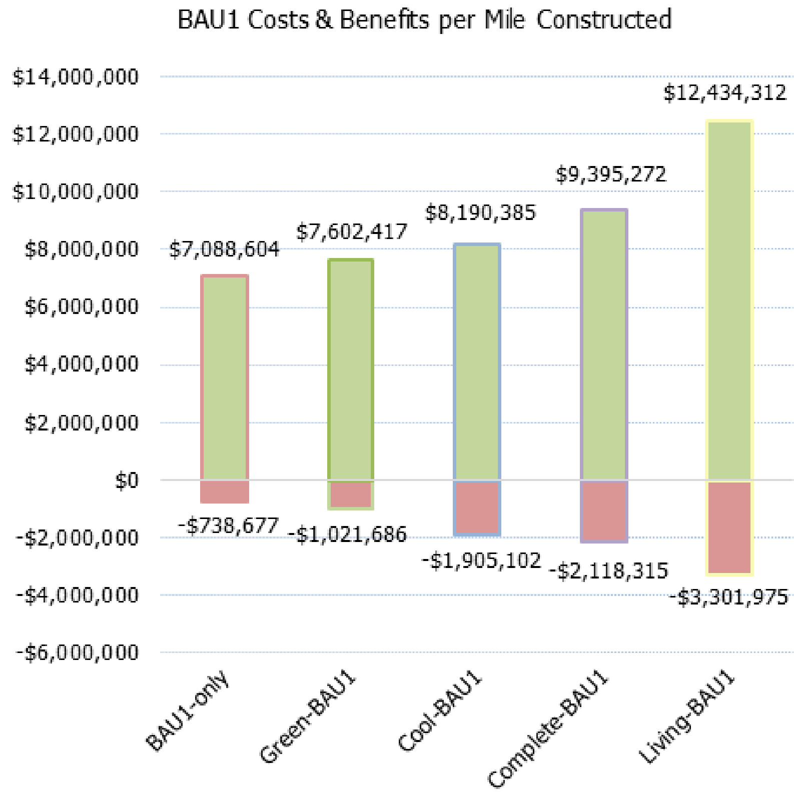


FIGURE 34: BAU1 TOTAL COSTS AND BENEFITS PER MILE CONSTRUCTED



Element Only (EO) Analysis under the BAU1 Scenario

Table 33 shows the cost and benefit data for each street Element Only – taking out the construction of the BAU1 elements and their associated benefits.

TABLE 33: COMPARISON OF THE COSTS AND BENEFITS OF EACH ELEMENT UNDER THE BAU1 CASE

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (Years)	Benefit-Cost Ratio
Green-BAU1-EO	$288,457,597	$513,813,622	$225,356,026	11.3	1.8
Cool-BAU1-EO	$1,171,874,156	$1,101,780,865	-$70,093,290	34.2	0.94
Complete-BAU1-EO	$1,385,086,647	$2,306,667,815	$921,581,168	12.4	1.7
Living-BAU1-EO	$3,229,563,592	$5,430,568,144	$2,201,004,552	10.9	1.7

When looking at the element costs and benefits independent of the street repaving, Living-BAU1-EO has the lowest payback period, meaning that their initial investments are recovered quicker that in the other cases. This is significant given that Living-BAU1-EO has a significantly higher investment than the other cases (about $1.84 Billion higher than the second most expensive investment).

Green-BAU1-EO has the highest benefit-cost ratio, although not by much (only 0.1 more than Complete-BAU1-EO and Living-BAU1-EO). More importantly, Living-BAU1-EO has a significantly larger net present value than Green-BAU1-EO and Complete-BAU1-EO.

Notably, Cool-BAU1-EO has a negative net present value; over the lifetime of the project, the total discounted benefits do not outweigh the total discounted costs. This is evident in the fact that, with the street construction costs included (see section 7.1.1 above), the net present value for the Cool Street was slightly lower than that of the BAU1-only case.
Of the three elements constructed independently, Complete-BAU1-EO has the highest total cost, total benefit, and net present value.

Living-BAU1-EO has the highest total benefits and total costs; it also has a significantly higher net present value than the other elements ($1.28 Billion higher than Complete-BUA1-EO), making it the best project to invest in from an economic perspective. These results are well represented in figures 35, 36, and 37:

FIGURE 35: BAU1 ELEMENT ONLY COST-BENEFIT SUMMARY

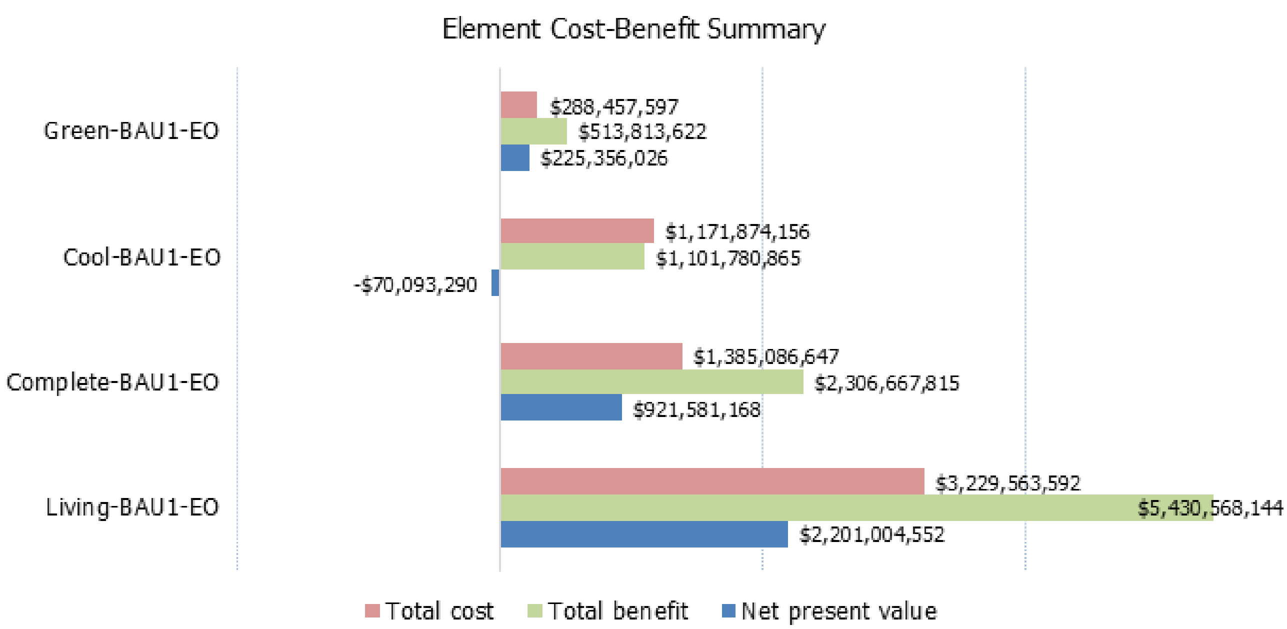


FIGURE 36: BAU1 ELEMENT ONLY COST-BENEFIT PER MILE CONSTRUCTED

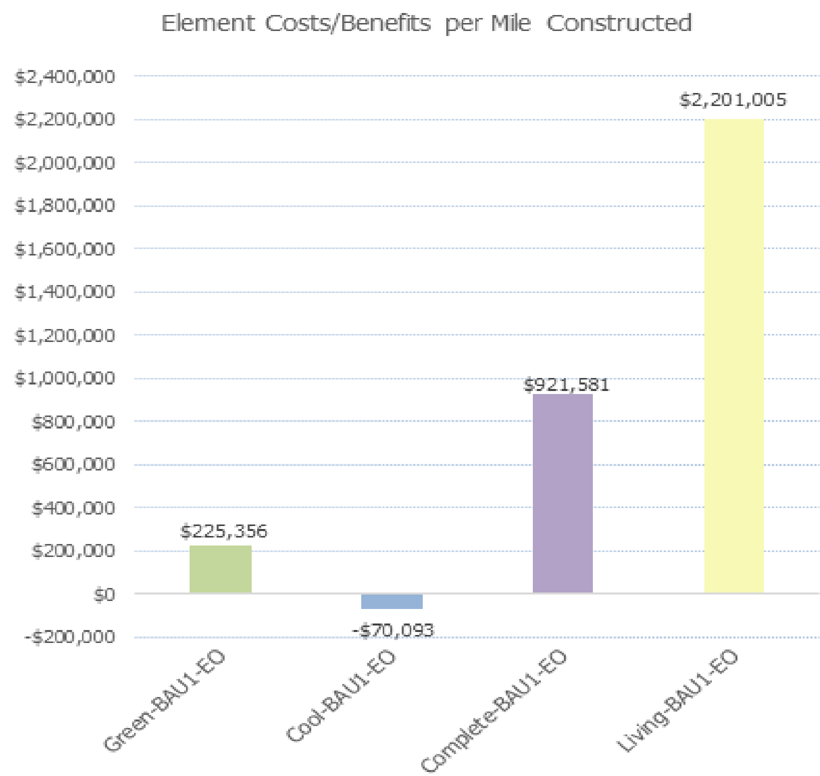
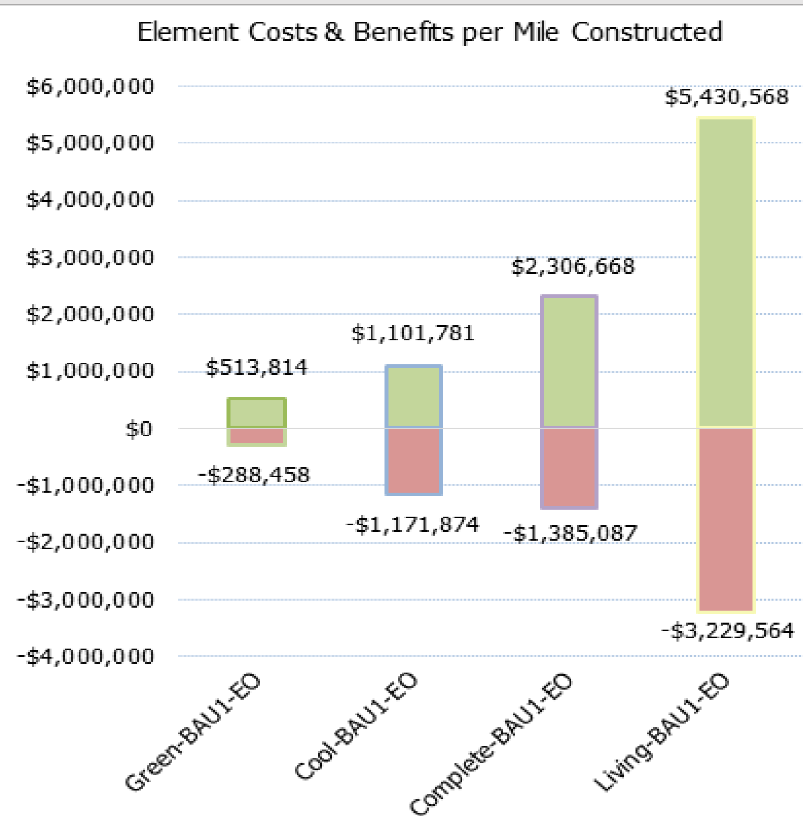


FIGURE 37: BAU1 ELEMENT ONLY TOTAL COSTS AND BENEFITS



Business as Usual 2 (BAU2)

BAU2 Analysis Compared to Different Street Designs

Table 34 shows a comparison of the various street design elements under the BAU2 scenario--full reconstruction of the street and sidewalk:

TABLE 34: COMPARISON OF THE COSTS AND BENEFITS ASSOCIATED WITH THE BAU2 CASE

Action code	Total cost	Total benefit	Net present value	Pay back (years)	Benefit-Cost Ratio
BAU2-only	$1,086,995,688	$7,144,352,396	$6,057,356,708	4.3	6.6
Green-BAU2	$1,285,372,720	$7,652,323,491	$6,366,950,771	4.5	6.0
Cool-BAU2	$2,250,851,059	$8,246,133,262	$5,995,282,202	5.4	3.7
Complete-BAU2	$2,034,655,649	$9,303,142,393	$7,268,486,744	6.1	4.6
Living-BAU2	$3,741,949,842	$12,419,670,386	$8,677,720,544	6.2	3.3

Looking at the overall costs and benefits of the entire project, the BAU2-only case has the lowest payback period. This means that the initial investment for BAU2-only is recovered quicker that in the other scenarios, although by only 0.2 years compared to the Green-BAU2. It is important to note, however, that the BAU2-only case has a lower total investment, meaning there is less of an investment to pay back. Despite the higher initial cost, all the other scenarios require less than two-years more to break even.

In this scenario, the BAU2-only case has the highest benefit-cost ratio, yet Living-BAU2 has the highest net present value. When there are conflicting rankings, the net present value is the better criterion to consider as it measures the economic contribution of each project in absolute terms. The benefit-cost ratio is limited in that it conceals absolute magnitudes. A project may have a high benefit-cost ratio but be small in terms of the absolute dollar amounts, as in the case of BAU2-only. Therefore, this project could be less desirable than another that has a lower benefit-cost ratio, but is larger in scale and impact.Similar to the BAU1 scenario, Cool-BAU2 has the lowest net present value, although the total benefits are higher than the Green-BAU2 (by $594 Million).

Of the three elements constructed independently (not including Living-BAU2), Complete-BAU2 has the highest total benefit, and net present value. Its total costs, however are lower than the Cool Street. This differs from the BAU1 scenario. In the BAU2 scenario, the sidewalks are being reconstructed across all the scenarios. Therefore, these costs are not considered added costs in Complete-BAU2. The sidewalks are also reconstructed in Green-BAU2 and Cool-BAU2 as part of the overall BAU2 scenario. This also has an effect on the benefit-cost ratio, improving the ranking of Complete-BAU2.

As in the BAU1 scenario, Living-BAU2 has the highest total benefits, total costs, and net present value. Living BAU-2 is the best project to invest in from an economic perspective. These results are aptly demonstrated in Figures 38, 39, and 40:

Figure 38: BAU2 Cost-Benefit Summary

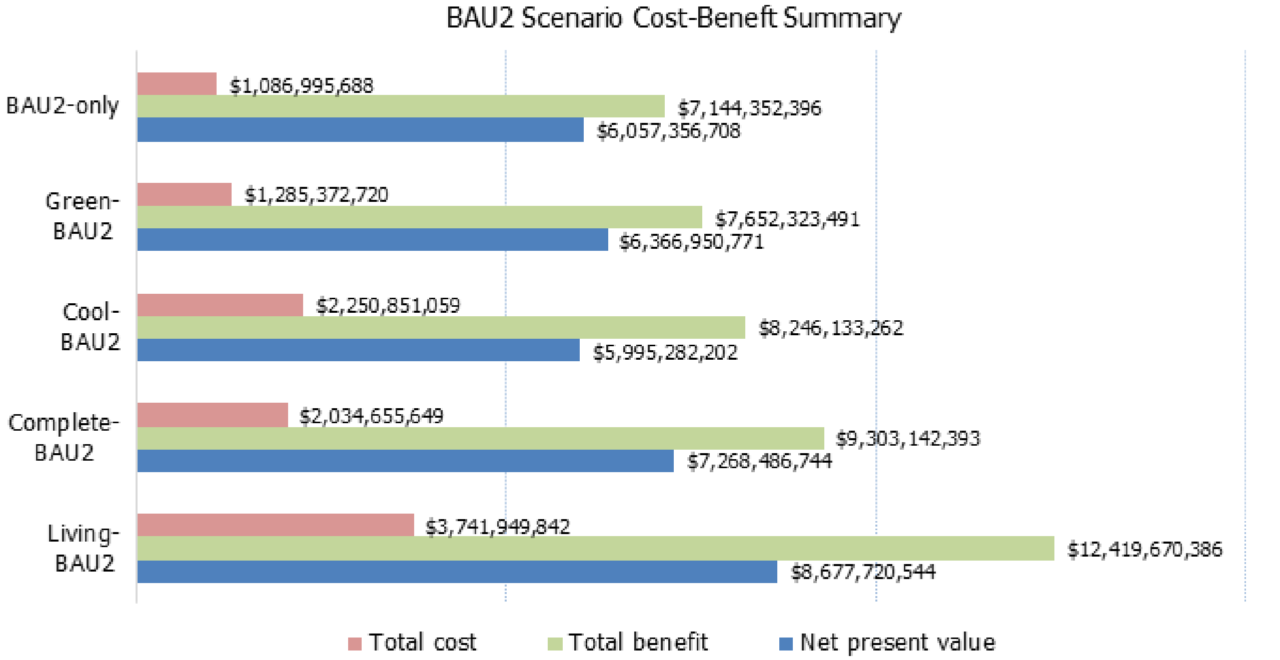


Figure 39: BAU2 Cost-Benefit per Mile Constructed

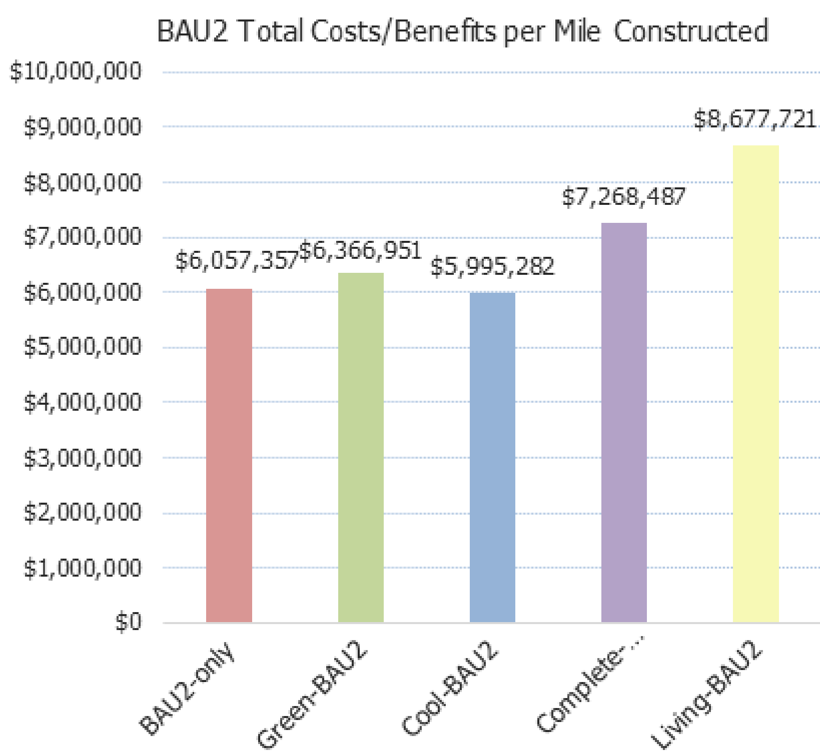
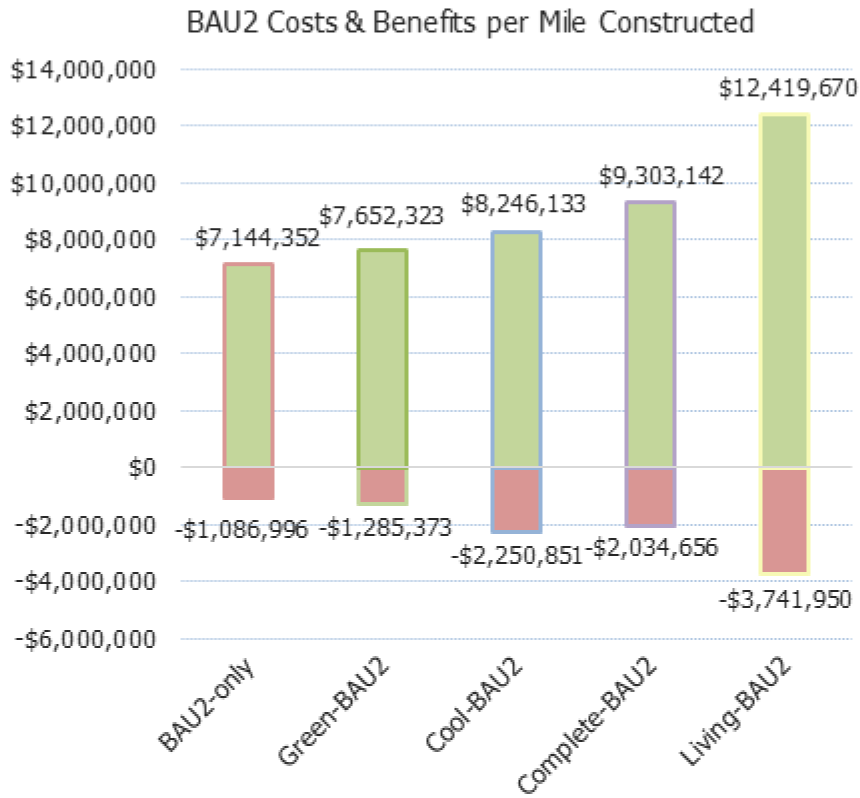


FIGURE 40: BAU2 TOTAL COSTS AND BENEFITS PER MILE CONSTRUCTED



Element Only Analysis under the BAU2 Scenario

Table 35 illustrates the cost and benefit data for each street design only – taking out the construction of the BAU2 elements and their associated benefits:

TABLE 35: COMPARISON OF THE COSTS AND BENEFITS ASSOCIATED WITH THE LIVING STREET ELEMENTS (BAU2)

Action Code	Total Cost	Total Benefit	Net Present Value	Pay Back (Years)	Benefit-Cost Ratio
Green-BAU2-EO	$274,860,840	$513,103,832	$238,242,992	10.9	1.9
Cool-BAU2-EO	$1,171,874,156	$1,101,780,865	-$70,093,290	34.2	0.94
Complete-BAU2-EO	$955,678,746	$2,158,789,997	$1,203,111,251	10.8	2.3
Living-BAU2-EO	$2,755,956,855	$5,287,258,731	$2,531,301,877	9.8	1.9

As can be seen in Table 35, Living-BAU2-EO has the lowest payback period, meaning that its initial investment is recovered quicker than in the other case. This is significant given that Living-BAU2-EO has the highest total investment (over $1.8 Billion more than the second largest investment). Complete-BAU2-EO has the highest benefit-cost ratio, meaning that for every dollar invested, it has the highest benefit output. This is different from the BAU1 analysis and is largely due to the fact that, in the BAU2 scenario, the sidewalks are being reconstructed across all the scenarios. Therefore, these costs are not considered added costs in this scenario. This is also a factor in the overall results of the scenario, in which the Complete Street has the highest total benefit and net present value of the three elements constructed independently. Its total costs, however are lower than the Cool-BAU2-EO.

Notably, Cool-BAU2-EO has a negative net present value, meaning that over the lifetime of the project, the total discounted benefits do not outweigh the total discounted costs. This is evident in the fact that, with the street and sidewalk construction costs included, the net present value for Cool-BAU2-EO was slightly lower than the BAU2-only case (see section 7.2.1.).

Living-BAU2-EO has the highest total benefits and total costs; it also has a significantly higher net present value than the other elements ($1.8 Billion higher than the second highest element, Complete-BAU2-EO). Living-BAU2-EO is the best project to invest in from an economic perspective. These results are represented in figures 41, 42, and 43:

FIGURE 41: BAU2 ELEMENT ONLY COST-BENEFIT SUMMARY

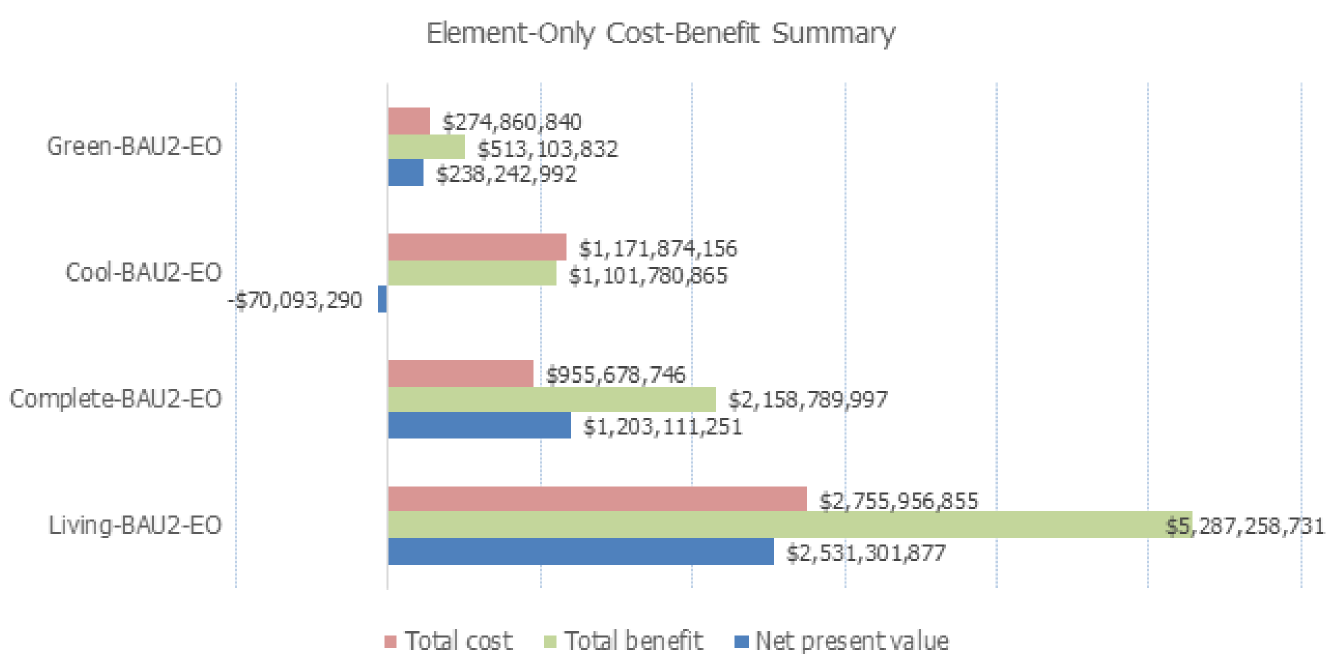


FIGURE 42: BAU2 ELEMENT ONLY COST-BENEFIT PER MILE CONSTRUCTED

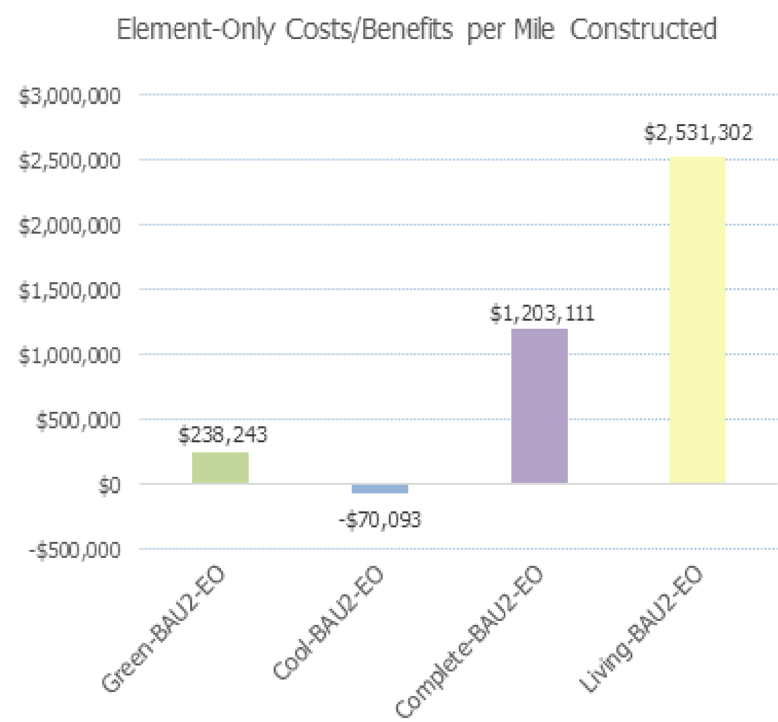
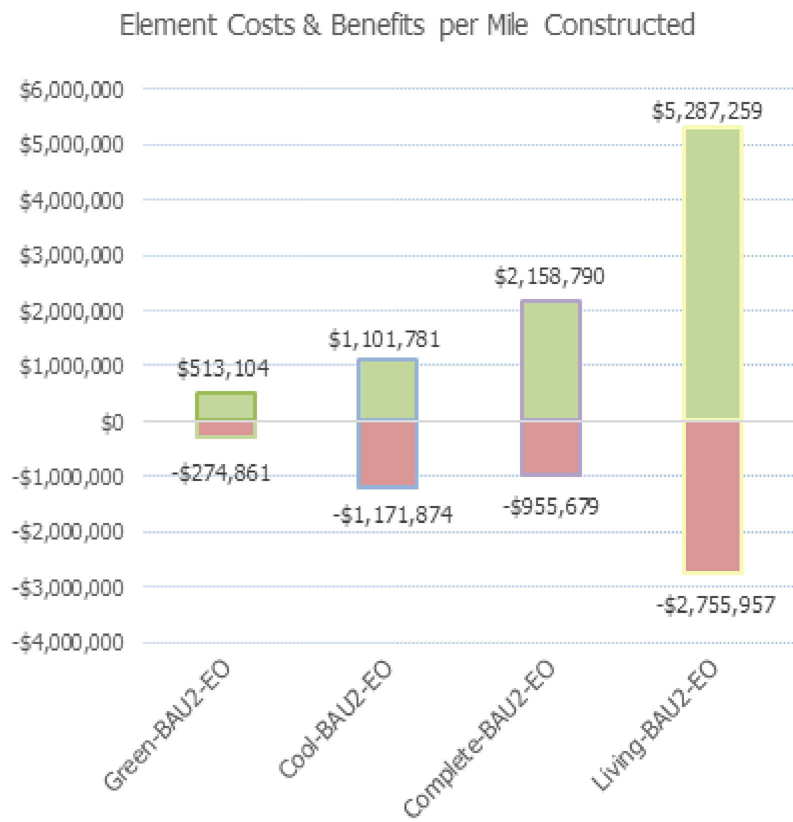


FIGURE 43: BAU2 ELEMENT ONLY COSTS AND BENEFITS PER MILE CONSTRUCTED



Overall Comparison of the BAU1 and BAU2 Scenarios

Complete Streets

- The Complete Street designs (Complete-BAU1 and Complete-BAU2) had the highest total benefits and the highest net present value.
- Complete-BAU1 also had the highest costs out of the three elements; however, Complete-BAU2 was relatively less costly when the sidewalk construction costs were incorporated into the overall BAU2 scenario.
- Compared to the BAU1-only case, Complete-BAU1 costs increased the total investment by 187%, since the cost of sidewalk construction is significant compared to simply repaving the street (BAU1-only). Conversely, in the BAU2 scenario, the cost of Complete-BAU2 was only 87% higher than the BAU2-only case.

Cool Streets

- The Cool Street cases (Cool-BAU1 and Cool-BAU2) have the lowest net present values of all the scenarios, making them less appealing that the BAU-only cases.

Green Streets

- Green-BAU2 has significantly lower costs compared to Green-BAU1.
- In the Green-BAU1 case, the cost of construction is 38% higher than the BAU1-only; however, Green-BAU2 is only 18% more costly than BAU2-only. This is due to the fact that in the BAU2 scenario, the sidewalk is already being taken out. In the BAU1 scenario, however, the sidewalk is not being replaced; therefore, excavation costs for the Green Street elements is an added cost above the BAU treatment.

Living Streets

- In both the BAU1 and BAU2 scenarios, the Living Street Designs (Living-BAU1 and Living-BAU2) had the highest total benefits and the highest net present value, making them the best investment from an economic perspective, regardless of the type of construction project implemented (BAU1 or BAU2).

Notes on Results – Assumptions Used and Gap Analysis for Further Investigation

While the results provide an estimate for the costs and benefits associated with the implementation of street design elements in the City of Los Angeles, it is important to note some of the shortcomings of this study and identify the areas of improvement and expansion for future economic analysis:

1. The scenarios have been created under several assumptions designing 1,000 center-line miles of road for each street element. It uses averages for Los Angeles' road, weather, and population conditions. The results, therefore, are meant to give a comparison of the costs and benefits associated with these elements. They are not meant to provide an estimate to the actual costs and benefits of a particular project implemented within the city.
2. The benefits are estimated assuming that the elements are placed in locations where their implementation is appropriate and strategic for the design requirements of the element.
3. When available, data specific to Los Angeles has been used in this study. However, in some cases, the data used in this study is not specific to Los Angeles. It is recommended that further research be done in order to collect context specific data in areas where generic costs and benefits are used.
4. The most recent data available was used. However, in some cases, the projections and estimations are from reports and articles from prior decades. For example, in the case of kWh saved by cool pavement treatments, the estimations are taken from a study published in 1997. Outdated data should be updated in future reports and calculations, when possible.
5. Demographic and population changes over the period of this study have not been included. Future cost and benefits may change as the population, number of registered vehicles, number of vehicle-miles travelled, etc. change in the next 35 years.

In this study, several impacts were unable to be included in the economic analysis due to a lack of information. This may have been due to a difficulty in estimating the level of impact for the City of Los Angeles or a lack of information regarding an economic valuation for the impact. The table below shows the additional benefits that have been identified, but unfortunately were not able to be quantified in this study:

TABLE 36: COSTS AND BENEFITS NOT QUANTIFIED IN THIS STUDY

Scenario	Benefits

BAU1 and BAU2	• Reduced fines due to poor road conditions
	  ◦ Reduced fines from improving the road/sidewalk conditions
	  ◦ Reduction in lawsuits due improved road conditions
	• Reduced frequency and severity of accidents
	Note: these street benefits would also occur for Cool Streets, where the streets are also repaved. The sidewalk benefits would also occur for Green and Complete Streets, where the sidewalks are reconstructed

<table>
<tr><th>Scenario</th><th>Benefits</th></tr>
<tr><td>Green Streets</td><td>

Reduced air pollutants

The sequestration of pollutants by grasses and shrubs: the calculation above only included information on pollutant sequestration by trees.
Reduced fines/liabilities with cleaner air
Carbon capture of soil

Reduced temperatures
Reduced incidence of heat-related illnesses
Increased pavement life: tree shade can slow deterioration of street pavement, decreasing the amount of maintenance needed
Reduced spending on stormwater and street infrastructure.

Reduced public expenditures on stormwater infrastructure including expensive retrofits
Reduced system wide operations and maintenance costs of pipe infrastructure. Extension of the useful life of central pipe infrastructure

Improved water quality
Stormwater benefits

Ecological/habitat benefits from capturing stormwater rather than allowing to run-off

Benefit of open/recreation spaces
Reduced noise levels
Improved human well-being and reduce associated medical costs from improved water quality
Improved safety
Improved economy

Job creation
Local economy

Gentrification (cost not included)

</td></tr>
<tr><td>Cool Streets</td><td>

Reduced temperatures
Reduced temperature of runoff, resulting in less thermal shock to aquatic life in the waterways into which stormwater drains.
Lower risk of heat-related illnesses and deaths
Improved well-being (cooler temperatures outside means more comfort for citizens)
Increased pavement performance
Better nighttime visibility (reflective pavements can enhance visibility at night, potentially reducing lighting requirements and saving both money and energy)
Job Creation
Increased property values

</td></tr>
</table>

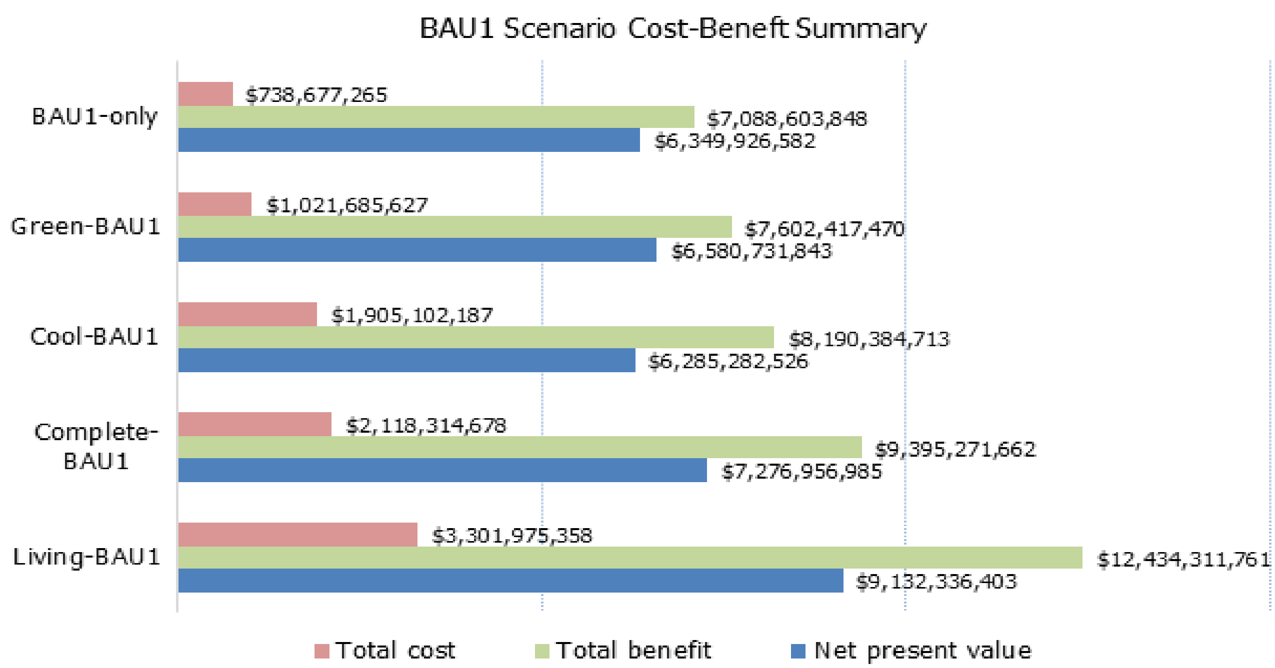
Scenario	Benefits
Complete Streets	• Increased transportation capacity • Benefit of "liveable" communities • Improved economy (increased employment, income, productivity, property values and tax revenues) • Gentrification (cost not included)

Conclusions

Living Streets are the best street paradigm to implement from an economic perspective. In both the BAU1 and BAU2 cases, the Living Street had the highest net present value, making it the best investment from an economic perspective regardless of the type of construction project implemented. Notably, it also had the highest total cost and total benefit; it requires the largest investment to implement.

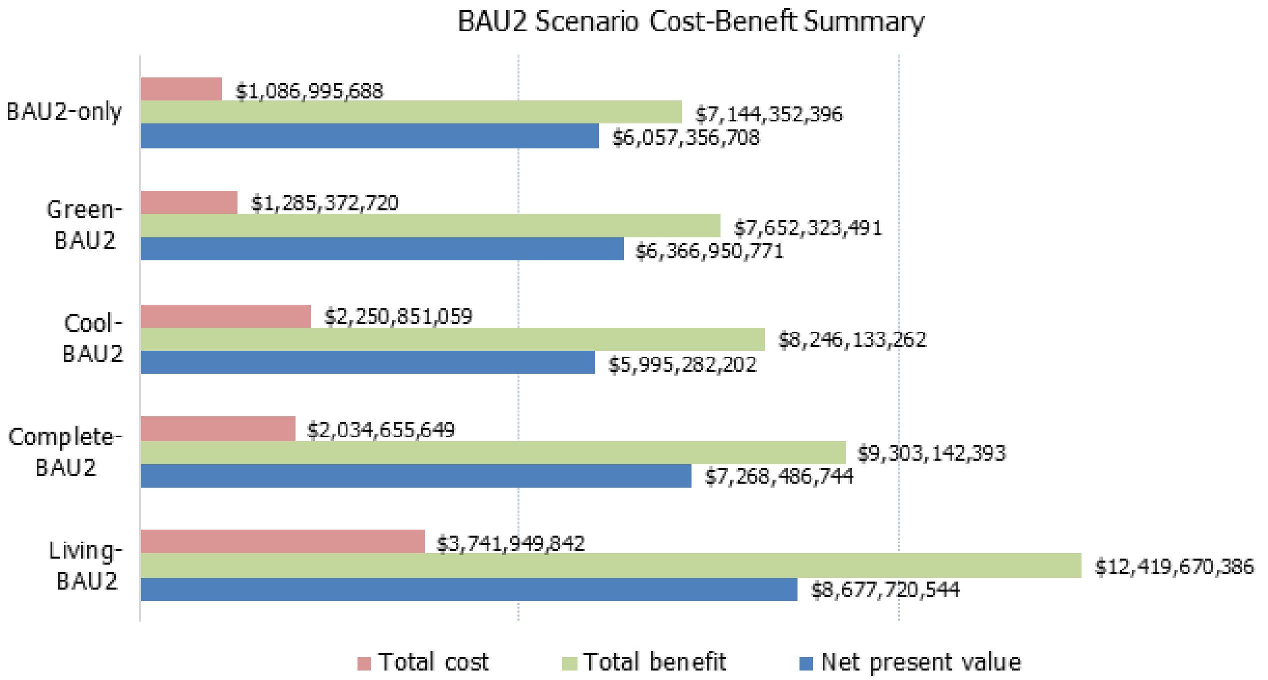
When the Living Street is compared to a simple re-paving of the existing subgrade street infrastructure (BAU1-only), the Living Street provides an additional $5.35 Billion in benefits to society compared to the BAU1-only case (75% increase). This results in an additional $2.78 Billion in net present value over the lifetime of the project compared to BAU1-only (44% increase). Figure 44 illustrates this analysis:

FIGURE 44: COST-BENEFIT SUMMARY COMPARING GREEN, COOL, COMPLETE, AND LIVING STREETS TO A SCENARIO WHERE THE STREETS ARE SIMPLY RE-PAVED (KNOWN AS BAU1)



When the Living Street is compared to a simultaneous reconstruction of the street and sidewalk (BAU2-only), the Living Street (Living-BAU2) provides an additional $5.28 Billion in benefits to society compared to BAU2-only (74% increase). This results in an additional $2.62 Billion in net present value over the lifetime of the project (43% increase). These results can be seen in Figure 45:

FIGURE 45: COST-BENEFIT SUMMARY COMPARING GREEN, COOL, COMPLETE, AND LIVING STREETS TO A SCENARIO WHERE THE STREETS AND SIDEWALKS ARE RECONSTRUCTED (KNOWN AS BAU2)



When only considering the Green, Cool, and Complete Street designs, the Complete Street had the highest total benefits and the highest net present value. It also has the highest costs out of the three elements. The Cool Street had the lowest net present value of all the scenarios, including the BAU scenarios. This is due to the fact that the costs of implementing the Cool Street treatment are lower than the total benefit. The Green Street had significantly lower relative costs under the BAU2 scenario than the BAU1. In the BAU1 scenario, the cost of construction for the Green Street (Green-BAU1) was 38% higher than the BAU1-only (repaving the street); however, the Green Street (Green-BAU2) was only 18% more costly than the BAU2-only case. This is due to the fact that in the BAU2 scenario the sidewalk is already being taken out. In the BAU1 scenario. However, the sidewalk is not being replaced; excavation costs for the Green Street elements are an added cost above the BAU treatment. Out of the four street design elements evaluated independently (BAU-only, Green, Cool, and Complete), Complete Streets have the highest total benefits and the highest net present value in both the BAU1 and BAU2 scenarios. However when we compare all the paradigms to the Living Street paradigm, Living Streets rank the highest overall.

Living Streets provide a comprehensive street ecosystem that incorporates all of the benefits achieved through Green, Cool, and Complete Streets. They can help improve the aesthetics, water quality, air quality, energy consumption, walkability and bikeability, health, wellbeing, etc. of the communities within which they are constructed. Living Streets have the ability to improve the economic, social, and environmental attribute of a community, benefitting all residents living and working in the area. With integrated, strategic design of Living Streets, the City of Los Angeles can drastically increase the overall benefits to society.

Glossary of Terms

Ac-ft. Acre-Feet.
Albedo: The ratio of reflected sunlight from a surface. The Albedo is valued from 0 and 1. A perfectly black surface with no reflection has an albedo of 0; a white surface that reflects 100% sunlight has an albedo of 1.
BAU: Business as Usual
Benefit-Cost Ratio: The ratio of the net present value of the benefits, divided by the net present value of the total costs. The result tells you the total benefits per dollar of cost over the lifecycle of the study. For example, if the benefit-cost ratio were 3.5, for every dollar of cost incurred, $3.5 of benefits are felt by society.
Center-Line Mile: One mile of road; this measurement does not take into account the amount of lanes the road has, but measure the length of road in a given space.
CY: Cubic Yard
Combined Sewer Overflow (CSO): Is the discharge of wastewater and stormwater from a combined sewer system directly into a river, stream, lake, or ocean.
EO: Element Only
Lane mile: A lane mile is a mile of one lane on a given road. Therefore, a Center-Line mile may consist of several lane miles, if the street has several lanes. According to the Los Angeles Bureau of Street Services one lane-mile is 11 feet wide and 1 mile long: 11' x 5,280 = 58,080 SF. (Strömmer-Van Keymeulen, 2014, P. 4)
Low Impact Design (LID): An approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible.
lb CO_2e: pound of carbon dioxide equivalent
LF: Linear Foot
MWD: Metropolitan Water District
NPV: Net Present Value.
Net Present Value: The sum of the benefits minus costs of each year of the project, discounted into the present.
Right of Way (ROW): a term used to describe the legal right, established by usage or grant, to pass along a specific route through grounds or property belonging to another.
SF: Square Foot
SY: Square Yard
Social Cost of Carbon: The total social cost that one unit of CO_2 emitted into the atmosphere incurs on society.
TCO_2e: metric ton of carbon dioxide equivalent – In this study, all tons are metric tons of carbon, unless otherwise noted.
Total Maximum Daily Load (TMDL): A regulatory term in the U.S. Clean Water Act, describing a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.
USD: United Stated Dollars
US EPA: United States Environmental Protection Agency
VMT: Vehicle Miles Travelled

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Appendix 1: Description of Excluded Elements

Excluded Cool Street Elements

The following information was taken from the EPA's, Cool Pavement: Compendium of Strategies.

Conventional asphalt pavements, which consist of an asphalt binder mixed with aggregate, can be modified with high albedo materials or treated after installation to raise reflectance. This material has been applied for decades in a wide range of functions from parking lots to highways. Conventional concrete pavements made by mixing Portland cement, water, and aggregate, can be used in a wide range of applications including trails, roads, and parking lots.
Other reflective pavements, made from a variety of materials, are mostly used for low-traffic areas, such as side- walks, trails, and parking lots. Examples include:

- Resin based pavements, which use clear tree resins in place of petroleum-based elements to bind an aggregate
- Colored asphalt and colored concrete, with added pigments or seals to increase reflectance

Nonvegetated permeable pavements contain voids and are designed to allow water to drain through the surface into the sub-layers and ground below. These materials can have the same structural integrity as conventional pavements. For example, some forms of porous pavements, such as open-graded friction course (OGFC) asphalt pavements, have been in use for decades to improve roadway friction in wet weather. Recently, rubberized asphalt has been used on roads and highways to reduce noise, and pervious concrete applications are being studied for roadway use. For some permeable pavement options, the typical use may be for lower traffic areas such as parking lots, alleys, or trails. Examples of nonvegetated permeable pavements include:

- Porous asphalt
- Rubberized asphalt, made by mixing shredded rubber into asphalt
- Pervious concrete
- Brick or block pavers, are generally made from clay or concrete, and filled with rocks, gravel, or soil; also available in a variety of colors and finishes designed to increase reflectance

Vegetated permeable pavements, such as grass pavers and concrete grid pavers, use plastic, metal, or concrete lattices for support and allow grass or other vegetation to grow in the interstices. Although the structural integrity can support vehicle weights comparable to conventional pavements, these materials are most often used in areas where lower traffic volumes would minimize damage to the vegetation, such as alleys, parking lots, and trails, and they may be best suited to climates with adequate summer moisture.
Chip seals consist of aggregate bound in liquid asphalt, and are often used to resurface low-volume asphalt roads and sometimes highways.

Whitetopping is a layer of concrete greater than 4 inches (10 cm) thick, often containing fibers for added strength. Typical applications include resurfacing road segments, intersections, and parking lots.

Ultrathin whitetopping is similar to whitetopping and can be used in the same applications, but is only 2–4 inches (5–10 cm) thick.

Microsurfacing is a thin sealing layer used for road maintenance. Light-colored materials can be used to increase the solar reflectance of asphalt. Re- searchers recently applied light-colored microsurfacing material that consisted of cement, sand, other fillers, and a liquid blend of emulsified polymer resin, and found the solar reflectance to be comparable to that of new concrete.

Excluded Complete Street Elements

Lane Reductions

Reducing the number of travel lanes on a multi-lane street can shift the balance of right-of-way (ROW) from motor vehicle to other users (pedestrians, bicyclists, etc.). This should be considered when traffic volumes are appropriate for it or all other reasonable options for reclaiming ROW have been exhausted. Must be based on analysis of traffic data. Lane reductions may be facilitated by a traffic shift to parallel streets (Greshem Smith and Partners, 2009).

Lane Width Reductions

This feature reduces the width of individual travel lanes, but keeping the total number of lanes constant. Lane width reductions are a good strategy for reclaiming street ROW for non-motor vehicle uses and for encouraging appropriate motor vehicle operating speeds (Greshem Smith and Partners, 2009).

Vertical Speed Control (speed hump, speed cushion, speed table)

Vertical speed control elements manage traffic speeds and reinforce pedestrian-friendly, safe speeds. These devices may be appropriate on a range of street types, but are most widely applied along neighborhood, residential, or low-speed streets where freight traffic is discouraged (NATCO). They may be installed in tandem with horizontal traffic calming measures such as curb extensions or chicanes, or applied individually on streets with a constrained right-of-way (NATCO).

Chicanes

A chicane is a series of alternating mid-block curb extensions or islands that narrow the roadway and require vehicles to follow a curving, S-shaped path. Either chicanes are used or curb extensions/pinch points are. For this study we went with curb extensions.

FIGURE 46: EXAMPLE OF A CHICANE (DRDUL, 2006)

Traffic-Calming Circles

A traffic-calming circle is a raised island located in the center of an intersection around which traffic must circulate. Traffic calming circles are generally used at low volume neighborhood intersections. Traffic calming circles should not be confused with roundabouts, which are designed to handle much higher traffic volumes and reduce vehicle delay.

FIGURE 47: EXAMPLE OF A TRAFFIC-CALMING CIRCLE (WATERSHED MANAGEMENT GROUP, 2010)

Raised crosswalk

Raised pedestrian crosswalks serve as traffic calming measures by extending the sidewalk across the road and bringing motor vehicles to the pedestrian level. Raised crosswalks also improve accessibility by allowing a pedestrian to cross at nearly a constant grade, without the need for a curb ramp. It makes the pedestrian more visible to approaching motorists.

FIGURE 48: EXAMPLE OF A PEDESTRIAN BICYCLE INFORMATION CENTER, RAISED PEDESTRIAN CROSSWALKS

The raised crosswalk in this parking lot slows traffic at the sidewalk crossing and draws more attention to the pedestrian crossing.

Public transit

Building streets to support transit entails considering every passenger's trip from start to finish. People walking to the transit stop should find their path safe and inviting. Dedicated transit lanes, appropriate base signal timings, and operational traffic improvements ensure that the transit vehicle experiences minimal wait time at intersections and can move freely regardless of traffic congestion, providing a passenger experience competitive with driving (NATCO).

Well-planned and designed transit facilities provide safe, comfortable and intentional locations for riders to access transit. They send a message to all street users that transit is a legitimate and viable form of transportation.

Generally speaking, there are three levels of transit passenger facilities on Complete Streets (Greshem Smith and Partners, 2009):

- Stops – dedicated waiting areas with appropriate signage for passengers waiting to board a transit vehicle;
- Benches – dedicated seating for transit passengers; and
- Shelters – covered locations, usually with seating and other amenities, for transit passengers.

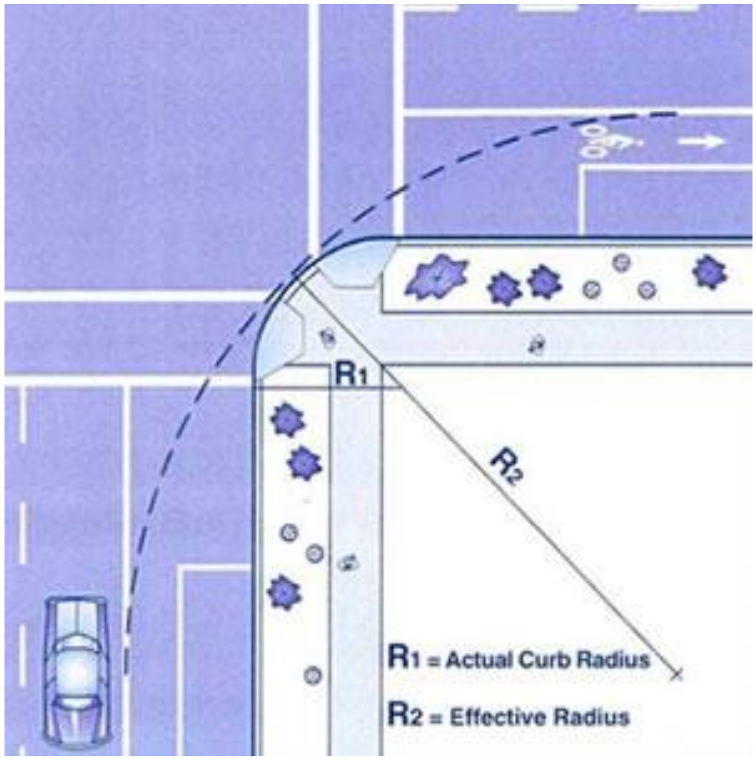
On Street Parking

On-street parking can be an important supporting element of a Complete Street. It provides an additional buffer between the sidewalk and travel lanes. Additionally, on-street parking encourages lower motor vehicle operating speeds (consistent with the target speed) (Greshem Smith and Partners, 2009).

Corner Radii Design

Corner radii, when designed appropriately, result in smaller, more pedestrian-scaled intersections, reduce pedestrian cross times, encourage appropriate vehicular speeds and allow for proper placement of marked crosswalks. The tendency, however, is to design intersections with very large corner radii to accommodate higher- speed vehicle turn movements and larger vehicles, such as tractor trailers (Pedestrian Bicycle Information Center, Reduced Corner Radii).

FIGURE 49: EXAMPLE OF A PEDESTRIAN BICYCLE INFORMATION CENTER, REDUCED CORNER RADII (SRTS GUIDE)



The effective radius that exists should include the width of parking lanes and bicycle lanes on both streets.

Lighting

Studies have shown that the presence of lighting not only reduces the risk of traffic crashes, but also their severity. In most cases, roadway street lighting can be designed to illuminate the sidewalk area as well. The visibility needs of both pedestrian and motorist should be considered (Greshem Smith and Partners, 2009).

Complete Street lighting designs should (Greshem Smith and Partners, 2009):

- Ensure pedestrian walkways and crossways are sufficiently lit;
- Consider adding pedestrian-level lighting in areas of higher pedestrian volumes, downtown, and at key intersections;
- Install lighting on both sides of streets in commercial districts; and
- Use uniform lighting levels.

Traffic Signal Treatments

Signal timing is an essential tool, not just for the movement of traffic, but also for a safer environment that supports walking, bicycling, and public transportation.

Some enhancements near transit can include (Sacramento Transportation and Air Quality Collaborative, 2005):

- Shorter and fewer traffic signal phases to reduce pedestrian wait times at intersections
- Pedestrian crossing improvements such as countdown signals and audible signals
- Priority for transit vehicles to encourage efficient transit operation

Smart Features

With all the current technology improvements streets can employ different features to make transit easier and safer for all user. Examples include (Zehngebot and Peiser, 2012):

- Smart Meters that accept prepaid cards, payment by mobile phones, and allow for variable pricing facilitate more efficient use of limited curbside space.
- Digital Tags and Information Panels integrated with street furniture and building facades enable wayfinding, community bulletin boards, trip planning, and place- based social networking.

Appendix 2: Economic Analysis: Assumptions Made

The economic analysis undertaken in this study looks at the implementation of 1,000 center-line miles of road construction. In each scenario, 1,000 center-line miles of road were constructed with the specific element's specifications. In order to calculate the net present value over the period of the project (35 years), several assumptions needed to be made. For each scenario, certain assumptions about road conditions, specific element implementation, user penetration rates, etc. were made in order to estimate the costs and benefits of each element. The table below provides a list of the assumptions taken in order to perform this analysis:

TABLE 37: SUMMARY MAJOR ASSUMPTION USED IN THE ECONOMIC ANALYSIS

Variable	Quantity	Unit	Source
Amount of Road LA	6,500	Center-Lane Miles	Bureau of Street Services. Resurfacing and Reconstruction Division, 2015 "We have a street network comprised of 6,500 centerline miles of streets, and 800 miles of alleys. The City of Los Angeles has the largest municipal street system in the nation."
Amount of Road LA	28,000	Lane Miles	Newton, D. (2013) "...to fix the 31% of city roads that rate either a "D" or "F" on road conditions in the next ten years... You can only bond for projects that are specifically listed by law," he explains. "We have conditions for all 28,000 lane miles. We know where all 9,000 lane miles that are in failed and degraded condition are at."
Amount of Road to be Repaired (center-line miles)	15%	%	Calculated
Amount of Road to be Repaired	4,307.7	lane miles	Calculated
Amount of Road to be Repaired	1,000	Center-lane miles	Assumption
Amount of Road to be Repaired	5,280,000	Linear Feet	Calculated
Amount of Road to be Repaired	250,190,769	SF	Calculated
Amount of Sidewalk to be Repaired	52,800,000	SF	Assumes all sidewalks along streets in this project are repaired.
Width of sidewalks put on each Side of Road	5.0	ft.	Assumption
LA City Population (estimated for 1/1/15)	3,957,022	People	California Department of Finance, 2014
LA County Population	10,136,559	People	California Department of Finance, 2014

Variable	Quantity	Unit	Source
Estimated Number of Registered Vehicles in Los Angeles City	3,005,972	Vehicles	Calculated using the vehicle per capita ratio of 0.76 "Los Angeles County counted 10,017,068 people in 2013 and 7,609,517 registered vehicles, bringing its per capita driver's ratio to 0.76." Strömmer-Van Keymeulen, 2014, p. 19
Electricity Price May 2014	0.215	USD/kWh	Strömmer-Van Keymeulen, 2014, p. 21
Gas Price May 2014	1.35	USD/ Therm	Strömmer-Van Keymeulen, 2014, p. 21
LADWP Distribution Emission Factor	1,135	lb CO2/MWh	Los Angeles Department of Water and Power, 2014, Appendix C
LADWP Distribution Emission Factor	0.00051	TCO2e/ kWh	Calculated
Imported Water Emissions Factor	0.000466	TCO2e/ kWh	LADWP (2010), from email correspondence with Glenn Micko, P.E. at LADWP: "Removed the local groundwater and recycled water carbon footrpints and took weighted average between 2003 and 2009"
Daily Miles Driven in LA City per Year	41,580,490	VMT	California State Transportation Agency Department of Transportation, 2014, p. 53
Annual Miles Driven in LA City	15,176,878,850	VMT	Calculated
Number of Years to Complete Construction	10	Year	Office of Councilmember Mitchell Englander, 2013
Average Weekly Gasoline Price (January 1st, 2014 to March 30th, 2015)	3.67	USD/Gallon	Energy Information Administration (2015a)
Average Weekly California No 2 Diesel Retail Prices (January 1st, 2014 to March 30th, 2015)	3.84	USD/Gallon	Energy Information Administration (2015b)

Appendix 3: Detailed Summaries of the Benefits and Costs Identified

A.3.1. Business as Usual (BAU)

- ***A.3.1.1. Summary of Quantified Costs and Benefits for BAU1-Only***

TABLE 38: SUMMARY OF QUANTIFIED COSTS AND BENEFITS FOR BAU1-ONLY

BAU 1: Costs		
Impact Category	**Description**	**Literature Review**
Construction Costs	The planning and construction costs associated with repaving the streets.	These costs include: engineering and planning (percentage of total capital cost); demolishing and removing existing asphalt or concrete; hauling; using traditional asphalt top course; and contingency planning[3].
Maintenance Costs	The costs of maintaining the streets.	For the purposes of this study, this is assumed to be 3% of the capital costs of construction[4].
Rehabilitation Costs	The costs of maintaining the streets.	For the purposes of this study, this is assumed to be 70% of the capital costs of construction[5].

[3] All costs were taken from the Stormwater Capture Master Plan Costs Development LADWP

[4] Assumption was taken from the Stormwater Capture Master Plan Costs Development LADWP following the assumptions for permeable pavement with run-on.

[5] Assumption was taken from the Stormwater Capture Master Plan Costs Development LADWP following the assumptions for permeable pavement with run-on.

BAU 1: Benefits		
Impact Category	**Description**	**Literature Review**
Vehicle Operating Costs	The avoided costs to private vehicles in LA due to better road conditions.	According to a TRIP report, 64% of roads in the greater Los Angeles area are so deteriorated that they cost drivers $850 in repairs and maintenance, increased fuel consumption, and tire repair annually. By "translating that percentage onto Los Angeles City means that 20% of the roads are in the same bad shape as roads in the greater Los Angeles area" (Strömmer-Van Keymeulen, 2014).
Less Road Congestion	Reduction in time spent in traffic due to improved road conditions.	According to a report by the U.S. Department of Transportation, Federal Highway Administration (2013), "Significant congestion and delays can be attributed to vehicles slowing down in heavy traffic to avoid potholes or rough pavement." In a report by the Texas A&M Transportation Institute, they estimate that a total of 501,881,000 hours are lost a year in traffic. 29,936,000 hours per year are lost by commercial trucks sitting in traffic in Los Angeles (Schrank, D., et al., 2012). The California Department of Transportation, Office of Transportation Economics, Division of Transportation Planning (2010) estimates that the value of driving time per hour, per vehicle is $12.50 – while the value of single unit trucks and combination trucks is $28.70 per hour, per vehicle. Therefore, the total cost of lost time to auto commuters from traffic in Los Angeles is estimated to be nearly 5.9 billion dollars per year. The loss of time for commercial trucks is over 859 million dollars per year.
	Fuel savings due to less congestion.	Nearly 220 million gallons of fuel are lost due to congested streets in Los Angeles (Schrank, D., et al., 2012). The total loss in gas and diesel due to congestion is estimated to be nearly 808 million dollars per year[6].

[6] This is calculated using the average of the weekly gas prices for Los Angeles and the average of the weekly diesel prices for California (from January 12st 2014 to March 30th 2015) provided by the Energy Information Administration (2015a and 2015b). The amount of gallons of diesel and gasoline were calculated based on the percentage of lost-miles by auto commuters (assumed to use gasoline) and commercial trucks (assumed to use diesel).

BAU 1: Benefits		
Impact Category	**Description**	**Literature Review**
	Social cost of carbon.	Each gallon of gasoline emits 0.00881 metric tons of carbon dioxide equivalent (tCO_2e) per gallon and diesel emits 0.0103 tCO_2e per gallon[7]. This amounts to a social cost of about $0.50 per gallon of gasoline and $0.59 per gallon of diesel[8].

- ***A.3.1.2. Summary of Quantified Costs and Benefits for BAU2-Only***

TABLE 39: SUMMARY OF QUANTIFIED COSTS AND BENEFITS FOR BAU2-ONLY

BAU 2: Costs		
Impact Category	**Description**	**Literature Review**
Construction Costs	The planning and construction costs associated with reconstructing the streets and sidewalks.	These costs include: engineering and planning (percentage of total capital cost); demolishing and removing existing asphalt or concrete; excavating; hauling; using traditional asphalt subgrade and base course; using traditional asphalt top course; using concrete slab on grade, 6"; concrete curb and gutter; and contingency planning[9].

[7] Emission factors were taken from the US Environmental Protection Agency (2014c). In the case of diesel, for CH_4 and N_20, the emissions factors from "other diesel" were used as the emission factors for "motor diesel" were given per mile, rather than per gallon.

[8] Assuming a Social Cost of Carbon of $57 (USD 2007), taken from the Interagency Working Group on Social Cost of Carbon (2013) and an inflation rate of 0.865 for USD 2007 to 2015.

[9] All costs were taken from the Stormwater Capture Master Plan Costs Development LADWP

Maintenance Costs	The costs of maintaining the streets and sidewalks.	For the purposes of this study, this is assumed to be 3% of the capital costs of construction[10].
Rehabilitation Costs	The costs of rehabilitating the streets and sidewalks.	For the purposes of this study, street rehabilitation is assumed to cost 70% of the capital costs of construction, and is done every 20 years[11].

BAU 2: Benefits		
Impact Category	**Description**	**Literature Review**
Vehicle Operating Costs	The avoided costs to private vehicles in LA due to better road conditions.	According to a TRIP report, 64% of roads in the greater Los Angeles area are so deteriorated that they cost drivers $850 in repairs and maintenance, increased fuel consumption, and tire repair annually. By "translating that percentage onto Los Angeles City means that 20% of the roads are in the same bad shape as roads in the greater Los Angeles area" (Strömmer-Van Keymeulen, 2014).
Less Road Congestion	Reduced time spent in traffic due to improved road conditions.	According to a report by the U.S. Department of Transportation, Federal Highway Administration (2013), "Significant congestion and delays can be attributed to vehicles slowing down in heavy traffic to avoid potholes or rough pavement." In a report by the Texas A&M Transportation Institute, they estimate that a total of 501,881,000 hours are lost a year in traffic. 29,936,000 hours per year are lost by commercial trucks sitting in traffic in Los Angeles (Schrank, D., et al., 2012). California Department of Transportation, Office of Transportation Economics, Division of Transportation Planning (2010) estimates that the value of driving time per hour, per vehicle is $12.50 – while the value of single unit trucks and combination trucks is $28.70 per hour, per vehicle. Therefore, the total cost of lost time to auto commuters from traffic in Los Angeles is estimated to be nearly 5.9

[10] Assumption was taken from the Stormwater Capture Master Plan Costs Development LADWP following the assumptions for permeable pavement with run-on.

[11] Assumption was taken from the Stormwater Capture Master Plan Costs Development LADWP following the assumptions for permeable pavement with run-on

BAU 2: Benefits		
Impact Category	**Description**	**Literature Review**
		billion dollars per year. The loss of time for commercial trucks is over 859 million dollars per year.
	Fuel savings due to less congestion.	Nearly 220 million gallons of fuel are lost due to congested streets in Los Angeles (Schrank, D., et al., 2012). The total loss in gas and diesel due to congestion is estimated to be nearly 808 million dollars per year[12].
	Social cost of carbon.	Each gallon of gasoline emits 0.00881 tCO_2e per gallon and diesel emits 0.0103 tCO_2e per gallon[13]. This amounts to a social cost of about $0.50 per gallon of gasoline and $0.59 per gallon of diesel[14].
Liabilities	Reduced liability spending due to sidewalk disrepair. Note: this is only included in BAU2 where the sidewalks are reconstructed.	The city has approximately 11,000 miles of sidewalks, of which 4,700 miles are in disrepair. The city spends somewhere between $4 and $6 million a year on liability claims (Brasuell, J., 2011). Note: this is only included in BAU2 where the sidewalks are reconstructed.

[12] This is calculated using the average of the weekly gas prices for Los Angeles and the average of the weekly diesel prices for California (from January 12st 2014 to March 30th 2015) provided by the Energy Information Administration (2015a and 2015b). The amount of gallons of diesel and gasoline were calculated based on the percentage of lost-miles by auto commuters (assumed to used gasoline) and commercial trucks (assumed to use diesel).

[13] Emission factors were taken from the US Environmental Protection Agency (2014c). In the case of diesel, for CH_4 and N_20, the emissions factors from "other diesel" were used as the emission factors for "motor diesel" were given per mile, rather than per gallon.

[14] Assuming a Social Cost of Carbon of $57 (USD 2007), taken from the Interagency Working Group on Social Cost of Carbon (2013) and an inflation rate of 0.865 for USD 2007 to 2015.

A.3.2. Green Streets

- ***A.3.2.1. Summary of Benefits Associated with Green Streets***

Table 40: Summary of Benefits Associated with Green Streets

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
Mitigate Urban Heat Island Effect	**Reduce Temperatures** Green Streets shade hardscape and provide cooling evapotranspiration that can reduce urban temperatures.	Trees and other greenspace within individual building sites may lower air temperatures 5° F (3° C) compared to outside the greenspace. At the larger scale of urban climate (6 miles or 10 km square), temperature differences of more than 9° F (5° C) have been observed between city centers and more vegetated suburban areas. (McPherson et al, 2000). Akbari (2002) and Taha (1996) show that increasing the canopy cover may also reduce air temperature by 1–3° C. Computer simulations for Los Angeles, CA show that resurfacing about two-third of the pavements and rooftops with reflective surfaces and planting three trees per house can cool down LA by an average of 2–3° C (Akbari, 2005).
	Reduce Incidence of Heat-Related Illnesses Cool temperatures reduce the risk of heat-related illnesses and deaths.	Vegetation provides shading and cooling evapotranspiration, which reduces local temperatures decreasing the risk of heat-related illnesses and deaths. Increased daytime surface temperatures, reduced nighttime cooling, and higher air pollution levels increases the risk of heat-related illnesses, particularly for low income populations, the elderly, and young children with no or limited access to air-conditioning and poor ventilation. Heat–related illnesses include: general discomfort, respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality. Some studies have also suggest that the lack of nighttime relief from hotter temperatures is highly correlated to increased mortality and may be even more significant that maximum day temperatures (U.S. Environmental Protection Agency, 2008). The Centers for Disease Control and Prevention calculated that the premature deaths in the US that occur as a result of exposure to extreme heat outnumber total deaths from hurricanes, lightning, tornadoes, flooding, and earthquakes combined. Not only do higher temperatures put sensitive populations at risk, but they also increase the formation of ground level ozone. A study in Los Angeles found that every increase in 1°F above 70°F results in a 3% increase in ozone levels, which have

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
		been shown to trigger asthma attacks and may even lead to the development of asthma in children (Detwiler, 2012). Increasing green space through green infrastructure practices such as building green roofs or planting rain gardens and trees can mitigate the Urban Heat Island Effect and the negative public health and economic consequences that result.
	Reduce Energy Consumption and GHG Emissions Cooler temperatures reduce air conditioning use and thus reduce energy consumption and associated GHG emission.	In a study by Rosenfeld, et al. (1998), implementing 10 million trees, 1,250 km^2 (about 483 mi^2) of cool roofs and 1,250 km^2 of cool pavements will directly reduce energy costs by about $100 million and will produce indirect energy savings equal to $70 million. The study estimates that avoided peak power for air conditioning can reach about 1.5 GW – over 15% of the city's air conditioning consumption. Research shows that peak urban electric demand rises by 2– 4% for each 1K rise in daily maximum temperature above a threshold of 15–20°C. Thus, the additional air-conditioning use caused by this urban air temperature increase is responsible for 5–10% of urban peak electric demand (Akbari, 2005). Reduced energy consumptions due to a reduction in the use of air conditioning in Los Angeles reduce greenhouse gas emissions – particularly by reducing the amount of peak power required, when "dirtier" technologies, such as aging natural gas plants, are brought online to meet demand (Freehling, R. and Doering, S.,2009) . Using the LADWP emissions factor and the social cost of carbon published by the White House, each kWh of electricity consumed in Los Angeles costs society $0.03.
	Increase Pavement Life Lower surface temperatures increase the longevity of pavement and do not require frequent maintenance or resurfacing.	Regular Slurry Seal costs approximately $0.27 per ft2 or $50,000 per linear mile. Because the oil does not dry out as fast on a shaded street as it does on a street with no shade trees, this street maintenance can be deferred. It is estimated that the Slurry Seal can be deferred from every 10 years to every 20-25 years for older streets with extensive tree canopy cover in Modesto (personal communication, John Brusca, Streets Superintendent, City of Modesto, November 17, 1998). (McPherson, 2001) By reducing pavement surface temperatures, the risk of premature asphalt pavement failure from rutting (depressions in the wheelpaths) decreases. This phenomenon occurs when slow heavy trucks or buses pass hot asphalt pavement. According to the Office of Atmospheric Programs of the U.S. Environmental

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
		Protection Agency (2008), "Some full-scale testing of a typical asphalt pavement showed that it took 65 times more passes of a truck wheel to rut the pavement when the temperature just below the surface was reduced from 120°F (49°C) to 106°F (41°C)." The risk of concrete pavement to crack is also reduced by decreasing the surface temperatures of the roads (U.S. Environmental Protection Agency, 2008).
Sequester Carbon/ Reduce Greenhouse Gas Emissions	Planting vegetation helps reduce the amount of atmospheric CO_2 through direct carbon sequestration, reductions in water and wastewater pumping and treatment and the associated energy demands.	One of the most comprehensive studies of atmospheric CO_2 reductions by an urban forest found that Sacramento's six million trees remove approximately 304,000 t (1.2 t/ha) of atmospheric CO_2 every year, with a value of $3.3 million (McPherson 1998). Avoided power plant emissions (75,600 t) accounted for 32% of the amount sequestered (238,000 t). The amount of CO_2 reduction by Sacramento's urban forest offsets 1.8% of total CO_2 emitted annually as a byproduct of human consumption. This savings could be substantially increased through strategic planting and long term stewardship that maximizes future energy savings from new tree plantings, as with the Cities for Climate Protection program (McPherson 1994, ICLEI 1997). The City of Chula Vista joined the Cities for Climate Protection program and adopted urban forestry as one means to reduce CO_2 emissions to a level below the 1990 base. Using computer simulations they estimated that annual CO_2 reductions 15 years after planting would range from 411 to 536 lb depending on location for a 24-ft tall tree (McPherson and Simpson 1998). Given this emission reduction rate, 29-39 trees will be required to offset average annual emissions per person in Chula Vista (15,811 lb/person) (McPherson et al, 2000).
Remove Air Pollutants	Planting trees and bioretention and infiltration practices can help reduce air pollutants through direct up-take and absorption, reduced electricity generation, and reduced ozone and smog formation.	Urban trees provide air quality benefits by (1) absorbing pollutants such as ozone and nitrogen oxides through leaf surfaces, (2) intercepting particulate matter (e.g., dust, ash, pollen, smoke), (3) releasing oxygen through photosynthesis, and (4) transpiring water and shading surfaces, which lowers local air temperatures, thereby reducing ozone levels. In the absence of the cooling effects of trees, higher air temperatures contribute to ozone formation. In a study by Trees New York and Trees New Jersey, Bisco Werner et al. (2001) report similar air-quality benefits of trees and vegetation in urban areas. Plumb and Seggos (2007) cite one study that found that a single tree can remove 0.44 pounds of air pollution per year.

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Impact Category	**Description**	**Literature Review**
		One study for the entire Los Angeles region found that 20 years after planting, 11 million trees would save $93 million in air conditioning costs and $180 million due to ozone reductions (Rosenfeld et al. 1998). The total annual savings of $273 million averages about $25 per tree, assuming no trees die after planting. Air pollution benefits focused on NOx reductions because this pollutant is involved in ozone formation. Reduced air conditioning demand was estimated to reduce NOx emissions at power plants by 3.5 tons/day, while citywide cooling by trees was estimated to lower ozone levels equivalent to removing 175 tons/day of NOx emissions. Thus, air temperature reductions due to evapotranspiration by trees was estimated to produce substantial air quality benefits through ozone reduction in Los Angeles. Other studies in Sacramento, the San Joaquin Valley and Davis, California, highlight recent research aimed at quantifying air quality benefits of urban trees. In Sacramento the total value of annual air pollutant uptake produced by Sacramento County's six million trees was $28.7 million, nearly $5/tree on average (Scott et al. 1998). The urban forest removed approximately 1,606 short tons (1,457 metric tons) of air pollutant annually. Trees were most effective at removing ozone and particulate matter (PM_{10}). Daily uptake of NO_2 and PM_{10} represented 1 to 2% of emission inventories for the county (McPherson et al, 2000). In the San Joaquin Valley the annual value of pollutant uptake by a typical medium- sized tree was about $12 (McPherson et al 1999a). The $12/tree value is more than twice the $5 amount reported for Sacramento due to larger tree sizes and higher pollutant concentrations in the San Joaquin Valley study (McPherson et al, 2000). The Urban Ecosystem Analysis of Washington, DC demonstrated that tree created $49.8 million in annual air quality savings by removing 20 million pounds of pollutants from the air every year (American Forests, 2002).
Recharge Groundwater/ Improve Storm Water Management	Green Street practices help to reduce the volume and rate of runoff entering sewer systems. These practices infiltrate runoff to recharge ground water. This reduces both the capital and operational	A study of the Los Angeles Region showed that implementation of distributed best management practices (BMPs) in all of the 49 identified candidate catchments has the potential to augment groundwater supplies by 17,000 acre feet/year. This represents nearly 10% of the 180,000 acre feet/year of runoff that is estimated to be available for capture (Council for Watershed Health, 2012) Southern California and San Francisco have the potential to increase water supplies by 420,000 to 630,000 acre-feet per year by adding Green Street elements. In areas overlying groundwater basins used for municipal water supply, an analysis found

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	costs of gray infrastructure systems such as storage tanks and pumping stations.	that between 365,000 and 440,000 acre-feet of runoff could be captured and stored for use each year. (Garrison, 2015) In Southern California, average interception loss for the land with tree canopy cover ranged from 6-13% (150 gal per tree on average), close to values reported for rural forests. In Modesto each street and park tree is estimated to reduce stormwater runoff by 845 gal (3.2 m3) annually, and the value of this benefit is $6.76 (McPherson et al. 1999b). 333,000 acre-feet of stormwater could be captured annually in urban Southern California alone. This would achieve a corresponding 200,000 metric tons of carbon dioxide reductions by 2020. In a 2005 report by the Los Angeles and San Gabriel Rivers Watershed Council noted that 500,000 acre-feet of stormwater runoff flows from the Los Angeles County basin to the ocean each year. (Sheehan, 2009) A study in Atlanta found that impervious surfaces reduced groundwater infiltration by up to 132 billion gallons each year— enough water to serve the household needs of up to 3.6 million people per year (Otto et al. 2002). A Green Street in Seattle, Washington, that included retrofits of bioswales with 100 evergreen trees and 1,100 shrubs and reduced street width from 25 feet to 14 feet, showed a 99 percent reduction in total potential surface runoff. The site is retaining more than the original design estimate of 0.75 inch of rain (Reducing Storm Water Costs through LID Strategies and Practices, 2007). In a controlled study, a bioswale integrating an engineered soil and trees was installed in a parking lot to evaluate its ability to reduce storm runoff. There were 50 storm events with a total precipitation of 563.8 mm during February 2007 and October 2008. The bioswale reduced runoff by 88.8% (Xiao and McPherson, 2011). The Urban Ecosystem Analysis of Washington, DC demonstrated that tree cover in the city saved $4.7 billion in avoided stormwater storage costs (American Forests, 2012).
Reduce Stormwater Treatment/ Filtration Costs	Increasing water infiltration and reducing pollutant loadings can decrease stormwater and drinking	According to the LA County Sanitation District[15], costs associated with dry weather urban runoff that municipalities are discharging into their system include a surcharge fee of $1 per one thousand gallons discharged. In addition, there is an annual, one time connection fee calculated based on discharge volume of $12 per

[15] Information taken from email correspondence with Dave Snyder, Industrial Waste Section Head, Los Angeles County Sanitation Districts

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Impact Category	**Description**	**Literature Review**
	water treatment costs by decreasing the need for regional stormwater management systems and expansions in drinking water treatment systems.	gallon per day. They estimate the annual average discharge over the last few years to be roughly 280,000 gallons per day for the county. The Trust for Public Lands noted Atlanta's tree cover has saved more than $883 million by preventing the need for stormwater retention facilities. A study of 27 water suppliers conducted by the Trust for Public Land and the American Water Works Association found a direct relationship between forest cover in a watershed and water supply treatment costs. In other words, communities with higher percentages of forest cover had lower treatment costs. According to the study, approximately 50 to 55 percent of the variation in treatment costs can be explained by the percentage of forest cover in the source area. The researchers also found that for every 10 percent increase in forest cover in the source area, treatment and chemical costs decreased approximately 20 percent (up to about 60 percent) (Reducing Stormwater Costs through Low Impact Development, 2007).
Reduce Flooding and Soil Erosion	Green Street elements reduce downstream flooding through the reduction of peak flows and the total amount or volume of runoff. Infiltrating stormwater, particularly the first flush of larger storms, reduces peak flows and erosive potential of stormwater released.	As part of the TreePeople's program called T.R.E.E.S. (Trans-agency Resources for Environmental and Economic Sustainability) it was determined that over $50 million ($500,000/sq mile) is spent annually controlling floods in the Los Angeles area (Condon and Moriarty 1999). Following the economic approach used in the T.R.E.E.S. cost-benefit analysis, they assumed that $50 million is spent per year for local problem areas and the annual value of peak flow reduction is $500,000 per square mile for each percent decrease in 25-year peak flow (Jones & Stokes Associates, Inc. 1998). In Southern California, a 25-year winter event deposits 5.3 inches (134 mm) of rainfall during 57 hours. Approximately $0.0054/gal ($1.44/m3) is spent annually for controlling flooding caused by such an event. This price is multiplied by the amount of rainfall intercepted during a single 25-year event to estimate the annual flood control benefit. (McPherson et al, 2000).
Reduce Spending on Stormwater and Street Infrastructure.	Flood prevention reduces property damage. It also can reduce the initial capital costs, and the operation and maintenance costs of stormwater and street infrastructure. Less money is	Braden and Johnston (2004) studied the flood-mitigation benefits of managing stormwater on site, including reduced frequency, area and impact of flooding events. In a follow-up study, Johnston, Braden, and Price (2006) focused on the downstream benefits accrued from flood reduction accomplished by greater upstream on-site retention of stormwater. These benefits included reduce expenditures on bridges, culverts and other water-related infrastructure. The Center for Watershed Protection (1998), Lehner et al. (2001), and U.S. EPA (2005) report that LID techniques, such as bioswales, rain gardens, and permeable

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
	spent on replacing curbs, gutters, storm sewers, pipe infrastructures.	surfaces, can help reduce the demand for conventional stormwater controls, such as curb-and-gutter, and pipe-and-pond infrastructure. Braden and Johnston (2004) report that retaining stormwater runoff on site reduces the size requirements for downstream pipes and culverts, and reduces the need to protect stream channels against erosion.
Improve water quality	Green Street infiltration practices result in pollutant removal through settling, filtration, adsorption, and biological uptake.	Brown and Schueler (1997), Center for Watershed Protection (1998), U.S. EPA and Low Impact Development Center (2000), and Braden and Johnston (2004) describe the water- quality benefits that Low Impact Design (LID) stormwater controls can provide. These benefits include effectively capturing oil and sediment, animal waste, landscaping chemicals, and other common urban pollutants that typically wash into sewers and receiving water bodies during storm events. Plumb and Seggos (2007) report that LID controls that include vegetation and soil infiltration, e.g., bioswales, can prevent more stormwater pollutants from entering New York City's harbor than conventional controls. A study of the Southern California Region shows that if 49 identified priority catchments had best management practices (BMP) the total pollutant loading for the region would be greatly reduced. (Council for Watershed Health, 2012) A 2007 study of Washington, DC found that implementing urban trees and green roofs to manage stormwater runoff would keep 1.2 billion gallons of stormwater out of the City's combined sewer system. As a result of the lower stormwater volumes, combined sewage overflow (CSO) frequencies would be reduced by approximately 7 percent and 120 pounds of copper, 180 pounds of lead, 340 pounds of phosphorous, and 530,000 pounds of total solids would be kept out of the Potomac and Anacostia Rivers annually (The Green Build Out Model, 2007). In a controlled study, a bioswale integrating an engineered soil and trees was installed in a parking lot to evaluate its ability to reduce storm runoff, pollutant loading, and support tree growth. The adjacent control and treatment sites each received runoff from eight parking spaces and were identical except that there was no bioswale for the control site. A tree was planted at both sites. Storm runoff, pollutant loading, and tree growth were measured. There were 50 storm events with a total precipitation of 563.8 mm during February 2007 and October 2008. The bioswale reduced runoff by 88.8% and total pollutant loading by 95.4%. The tree growth at the treatment site was slightly better (visual observation of leaves and new branches) than growth at the control site. The superior performance of the

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
		bioswale demonstrated its potential use for large-scale application in parking lots and roadsides to reduce runoff and support tree growth (Xiao and McPherson, 2011). In another controlled study, two full-scale grass swales in the median of a four-lane highway were monitored during 18 storm events to characterize the overall performance of grass swales as a stormwater management technology and to evaluate the effect of the shallow-sloped grass pre-treatment area adjacent to the swale in most designs. The study was designed as an input/output comparison between the water quantity and quality captured directly from the roadway and the effluent from the swales. Both swales exhibited significant removal of suspended solids (65-71% based on EMCs) and zinc (30-60% based on EMCs) (Satagee and Davis, 2006).
Avoid Regulatory Fines	By reducing the amount of stormwater runoff and improving water quality, there are reduced regulatory costs associated with water quality impacts such as threats to sensitive species, Total Maximum Daily Load (TMDL) compliance, etc.	
Create/Improve Habitats	Vegetation in the urban environment provides habitat for birds, mammals, amphibians, reptiles, and insects. Planting vegetation builds organic matter in soil. Furthermore, strategies designed to manage runoff, on-site or as close as possible to its point of generation, can reduce erosion and sediment transport as well as reduce flooding and downstream erosion, which improves habitats in small streams and washes.	
Create Open/Recreation Spaces	Commercial greet streets provide a public greenway that can provide recreational opportunities for the surrounding neighborhood. Many of the candidate catchments include disadvantaged communities (per California Public Resources Code Section 75005) with limited access to existing green space and recreation.	
Reduce noise levels	Green Streets have the potential to reduce road traffic noise in the urban environment by absorbing sound. Trees also reduce noise transmission. Certain hard, manmade, surfaces tend to amplify traffic noise.	In a study that looked at substrate materials on green roofs, green facade walls on the fronts of buildings and low, vegetated screens at the edges of flat roof showed that green roofs have the greatest potential for attenuating noise, and on certain roof shapes, may be able to reduce noise by up to 7.5 decibels. The noise reduction was smaller for green facade walls, and depended on the materials used in the adjacent street – the harder the bricks in buildings on the street, the greater the reduction in noise in the roadside courtyard (Van Renterghem et al., 2013).

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
Improve Human Well-being and Reduce Associated Medical Costs	**From Access to Green Space** Green spaces are aesthetically pleasing and more inviting. People are more likely to go outside and stay active. People with access to green spaces are less stressed and prone to anxiety, have lower blood pressure and cholesterol, lower rates of obesity, have faster recovery from surgery and heart attacks, and show more improvement managing attention and behavioral disorders.	Landscaped green public spaces are not only used more, but also attract a wide variety of users from children to the elderly. Children are twice as likely to be supervised by adults when playing in green urban neighborhood spaces compared to public spaces without vegetation (Taylor et al, 1998). A considerable body of studies indicates that vegetation aids in the recovery from mental fatigue. Contact with nature in a variety of forms—wilderness areas, prairie, community parks, window views, and interior plants—is systematically linked with enhanced cognitive functioning as measured by both self-report and performance on objective tests (e.g., Canin, 1991; Cimprich, 1993; Hartig, Mang, & Evans, 1991; R. Kaplan, 1984; Lohr, Pearson-Mimms, & Goodwin, 1996; Miles, Sullivan, & Kuo, 1998; Ovitt, 1996; Tennessen & Cimprich, 1995). Studies have demonstrated that people with access to parks and green space are less stressed and prone to anxiety, have lower blood pressure and cholesterol, lower rates of obesity, have faster recovery from surgery and heart attacks, and show more improvement managing attention and behavioral disorders (Kuo, 2012; How Cities Use Parks, 2012; Salois, 2012). By making it easier and safer for people to get outside and stay active, green infrastructure can yield cost savings by helping to keep medical expenses low. One study found that inactive adults who began regularly exercising could save $865 in annual mean medical costs (Pratt et al, 2000). In a study of Philadelphia's park system, the cost savings in avoided medical expenses due to park use in 2007 was estimated to be $69,419,000 (Detwiler, 2012).
	From Improved Water Quality. Green Street elements are used to protect water resources that are downstream in the watershed, this can reduce incidence of illness and associated costs from contact with polluted	Four in ten of California's most polluted beaches are in Los Angeles County. 48% of beaches in LA County received an F grade for wet weather water quality (2008 - 2012 average) (LA Mobility Plan 2035). A study of over 13,000 swimmers in Santa Monica Bay found that those swimmers who swam within 100 yards of a storm drain experiences increased incidences of gastrointestinal illness, with rates highest for those who swam nearest the storm drain outlet (Haile et al, 1996). Swimming or boating in rivers and lakes polluted by runoff not only can cause gastrointestinal illness, but can also cause eye and skin infections (Gaffield et al, 2003).

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
	water and contaminated seafood that lives in it.	A 2004 study of Huntington Beach and Newport Beach in California determined that the cost of illness from water-borne gastrointestinal illness was $36.58 per person in lost work days and medical costs, not including lost recreational values or willingness to pay of individuals to avoid getting sick (Given et al, 2006). For another two beaches in California, illness associated with swimming in water contaminated by polluted runoff at those beaches cost the public over $3 million every year (All Stormwater is Local, 2008). Beach closures put in place to protect the public from contaminated waters can have a detrimental economic impact as well. Tourism associated with coastal states comprise 85 percent of total US tourism revenues, with the average American spending 10 recreational days along the coast every year (All stormwater is local, 2008; Public Health Protection, 2004). Across the country, coastal and marine waters support 28.3 million jobs which depend upon safe, clean water (NOAA, 2002). According to the National Research Council, in 2011, 36 percent of beach closures across the country were due to "polluted runoff and stormwater" (Testing the Waters, 2011). In addition to swimming, eating seafood from rivers and lakes contaminated by polluted runoff can also pose a risk to health. Gastrointestinal illness and infection can occur when people eat shellfish from waters contaminated by bacteria, sewage, or excess nutrients that cause toxic algal blooms (Testing the Waters, 2011; Effects of Nitrogen and Phosphorous Pollution). The National Oceanic and Atmospheric Administration (NOAA) reported that CSOs are a significant source of pollution for shellfish beds and fisheries. In fact, NOAA estimated that CSOs were linked to harvest restrictions on nearly 600,000 acres of shellfish beds in 1997 (NOAA, 2002). Shellfish harvesting is prohibited or highly limited in 40 percent of existing harvest areas because of high bacteria levels, primarily due to the presence of urban runoff discharges (Urban Stormwater Management). In the Puget Sound, one harvest area alone lost $3 million in shellfish sales due to forced closures (Booth et al, 2006). An EPA study found the contamination and loss of aquatic species and habitats from polluted stormwater runoff costs the commercial fish and shellfish industry up to $30 million every year (All Stormwater is Local, 2008). Illness and death caused by eating contaminated seafood is estimated to cost local economies an

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
		average of $22 million per year from missed work days, medical expenses, and investigation of the contamination (NOAA Economic Statistics, 2002).
	From Improved Air Quality Trees and vegetative cover improve air quality, which decreases the incidence of respiratory illnesses.	In one study of a metropolitan area of Barcelona, the annual mean health benefits of reducing the mean PM10 exposure estimated for the population in the study area (50mg/m3) to the annual mean value recommended by the World Health Organization (20mg/m3) were estimated to be 3,500 fewer deaths (representing an average increase in life expectancy of 14 months), 1,800 fewer hospitalizations for cardio-respiratory diseases, 5,100 fewer cases of chronic bronchitis among adults, 31,100 fewer cases of acute bronchitis among children, and 54,000 fewer asthma attacks among children and adults. The mean total monetary benefits were estimated to be 6,400 million euros per year. Reducing PM10 to comply with the current European Union regulatory annual mean level (40 mg/m3) would yield approximately one third of these benefits. This study shows that reducing air pollution in the metropolitan area of Barcelona would result in substantial health and economic benefits (Perez et al., 2008). It has also been estimated by Hall et al. (1992) that Los Angeles residents would be willing to pay about $10 billion per year to avoid the medical costs and lost work time from air pollution. While the greater part of pollution is particulates, "the ozone contribution averages about $3 billion/yr. Assuming a proportional relationship of the cost with the amount of smog exceedance, the cooler-surfaced city would save 12% of $3 billion/yr, or $360M/yr" (Akbari, H., 2005). A study in Los Angeles found that every increase in 1°F above 70°F results in a 3% increase in ozone levels, trigger asthma attacks and may even lead to the development of asthma in children (Detwiler, 2012).
Improve Safety	Green spaces increase public presence. More implied or actual surveillance decreases criminal activity.	Proximity to green space has been linked to reduced criminal activity through increased implied and actual surveillance, where people are more likely to be present and active in outdoor spaces. In addition, the presence of green space alleviates conditions that lead to aggressive and violent behavior (Bennett and Wright, 1984; Coleman, 1987; Rhodes and Conley, 1981). While vegetated areas that aren't maintained or that have reduced visibility can be perceived as dangerous, green spaces that are well maintained have proven to have the opposite effect (Kuo and Sullivan, 2001; Kuo et al, 2010).

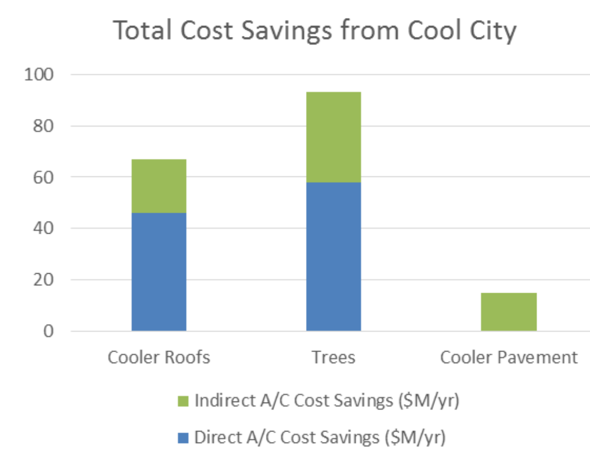
Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
		A study of 2,813 single-family homes in Portland, Oregon found that large trees in lots and in the public right-of-way decreased the occurrence of crime (Donovan and Prestemon, 2010). In Kitchener, Ontario, a community garden was built on the site of a vacant lot at the center of the community. Following the first summer after the garden was built, crime in the immediate area dropped by 30 percent. A few years later, crime had dropped by over 75 percent. Residents stated that the garden created a sense of community, where people spent time outside and socialized with their neighbors (Herod, 2012). One study of 98 apartment buildings in the Ida B. Wells public housing development in Chicago found a significant correlation between the amount of greenery and the number of reported property crimes and violent crime. Buildings that had the most green also had the lowest levels of reported crime (Kuo and Sulilivan, 2001). A corresponding study found that residents who lived in buildings with more vegetation at the Robert Taylor Homes public housing development in Chicago reported less aggression and violence. Mental fatigue and aggression were higher among residents living in buildings without vegetation (Kuo and Sullivan 2001b). There is some evidence to suggest that residential vegetation can act as a territorial marker. Chaudhury (1994) showed front views of houses to students and examined how a host of environmental features affected their ratings of territorial personalization. He found that the presence and maintenance of vegetative features was the strongest predictor of territorial personalization, with an R -squared of .65. Similarly, Brown and colleagues (Brown & Altman, 1983; Brown & Bentley, 1993) found evidence suggesting that plants and other territorial markers make properties less attractive for burglary. We suggest that well-maintained vegetation may constitute a particularly effective territorial marker. Well-maintained vegetation outside a home serves as one of the cues to care (Nassauer, 1988), suggesting that the inhabitants actively care about their home territory and potentially implying that an intruder would be noticed and confronted.

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
		Another mechanism by which vegetation might inhibit crime is through mitigating mental fatigue. S. Kaplan (1987) suggested that one of the costs of mental fatigue may be a heightened propensity for "outbursts of anger and potentially . . . violence" and three proposed symptoms of mental fatigue—irritability, inattentiveness, and decreased control over impulses—are each well-established psychological precursors to violence. Irritability is linked with aggression innumerous studies (e.g., Caprara & Renzi, 1981; Coccaro, Bergeman, Kavoussi, & Seroczynski, 1997; Kant, Smith-Seemiller, & Zeiler, 1998; Kavoussi & Coccaro, 1998; Stanford, Greve, & Dickens, 1995). Inattentiveness has been closely tied to aggression in both children (Stewart, 1985) and adolescents (Scholte, van Aken, & van Leishout, 1997). And, impulsivity is associated with aggression and violence in a variety of populations (for reviews, see Brady, Myrick & McElroy, 1998; Markovitz, 1995; Tuinier, Verhoeven, & Van Praag, 1996). Stamen (1993) surveyed landscaped and nonlandscaped areas in a community and found that the incidence of vandalism or graffiti in sites without plantings was 90% as compared to 10% in sites with plantings.
Increase Property Values	Green spaces increase adjacent property values. Property owners are willing to pay a premium to be located next to or near aesthetically pleasing amenities like water features and green spaces.	Designs that enhance a property's aesthetics are trees, shrubs, and flowering plants that complement other landscaping features. The use of these designs may increase property values or result in faster sale of the property due to the perceived value of the "extra" landscaping. Some stormwater treatment systems can be beneficial to developers because they can serve as a "water" feature or other visual or recreational amenity that can be used to market the property. Several studies including Lacy (1990), Mohamed (2006), U.S. Department of Defense (2004), and Bisco Werner et al. (2001) report that the natural features and vegetative cover of LID can enhance an area's aesthetics, and increase adjacent property values. The U.S. Department of Defense (2004) highlights how LID can improve the aesthetics of the landscape and increase adjacent property values by providing architectural interest to otherwise open spaces. On commercial sites, Bisco Werner et al. (2001) found that LID on commercial sites provided amenities for people living and working in the area and complemented the site's economic vitality, which improved its competitive advantage over similar establishments for customers and tenants.

Benefits: Green Streets		
Impact Category	**Description**	**Literature Review**
		One of the most comprehensive studies of the influence of trees on residential property values was based on actual sales prices for 844 single family homes in Athens, Georgia (Anderson and Cordell 1988). Using regression analysis, each large front-yard tree was found to be associated with about a 1% increase in sales price ($336 in 1985 dollars). This increase in property value resulted in an estimated increase of $100,000 (1978 dollars) in the city's property tax revenues. A much greater value of 9% ($15,000) was determined in a U.S. Tax Court case for the loss of a large black oak on a property valued at $164,500 (Neely 1988). In Southern California a typical large street and park trees are estimated to increase property values by $0.79 and $0.83/ft2 of leaf surface area, respectively ($8.49 and $8.94/m2) (McPherson, 2000).
Increase Jobs	Green infrastructure can reduce a community's infrastructure costs, promote economic growth, and create construction and maintenance jobs.	In a study that examined the job impact of a $188.4 billion investment on greening water infrastructure in the US equally over the next five years shows that this investment would generate $265.6 billion in economic activity (i.e., growth in GDP) and create close to 1.9 million jobs. These figures are in job-years, which is equivalent to one job for one year. In California this means 80,000 more jobs (Gordon et al, 2011).

- ***A.3.2.2. Summary of Quantified Benefits Used for Calculations***

TABLE 41: SUMMARY OF QUANTIFIED BENEFITS USED FOR CALCULATIONS

Green Streets: Quantified Benefits and Literature Used for Calculations		
Impact Category	**Description**	**Literature Review**
Urban Heat Island Mitigation	Indirect energy savings due to a cooler community.	Rosenfeld et. al (1997) estimated that 10 million trees could save a total of 93 million dollars (1997) per year from air conditioning energy savings[16]: **TABLE 14: TOTAL COST SAVINGS FROM A COOL CITY OF LOS ANGELES (ROSENFELD ET. AL, 1997)**  Of those savings, 58 million dollars would come from direct savings due to trees shading residential buildings and reducing air conditioning usage. An additional 35 million dollars would come from indirect savings due to trees helping to reduce the

[16] From Rosenfeld et. al (1998), " 'Direct' savings refer to the cooling effect on individual buildings. 'Indirect' savings refer to cuts in air conditioning load for all buildings as the temperature of the surrounding community drops. The figures assume the planting of 10 million new trees and the lightening of 2,500 square kilometers of roofs and pavement."

		overall temperature of the community, indirectly reducing air conditioning usage in the area. For this analysis, it has been assumed that the majority of the street trees will not be directly shading buildings and therefore, only the indirect energy savings from trees has been included.
	The social cost of carbon associated with the reduction in energy consumption.	Both the energy savings from electricity and the reduced use of natural gas provides a climate change mitigation benefit of avoided greenhouse gas emissions. In the case of McPherson's study, the reduction in 917,000 MWh of electricity consumption equates to over 513,500 tons of carbon dioxide equivalent, amounting to nearly $34 million dollars in costs to society[17].
Sequester Carbon	The value of the carbon sequestered from increased trees and increased vegetative cover.	Annual carbon sequestered from grasses and shrubs has been estimated at .7 metric tons of carbon per acre, per year (Earsom, S., et al., 2010). For trees, according to a report titled "Los Angeles 1-Million Tree Canopy Cover Assessment" by McPherson G. et al., (2008), "over the 35-year planning horizon, the 1 million trees are projected to reduce atmospheric carbon dioxide (CO2) by 764,000 to 1.27 million tons, for the high- and low-mortality scenarios. Emission reductions at power plants associated with effects of the trees on building energy use (498,000 to 772,000 tons) are greater than biological sequestration of CO_2 by the trees themselves (389,000 to 598,000 tons)". This amounts to a social cost of about $0.04 per square feet for grasses and shrubs per year and an average of $0.72 per tree per year[18].
Reduce Air Pollutants	The value of the removal of PM10, NOx, SO2, VOCs, and BVOCs from the environment from tree planting.	According to the South Coast Air Quality Management District (2014) average costs for reduced emissions of: NOx was $80,122 per ton, PM10 was $522,920 per ton, SOx was $404,110 per ton, and of VOCs (ROG) was $19,877 per ton. It is important to note that these benefits are for the trees only and do not include air pollution reduction from the lower-lying vegetation implemented.
Recapture Water	Savings to the city from a reduction in the quantity of imported water from the	LADWP recently examined the economic case for investing in water conservation and found that the savings to its energy budget from importing less water (Bloome, D and Lipkis, P., 2015). Each acre-foot conserved costs $250, compared to the $582 for an acre-foot purchased through Metropolitan Water District (MWD)[19].

[17] Assuming an Emission Factor of 0.00056 short tons CO2e/kWh (Micko, G, 2015) and a Social Cost of Carbon of $57, taken from the Interagency Working Group on Social Cost of Carbon (2013).

[18] Assuming a Social Cost of Carbon of $57 (USD 2007), taken from the Interagency Working Group on Social Cost of Carbon (2013) and an inflation rate of 0.865 for USD 2007 to 2015.

[19] Costs received via email from Glenn Micko, P.E. at LADWP.

	Metropolitan Water District (MWD).	
	The energy embedded in the water that no longer needs to be imported from MWD.	The energy required to supply and distribute groundwater has been calculated at 726 kWh/ac-ft. while the energy required to supply and distribute imported water is 1,566 kWh/ac-ft20. This difference in energy intensity costs LADWP 0.3232 metric tons of CO2 per ac-ft. imported rather than retrieved from local groundwater.
	The social cost of the carbon not emitted due to the lower energy consumption to supply groundwater.	This difference in energy intensity between imported water and groundwater amounts to a social cost of carbon of about $21 per ac-ft. of imported water21.
Reduce Stormwater Treatment Costs	Costs avoided due to improved storm water runoff protection.	According to a report by McPherson, G. et al. (2010), "Stormwater runoff reduction benefits were priced by estimating costs of controlling stormwater runoff and treating sanitary waste in Los Angeles. During small rainfall events, excess capacity in sanitary treatment plants can be used to treat stormwater. In the Los Angeles region, it costs approximately $0.48 per m3 to treat sanitary waste (Condon and Moriarty, 1999). The cost of treating stormwater in central facilities is likely to be close to the cost of treating an equal amount of sanitary waste.
Reduce Flooding	Costs avoided by not having to control floods.	Although storm drains are designed to control 25-year events, localized flooding is a problem during smaller events. Approximately $50 million is spent annually controlling floods in Los Angeles, and the annual value of peak flow reduction is $193,050 per km2 for each 25-year peak flow event (Jones and Stokes Associates, Inc., 1998). A 25-year winter event deposits 170 mm of rainfall during 67 h. Approximately $1.42 per m3 is spent annually for controlling flooding caused by such an event. Water quality and flood control benefits were summed to calculate the total hydrology benefit of $1.90 per m3. This price was multiplied by the amount of rainfall intercepted annually.
Improve Water Quality	Water quality benefit.	Although storm drains are designed to control 25-year events, localized flooding is a problem during smaller events. Approximately $50 million is spent annually controlling floods in Los Angeles, and the annual value of peak flow reduction is $193,050 per km2 for each 25-year peak flow event (Jones and Stokes Associates,

[20] Energy intensities received via email from Glenn Micko, P.E. at LADWP.

[21] Assuming an emissions factor of 0.0056 TCO_2e/kWh for the LADWP and an emissions factor of 0.000466 TCO_2e/kWh for imported water, taken from an email correspondence (Mick, G., 2015) with the LADWP and a Social Cost of Carbon of $57/ TCO_2e, taken from the Interagency Working Group on Social Cost of Carbon (2013).

		Inc., 1998). A 25-year winter event deposits 170 mm of rainfall during 67 h. Approximately $1.42 per m3 is spent annually for controlling flooding caused by such an event. Water quality and flood control benefits were summed to calculate the total hydrology benefit of $1.90 per m3. This price was multiplied by the amount of rainfall intercepted annually.
Avoid Regulatory Fines	Avoided fines born by city departments due to non-compliance with water quality regulations.	Non-compliance with Clean Water Act (Federal) or Porter/Cologne Act (State) through National Pollutant Discharge Elimination System (NPDES) can trigger daily fines from $10,000 to $37,500 depending on the enforcement agency and severity of impact. In addition to daily fines, there could also be per gallon discharged fines. This measure could help avoid these fines, assuming the green spaces are strategically designed to capture significant runoff.
Improve Human Well-being and Associated Medical Costs from Air Quality Improvements.	Value of avoiding respiratory illness from poor air quality.	In a study by Hall et al (1992), the authors conclude, "An assessment of health effects due to ozone and particulate matter (PM10) suggests that each of the 12 million residents of the South Coast Air Basin of California experiences ozone-related symptoms on an average of up to 17 days each year and faces an increased risk of death in any year of 1/10,000 as a result of elevated PM10 exposure. The estimated annual economic value of avoiding these effects is nearly $10 billion. Attaining air pollution standards may save 1600 lives a year in the region."
Aesthetic Value (Create/Improve Habitats, Increase Human Well-being and Property Values)	This value reflects "the economic contribution of trees to property sales prices and retail sales, as well as other benefits such as beautification, privacy, wildlife habitat, sense of place, and psychological and spiritual well-being" (McPherson G. et. al., 2010).	In a report estimating the costs and benefits associated with planting one million trees in Los Angeles, aesthetic benefits "ranged from $1.1 to $1.6 billion, or $31 to $45 per tree per year for the high- and low-mortality scenarios. These amounts reflect the economic contribution of trees to property sales prices and retail sales, as well as other benefits such as beautification, privacy, wildlife habitat, sense of place, and psychological and spiritual well-being" (McPherson G. et. al., 2010).

- ***A.3.2.3. Summary of Quantified Costs Used for Calculations***

TABLE 42: SUMMARY OF QUANTIFIED COSTS USED FOR CALCULATIONS

Green Trees: Quantified Costs and Literature Use for Calculations		
Impact Category	**Description**	**Literature Review**
Construction Costs	Construction costs include demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil and infrastructure.	These costs include: engineering and planning; demolishing and removing existing asphalt or concrete; excavating, small scale to 250CY; hauling and disposal; finish grading; installing curb inlet and/or area drain; installing rip-rap at inlets for energy dissipation; using mulch; doing surface treatments / finishing - soil preparation; doing surface treatments / finishing - mixed BMP vegetation; installing washed pea gravel filter layer; installing washed Pea Gravel forebay; installing drainage/storage rock; tree planting; and contingency (percentage of total capital cost).[22]
Maintenance Costs	This includes ongoing maintenance activities such as pruning, pest and disease control, and irrigation (can be reduced or eliminated if native plants are used).	For the purposes of this study, this is assumed to be 3% of the capital costs of construction[23].
Rehabilitation Costs	Every 15-20 years streets have to be rehabilitated, which includes grinding off old roadway surfaces, resurfacing the pavement with new asphalt, and repairing/replacing curbs where necessary.	For the purposes of this study, rehabilitation of Green Elements is assumed to be 50% of the capital costs of construction, undertaken every 15 years[24].

[22] All costs were taken from the Stormwater Capture Master Plan Costs Development LADWP

[23] Assumptions and costs were taken from the Stormwater Capture Master Plan Costs Development LADWP, Assumptions taken from the "Complex Bioretention" design.

[24] Assumptions and costs were taken from the Stormwater Capture Master Plan Costs Development LADWP, Assumptions taken from the "Complex Bioretention" design.

Increased Liability	As you add trees to sidewalks there is increased liability from injuries and the costs of trip and fall claims and legal staff salaries for tree-related cases increases.	According to a report by McPherson et al. (2000) "annual payments for trip and fall claims and legal staff salaries for tree-related cases averaged $1.81/tree" (McPherson, G. et al., 2000). This is considered an added cost to tree implementation.

A.3.3. Cool Streets

- ***A.3.3.1. Summary of Benefits Associated with Cool Streets***

TABLE 43: SUMMARY OF BENEFITS ASSOCIATED WITH COOL STREETS

Benefits: Cool Streets		
Impact Category	**Description**	**Literature Review**
Urban Heat Island (UHI) Mitigation	Cool Streets reflect radiation which can lower temperatures.	For every 10 to 25% increase in surface reflectance, measured as albedo, surface temperatures could decrease by as much as 1°F (City of Chula Vista, 2012). According to simulations, "a reasonable change in the albedo of the city" – assuming that all roads and roofs are improved - could result in a 1.5K decrease in temperature of the downtown area (Akbari, H., 2005).
Reduce energy consumption.	Cool Streets indirectly reduce energy consumption from reduced air-conditioning use.	Cool pavements indirectly reduce energy consumption by reducing air-conditioning use, both in buildings and vehicles. The increase in air temperature in a UHI is responsible for 5 to 10% of the urban peak electrical demand for air conditioning. On a clear summer day, air temperatures can reach as high as 4.5°F higher than the surrounding rural areas, and the peak urban electrical demand can rise by 2 to 4% for each 1.8°F rise in the daily maximum temperature above a threshold of 59° to 68°F (City of Chula Vista, 2012). In a study by Rosenfeld, et al. (1998), implementing 10 million trees, 1,250 km^2 (about 483 mi^2) of cool roofs and 1,250 km^2 of cool pavements will will directly reduce energy costs by about $100 million and will produce indirect energy savings equal to $70 million. The study estimates that avoided peak power for air conditioning can reach about 1.5 GW – over 15% of the city's air conditioning consumption. From 1930 to 1990, downtown Los Angeles recorded a growth of 1°F per decade. Every degree increase adds about 500 megawatts to the air conditioning load in the Los Angeles Basin (Akbari, 2005).

Benefits: Cool Streets		
Impact Category	**Description**	**Literature Review**
		In Los Angeles, it is estimated that increasing the albedo of 480 sq. miles of pavement by 0.25 would save cooling energy worth $15 million per year (Levinson, 2001). The Heat Island Group projected in 1998 that Los Angeles could save $90 million per year if the city improved albedo of its pavements (Levine, 2011). A 5.4°F reduction of temperatures in Los Angles reduces power demands by 1.6 gigawatts which results in savings of about $175 million per year (based on electricity prices in 1996), of which $15 million is contributed by cool pavements (Cool Roofs Toolkit, 2012).
Reduce greenhouse gas emissions.	Cool Streets indirectly reduce greenhouse gas emissions by reducing energy consumption from air conditioning use.	Reduced energy consumptions due to a reduction in the use of air conditioning in Los Angeles reduce greenhouse gas emissions – particularly by reducing the amount of peak power required, when "dirtier" technologies, such as aging natural gas plants, are brought online to meet demand (Freehling, R. and Doering, S.,2009) . Using the LADWP emissions factor and the social cost of carbon published by the White House, each kWh of electricity consumed in Los Angeles costs society $0.03. Low albedo surfaces – like black asphalt - radiate heat energy directly into the atmosphere, which is then absorbed by the nearest clouds and ends up trapped by the greenhouse effect, contributing to global warming (Chao, 2010).
Reduce smog exceedance levels.	Cool Streets reduce ambient temperatures which reduce the photochemical reaction rate of pollutants that create smog. This reduction in smog also means reduced health related costs from smog.	Smog is created by photochemical reactions of pollutants in the air; and these reactions are more likely to intensify at higher temperatures. For example, in Los Angeles, for every 1°C the temperature rise above 22°C, incident of smog increases by 5% (Akbari, 2005). A study in Los Angeles found that every increase in 1°F above 70°F results in a 3% increase in ozone levels, which have been shown to trigger asthma attacks and may even lead to the development of asthma in children (Detwiler, 2012).

Benefits: Cool Streets		
Impact Category	**Description**	**Literature Review**
		The increase in air temperature in a UHI is responsible for as 20% of the population-weighted smog concentrations in the urban area (City of Chula Vista, 2012). Hall et al. (1992) estimate that Los Angeles residents would be willing to pay about $10 billion per year to avoid the medical costs and lost work time from air pollution. While the greater part of pollution is particulates, ozone contributes on average about $3 billion/yr. A cooler-surfaced city would save 12% of $3 billion/yr, or $360M/yr, assuming a proportional relationship of the cost with the amount of smog exceedance (Akbari, H., 2005). In Los Angeles, it is estimated that increasing the albedo of 480 sq. miles of pavement by 0.25 would reduce smog-related medical and lost-work expenses by $76 million per year (Levinson, 2001).
Reduce Heat-Related Illnesses	Cool Streets reduce heat–related illnesses including, general discomfort, respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality are reduced.	Increased daytime surface temperatures, reduced nighttime cooling, and higher air pollution levels increases the risk of heat-related illnesses, particularly for low income populations, the elderly, and young children with no or limited access to air-conditioning and poor ventilation. Heat–related illnesses include: general discomfort, respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality. Some studies have also suggest that the lack of nighttime relief from hotter temperatures is highly correlated to increased mortality and may be even more significant that maximum day temperatures (U.S. Environmental Protection Agency, 2008). Of all hazard-related deaths in the U.S. between 1970 and 2004, heat and drought top the charts with 19.6%. A total of 7,415 deaths associated with exposure to excessive natural heat occurred in the U.S. from 1999 to 2010. That translates into an average of 618 deaths per year (Cool Pavements for the City of Los Angeles).

Benefits: Cool Streets		
Impact Category	**Description**	**Literature Review**
		Chicago incurred 739 deaths in the heatwave of 1995, in which virtually all deaths occurred on the top floors of buildings with dark roofs (Cool Roofs Toolkit, 2012). The Centers for Disease Control and Prevention calculated that the premature deaths in the US that occur as a result of exposure to extreme heat outnumber total deaths from hurricanes, lightning, tornadoes, flooding, and earthquakes combined (Detwiler, 21012).
Reduce Thermal Shock to Aquatic Life	Cool Streets' cool pavements reduce runoff temperature, resulting in less thermal shock to aquatic life meeting with runoff water.	According to the report *Reducing Urban Heat Islands: Compendium of Strategies* published by the U.S. Environmental Protection Agency (2008), "Pavements with lower surface temperatures—whether due to high solar reflectance, permeability, or other factors—can help lower the temperature of stormwater runoff, thus ameliorating thermal shock to aquatic life in the waterways into which stormwater drains". One study showed that on summer days - when pavement temperatures at midday were 20-35°F above air temperature - runoff from urban areas was about 20-30°F hotter than runoff from a nearby rural area. When rain came before the pavement had a chance to heat up, the runoff temperatures between urban and rural areas differed by less than 4°F (U.S. Environmental Protection Agency, 2008).
Increase Pavement Life	Cool Streets reduce the risk of pavement deformation and pavement weathering with lower ambient temperatures.	At early ages, high temperatures make asphalt softer, increasing the risk for permanent deformation (rutting) (McPherson, 2005). Over time, the increase in pavement temperature causes volatilization of the asphalt binder and oxidization, which results in hardening of the binder, making it more susceptible to raveling and weathering as well as fatigue cracking (Chula Vista, 2012). A rutting experiment performed by Pomerantz, Akbari, and Harvey (2001) whereby asphalt concrete pavement temperature is reduced from 127°F (53°C) to 108°F (42°C) shows a more than 10 fold increase in pavement lifetime. Another rutting

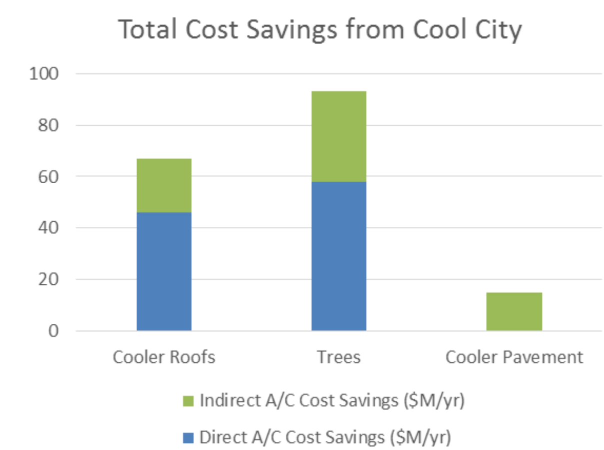
Benefits: Cool Streets		
Impact Category	**Description**	**Literature Review**
		experiment shows that it took 65 times more passes of a truck wheel to rut the pavement when the temperature just below the surface was reduced from 120°F (49°C) to 106°F (41°C). By reducing pavement surface temperatures, the risk of premature asphalt pavement failure from rutting (depressions in the wheelpaths) decreases. This phenomenon occurs when slow heavy trucks or buses pass hot asphalt pavement. According to the Office of Atmospheric Programs of the U.S. Environmental Protection Agency (2008), "Some full-scale testing of a typical asphalt pavement showed that it took 65 times more passes of a truck wheel to rut the pavement when the temperature just below the surface was reduced from 120°F (49°C) to 106°F (41°C)." The risk of concrete pavement to crack is also reduced by decreasing the surface temperatures of the roads (U.S. Environmental Protection Agency, 2008).
Enhance Complete Streets by Visibly Establishing Spaces for Bicycles and Pedestrians	Cool Streets' reflective pavement (different than the streetscape pavement) create visually distinctive bicycle lanes and pedestrian walkways.	
Better Nighttime Visibility	Cool Streets' reflective pavements improve visibility at night, potentially reducing lighting requirements	According to the report *Reducing Urban Heat Islands: Compendium of Strategies* published by the U.S. Environmental Protection Agency (2008), reflective pavements can enhance visibility at night, potentially reducing lighting requirements and saving money and energy. European road designers often take pavement color into account when planning lighting. It takes about 30% more lighting fixtures to have the same amount of lighting on low albedo pavements than high albedo pavements (Riley). The lighter pavement creates a brighter area and a safer environment.

- ***A.3.3.2. Summary of Quantified Cool Street Benefits Used for Analysis***

TABLE 44: SUMMARY OF QUANTIFIED COOL STREET BENEFITS USED FOR ANALYSIS

Cool Streets: Quantified Benefits and Literature Used for Analysis		
Impact Category	**Description**	**Literature Review**
Annual Ozone Related Health Savings	The benefits related savings from ozone due to Cool Streets.	In an article written by Hashem Akbari (2005), the author cites an article by Rosenfeld et al. (1998) that estimates the costs savings of reduced demand for electricity and the value of the externalities avoided by lower ozone concentrations in the Los Angeles Basin. In this study, the benefits from smog improvement from altering the albedo of 1250 km^2 of pavement by 0.25 saves about $76M/year (about 0.01/$ft^2$ per year)."
	The willingness to pay of Los Angeles residents to avoid health related costs from ozone.	Akbari (2005) also cites another study by Hall et al. (1992) that concludes, "residents of L.A. would be willing to pay about $10 billion per year to avoid the medical costs and lost work time due to air pollution. The greater part of pollution is particulates, but the ozone contribution averages about $3 billion/yr. Assuming a proportional relationship of the cost with the amount of smog exceedance, the cooler-surfaced city would save 12% of $3 billion/year, or $360 million/year."
Reduced Energy Consumption	Indirect energy savings due to a cooler community.	Rosenfeld et. al (1998) estimates that 1,250 km^2 of cool pavement (about 483 mi^2) could save a total of 15 million dollars from indirect air conditioning energy savings[25]:

[25] From Rosenfeld et. al (1997), " 'Direct' savings refer to the cooling effect on individual buildings. 'Indirect' savings refer to cuts in air conditioning load for all buildings as the temperature of the surrounding community drops. The figures assume the planting of 10 million new trees; 1,250 square kilometers of cool roofs, and 1,250 square kilometers of cool pavement."

Cool Streets: Quantified Benefits and Literature Used for Analysis		
Impact Category	**Description**	**Literature Review**
		FIGURE 50: TOTAL COST SAVINGS FROM COOLING THE CITY OF LOS ANGELES (ROSENFELD ET. AL, 1998)  These savings are indirect as cool pavements do not directly reduce the temperature of buildings (like shade trees and cool roofs do). Instead, they help to reduce the overall temperature of the community.
Reduced GHG Emission	The social cost of carbon associated with the	Rosenfeld et al. (1997) estimated that 1,250 km^2 (about 483 mi^2) of cool pavement attributes to the indirect energy savings totaling 0.7 billion kWh[26]. This would amount to over 10 million dollars in carbon emissions avoided[27].

[26] From Rosenfeld et. al (1997), Indirect savings refer to reductions in air conditioning demand for all buildings as the temperature of the surrounding area drops. The study assumed the planting of 10 million new trees; 1,250 square kilometers of cool roofs, and 1,250 square kilometers of cool pavement.

[27] Assuming an Emission Factor of 0.00056 short tons CO2e/kWh (Micko, G, 2015); 0.005302 TCO2e/Therm for natural gas (EPA, 2014b); and a Social Cost of Carbon of $57, taken from the Interagency Working Group on Social Cost of Carbon (2013).

Cool Streets: Quantified Benefits and Literature Used for Analysis		
Impact Category	**Description**	**Literature Review**
	reduction in energy consumption.	

- ***A.3.3.3. Summary of Costs Associated with Cool Streets***

Table 45 shows a list of approximate installation and maintenance costs and estimated service life of the different Cool Street treatments currently available according to the U.S. Environmental Protection Agency's *Reducing Urban Heat Islands: Compendium of Strategies*, the follow table:

Table 45: Summary of Costs Sssociated with Cool Streets (U.S. Environmental Protection Agency, 2008)

Costs: Cool Streets			
Basic Pavement Types	**Example Cool Approaches**	**Approximate Installed Cost, $/square foot[28]**	**Estimated Service Life, Years**
New Construction			
Asphalt (conventional)	Hot mix asphalt with light aggregate, if locally available	$0.10–$1.50	7–20
Concrete (conventional)	Portland cement, plain-jointed	$0.30–$4.50	15–35
Nonvegetated permeable pavement	Porous asphalt	$2.00–$2.50	7–10
	Pervious concrete	$5.00–$6.25	15–20
	Paving blocks	$5.00–$10.00	> 20

[28] Some technologies, such as permeable options, may reduce the need for other infrastructure, such as stormwater drains, thus lowering a project's overall expenses. Those savings, however, are not reflected in this table. (1 square foot = 0.09 m^2)

Vegetated permeable pavement	Grass/gravel pavers	$1.50–$5.75	> 10
Maintenance			
Basic Pavement Types	**Example Cool Approaches**	**Approximate Installed Cost, $/square foot29**	**Estimated Service Life, Years**
Surface applications	Chip seals with light aggregate, if locally available	$0.10–$0.15	2–8
	Microsurfacing	$0.35–$0.65	7–10
	Ultra-thin whitetopping	$1.50–$6.50	10–15

[29] Some technologies, such as permeable options, may reduce the need for other infrastructure, such as stormwater drains, thus lowering a project's overall expenses. Those savings, however, are not reflected in this table. (1 square foot = 0.09 m^2)

A.3.4. Complete Streets

- ***A.3.4.1. Summary of Benefits Associated with Complete Streets***

TABLE 46: SUMMARY OF BENEFITS ASSOCIATED WITH COMPLETE STREETS

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
Reduce Energy Consumption	By shifting to modes of travel other than the automobile we reduce energy consumption.	Active transport can provide relatively large energy savings because it tends to substitute for short urban trips that have high emission rates per mile due to cold starts (engines are inefficient during the first few minutes of operation) and congestion. As a result, each 1% shift from automobile to active travel typically reduces fuel consumption 2-4% (Komanoff and Roelofs, 1993). In a study looking at bicycling investments in Portland Oregan, it was found that by 2040, investments in the range of $138 to $605 million in bicycling infrastructure will result in fuel savings of $143 to $218 million (Gotschi, 2011) In a study looking at the annual fuel saving in the US, shifting more short trips to bicycling or walking could amount to 2.4 billion gallons to five billion gallons of fuel. The total savings that would result from improving public transportation by bicycling or walking would result in 100 million to 1.6 billion gallons of fuel a year in the US. (Gotschi and Mills, 2008). In a study looking at monetary benefits from bicycling and walking, fuel saving from shifting short car trips to biking or walking, excluding secondary savings from congestion relief, ranged from $6.2-$17.1 billion per year for the United States. Fuel saving from biking, walking, and public transportation synergy can result in $280 million-$5.6 billion per year for the US. Fuel savings from trip length reduction through mixed use is $1.6-$5.5 billion per year. Fuels saving from secondary savings from congestion relief can range from $1.4-6.8 billion per year for the US (Gotschi and Mills, 2008).

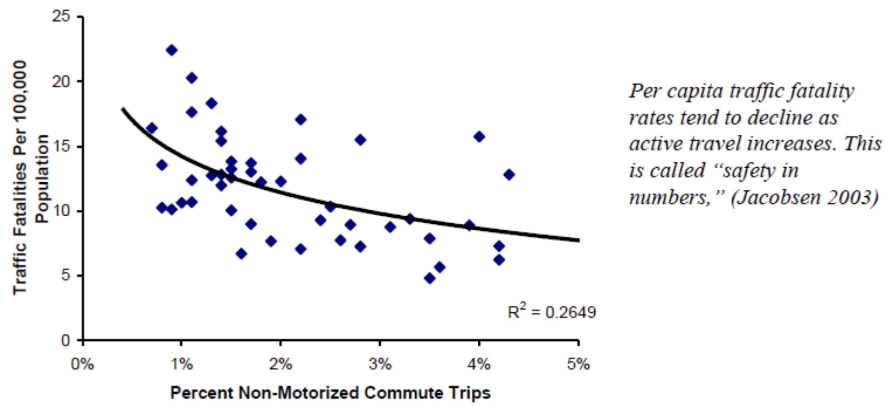
Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
Reduce GHG Emissions	By shifting to modes of travel other than the automobile we reduce GHG.	If each resident of an American community of 100,000 replaced one car trip with one bike trip just once a month, it would cut carbon dioxide (CO) emissions by 3,764 tons of per year in the community. A bicycle commuter who rides five miles to work, four days a week, avoids 2,000 miles of driving a year—the equivalent of 100 gallons of gasoline saved and 2,000 pounds of CO_2 emissions avoided. CO_2 savings of this magnitude reduce the average American's carbon footprint by about 5 percent. (Gotschi and Mills, 2008) According to data used by the Texas Transportation Institute to assess nationwide congestion, for every 1000 miles of driving avoided by public transportation, approximately 9 gallons of fuel and 0 .08 tons of CO2 were saved in 2005 (Shrank et al., 2007). In a study that looked at monetary benefits from bicycling and walking, CO_2 reductions from avoided miles driven, including congestion relief and trip length reduction through induced mixed use was $300million -$2.7 billion per year for the US (Gotschi and Mills, 2008). The total savings that could result from shifting more short trips to bicycling or walking ranges from 21 to 45 million tons of CO_2 a year for the US. The total savings that would result from improving public transportation by bicycling or walking ranges from one million to 14 million tons of CO_2 a year (Gotschi and Mills, 2008). Boulder, Colorado is working to create a Complete Streets network with over 350 miles of dedicated bike facilities, paved shoulders and a comprehensive transit network. Between 1990 and 2003, fewer people in the city drove alone, more people bicycled, and transit trips grew by a staggering 500 percent. The reduction in car trips has cut annual CO_2 emissions by half a million pounds (National Research Center, 2004).

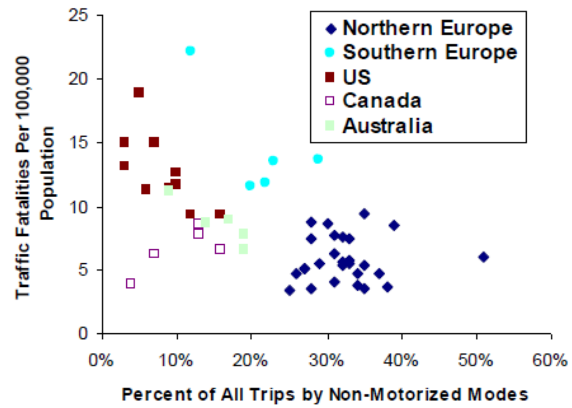
Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
Reduce Pollution	By shifting to more active transport we reduce air, noise and water pollution.	In 2012 there were 57 unhealthy air quality days, when air pollution levels exceeded federal standards. Researchers estimate that air pollution is responsible for more than 7,500 premature deaths per year in the Los Angeles metro area, of which more than 2,000 can be attributed to vehicle emissions alone (Fabio, 2005). Statewide, vehicle emissions result in more than twice as many premature deaths as car crashes. The economic impact of this public health burden is estimated at $22 billion per year in the South Coast Air Basin (in lost days at work, lost days at school, health care, and premature death) (SCAG, 2012). The annual cost of health impacts from air pollution in the South Coast Air Basin is $22 billion (LA Mobility Plan 2035) In greater Los Angeles air pollution from vehicles causes 2,000+ premature deaths per year (LA Mobility Plan 2035) A study from Washington State found that people who work in the most concentrated jobs center – that is, the middle of the city – emit 30% less nitrogen oxides and 20% less carbon dioxide than people who work in areas with lower concentrations of jobs (Lawrence Frank and Co., 2005). Automobile air, noise and water pollution costs are typically estimated to average 2¢ to 15¢ per vehicle-mile, with lower-range values in rural conditions and higher values under congested urban conditions. Relatively high values can be justified to reflect the tendency of walking and cycling to reduce short urban trips (Delucchi 2007; Litman 2009; TC 2008; Vermeulen, et al. 2004). A British study estimates that shifts from driving to active modes provide air pollution reduction benefits of £0.11 (16¢) in urban areas and £0.02 (3¢) in rural areas, with higher values for diesel vehicles (SQW 2007). A reasonable estimate is 10¢ per mile for urban-peak driving, 5¢ for urban off-peak and 1¢ for rural driving (Litman, T., 2013).

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
Improve Safety	Streets without safe places to walk, cross, catch a bus, or bicycle put people at risk. By making transit safe, convenient, and comfortable we reduce traffic injuries and fatalities.	California's overall traffic fatality rate of 0.88 fatalities per 100 million vehicle miles of travel in 2012 is lower than the national average of 1.13. The fatality rate on California's non-Interstate rural roads was 2.61 fatalities per 100 million vehicle miles of travel in 2012, more than four times the fatality rate of 0.63 on all other roads and highways in the state (TRIP, 2013). In the US in 2007, there were 4,654 pedestrian deaths and 70,000 reported pedestrian injuries –- nearly one every eight minutes. In a poll of people over 50 years old, 47 percent said it was unsafe to cross the street near their home. In neighborhoods where traffic is a nuisance and a threat, residents both young and old are more inclined to stay in their homes. (Lynott, 2011) Almost 40% of Americans over the age of 50 say their neighborhoods lack adequate sidewalks, 55% report inadequate bike lanes or paths, and 48% have no comfortable place to wait for the bus (Lynott et al., 2009). These in Complete Streets have deadly results: In 2008, older pedestrians were overrepresented in fatalities; while comprising 13% of the population, they accounted for 18% of the fatalities (National Highway Traffic Safety Administration's National Center for Statistics and Analysis, 2008). Road incidents Analysis by Lovegrove and Litman (2008) using community based, macro level collision prediction models suggests that improving transportation options (better walking and cycling conditions, and improved ridesharing and public transit services) could reduce collision frequency by 14% (total) and 15% (severe). The study suggests that vehicle kilometers traveled (VKT) and safety are so closely correlated that VKT can be used as a proxy for predicting the safety impacts of specific policies and programs.
		One project, in Seattle, Washington, to create Complete Streets along a major arterial, Aurora Avenue, included the installation of new crossings, bus plazas, and redesign of the street. Total crashes dropped by 21 percent. In another, the city redesigned Stone Way North to better accommodate both freight vehicles and bicycles. After the redesign, speeding dropped by 75 percent; bicycle traffic increased by 35 percent, the collision rate for bicyclists declined, and

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		collisions involving pedestrians dropped 80 percent. Peak traffic volumes remained consistent with citywide levels, and no traffic diversion to parallel streets occurred (National Complete Streets Coalition).
		A road diet on Edgewater Drive in Orlando, Florida, which features two travel lanes, a center turn lane, parallel parking, and bicycle lanes, reduced the frequency of crashes involving injuries from every 9 days to once every 30 days (National Complete Streets Coalition).
		In Vancouver Washington, Fourth Plain Boulevard was converted from four lanes with poor provisions for people walking, bicycling, or in wheelchairs into a street with two through lanes, a center turn lane, two bicycle lanes, curb ramps, and improved sidewalks. After this inexpensive treatment, vehicle collisions dropped 52 percent, and the number of crashes involving pedestrians dropped from two per year to zero (National Complete Streets Coalition).
		One study found that designing for pedestrian travel by installing raised medians and redesigning intersections and sidewalks reduced pedestrian risk by 28 percent. Speed reduction has a dramatic impact on pedestrian fatalities. Eighty percent of pedestrians struck by a car going 40 mph will die; at 30 mph the likelihood of death is 40 percent. At 20 mph, the fatality rate drops to just 5 percent (Leaf and Preusser, 1999).
		A recent review of bicyclist safety studies found that the addition of well-designed bicycle-specific infrastructure tends to reduce injury and crash risk. On-road bicycle lanes reduced these rates by about 50% (Conner et al., 2009).
		Marshall and Garrick (2011) found that U.S. cities with higher per capita bicycling rates tend to have much lower traffic fatality rates for all road users than other cities. They conclude that this results, in part, because increased

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		street network density both supports cycling and reduces traffic speeds and therefore risk.
		In Portland, Oregon crash and fatality rates among cyclists significantly decreased since 2011 as the city has expanded its network of bicycle facilities. They also observed a constant growth in bicycling. Between 1991 and 2006, Portland was able to reduce the crash rate by more than 69 percent. In that time period, the number of bicyclists grew more than four fold, while the number of fatalities remained low, between zero and five per year (Gotschi and MIlls, 2008). In a study looking at bicycling investments in Portland Oregan, it was shown that by 2040, investments in the range of $138 to $605 million in bicycling infrastructure will result in savings in value of statistical lives of $7 to $12 billion. (Gotschi, 2011) Various studies indicate that automobile external accident costs on average 2¢ to 12¢ per vehicle-mile, depending on driver and travel conditions and the scope of costs considered. Net safety benefits provided by automobile to active travel shifts are estimated to average 5¢ per urban peak mile, 4¢ per urban off-peak mile, and 3¢ per rural mile, with greater benefits from strategies that reduce walking and cycling risk, for example if active travel increases due to more separated facilities (e.g., sidewalks and paths), traffic speed reductions, improved traffic law enforcement and cycling education (Litman 2009; van Essen, et al. 2007; Transport Canada, 2008).

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		FIGURE 51: TRAFFIC FATALITIES VS. ACTIVE TRANSPORT: US CENSUS (LITMAN, 2013)  **FIGURE 52: TRAFFIC FATALITIES VS. ACTIVE TRANSPORT: KENWORTHY AND LAUBE, 2000 (LITMAN, 2013)**

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		 *Per capita traffic fatalities tend to decline as the portion of active urban travel increases.* Robinson (2005), Geyer, Raford and Ragland (2006), and Turner, Roozenburg and Francis (2006) find that shifts from driving to active modes by sober, responsible adults are unlikely to increase total accidents. Per capita collisions between motorists, pedestrians and cyclists decline as active transport activity increases.
Increase Transportation Capacity	Complete Streets reduce short-distance car trips thereby increasing the street's overall capacity to accommodate more travelers.	Decades of investment in expanding automobile capacity have not succeeded in keeping congestion in check in the United States. Sixty to seventy percent of increased road capacity (additional lane-miles) on state highways in California counties was filled with new automobile traffic within just five years; at the municipal level, 90% was filled over the same period (Hansen and Huang, 1997).
Reduce Congestion	Providing travel choices – walking, bicycling, and public transportation – can reduce the demand for peak-hour travel in	About 44% of all vehicle trips in both congested areas and other areas made during the morning peak are not to work or related to a work trip. Instead, they are for shopping, going to school or the gym, or running errands. Many such trips are short and could be made by walking, bicycling, or taking transit – if the streets are complete. Parents cite traffic as a primary reason for driving children

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
	cars, the principal cause of daily congestion.	to school, yet in doing so, they account for 7 to 11% of non-commuting vehicle traffic during morning rush hour (US Department of Transportation, 2007). Currently, short bicycling and walking trips account for 23 billion miles traveled every year. Modest increases in bicycling and walking modes share of trips three miles or less could double that figure. More substantial increases could yield four times more miles bicycled or walked. Taking into account secondary effects from synergies with public transportation and mixed-use development, modest increases in active transportation could avoid 69 billion miles driven. Substantial increases could lead to 199 billion miles of avoided driving. Congestion directly results from driving exceeding the capacity of road infrastructure. Reducing miles driven therefore helps reduce congestion; in particular when driving is reduced during peak hours. Avoiding miles driven can be much more cost-effective than trying to reduce congestion by expanding highway infrastructure capacity to accommodate increased use (Gotchi, 2008). A major study for the Arizona Department of Transportation analyzed the relationships between land use patterns and traffic conditions in Phoenix, Arizona (Kuzmyak 2012). It found significantly less congestion on roads in older, higher density areas than in newer, lower density suburban areas due to more mixed land use (particularly more retail in residential areas), more transit and nonmotorized travel, and a more connected street grid which provides more route options and enables more walking and cycling. As a result, residents of older neighborhoods generate less total vehicle travel and drive less on major roadways, reducing traffic congestion. Boulder Colorado invested in making its major arterials into Complete Streets that accommodate all transportation modes. While Boulder has grown over the past 10 years, the level of congestion on its streets has stayed steady while bicycling, walking, and transit use has increased. Over 20 years, the city has seen a 7 percent drop in trips taken by single-occupancy vehicles; a bicycle commuting rate that is about 20 times the national average; transit use at twice the national average; and the number of trips made on foot at three times the national average(National Complete Streets Coalition).

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		In Vancouver, BC, One travel lane on Burrard Bridge that had been for automobile use only was reallocated as a bicycle-only travel lane. This simple change resulted in 200,000 additional bicycle rides over this bridge from 2009 to 2010.19 Since the installation of more bicycle lanes, 300,000 more bicycle trips have occurred without significant negative impact for autos and other transit (National Complete Streets Coalition). Various studies estimate that the congestion costs a motor vehicle imposes on other road users average 10¢ to 35¢ per urban-peak vehicle mile, with lower values under urban off-peak and rural travel conditions (Grant-Muller and Laird 2007; Litman 2009; Transport Canada, 2006). SQW (2007) estimates that a traveler shifting from driving to cycling 160 annual trips averaging 3.9 kms reduces congestion costs to other road users £137.28 (£0.22 per km) in urban areas and £68.64 (£0.11 per km) in rural environments. Traffic congestion costs businesses in the San Francisco Bay Area over $2 billion a year due to time employees spend stuck in traffic. The total cost of congestion in the Los Angeles region tops $1.1 billion each year (Local Government Commission Center for Livable Communities).
Reduce Roadway Costs	Investing in Complete Streets reduces roadway construction, maintenance and operating costs.	Roadway construction and maintenance costs are a function of vehicle size, weight, speed, and, in some regions, studded tire use (FHWA 1997). Walking and cycling impose minimal roadway costs and are relatively inexpensive to build and maintain. Providing non-motorized lanes sometimes require wider roads, but bicycle lanes are usually developed using existing road shoulders, parking lanes, or by narrowing traffic lanes. As a result, shifting travel from motorized to active modes generally reduces total roadway costs with roadway facility and traffic service cost savings of approximately 5¢ per mile for urban driving and 3¢ per mile for rural driving, including indirect travel reductions leveraged by active transport improvements (Litman, 2013).
Reduce Parking Cost	Fewer parking spots are needed when fewer people rely on	A typical urban parking space has annualized costs (including land, construction and operating costs) totaling $500 to $3,000. There are estimated to be two to six off-street parking spaces (one residential and two non-residential)

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
	automobiles to get to their destinations.	per motor vehicle (Litman, 2009). Pedestrians only require umbrella stands and coat racks; 10-20 bicycles can typically be stored in the space required for one automobile. In the short run, reductions in automobile travel may simply result in unoccupied parking spaces, but eventually most parking facilities have opportunity costs: reduced parking demand allows property owners to avoid expanding parking supply. They can also rent, sell or convert parking facilities to other uses. Parking costs are not generally affected by trip length, so this cost is measured per trip rather than per mile. Shifting from automobile to active travel is estimated to provide parking savings of \$2-4 per urban-peak trip (a typical commute has \$4-8 per day parking costs), \$1-3 per urban off-peak trip, and about \$1 per rural trip (Litman, 2009).
Provide Option Value	Complete Streets give people different travel options that they currently do not use. Option value refers to the value people may place on having an option available.	An example of an option value is the value ship passengers place on having lifeboats available for emergency use. Because walking and cycling can serve various roles in a transport system, including basic mobility for non-drivers, affordable transport, recreation and exercise, their potential option value is high. The UK Department for Transport developed specific guidance for evaluating option value (Department of Transportation, 2003). The "Transport Diversity Value" chapter of *Transportation Cost and Benefit Analysis* (Litman, 2009) estimates that improvements in affordable alternative modes can be valued at 7¢ per passenger-mile, although this value can vary significantly depending on conditions and assumptions.
Reduce Transportation costs	Transportation expenses are reduced when local infrastructure encourages active transportation, which helps families replace car trips with bicycling,	Households in auto-dependent communities devote 20% of household income more to transportation than communities with Complete Streets. In communities with more transportation options, 14 percent of household income in spent on transportation (Surface Transportation Project, 2003). Households that locate near public transportation drive an average of 16 fewer miles per day compared to a similar household without access to public transportation, which results in hundreds of dollars in savings each year. In fact,

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
	walking, or taking public transit.	a two-person adult household that uses public transportation saves an average of $6,251 annually compared to a household with two cars and no public transportation accessibility (Litman, 2006). In Wisconsin, public transit riders save almost $7 per trip over driving. Because of these individual savings, additional money is invested in the economy, resulting in 11,671 new jobs, $163.3 million in tax revenue, and $1.1 billion in total output (Khalid 2003). Since 2000, rapid bus service in Los Angeles has used a priority signal system that allows buses to extend green lights or shorten red ones. Within the first year of operation, travel time decreased by 25% and ridership increased by more than 30% (Thomas et al., 2003). Improving access to transit also reduces dependence on more costly alternatives, such as paratransit or private transportation services. A calculation by the Maryland Transit Administration found that providing paratransit for a daily commuter costs about $38,500 a year. Basic improvements to a transit stop costs $7,000, the equivalent of just two months' worth of that service for a single rider. More extensive improvements, such as adding a lighted shelter and bench and replacing the sidewalk leading to the stop, costs about $58,000 – just 33% more than providing a single year of paratransit service for one person (Schnider, 2005).
More equitable	Complete Streets allow different populations (children, elderly, and economically, socially or physically disadvantaged people) to fairly use and share in public resources by increasing accessibility,	Studies show that core riders of public transit have relatively low incomes. A comprehensive review of literature finds that low-income people, along with people of color and renters, ride public transit at much greater rates than others (Pollack). Households earning less than $25,000 annually are represented disproportionately among public transit riders (American Public Transportation Association, 2007), and account for over 75% of workers who commute by transit in Los Angeles (LA Housing Dept). In most communities, 20-40% of the population cannot or should not drive due to disability, low incomes, or age. Walking and cycling facility improvements

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
	connectivity, and affordability.	benefit existing users (people who currently walk and bicycle), plus new users (people who walk and bike more due to improvements) (Litman 2004c). Complete Streets provide children with opportunities to walk, bike and play in a safe environment. More children are likely to walk or bike to school when sidewalks or footpaths are present, when there are safe street crossings, and when school zones enforce a reduced vehicle speed. Streets that provide dedicated space for bicycling and walking help kids get physical activity and gain independence. One recent survey found that, while 71% of adults walked or rode their bicycles to school as a child, a mere 17% of their own children currently do so. While 'stranger danger' is often cited as a primary factor, a CDC survey found that traffic-related danger is a more common reason children did not walk to school (Martin and Carlson, 2005). In Illinois, 15% of students who ride the bus to school do so because it is considered too dangerous to walk from home, less than 1.5 miles away (Martin and Carlson, 2005). InComplete Streets limit safe mobility and can breed isolation. As people age, some will stop or limit their driving. More than 50% of older Americans who do not drive stay home on a given day because they lack transportation options. Older Americans make just 6% of their trips on foot or bike – far less than in some European countries, where adults over the age of 65 use these active modes for about half of all trips. Non-driving seniors make 65% fewer trips to visit family, friends or go to church; many report they do not like to ask for rides (Pucher, and Dijkstra, 2005).
Reduce Chauffeuring Burdens	With different travel options chauffeuring burdens are reduced.	Chauffeuring is particularly inefficient because it often requires empty return trips, so transporting a passenger 5 miles generates 10 vehicle-miles. Improving alternative modes can reduce chauffeuring burdens, saving driver travel time, vehicle operating costs, external costs, and increasing non-drivers' independence. Although data are limited, chauffeuring appears to represent

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		about 10% of total vehicle trips (Transport for London, 2011); this is probably higher in automobile-dependent communities, and lower in multi- modal communities where adolescents, people with minor impairments, and people who cannot afford to own a motor vehicle have good mobility options. Reduced chauffeuring benefits include vehicle cost savings, driver travel time savings that are typically estimated at 30-50% of average wage rates, and reduced external costs (congestion, accident risk and pollution). Assuming that a typical chauffeuring trip involves 5 miles of vehicle travel at 25¢ per mile in vehicle costs, and 20 minutes of travel time valued at $9.00 per hour, this totals $4.25 per trip or $0.85 per vehicle-mile (Litman, 2014).
Improve User Travel Experience.	Complete Streets increase convenience, comfort, safety, accessibility and enjoyment of travel.	Litman, T. (2013) states that user benefits "can be worth as much as $0.50 per user-mile (i.e., one person walking or bicycling one mile under improved walking and cycling conditions) where walking and cycling conditions improve from very poor to very good, based on evidence from hedonic pricing studies and avoided cost analysis (such as savings to parents who avoid the need to chauffeur children to school). In most cases, NMT improvement user benefits will be somewhat smaller, perhaps $0.25 per passenger-mile."
Create more "liveable" communities	Residents of walkable/bikeable communities are more likely to be socially engaged and trusting, and they report being in good health and happy more often. These areas tend to be more secure because many strategies for improving walking and cycling conditions can increase security.	Walkable/bikable communities increase security by directly increasing security patrols and trimming landscaping, and indirectly by increasing the number of responsible (non-criminal) people on sidewalks and paths, which increases passive surveillance (more people ready to report threats). Furthermore a variety of transportation options allow everyone – particularly people with disabilities, older adults, and children – to get out and stay connected to the community. In San Diego, where a number of Complete Streets policies are in place, the La Jolla neighborhood saw its namesake boulevard become vibrant and alive, with pedestrians, bicyclists, and shoppers. Despite the economic meltdown, the street is outperforming on every factor, from numbers of bicyclists and pedestrians to number of smiles (Mason, 2007).

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		Contrary to popular assumptions, per capita crime rates tend to decline in more compact, mixed, walkable communities, probably due to a combination of improved surveillance, better policing and emergency response, and improved economic opportunity for at-risk residents (Litman, 2013).
Improve Health and Fitness	By encouraging active transport peoples' health and fitness levels improve.	A 2004 analysis found that each additional hour spent in a car per day was associated with a six percent increase in the likelihood of obesity (SCAG, 2012). Residents of multi-modal communities exercise more and are less likely to be overweight than in automobile-oriented communities (Ewing, Schieber and Zegeer 2003; Frank 2004). A comprehensive study of walkability has found that people in walkable neighborhoods did about 35-45 more minutes of moderate intensity physical activity per week and were substantially less likely to be overweight or obese than similar people living in low-walkable neighborhoods (Sallis et al., 2009). One study found that 43% of people with safe places to walk within 10 minutes of home met recommended activity levels; among those without safe places to walk just 27% met the recommendation (Giles-Corti, and Donovan, 2002). Residents are 65% more likely to walk in a neighborhood with sidewalks (Sallis et al, 2009). Analysis of 11,041 high- school students in 154 U.S. communities found that their odds of being overweight or obese decreased if they lived in more walkable communities (Slater, et al. 2013). Increased walking appears to reduce long-term cognitive decline and dementia (Erickson, et al. 2010). A major ten-year study found that the overall health of residents of new housing developments improved when their daily walking increased as a result of more access to parks, public transport, shops and services (Giles-Corti, et al. 2013). Rojas-Rueda, et al. (2011) quantified the overall health impacts to users from shifting urban driving to cycling, including changes in accident risk, pollution exposure and public fitness. The study concluded that Barcelona's public bike

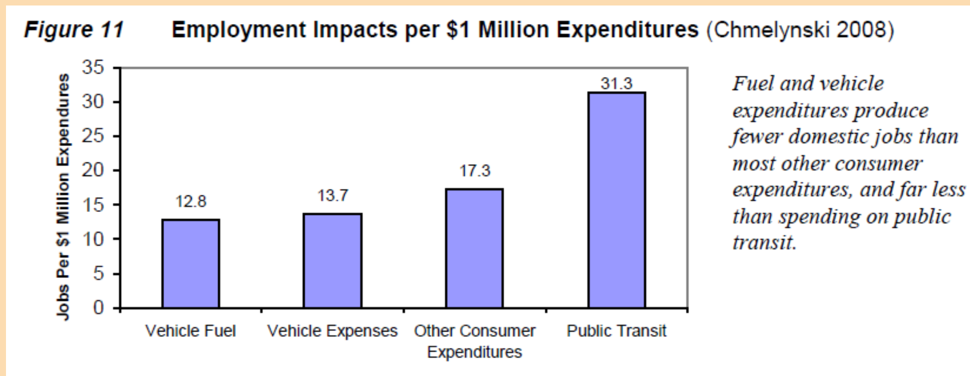
Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		rental system causes 0.03 additional annual traffic accident deaths, 0.13 additional air pollution deaths, and 12.46 fewer deaths from improved fitness, resulting in 12.28 deaths avoided and a 77 benefit/risk ratio. This does not account for the additional health benefits from reduced accident risk and reduced air pollution exposure to other residents. The authors conclude that public bicycle sharing schemes can help improve public health and provide other benefits. Grabow, et al. (2011) estimated changes in health benefits and monetary costs if 50% of short trips were made by bicycle during summer months in typical Midwestern U.S. communities. Across the study region of approximately 31.3 million people, mortality is projected to decline by approximately 1,100 annual deaths. The combined benefits of improved air quality and physical fitness are estimated to exceed $7 billion/year. These findings suggest that significant health and economic benefits are possible if bicycling replaces short car trips. Guo and Gandavarapu (2010) conclude that the incremental costs of residential sidewalk construction are usually repaid by the health benefits of increased physical fitness and reduced vehicle air pollution. They estimate that building sidewalks on all city streets would increase average daily active travel 0.097 miles and reduce automobile travel 1.142 vehicle-miles per capita. The increased walking and cycling provide 15 kcal/day per capita in average additional physical activity, predicted to offset weight gain in about 37% of residents, providing substantial healthcare cost savings. Rabl and de Nazelle (2012) estimate the health impacts caused by shifts from car to bicycling or walking, considering four effects: changes in physical fitness and ambient air pollution exposure to users, reduced pollution to other road users, and changes in accident risk. Switching from driving to bicycling for a 5 km one-way commute 230 annual days provides physical activity health benefits worth 1,300 € ($1470) annually and air emission reduction worth 30 €/yr ($34/yr) overall. The commuter that switches mode bears additional air pollution costs averaging 20 €/yr ($23/yr), but this impact depends on cycling conditions; cyclists' pollution exposure can be reduced if they ride separated from major

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		roadways. Data from Paris and Amsterdam imply that any increase in accident risk is at least an order of magnitude smaller than physical activity health benefit. Cavill, Cope and Kennedy (2009) estimated that an integrated program that increases walking in British towns provides benefits of reduced mortality worth £2.59 ($4) for each £1.00 ($1.6) spent. Including other benefits (reduced morbidity, congestion and pollution) would increase this value. The Department for Transport found even higher economic returns (Department of Transportation, 2010). In a study looking at the monetary value of bicycling and walking, health cost reduction increase in physical activity among those who do not currently meet recommended levels could range between $420 million to $28 billion/year for the US (Gotschi and Mills, 2008) In a study looking at bicycling investments in Portland Oregan, it found that by 2040, investments in the range of $138 to $605 million in bicycling infrastructure will result in health care cost savings of $388 to $594 million, and savings in value of statistical lives of $7 to $12 billion (Gotschi, 2011). Sælensminde (2002) estimates that each physically inactive person who starts bicycle commuting provides €3,000-4,000 ($3400-4500) annual economic benefits. Meta-analysis by de Hartog, et al. (2010) indicates that people who shift from driving to bicycling enjoy substantial health benefits (3 to 14 month longevity gains), plus additional benefits from reduced air pollution and crash risk to other road users.
Improve Economy	**Increase regional economic growth** Shifts spending from vehicles and fuel to goods with increased regional value	People living in Dallas, TX save an average of $9,026 annually by switching from driving to taking transit, and those in Cleveland, OH save an average of $9,576 (American Public Transportation Association, 2012). The total savings from biking, walking, or taking transit instead of driving can really add up across a city, ranging from $2.3 billion in Chicago (CEOs for Cities, 2008) to an astounding $19 billion a year in New York City (CEOs for Cities, 2010). This "green dividend" means that residents can spend that money in other ways, such as housing,

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		restaurants, and entertainment, that keep money circulating in the local economy. It's not just big cities that see these impacts: in Wisconsin, economic benefits from public transit alone are $730 million. In Wisconsin, public transit riders save almost $7 per trip over driving. Because of these individual savings, additional money is invested in the economy, resulting in 11,671 new jobs, $163.3 million in tax revenue, and $1.1 billion in total output. (Wisconsin Dept. of Transportation, 2003).
	Increase retail and tourism Store traffic is increased with pedestrian, bicycle, and public transit traffic. Tourism also increases in pedestrian, bicycle, public transit friendly areas.	Local businesses see many benefits in improving access to people traveling by foot or bicycle. When a bike lane was added along Valencia Street in San Francisco's Mission district, nearby businesses saw sales increase by 60 percent, which merchants attributed to increased pedestrian and bicycle activity (National Complete Streets Coalition, 2012). Similarly, a study in Toronto showed that nearly three-quarters of merchants along Bloor Street expected that better bicycle and pedestrian facilities would improve business (The Clean Air Partnership, 2009). In Washington, D.C., design improvements along a three-quarter mile corridor in Barracks Row, including new patterned sidewalks and traffic signals, helped attract 44 new businesses and 200 new jobs, along with increases in sales and foot traffic (Barracks Row Main Street, 2005). Lancaster, California added pedestrian safety features as part of a downtown revitalization effort, including a pedestrian-only plaza, wider sidewalks, landscaping and traffic calming. The project spurred $125 million in private investment, a 26% increase in sales tax revenue, and 800 new jobs, after a public investment of $10.6 million (National Complete Streets Coalition, 2012). In Mountain View, California, the addition of space for sidewalk cafes and a redesign of the street for pedestrians were followed by private investment of $150 million, including residential, retail and offices, resulting in a vibrant downtown destination (Local Government Commission Center for Livable Communities). Clifton, et al (2012 and 2013) found that shoppers who arrive walking, cycling or public transport tend to spend less per trip but make more trips per month and so spend more in total than automobile shoppers. In a survey of urban retail business owners, Drennen (2003) found that 65% consider a local traffic calming program to provide overall economic benefits and support program expansion, compared with 4% that consider it overall negative. Conversion of San Francisco's Central

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		Freeway into pedestrian- and bicycle-friendly Octavia Boulevard significantly increased local commercial activity and property values (CNU 2009). In terms of parking spaces bicycle parking is space efficient it generates about five times as much spending per square meter as automobile parking (Lee and March 2010). Portland benefits $90 million per year from their bicycling industry (Alta Planning + Design, 2008), and the state of Colorado reaps a benefit of over $1 billion each year from bicycle manufacturing, retail, and tourism (Colorado Department of Transportation). In some areas, such as the northern Outer Banks of North Carolina, bicycle facilities partly drive tourism. A 2003 economic impact analysis of a bicycle trail system in this area focused on economic benefits such as tourist spending on food, lodging, and entertainment.5 Data were gathered through user surveys and bicycle traffic counts to estimate the amount of money that tourists spent during a visit, the total number of tourists, and the proportion of tourists for whom bicycling was an important reason for the visit. The researchers found that, annually, approximately 68,000 tourists visited the area at least partly to cycle. This led to an estimate that $60 million in tourism spending and multiplier effects came to the area in relation to the bikeways, and supported approximately 1,400 jobs (Lawrie et al., 2006).
	Increase property values Transit rich areas increase the property values of surrounding areas.	Tu (2000) found 11% higher property values in New Urbanist neighborhoods compared with otherwise similar homes in conventional, automobile-dependent communities. In a survey of 15 real estate markets from Jacksonville, Florida to Stockton, California a one-point increase in the walkability of a neighborhood as measured by WalkScore.com increased home values by $700 to $3,000 (CEOs for Cities, 2009). For neighborhoods in the Washington, D.C. region, becoming one step more walkable on a five-point scale can add $9 per square foot to retail rents and nearly $82 per square foot to home values (Leinberger, 2012). Buchanan (2007) found that residential property values are 5.2% higher and retail rents 4.9% higher in more walkable London neighborhoods. Song and Knaap (2003) found that, all else being equal, house values are 15.5% higher in walkable neighborhoods. Eppli and Cortright (2009) found that a one-point Walkscore increase is associated with a $700 and $3,000 increase in home resale

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		value, so a 10-point increase raises annualized housing costs approximately $350-$1,500. Pivo and Fisher (2010) found that office, retail and apartment values increased 1% to 9% for each 10-point WalkScore increase. Assuming a 10-point Walkscore increase causes average daily walking to increase one-mile per household (0.4 miles per capita), this indicates that consumers willingly pay $1 to $4 in higher housing costs per additional mile walked. Similar impacts are found in Canadian cities. In Calgary, Alberta found that between 2000 and 2012 the neighborhoods with the greatest home price increases were in or near the city's core with higher walkscore (Toneguzzi 2013). This increase is amplified when walkable neighborhoods are near each other, demonstrating the value of networks of Complete Streets connected throughout a community (The Brookings Institution, 2012). Of course, the positive correlation between WalkScore and property values may partly reflect other factors such as land use density, transit accessibility, and employment access. The preference for walkable neighborhoods is likely to increase in coming decades, as today's young college graduates flock to downtowns and close-in suburbs. The population of college-educated 25 to 34 year olds in these walkable neighborhoods has increased by 26% in the last decade, creating a workforce that can further add to economic growth in these communities (CEOs for Cities, 2005).
	Increase jobs With increased tourism more jobs are created. Furthermore, bicycle lane and pedestrian only projects create more jobs per spending than roadway projects.	Better bicycle infrastructure can create jobs directly. Cycling adds over $556 million and 3,400 jobs to Wisconsin's economy through increased tourism, bicycle manufacturing, sales and repair, bike tours, and other activities (Bicycle Federation of Wisconsin). Analysis by Garrett-Peltier (2010) found that a $1 million spent on bike lanes directly creates 11.0 to 14.4 jobs, compared with approximately 7.8 jobs created by the same expenditure on roadway projects. Pedestrian-only projects create an average of about 10 jobs per $1 million and multi-use trails create nearly as many, at 9.6 jobs per $1 million. Infrastructure that combines road construction with pedestrian and bicycle facilities creates slightly fewer jobs for the same amount of spending.

Benefits: Complete Streets		
Impact Category	**Description**	**Literature Review**
		FIGURE 53: EMPLOYMENT IMPACTS PER 1 MILLION EXPENDITURES (LITMAN, 2013) 

- ***A.3.4.2. Quantified Complete Street Benefits Used for Analysis***

TABLE 47: QUANTIFIED COMPLETE STREET BENEFITS USED FOR ANALYSIS

Complete Streets: Quantified Benefits and Literature Used for Calculations		
Impact Category	Description	Literature Review
Reduce Energy Consumption	Economic and environmental benefits from reduced energy consumption.	The external costs of petroleum consumption are estimated to be about $0.01 to $0.04 per vehicle-mile. They could however, be higher if externalities from extraction were considered in the calculation. Active transport is highly effective in reducing energy because it tends to substitute for short trips that are the most inefficient use of energy due to cold starts and congestion. (Litman, 2015)
Reduce Pollution	Economic and environmental benefits from reduced air, noise and water pollution.	In a report by Litman (2015), the author notes that "some pollutants, such as noise, carbon monoxide and particulates, have local impacts so their costs vary depending on where emissions occur, while others, such as ozone, methane and carbon dioxide, have regional and global impacts… automobile air, noise and water pollution costs are typically estimated to average 2¢ to 15¢ per vehicle-mile, with lower-range values in rural conditions and higher values under congested urban conditions, but relatively high values can be justified to reflect the tendency of walking and cycling to reduce short urban trips". The study estimates that the benefits form shifting from automobiles to active transports is $0.10 per urban-peak mile and $0.05 per urban off-peak mile.
Improve Safety	Increased safety for active travel conditions due to reduced traffic speeds and volumes.	Automobile external accident costs average $0.02 to $0.12 per vehicle-mile depending on scope of costs considered and the conditions. Net safety benefits provided by shifting from automobiles to active transport modes is estimated to be $0.05 per urban peak mile and $0.04 per urban off-peak mile. These benefits are increased if infrastructure promotes safety, such as separate paths for bikers and walkers, and infrastructure to reduce traffic speeds. (Litman, 2015).
Reduce Congestion	Reduced traffic congestion from automobile travel on congested roadways.	It is possible that bicycle and pedestrian traffic can increase congestion by increasing wait times at crosswalks and if the streets are narrow. However, Litman (2015) concludes that "reductions in urban-peak automobile travel tend to reduce traffic congestion. Various studies estimate that the congestion costs a motor vehicle imposes on other road users average 10¢ to 35¢ per urban-peak vehicle mile, with lower values under urban off-peak and rural travel conditions."

Complete Streets: Quantified Benefits and Literature Used for Calculations		
Impact Category	Description	Literature Review
Reduce Roadway Costs	Complete Streets reduce infrastructure costs by requiring far less pavement per user; this saves money at the onset of the project and reduces maintenance costs over the long-term.	Walking and cycling impose minimal roadway costs compared to vehicles. With increased use of active transport modes, facility and traffic services benefits are estimated to be $0.05 per urban mile (Litman, 2015). Neighborhood streets built in a grid to serve all users reduce the need for wide automobile lanes and complex intersections, and can lower infrastructure costs 35-40% compared to conventional suburban development (National Complete Streets Coalition).
Reduce Parking Cost	Reduced parking problems and facility cost savings. Reduction in road and parking facility land requirements.	People who switch from automobiles to active transport modes will benefit from paying less in parking fees annually. These benefits are estimated at $2 to $4 per urban peak trip and $1 to 3 per urban off-peak trip (Litman, 2015). In the short run, an increased use of active transport modes will result in an increase in unused parking spaces; however, in the medium and long run, building developers can design buildings with less parking spaces and current buildings can rent or reuse existing parking spaces for other purposes. Litman (2015) calculates these benefits to be $0.01 per urban peak mile and $0.005 urban off-peak mile.
Provide Option Value	Benefits of having mobility options available in case they are ever needed.	In the “Transport Diversity Value” chapter of the paper “Transportation Cost and Benefit Analysis”, Todd Litman (2009) argues that improvements in affordable alternative modes of transport is estimated to be valued at $0.07 per passenger-mile. This value, however, can vary significantly depending on conditions and assumptions made.
Reduce Transportation costs	Consumer savings from reduced vehicle ownership and use due to increased active travel.	Vehicle costs are estimated to be $0.10 and $0.15 per vehicle-mile for operating costs (fuel, oil, tire wear) and $0.05 to $0.15 per vehicle-mile for mileage depreciation, repair costs, and lease fees (Litman, 2015). These costs become costs avoided for every vehicle mile transferred to an active transport mode. Vehicle costs savings can increase if certain users reduce their car ownership due to an availability of other forms of transportation.
More equitable	Benefits to low-income and socially or physically disadvantaged people.	Todd Litman (2015) states that Equity Benefits should be estimated at half of the Diversity Benefits (see “option value” above) and should be considered higher if “a project significantly benefits disadvantaged people”. As an explanation of the valuation of Equity Benefits, Litman states, “Transit subsidies can indicate

Complete Streets: Quantified Benefits and Literature Used for Calculations		
Impact Category	Description	Literature Review
		society's willingness-to-pay to provide basic mobility for non-drivers. Such subsidies average about 60¢ per transit passenger-mile, about half of which are justified to provide basic mobility for non-drivers (the other half is intended to reduce congestion, parking and pollution problems), indicating that basic mobility is worth at least 30¢ per passenger-mile to society".
Reduce Chauffeuring Burdens	Reduced chauffeuring responsibilities due to improved travel options	In the paper "Evaluating Transit Benefit and Costs", Todd Litman (2015), "poor walking and cycling conditions increases chauffeuring trips (special trips made to transport a non-driver) which often include empty backhauls, which also add congestion". Litman estimates that the value of reduced responsibilities due to improved transport options is $0.07 per reduced motor vehicle-mile at peak traffic hours and $0.06 per reduced motor vehicle-mile at non-peak hours. It is estimated that roughly 10% of trips are chauffeured. This percentage is likely higher in automobile-dependent cities, like Los Angeles (Litman, 2015).
Improve User Travel Experience.	Increased user convenience, comfort, safety, accessibility and enjoyment.	Litman, T. (2013) states that user benefits "can be worth as much as $0.50 per user-mile (i.e., one person walking or bicycling one mile under improved walking and cycling conditions) where walking and cycling conditions improve from very poor to very good, based on evidence from hedonic pricing studies and avoided cost analysis (such as savings to parents who avoid the need to chauffeur children to school). In most cases, NMT improvement user benefits will be somewhat smaller, perhaps $0.25 per passenger-mile."
Improve Health and Fitness	Improved public fitness and health.	The New Zealand Transport Agency's Economic Evaluation Manual provides monetary values for active transport of $0.0002 per mile on bicycle and $0.0005 per mile on foot[30]. It assumes that "half of the benefit is internal to the people who increase their activity level by walking or cycling, and half are external benefits to society such as hospital cost savings" (Litman, 2009). It is important to note that higher values for health and fitness "may be justified if an unusually large number of users would otherwise be sedentary" (Litman, 2015).

[30] Note, for this analysis, the average of the benefits for biking and walking were used.

- ***A.3.4.3. Complete Street Costs and Literature Review***

TABLE 48: COMPLETE STREETS COSTS AND LITERATURE REVIEW

Costs: Complete Streets		
Cost	**Description**	**Literature Review**
Construction Costs	The planning and construction cost associated with implementing the Complete Street elements.	The San Diego region has been integrating small improvements for pedestrians, bicyclists, and transit users into its street network since the continuation of a transportation sales tax with a Complete Streets provision in 2004, and the city has followed suit. For example, the addition of a midblock crossing cost only $20,000 but it provided residents in a lower-income neighborhood safe access to their only park. Andy Hamilton, president of Walk San Diego, said the project "made a huge difference calming traffic for two blocks, giving a whole neighborhood better access to its park." Another low-cost solution was also funded through that sales tax money. Coming in at just $4,500, a project at the 50th and University Avenue intersection enhanced safety and calmed traffic through the application of paint and the installation of a few bollards (National Complete Streets Coalition). New York City was able to improve safety with many low-cost solutions that reduced fatalities and pedestrian crashes in almost all improved areas from 9 percent to as much as 60 percent. Traffic fatalities have fallen to an all-time low. Targeted spending to install low-cost features to make walking safer included the creation of 35 pedestrian refuge islands, 55 new left turn lanes to better manage traffic, 12 curb extensions to shorten crossing distances, eight median tip extensions to provide safer crossings, and four pedestrian fences to encourage pedestrians to use crosswalks. Six hundred intersections now allow more time to cross the street (National Complete Streets Coalition). On a recent reconstruction project, in Redding California, the city invested in low-cost treatments to improve pedestrian safety and comfort: six curb extensions and two refuge islands. The total cost of these elements, $40,000, represented just 13 percent of the overall project budget (National Complete Streets Coalition).

Costs: Complete Streets		
Cost	**Description**	**Literature Review**
		In Charlotte, North Carolina simple road conversions—converting a four-lane undivided roadway into two travel lanes, a center turn lane, and two bicycle lanes—costs the city about $250,000–$300,000 when done in conjunction with resurfacing. Approximately 15 percent of that cost, or $40,000–$50,000, can be attributed to conversion elements. The Charlotte Department of Transportation has found that routinely narrowing travel lanes when appropriate from 12 feet to 11 feet can save about 2 percent of project costs (National Complete Streets Coalition). In Brown County, Wisconsin the county highway department built a three-lane street with two bicycle lanes on the existing four-lane roadway and replaced expensive traffic signals with roundabouts. These changes saved the county $347,515—16.5 percent below the original project estimate (National Complete Streets Coalition). In implementing Complete Streets, Charlotte, North Carolina has found that project costs vary greatly by adjoining land use, terrain, and the need to purchase right-of-way. For example, the city runs a program to improve rural, farm-to-market roads to serve new development, which can include installation of curbs and gutters, stormwater drainage, roundabouts, turn lanes, medians, bicycle lanes, sidewalks, and other necessary infrastructure. Such projects can cost as little as $6 million per mile or double that. New arterials can cost the city $5 million per mile or up to twice that amount. The costs that can be attributed to Complete Streets features on these projects are relatively small, 4–8 percent of total project costs, but add high value and are simply part of the highly variable mix of project costs (National Complete Streets Coalition). Higher visibility crosswalks cost $1,000 to $5,000, depending on the design technique. Median barriers cost approximately $15,000 to $25,000. Roundabouts cost approximately $30,000 to $70,000 each. Traffic circles cost approximately $5,000 to $10,000 each. Curb extensions costs $7,000 to $10,000.

Costs: Complete Streets		
Cost	**Description**	**Literature Review**
		Speed humps cost approximately $2,000 to $2,500 each. (Minimum $6,000 for a series) (City of Rancho Palos Verdes, CA)
Maintenance Costs	The cost of maintaining the Complete Street elements.	
Rehabilitation Costs	Every 15-20 years streets have to be rehabilitated, which includes grinding off old roadway surfaces, resurfacing the pavement with new asphalt, and repairing/replacing curbs where necessary.	
Equipment Costs	The cost of bike ownership and appropriate walking shoes.	Bikes are estimated to cost $0.05 per walk-mile and walking shoes cost $0.10 per walk-mile (Litman, T. 2015).
Vehicle Traffic Impacts	The cost of incremental delays to motor vehicle traffic or parking.	Travel time is one of the largest transportation costs. Since walking and cycling tend to be slower than motorized modes, they are sometimes considered inefficient and costly. However, this is not necessarily true. Measured door-to-door, active travel is often time competitive for short trips: for walking up to a half-mile, which represents about 14% of total personal trips, and for cycling up to three miles, which represents about half of total trips (Dill and Gliebe 2008; Litman 2010). Transport planning that improves pedestrian and cycling connectivity, and land use planning that creates more compact, mixed development increases the portion of trips for which active modes are time-competitive. Travel time unit costs (cents per minute or dollars per hours) vary significantly depending on conditions and preferences (Litman 2009; Mackie, et al. 2003). Under favorable conditions, walking and cycling time has low or negative costs; users considered time spent on this activity a benefit rather than a cost, because it is enjoyable and provides exercise which reduces the need to spend special time exercising. Users will choose these modes even if they take longer than driving (Björklund and Carlén 2012). Because walking and cycling are inexpensive travel modes, their *effective speed* (travel time plus time spent earning money to pay for transport) is often faster than driving (Tranter 2004). These factors are highly variable. A person may one day prefer walking and another day prefer driving. If people have high quality walk and cycling

Costs: Complete Streets		
Cost	**Description**	**Literature Review**
		conditions they can choose the mode they consider best overall, taking into account all benefits and costs.
Gentrification	The social cost of possibly displacing low-income families and small businesses. Complete Streets increases property values which can displace low-income families and small businesses if the health and economic stability of current residents is not considered.	

- ***A.3.3.3. Quantified Complete Street Costs Used for Analysis***

Table 49: Quantified Complete Street Costs Used for Analysis

Complete Streets: Quantified Costs and Literature Used for Calculations		
Cost	Description	Literature Review
Construction Costs	The planning and construction cost associated with implementing Complete Street elements.	These costs include: These costs include: engineering and planning (percentage of total capital cost); demolishing and removing existing asphalt or concrete; excavating; hauling; using concrete slab on grade, 6"; concrete curb and gutter; constructing bike lanes, installing bike parking; constructing curb extensions; building center medians; installing mid-block pedestrian crossings; and contingency planning.[31]
Maintenance Costs	The cost of maintaining the Complete Street elements.	For the purpose of this study, maintenance in the BAU2 case is assumed to be zero above and beyond normal maintenance of the streets and sidewalks constructed in this case. In the BAU1 case, this is assumed to be 3% of the capital costs of construction of the Complete Street elements[32].

[31] All costs were taken from the Stormwater Capture Master Plan Costs Development LADWP and Litman, T. (2015)

[32] Assumption was taken from the Stormwater Capture Master Plan Costs Development LADWP following the assumptions for permeable pavement with run-on.

Rehabilitation Costs	The cost of rehabilitating the Complete Street elements.	For the purpose of this study, rehabilitation in the BAU2 case is assumed to be zero above and beyond normal maintenance of the streets and sidewalks constructed in this case. In the BAU1 case, rehabilitation of the Complete Street elements is assumed to cost 70% of the capital costs of construction, and is done every 20 years[33].
Equipment Costs	The cost of bike ownership and appropriate walking shoes.	Bikes are estimated to cost $0.05 per walk-mile and walking shoes cost $0.10 per walk-mile (Litman, T. 2015).

[33] Assumption was taken from the Stormwater Capture Master Plan Costs Development LADWP following the assumptions for permeable pavement with run-on.

Appendix 4: Economic Analysis: Economic Calculation

Please see the attached excel files for the detailed economic analysis undertaken in this study.

Appendix 5: Sensitivity Analysis

In order to confirm the sensitivity of this analysis to the assumptions chosen, several variables were subjected to a sensitivity analysis in order to determine the results' sensitivity to these numbers.
The study uses a discount rate of 4% as instructed by the Caltrans for Life-Cycle Cost Analysis of pavement structures (State of California, Department of Transportation, Pavement Standards Team & Division of Design, 2010). In order to determine the effect that the discount rate has on the results, a sensitivity analysis was done using two additional discount rates, chosen as 7%, recommended by the Office of Management and Budget (OMB, 1992) and 2%, recommended by the Congressional Budget Office (Bazelon and Smetters, 1999) as the time preference of consumption. In addition, to these two different discount rates, an incremental change in the discount rate was looked at. This was done by changing the discount rate up and down 10% (0.4).
Lastly, a select set of variables and assumptions used in the analysis have been analyzed to determine the net present value's sensitivity to these variables. These results are shown in the second subsection for each scenario listed below.

A.5.1. Green Street

Discount Rate:

Green-BAU1:

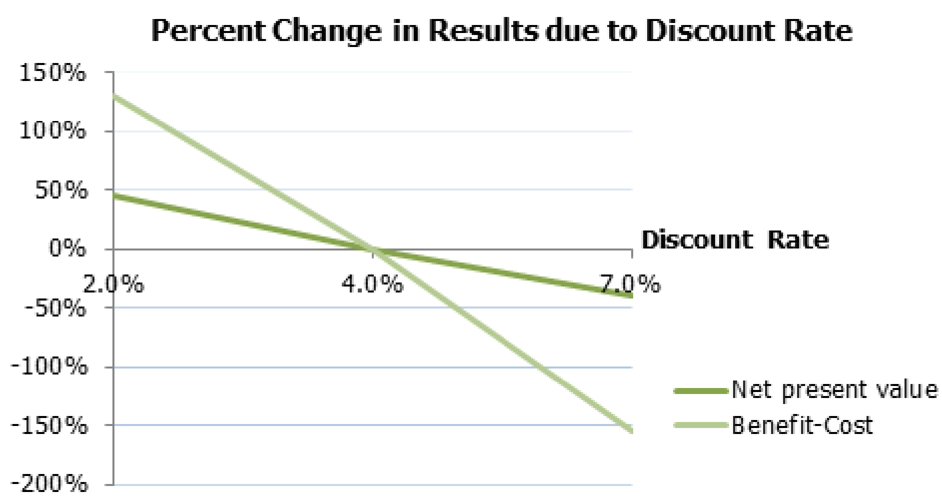
The section below describes how the Green Street results vary depending on the discount rate used. As can be seen in the two tables and graph below, in the Green-BAU1 scenario, the results vary significantly between a discount rate of 2%, 4% and 7%. This is due to the fact that many of the benefits for Green Streets are felt further into the future, which are greatly affected by the discount rate. The more you discount the future years, the lower the net present value.
As can be seen in the figures below, a 2% discount rate increases the results by $2.97 billion (45%), compared to a 4% discount rate. A 7% discount rate decreases the net present value by $2.59 billion (39%).

TABLE 50: PERCENT CHANGE IN GREEN-BAU1 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	9,555,215,740	45%	2,974,483,898
4%	**6,580,731,843**	**0%**	**0**
7%	3,994,413,520	-39%	-2,586,318,323

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	8.74	130%	1.30
4%	**7.44**	**0%**	**0.00**
7%	5.90	-154%	-1.54

FIGURE 54: PERCENT CHANGE IN GREEN-BAU1 RESULTS DUE TO DISCOUNT RATE

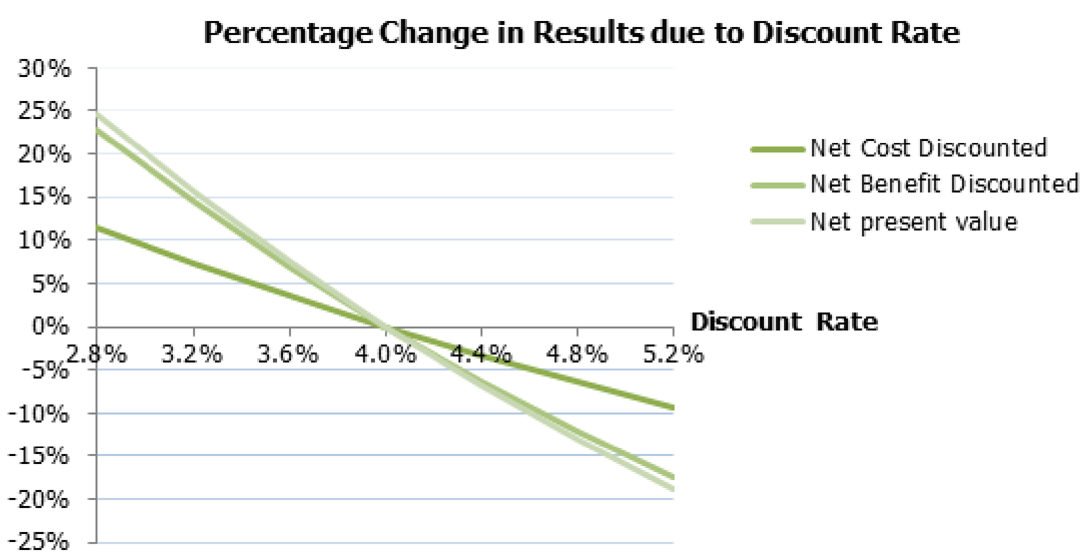


In addition to looking at 2%, 4% and 7%, an analysis on the percent change in discount rate was done. As can be seen in the table and graph below, in the Green-BAU1 scenario, a 0.4% increase in the discount rate changes the net present value by about 450 million dollars (7%). A 0.4% decrease in the discount rate changes the net present value by about 490 million dollars (7.5%).

TABLE 51: PERCENT CHANGE IN GREEN-BAU1 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	8,196,999,733	24.6%	1,616,267,890
3.2%	7,608,044,090	15.6%	1,027,312,247
3.6%	7,071,041,062	7.5%	490,309,220
4.0%	**6,580,731,843**	**0.0%**	**0**
4.4%	6,132,442,112	-6.8%	-448,289,731
4.8%	5,722,012,487	-13.0%	-858,719,355
5.2%	5,345,737,702	-18.8%	-1,234,994,140

FIGURE 55: PERCENT CHANGE IN GREEN-BAU1 RESULTS DUE TO DISCOUNT RATE



Green-BAU1, Element Only (Green-BAU1-EO):

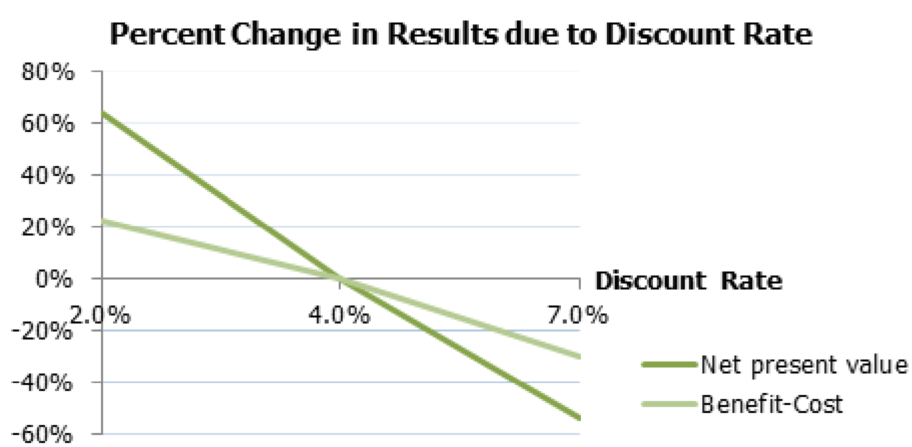
As can be seen from the two tables and graph below, the discount rate has a significant impact on the results of the study when we only take into account the Green Elements (and do not include the street construction costs and benefits). The results at 2% are 64% higher than at 4%. At 7%, the results are 54% lower than at 4%. This is due to the fact that many of the benefits are felt out into the future, and therefore are greatly susceptible to changes in the discount rate.

TABLE 52: PERCENT CHANGE IN GREEN-BAU1-EO RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	369,743,529	64%	144,387,503
4%	**225,356,026**	**0%**	**0**
7%	104,773,500	-54%	-120,582,526

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	2.01	22%	0.22
4%	**1.78**	**0%**	**0.00**
7%	1.49	-29%	-0.29

FIGURE 56: PERCENT CHANGE IN GREEN-BAU1-EO RESULTS DUE TO DISCOUNT RATE

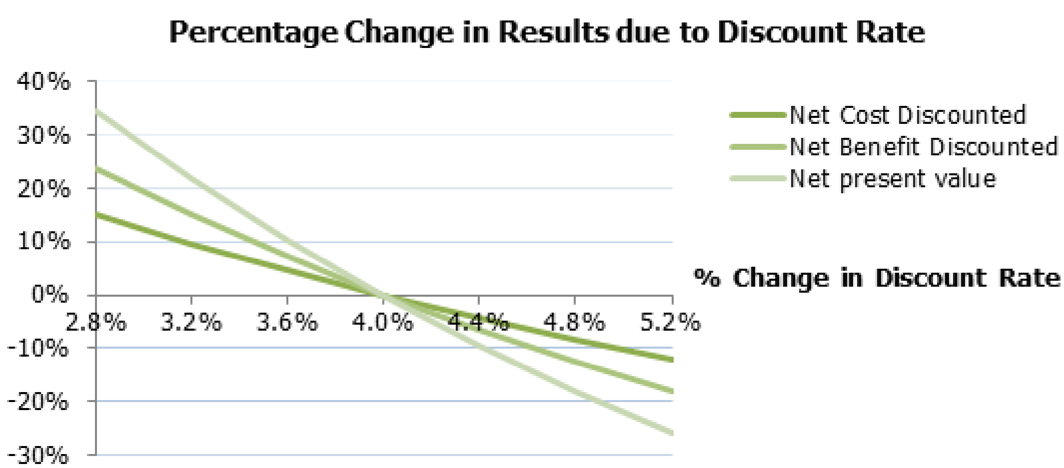


As in Green-BAU1, an analysis on the percent change in discount rate was done. As can be seen in the table and graph below, when looking at the Element Only results in the Green-BAU1 scenario, a 0.4% increase in the discount rate (0.4%) changes the net present value by about 21 million dollars (9.5%). A 0.4% decrease in the discount rate changes the net present value by about 23 million dollars (10.4%).

TABLE 53: CHANGE NET PRESENT VALUE DUE TO DISCOUNT RATE, GREEN-BAU1-EO

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	303,281,984	34.6%	77,925,958
3.2%	274,720,473	21.9%	49,364,447
3.6%	248,838,169	10.4%	23,482,143
4.0%	**225,356,026**	0.0%	**0**
4.4%	204,026,570	-9.5%	-21,329,456
4.8%	184,630,096	-18.1%	-40,725,929
5.2%	166,971,342	-25.9%	-58,384,684

FIGURE 57: PERCENT CHANGE IN NET PRESENT VALUE DUE TO DISCOUNT RATE, GREEN-BAU1-EO



Green-BAU2:

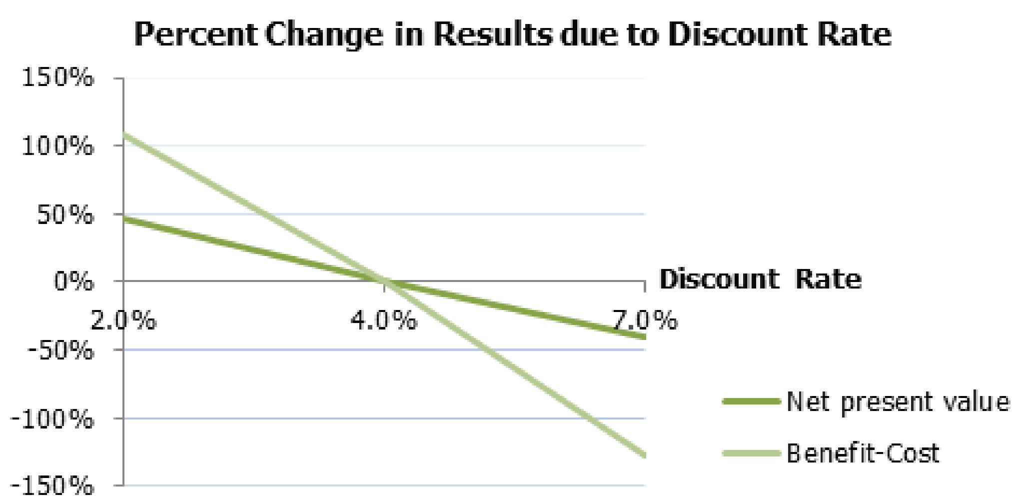
The sensitivity results for the BAU2 scenarios were fairly similar to those found in BAU1 in the case of Green Streets. For Green-BAU2, A 2% discount rate increases the results by nearly 3 billion dollars (47%). A 7% discount rate decreases the results by over 2.5 billion dollars (40%).

TABLE 54: CHANGE IN GREEN-BAU2 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	9,333,210,465	47%	2,966,259,694
4%	**6,366,950,771**	**0%**	**0**
7%	3,801,276,518	-40%	-2,565,674,253

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	7.04	108%	1.08
4%	**5.95**	**0%**	**0.00**
7%	4.68	-127%	-1.27

FIGURE 58: PERCENT CHANGE IN GREEN-BAU2 RESULTS DUE TO DISCOUNT RATE

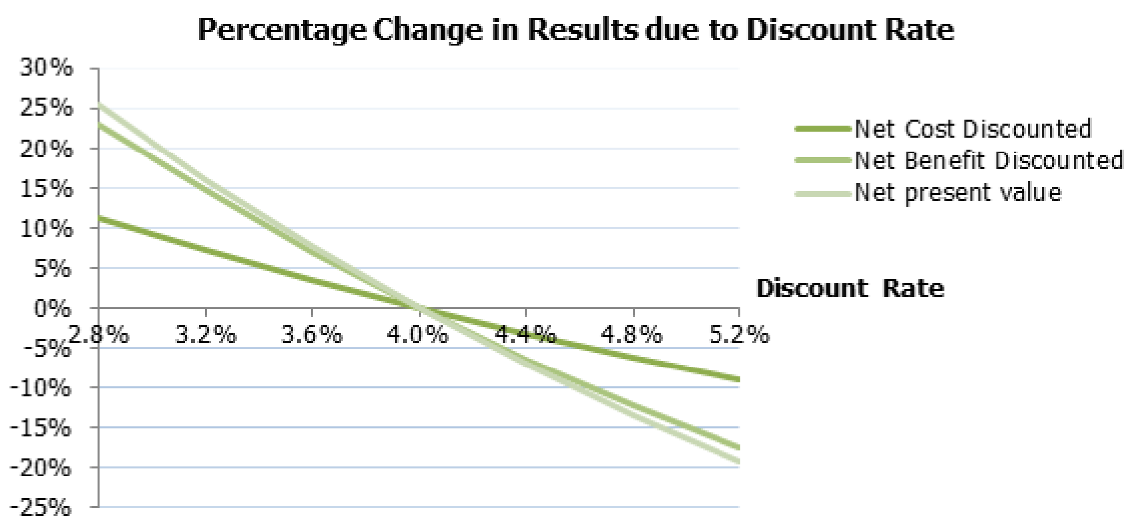


As in the BAU1 case, an analysis on a incremental change in discount rate was completed. A 0.4% decrease in discount rate results in about a 8% increase (about 490 million dollars) in the net present value. A 0.4% increase in discount rate results in about a 7% decrease (about 450 million dollars) in the net present value.

TABLE 55: PERCENT CHANGE IN GREEN-BAU2 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	7,977,155,402	25.3%	1,610,204,631
3.2%	7,389,927,044	16.1%	1,022,976,273
3.6%	6,854,967,962	7.7%	488,017,191
4.0%	**6,366,950,771**	**0.0%**	**0**
4.4%	5,921,143,880	-7.0%	-445,806,890
4.8%	5,513,340,190	-13.4%	-853,610,581
5.2%	5,139,794,777	-19.3%	-1,227,155,994

FIGURE 59: PERCENT CHANGE IN GREEN-BAU2 RESULTS DUE TO DISCOUNT RATE



Green-BAU2, Element Only (Green-BAU2-EO):

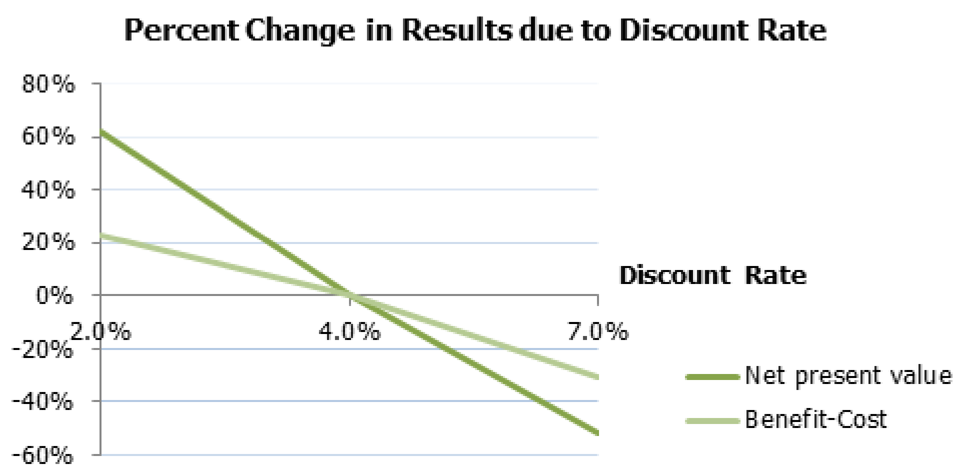
As in the BAU1 scenario, the Element Only results are more sensitive to the discount rate than the complete construction cost-benefit analysis. The results below show that a 2% discount rate increases the net present value by 62% (147 million dollars). The 7% discount rate decreases the net present value by 52% (123 million dollars).

TABLE 56: PERCENT CHANGE IN GREEN-BAU2-EO RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	385,184,117	62%	146,941,125
4%	**238,242,992**	**0%**	**0**
7%	115,040,893	-52%	-123,202,098

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	2.10	23%	0.23
4%	**1.87**	**0%**	**0.00**
7%	1.56	-30%	-0.30

FIGURE 60: PERCENT CHANGE IN GREEN-BAU2-EO RESULTS DUE TO DISCOUNT RATE



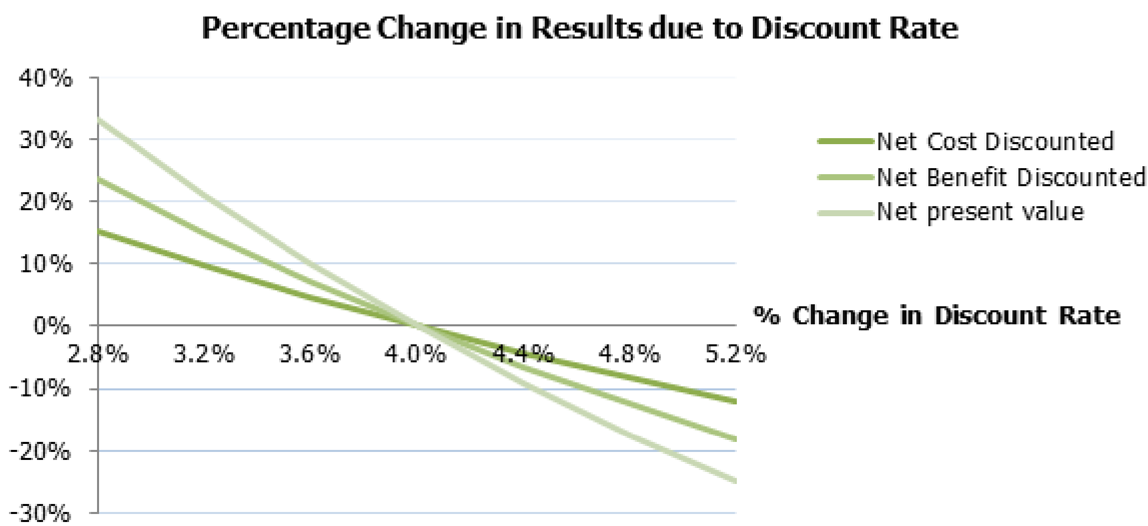
As can be seen in the table and figure below, a 0.4% decrease in the discount rate has a 10% increase in the net present value ($24 Million). Conversely, a 0.4% increase in the discount rate means a 9% decrease in the net present value ($22 Million).

TABLE 57: CHANGE NET PRESENT VALUE DUE TO DISCOUNT RATE, GREEN-BAU2-EO

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	317,600,937	33.3%	79,357,945
3.2%	288,531,314	21.1%	50,288,322

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
3.6%	262,172,479	10.0%	23,929,487
4.0%	**238,242,992**	**0.0%**	**0**
4.4%	216,493,182	-9.1%	-21,749,810
4.8%	196,701,325	-17.4%	-41,541,667
5.2%	178,670,307	-25.0%	-59,572,685

FIGURE 61: PERCENT CHANGE IN NET PRESENT VALUE DUE TO DISCOUNT RATE, GREEN-BAU2-EO



Sensitivity Analysis on Variables:

In this section, different assumptions are analyzed to determine the level of sensitivity of the net present value to a change in these variables.

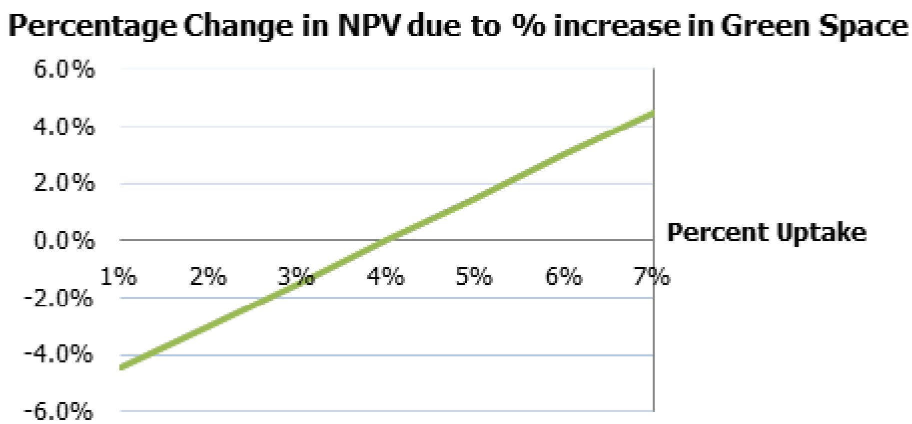
Green-BAU1:

One of the major assumptions used in the Green Street analysis is the amount of green space incorporated in the street. The following table and figure show how changes in the amount of green space implemented affect the net present value. The results are increased or decreased from 4% - the assumption used in the analysis. A 1% change in the total amount of green space in the street and sidewalk area results in an change of $98 Million in net present value.

TABLE 58: PERCENT CHANGE IN NET PRESENT VALUE DUE TO GREEN SPACE IMPLEMENTED, GREEN-BAU1

Variable	% Change	NPV	% Change	Actual Change
Percentage of Green Space Implemented	7%	6,875,271,695	4.5%	294,539,852
	6%	6,777,088,136	3.0%	196,356,294
	5%	6,678,909,990	1.5%	98,178,147
	4%	**6,580,731,843**	**0.0%**	**0**
	3%	6,482,553,696	-1.5%	-98,178,147
	2%	6,384,375,549	-3.0%	-196,356,294
	1%	6,286,197,402	-4.5%	-294,534,441

FIGURE 62: PERCENT CHANGE IN NET PRESENT VALUE DUE TO GREEN SPACE IMPLEMENTED, GREEN-BAU1



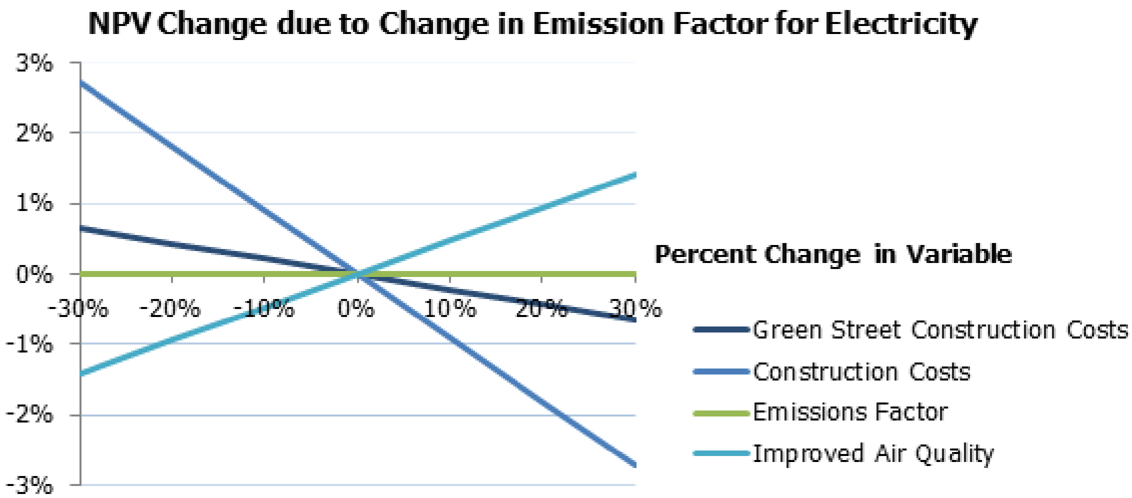
The following table and figure show how 10% changes in different variables affect the net present value. The street construction costs affected the results more than the other variables analyzed, followed by a change in the economic value of improved air quality. A change in the emission factor has very small change in the overall results of the green street scenario. An increase or decrease in the emissions factor of 30% changes the net present value by less than 1%.

TABLE 59: CHANGE IN GREEN-BAU1 RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Street Construction Costs	-30%	6,759,830,994	2.7%	179,099,152
	-20%	6,700,131,277	1.8%	119,399,435
	-10%	6,640,431,560	0.9%	59,699,717
	0%	**6,580,731,843**	**0.0%**	**0**

Variable	% Change	NPV	% Change	Actual Change
	10%	6,521,032,125	-0.9%	-59,699,717
	20%	6,461,332,408	-1.8%	-119,399,435
	30%	6,401,632,691	-2.7%	-179,099,152
Green Street Construction Costs	-30%	6,623,620,497	0.7%	42,888,655
	-20%	6,609,324,279	0.4%	28,592,436
	-10%	6,595,028,061	0.2%	14,296,218
	0%	**6,580,731,843**	**0.0%**	**0**
	10%	6,566,435,624	-0.2%	-14,296,218
	20%	6,552,139,406	-0.4%	-28,592,436
	30%	6,537,843,188	-0.7%	-42,888,655
Emissions Factor	794.5 (-30%)	6,580,692,524	-0.0006%	-39,318
	908.0 (-20%)	6,580,705,631	-0.0004%	-26,212
	1021.5 (-10%)	6,580,718,737	-0.0002%	-13,106
	1135.0 (-0%)	**6,580,731,843**	**0.0000%**	**0**
	1248.5 (-10%)	6,580,744,949	0.0002%	13,106
	1362.0 (-20%)	6,580,758,055	0.0004%	26,212
	1475.5 (-30%)	6,580,771,161	0.0006%	39,318
Improved Air Quality	-30%	6,487,592,798	-1.4%	-93,139,045
	-20%	6,518,639,146	-0.9%	-62,092,697
	-10%	6,549,685,494	-0.5%	-31,046,348
	0%	**6,580,731,843**	**0.0%**	**0**
	10%	6,611,778,191	0.5%	31,046,348
	20%	6,642,824,539	0.9%	62,092,697
	30%	6,673,870,887	1.4%	93,139,045

FIGURE 63: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, GREEN-BAU1



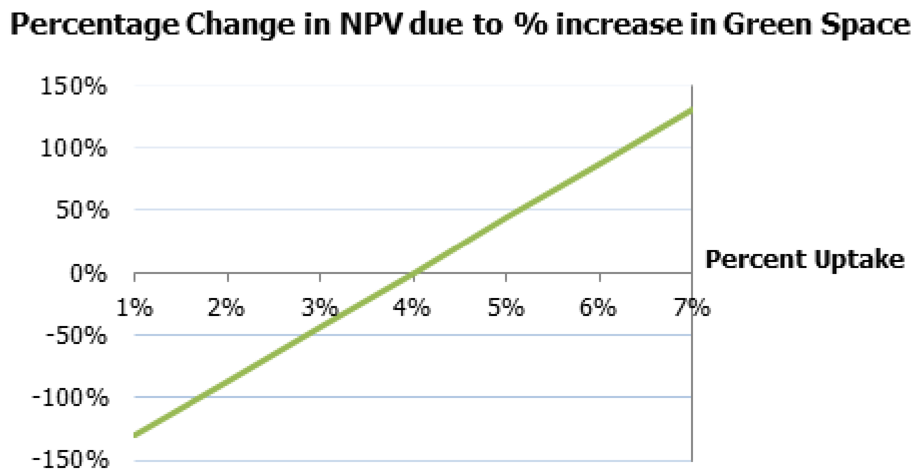
Green-BAU1, Element Only (Green-BAU1-EO):

The following table and figure show how changes in the amount of green space implemented affect the net present value of the Green Street Element Only costs and benefits (Green-BAU1-EO and Green-BAU2-EO). The results are changed from 4% - the assumption used in the analysis. A 1% change in the amount of green space implemented changes the Element Only results by almost 44%. This shows that the net present value is heavily sensitive to the amount of green space implemented.

TABLE 60: PERCENT CHANGE IN NET PRESENT VALUE DUE TO GREEN SPACE IMPLEMENTED, GREEN-BAU1-EO

Variable	% Change	NPV	% Change	Actual Change
Percentage of Green Space Implemented	7%	519,895,878	130.7%	294,539,852
	6%	421,712,320	87.1%	196,356,294
	5%	323,534,173	43.6%	98,178,147
	4%	**225,356,026**	**0.0%**	**0**
	3%	127,177,879	-43.6%	-98,178,147
	2%	28,999,732	-87.1%	-196,356,294
	1%	-69,178,415	-130.7%	-294,534,441

FIGURE 64: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN GREEN SPACE, GREEN-BAU1-EO



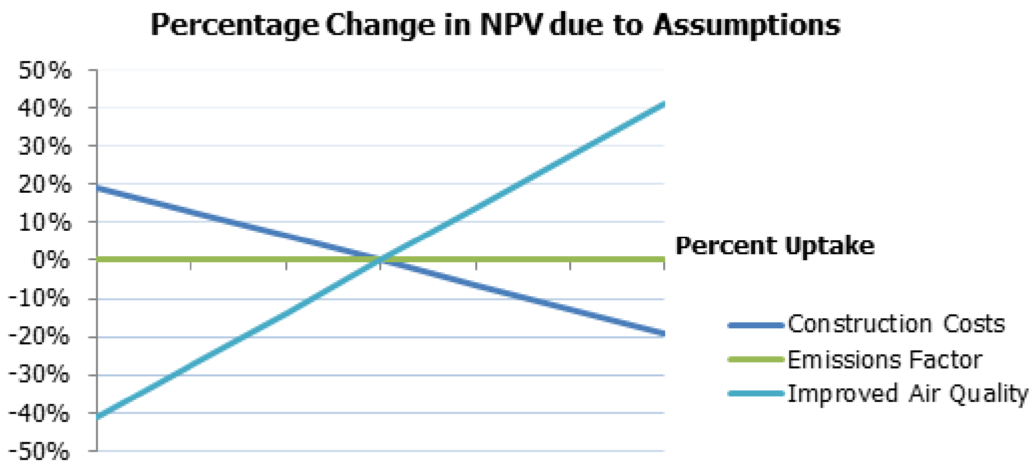
The following table and figure show the change in net present value due to the changes in several different variables used in the analysis. As in the street construction case, a change in the emission factor changes the net present value very little. The benefits associated from Improved Air Quality affect the results more than the other variables analyzed.

TABLE 61: CHANGE IN GREEN-BAU1-EO RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Green Street Construction Costs	-30%	268,244,680	19.0%	42,888,655
	-20%	253,948,462	12.7%	28,592,436
	-10%	239,652,244	6.3%	14,296,218
	0%	**225,356,026**	**0.0%**	**0**
	10%	211,059,808	-6.3%	-14,296,218
	20%	196,763,590	-12.7%	-28,592,436
	30%	182,467,371	-19.0%	-42,888,655
Emissions Factor	794.5 (-30%)	225,316,708	0%	-39,318
	908.0 (-20%)	225,329,814	-0.012%	-26,212
	1021.5 (-10%)	225,342,920	-0.006%	-13,106
	1135.0 (-0%)	**225,356,026**	**0.000%**	**0**
	1248.5 (-10%)	225,369,132	0.006%	13,106
	1362.0 (-20%)	225,382,238	0.012%	26,212
	1475.5 (-30%)	225,395,344	0.017%	39,318
Improved Air Quality	-30%	132,216,981	-41.3%	-93,139,045

Variable	% Change	NPV	% Change	Actual Change
	-20%	163,263,329	-27.6%	-62,092,697
	-10%	194,309,678	-13.8%	-31,046,348
	0%	**225,356,026**	**0.0%**	**0**
	10%	256,402,374	13.8%	31,046,348
	20%	287,448,722	27.6%	62,092,697
	30%	318,495,071	41.3%	93,139,045

FIGURE 65: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, GREEN-BAU1-EO



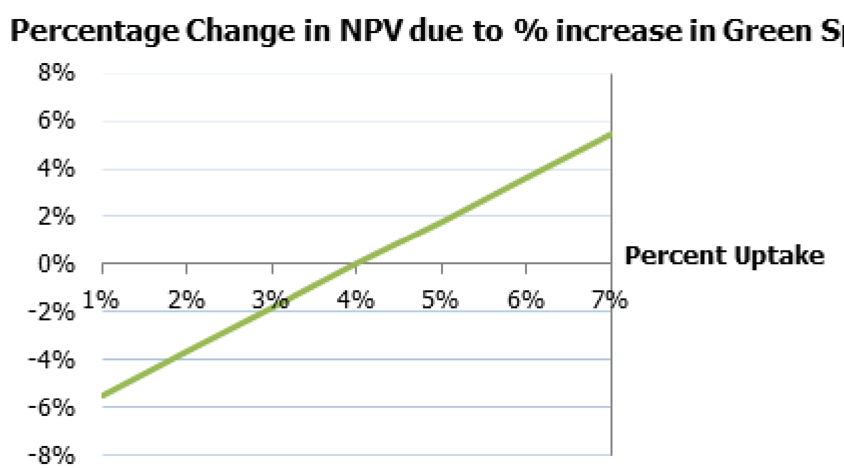
Green-BAU2:

In the Green Street analysis, one of the major assumptions is the amount of green space incorporated in the street. The following table and figure show how changes in the amount of green space implemented affect the net present value. The results are increased or decreased from 4% - the assumption used in the analysis. A 1% change in the amount of green space incorporated in the street and sidewalk construction changes the net present value by 1.8% ($116 Million).

TABLE 62: PERCENT CHANGE IN NET PRESENT VALUE DUE TO GREEN SPACE IMPLEMENTED, GREEN-BAU2

Variable	% Change	NPV	% Change	Actual Change
Percentage of Green Space Implemented	7%	6,715,821,645	5.5%	348,870,874
	6%	6,599,527,746	3.7%	232,576,975
	5%	6,483,239,258	1.8%	116,288,487
	4%	**6,366,950,771**	**0.0%**	**0**
	3%	6,250,662,284	-1.8%	-116,288,487
	2%	6,134,373,796	-3.7%	-232,576,975
	1%	6,018,085,309	-5.5%	-348,865,462

FIGURE 66: PERCENT CHANGE IN NET PRESENT VALUE DUE TO GREEN SPACE IMPLEMENTED, GREEN-BAU2



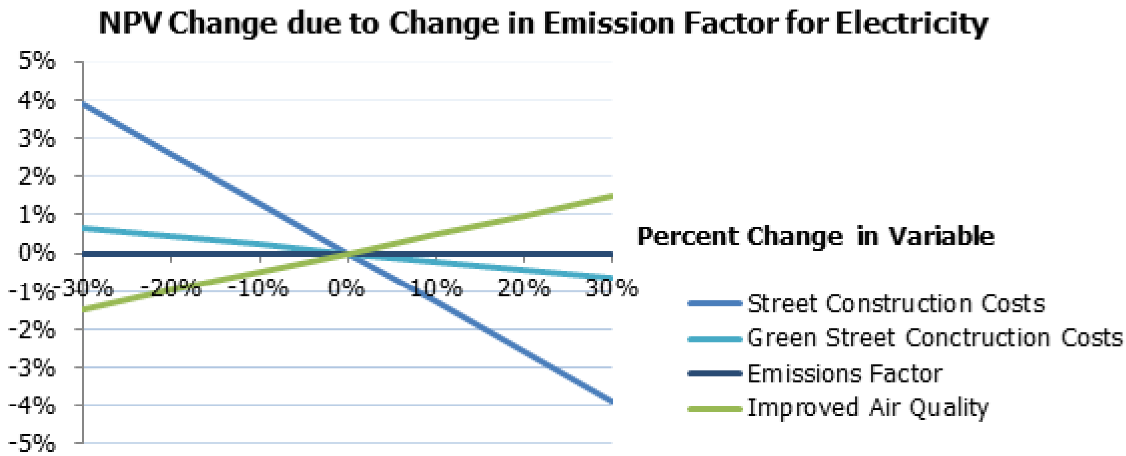
The following table and figure show how a 10% change in different variables affect the net present value. As in the BAU1 scenario, a change in the emission factor has an insignificant effect on the overall results of the scenario. A 30% change in the emission factor changes the net present value by less than 1%. A change in the Street Construction Costs affect the results more than the other variables analyzed.

TABLE 63: CHANGE IN GREEN-BAU2 RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Street Construction Costs	-30%	6,613,497,313	3.9%	246,546,542
	-20%	6,531,315,132	2.6%	164,364,361
	-10%	6,449,132,952	1.3%	82,182,181

Variable	% Change	NPV	% Change	Actual Change
	0%	**6,366,950,771**	**0.0%**	**0**
	10%	6,284,768,590	-1.3%	-82,182,181
	20%	6,202,586,410	-2.6%	-164,364,361
	30%	6,120,404,229	-3.9%	-246,546,542
Green Street Construction Costs	-30%	6,407,358,643	0.63%	40,407,872
	-20%	6,393,889,353	0.42%	26,938,582
	-10%	6,380,420,062	0.21%	13,469,291
	0%	**6,366,950,771**	**0.00%**	**0**
	10%	6,353,481,480	-0.21%	-13,469,291
	20%	6,340,012,189	-0.42%	-26,938,582
	30%	6,326,542,899	-0.63%	-40,407,872
Emissions Factor	794.5 (-30%)	6,366,911,453	-0.00062%	-39,318
	908.0 (-20%)	6,366,924,559	-0.00041%	-26,212
	1021.5 (-10%)	6,366,937,665	-0.00021%	-13,106
	1135.0 (-0%)	**6,366,950,771**	**0.00000%**	**0**
	1248.5 (-10%)	6,366,963,877	0.00021%	13,106
	1362.0 (-20%)	6,366,976,983	0.00041%	26,212
	1475.5 (-30%)	6,366,990,089	0.00062%	39,318
Improved Air Quality	-30%	6,273,811,726	-1.5%	-93,139,045
	-20%	6,304,858,074	-1.0%	-62,092,697
	-10%	6,335,904,423	-0.5%	-31,046,348
	0%	**6,366,950,771**	**0.0%**	**0**
	10%	6,397,997,119	0.5%	31,046,348
	20%	6,429,043,467	1.0%	62,092,697
	30%	6,460,089,816	1.5%	93,139,045

FIGURE 67: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, GREEN-BAU2



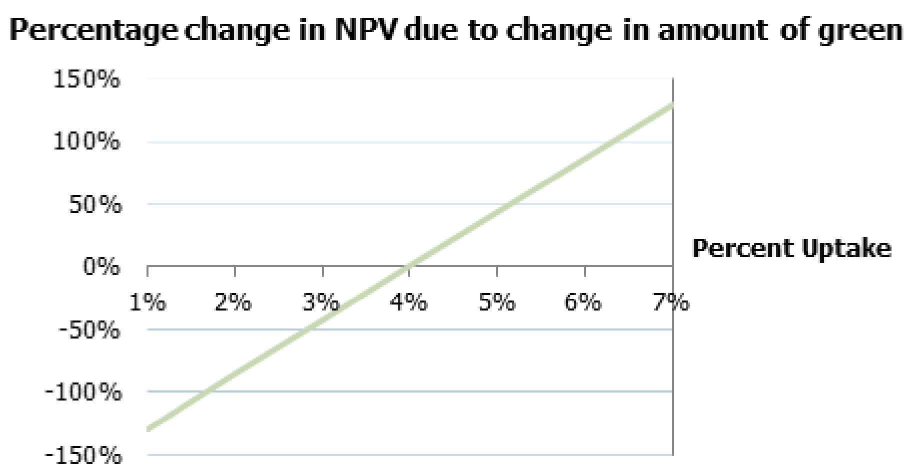
Green-BAU2, Element Only (Green-BAU2-EO):

One of the major assumptions used in the Green Street analysis is the amount of green space incorporated in the street. The following table and figure show how changes in the amount of green space implemented affect the net present value. The results are increased or decreased from 4%, used in the analysis. A 1% change in the amount of green space implemented results in a 43% change in the net present value of the Green Street Element Only results, showing the significant affect the assumption has on the net present value.

TABLE 64: PERCENT CHANGE IN NET PRESENT VALUE GREEN-BAU2-EO DUE TO GREEN SPACE IMPLEMENTED

Variable	% Change	NPV	% Change	Actual Change
Green Space to Treated Impervious Space	-7%	545,669,810	129%	307,426,818
	-6%	443,190,596	86%	204,947,604
	-5%	340,716,794	43%	102,473,802
	-4%	**238,242,992**	**0%**	**0**
	-3%	135,769,190	-43%	-102,473,802
	-2%	33,295,387	-86%	-204,947,604
	-1%	-69,178,415	-129%	-307,421,407

FIGURE 68: PERCENT CHANGE IN NET PRESENT VALUE DUE TO GREEN SPACE IMPLEMENTED, GREEN-BAU2-EO



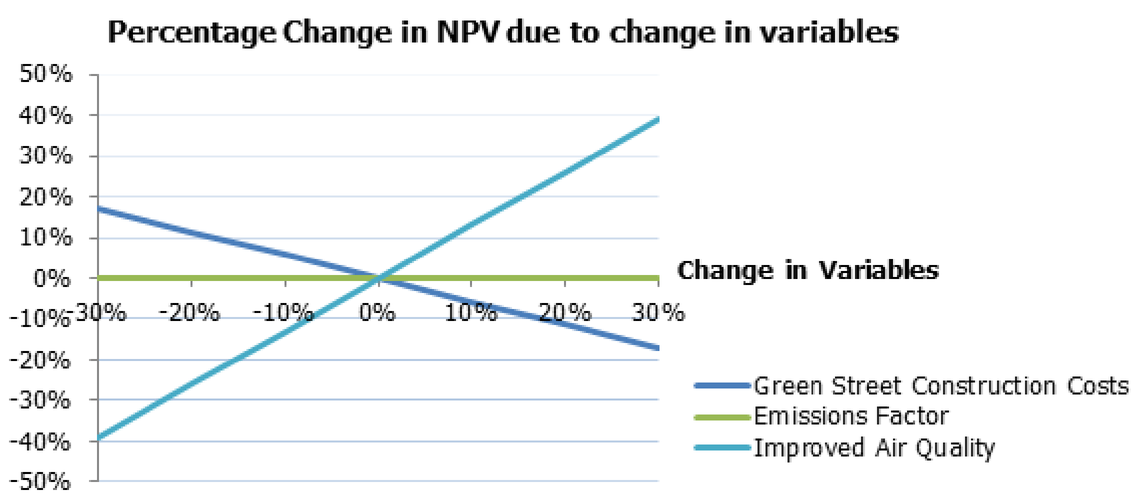
The following table and figure show how 10% changes in different variables affect the net present value. As in the Green-BAU2 case, a change in the emission factor by 30% changes the net present value by less than 1%. Improved Air Quality affects the net present value more than any other variable analyzed.

TABLE 65: PERCENT CHANGE IN NET PRESENT VALUE GREEN-BAU2-EO DUE TO CHANGE IN DIFFERENT VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Green Street Construction Costs	-30%	278,650,864	17%	40,407,872
	-20%	265,181,573	11%	26,938,582
	-10%	251,712,283	6%	13,469,291
	0%	**238,242,992**	**0%**	**0**
	10%	224,773,701	-6%	-13,469,291
	20%	211,304,410	-11%	-26,938,582
	30%	197,835,120	-17%	-40,407,872
Emissions Factor	794.5	6,366,911,453	-0.00062%	-39,318
	908.0	6,366,924,559	-0.00041%	-26,212
	1021.5	6,366,937,665	-0.00021%	-13,106
	1135.0	**6,366,950,771**	**0.00000%**	**0**
	1248.5	6,366,963,877	0.00021%	13,106

Variable	% Change	NPV	% Change	Actual Change
	1362.0	6,366,976,983	0.00041%	26,212
	1475.5	6,366,990,089	0.00062%	39,318
Improved Air Quality	-30%	145,103,947	-39%	-93,139,045
	-20%	176,150,295	-26%	-62,092,697
	-10%	207,196,644	-13%	-31,046,348
	0%	**238,242,992**	**0%**	**0**
	10%	269,289,340	13%	31,046,348
	20%	300,335,688	26%	62,092,697
	30%	331,382,037	39%	93,139,045

FIGURE 69: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, GREEN-BAU2-EO



A.5.2. Cool Street

Discount Rate:

Cool-BAU1:

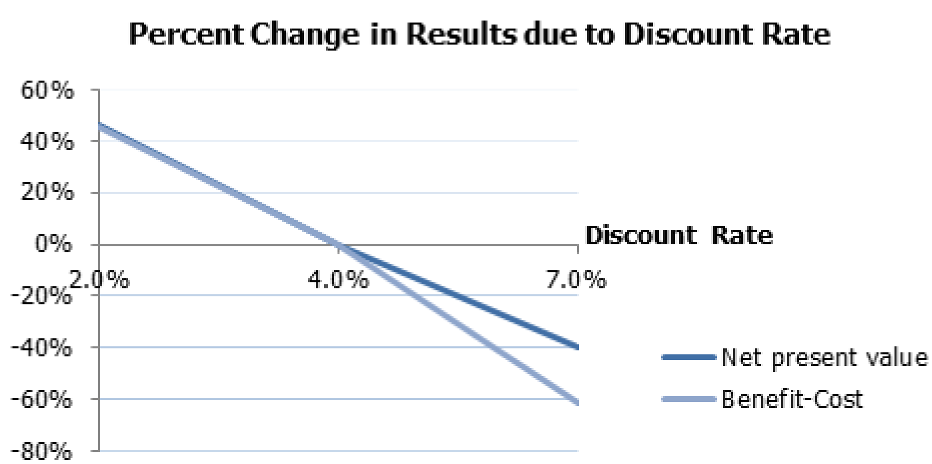
For Cool Streets, the change in discount rate from 4% to 2% results in an increase in the net present value of 46% ($2.9 Billion). The change in discount rate from 4% to 7% results in a decrease in the net present value of 40% ($2.5 Billion). The sensitivity results for Cool Streets in the BAU1 (Cool-BAU1) case are shown below:

TABLE 66: CHANGE IN COOL-BAU1 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	9,182,505,979	46%	2,897,223,453
4%	**6,285,282,526**	**0%**	**0**
7%	3,775,363,970	-40%	-2,509,918,557

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	4.75	45%	0.45
4%	**4.30**	**0%**	**0.00**
7%	3.69	-61%	-0.61

FIGURE 70: PERCENT CHANGE IN COOL-BAU1 RESULTS DUE TO DISCOUNT RATE

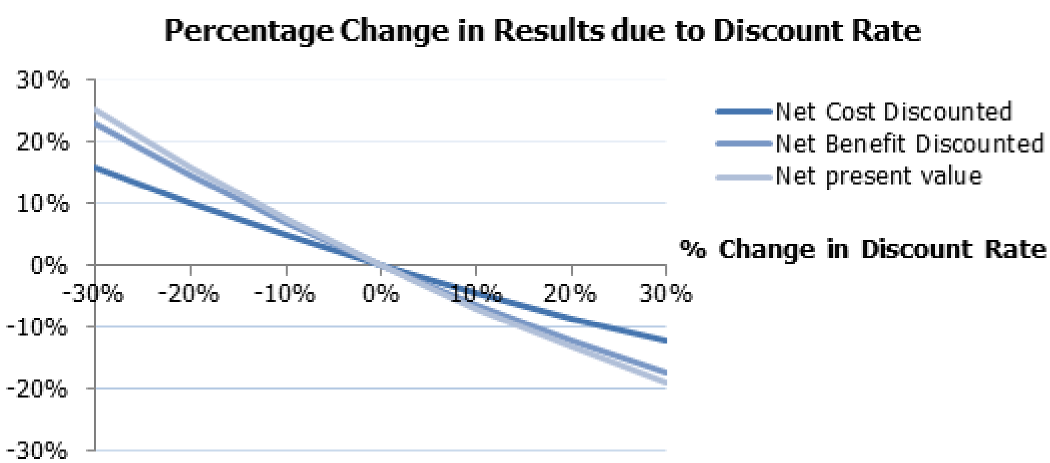


Incremental change in the discount rate was also analyzed. When the discount rate is decreased by 0.4%, the net present value increases by over 7% ($476 Million). When the discount rate is increased by 0.4%, the net present value decreases by nearly 7% (436 Million). It is important to note, that at a Discount rate of 2% Discount Rate, the Net Present Value for Cool Streets is higher than BAU1-Only, making the scenario more desirable from an economic perspective. The results are displayed in the table and figure below:

TABLE 67: PERCENT CHANGE IN COOL-BAU1 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	7,858,425,393	25.0%	1,573,142,867
3.2%	7,284,843,176	15.9%	999,560,649
3.6%	6,762,190,710	7.6%	476,908,184
4.0%	**6,285,282,526**	**0.0%**	**0**
4.4%	5,849,512,603	-6.9%	-435,769,924
4.8%	5,450,785,079	-13.3%	-834,497,447
5.2%	5,085,453,700	-19.1%	-1,199,828,827

FIGURE 71: PERCENT CHANGE IN COOL-BAU1 RESULTS DUE TO DISCOUNT RATE



It is important to note, that at a discount rate of 2% Discount Rate, the net present value for Cool-BAU1 is higher than BAU1-Only, making the scenario more desirable from an economic perspective.

Cool-BAU1, Element Only (Cool-BAU1-EO):

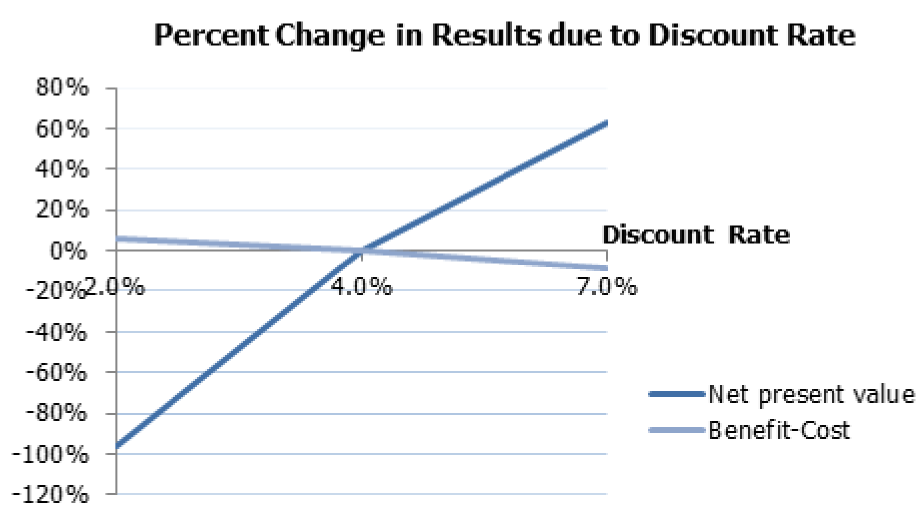
As can be seen from the results below, the BAU1 Cool Street Element Only analysis shows that, when the discount rate is 2%, the net present value increases by 96% - getting less negative; this gets the net present value close to 0, meaning that the present value of costs and benefits are equal. When the discount rate is changed to 7%, the net present value decreases by 63% - getting more negative.

TABLE 68: PERCENT CHANGE IN COOL-BAU1 RESULTS DUE TO DISCOUNT RATE (ELEMENT ONLY ANALYSIS)

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	-2,966,233	96%	67,127,058
4%	**-70,093,290**	**0%**	**0**
7%	-114,276,050	-63%	-44,182,760

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	0.998	6%	0.06
4%	**0.94**	**0%**	**0.00**
7%	0.86	-9%	-0.08

FIGURE 72: PERCENT CHANGE IN COOL-BAU1 RESULTS DUE TO DISCOUNT RATE (ELEMENT ONLY)

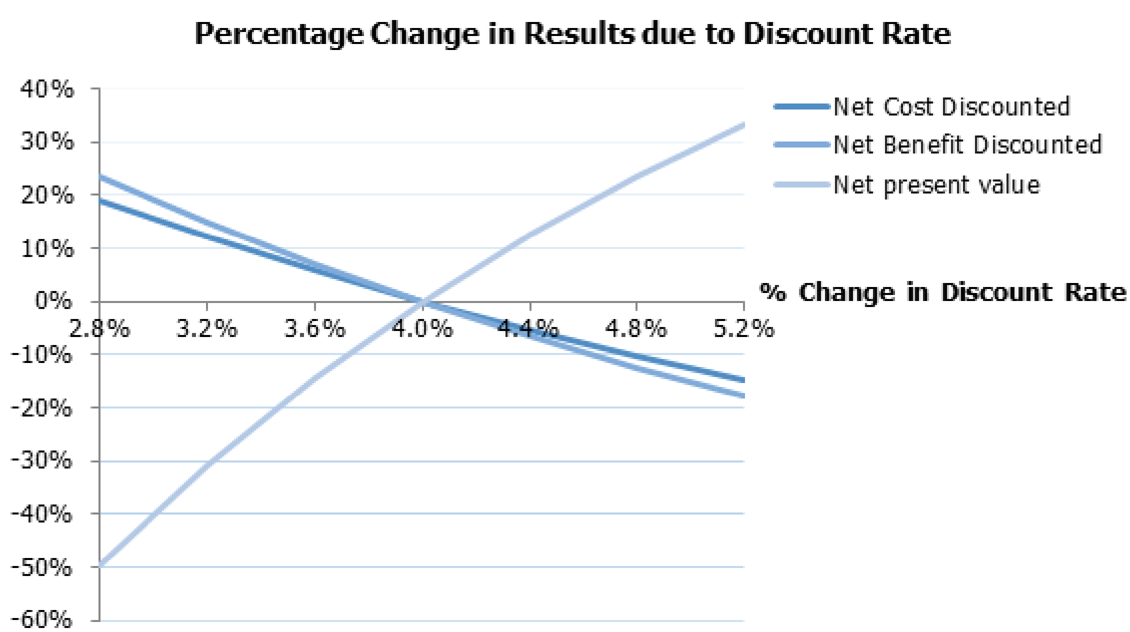


When the discount value is increased by 0.4%, the net present value changes by over 14% (over $10 Million). When the discount value is decreased by 0.4%, the net present value changes by over 12% (nearly $9 Million).

Table 69: Change net present value due to discount rate, Cool-BAU1 (Element Only)

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	-35,292,356	49.6%	34,800,934
3.2%	-48,480,442	30.8%	21,612,849
3.6%	-60,012,183	14.4%	10,081,108
4.0%	**-70,093,290**	**0.0%**	**0**
4.4%	-78,902,939	-12.6%	-8,809,648
4.8%	-86,597,312	-23.5%	-16,504,021
5.2%	-93,312,661	-33.1%	-23,219,371

Figure 73: Percent change in net present value due to discount rate, Cool-BAU1-EO



Cool-BAU2:

Discount Rate:

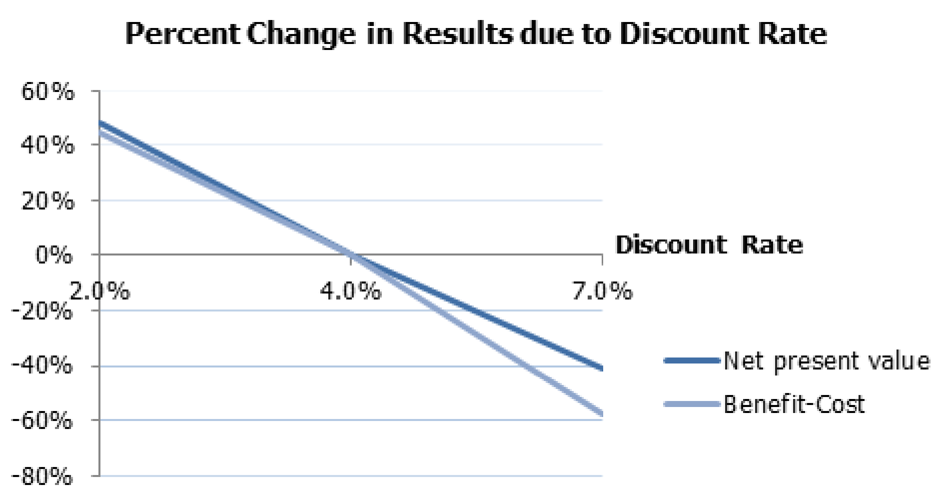
Cool-BAU2 is very similar to the Cool-BAU1. When the discount rate is 2%, the net present value increases by 48%, getting less negative. This is similar to the Cool-BAU1 change, which was 46%. When the discount rate is changed to 7%, the net present value decreases by 41%, getting more negative. This is similar to the Cool-BAU1 change, which was 40%.

TABLE 70: CHANGE IN COOL-BAU2 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	8,877,466,018	48%	2,882,183,816
4%	**5,995,282,202**	**0%**	**0**
7%	3,515,793,481	-41%	-2,479,488,721

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	4.11	44%	0.44
4%	**3.66**	**0%**	**0.00**
7%	3.08	-58%	-0.58

FIGURE 74: PERCENT CHANGE IN COOL-BAU2 RESULTS DUE TO DISCOUNT RATE

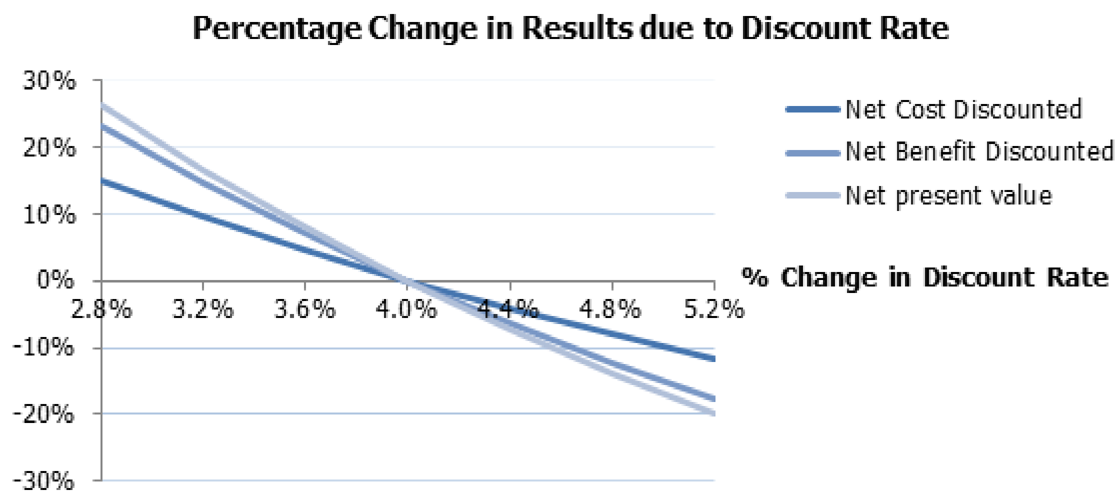


When looking at how incremental change in the discount rate affects the net present value, a 0.4% increase in the discount rate decreases the net present value by 7% ($473 Million). A 0.4% decrease in the discount rate increases the net present value by nearly 8% ($431 Million).

TABLE 71: PERCENT CHANGE IN COOL-BAU2 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	7,558,211,816	26.1%	1,562,929,613
3.2%	6,987,733,164	16.6%	992,450,962
3.6%	6,468,511,501	7.9%	473,229,299
4.0%	**5,995,282,202**	**0.0%**	**0**
4.4%	5,563,373,503	-7.2%	-431,908,699
4.8%	5,168,635,101	-13.8%	-826,647,101
5.2%	4,807,375,817	-19.8%	-1,187,906,385

FIGURE 75: PERCENT CHANGE IN COOL-BAU2 RESULTS DUE TO DISCOUNT RATE



Cool-BAU2, Element Only (Cool-BAU2-EO):

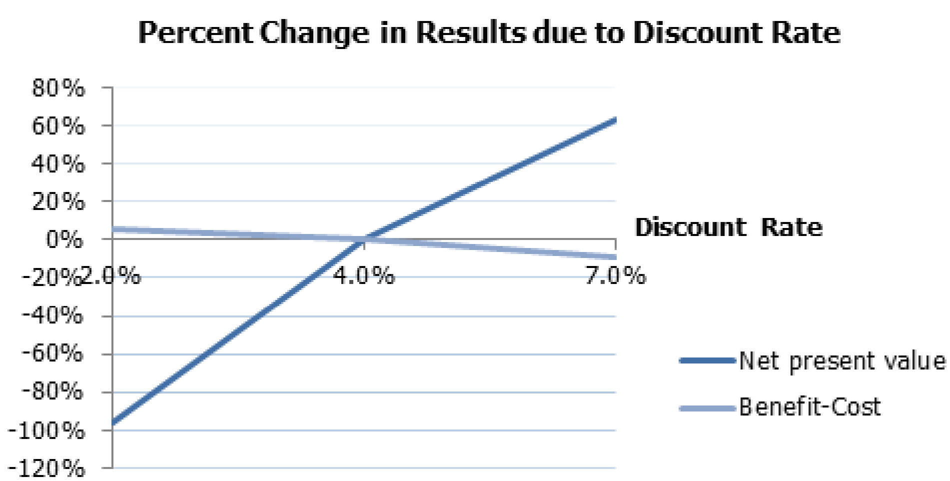
The BAU2 Cool Street Element Only analysis is exactly the same at the Cool-BAU1-Element Only analysis. This is due to the fact that the cool element costs and benefits are the same in both scenarios. The different street construction designs do not affect the costs associated with cool pavement. When the discount rate is 2%, the net present value increases by 96%, getting less negative; this gets the net present value close to 0. When the discount rate is changed to 7%, the net present value decreases by 63%, getting more negative.

TABLE 72: PERCENT CHANGE IN COOL-BAU2-EO RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	-2,966,233	96%	67,127,058
4%	**-70,093,290**	**0%**	**0**
7%	-114,276,050	-63%	-44,182,760

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	1.00	6%	0.06
4%	**0.94**	**0%**	**0.00**
7%	0.86	-9%	-0.08

FIGURE 76: PERCENT CHANGE IN COOL-BAU2-EO RESULTS DUE TO DISCOUNT RATE

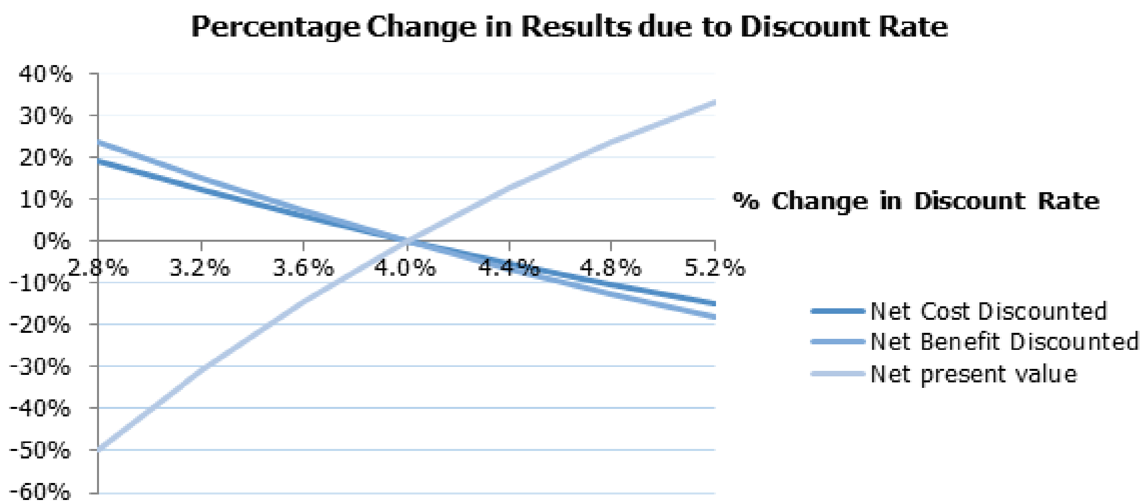


As in Cool-BAU2-Element Only, when the discount value is increased by 0.4%, the net present value changes by over 14% (over 10 million dollars). When the discount value is decreased by 0.4%, the net present value changes by over 12% (nearly $9 million dollars).

TABLE 73: PERCENT CHANGE NET PRESENT VALUE DUE TO DISCOUNT RATE, COOL-BAU2-EO

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	-35,292,356	50%	34,800,934
3.2%	-48,480,442	31%	21,612,849
3.6%	-60,012,183	14%	10,081,108
4.0%	**-70,093,290**	**0%**	**0**
4.4%	-78,902,939	-13%	-8,809,648
4.8%	-86,597,312	-24%	-16,504,021
5.2%	-93,312,661	-33%	-23,219,371

FIGURE 77: PERCENT CHANGE IN NET PRESENT VALUE DUE TO DISCOUNT RATE, COOL--EO



Sensitivity Analysis on Variables:

Cool-BAU1:

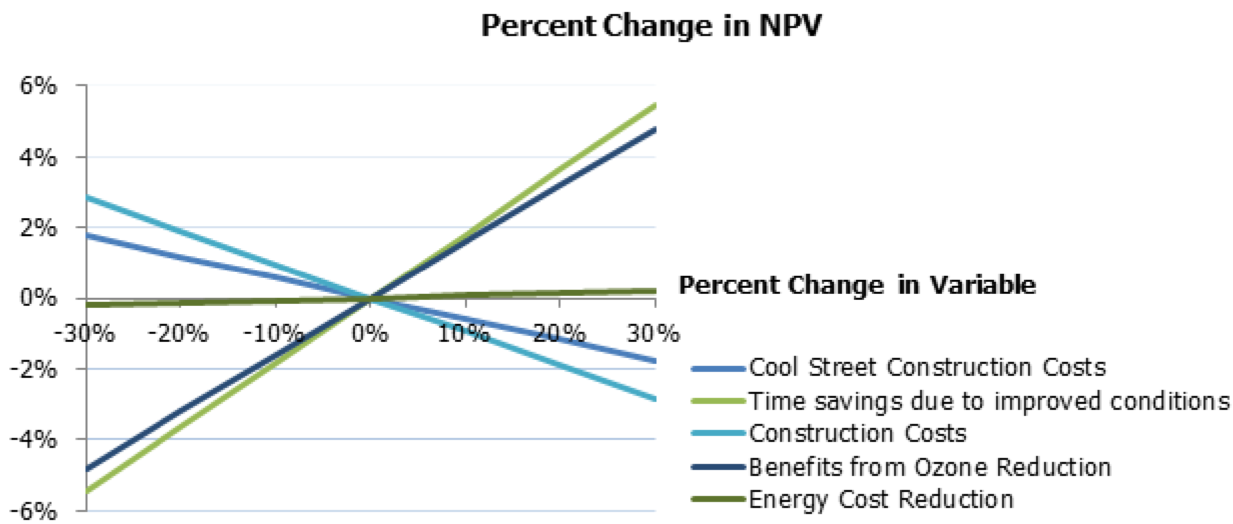
The following table and figure show how Cool-BAU1 is affected by different variables: cool street costs; street construction costs; time savings due to improved conditions; benefits from ozone reduction; and energy cost reduction. As can be seen from the results, time savings due to improved conditions and the benefits from ozone reduction had the largest effect on the net present value.

TABLE 74: PERCENT CHANGE IN COOL-BAU1 RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Cool Street Construction Costs	-30%	6,396,080,737	1.8%	110,798,210
	-20%	6,359,148,000	1.2%	73,865,474
	-10%	6,322,215,263	0.6%	36,932,737
	0%	**6,285,282,526**	**0.0%**	**0**
	10%	6,248,349,789	-0.6%	-36,932,737
	20%	6,211,417,053	-1.2%	-73,865,474
	30%	6,174,484,316	-1.8%	-110,798,210
Street Construction Costs	-30%	6,464,381,678	2.8%	179,099,152
	-20%	6,404,681,961	1.9%	119,399,435
	-10%	6,344,982,244	0.9%	59,699,717
	0%	**6,285,282,526**	**0.0%**	**0**
	10%	6,225,582,809	-0.9%	-59,699,717
	20%	6,165,883,092	-1.9%	-119,399,435
	30%	6,106,183,375	-2.8%	-179,099,152

Variable	% Change	NPV	% Change	Actual Change
Time savings due to improved conditions	-30%	5,943,219,664	-5.4%	-342,062,862
	-20%	6,057,240,618	-3.6%	-228,041,908
	-10%	6,171,261,572	-1.8%	-114,020,954
	0%	**6,285,282,526**	**0.0%**	**0**
	10%	6,399,303,480	1.8%	114,020,954
	20%	6,513,324,435	3.6%	228,041,908
	30%	6,627,345,389	5.4%	342,062,862
Benefits from Ozone Reduction	-30%	5,982,909,090	-4.8%	-302,373,437
	-20%	6,083,700,235	-3.2%	-201,582,291
	-10%	6,184,491,381	-1.6%	-100,791,146
	0%	**6,285,282,526**	**0.0%**	**0**
	10%	6,386,073,672	1.6%	100,791,146
	20%	6,486,864,817	3.2%	201,582,291
	30%	6,587,655,963	4.8%	302,373,437
Energy Cost Reduction	-30%	6,272,896,621	-0.2%	-12,385,906
	-20%	6,277,025,256	-0.1%	-8,257,270
	-10%	6,281,153,891	-0.1%	-4,128,635
	0%	**6,285,282,526**	**0.0%**	**0**
	10%	6,289,411,162	0.1%	4,128,635
	20%	6,293,539,797	0.1%	8,257,270
	30%	6,297,668,432	0.2%	12,385,906

FIGURE 78: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, COOL-BAU1



Cool-BAU1, Element Only (Cool-BAU1-EO):

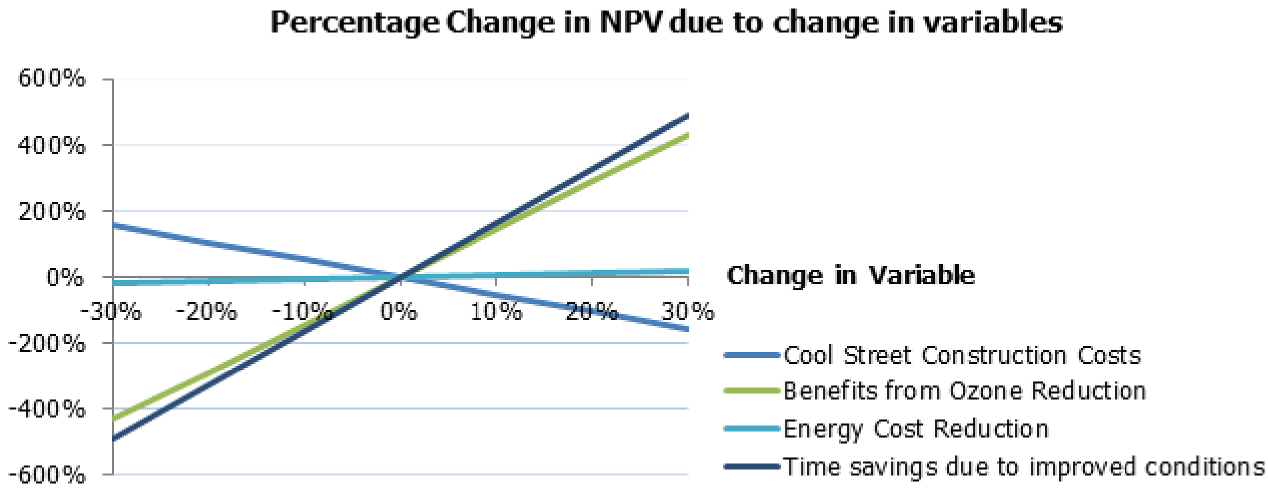
As in the Cool-BAU1 scenario above, time savings due to improved conditions and the benefits from ozone reduction had the largest effect on the net present value. It is important to note that a 0.4% increase in either of these variables make the net present value positive for the implementation of Cool Street pavement.

TABLE 75: PERCENT CHANGE IN COOL-BAU1-EO RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Cool Street Construction Costs	-30%	40,704,920	158%	110,798,210
	-20%	3,772,183	105%	73,865,474
	-10%	-33,160,554	53%	36,932,737
	0%	**-70,093,290**	**0%**	**0**
	10%	-107,026,027	-53%	-36,932,737
	20%	-143,958,764	-105%	-73,865,474
	30%	-180,891,501	-158%	-110,798,210
Benefits from Ozone Reduction	-30%	-372,466,727	-431%	-302,373,437
	-20%	-271,675,582	-288%	-201,582,291
	-10%	-170,884,436	-144%	-100,791,146
	0%	**-70,093,290**	**0%**	**0**

Variable	% Change	NPV	% Change	Actual Change
	10%	30,697,855	144%	100,791,146
	20%	131,489,001	288%	201,582,291
	30%	232,280,146	431%	302,373,437
Energy Cost Reduction	-30%	-82,479,196	-18%	-12,385,906
	-20%	-78,350,561	-12%	-8,257,270
	-10%	-74,221,926	-6%	-4,128,635
	0%	**-70,093,290**	**0%**	**0**
	10%	-65,964,655	6%	4,128,635
	20%	-61,836,020	12%	8,257,270
	30%	-57,707,385	18%	12,385,906
Time savings due to improved conditions	-30%	-412,156,153	-488%	-342,062,862
	-20%	-298,135,199	-325%	-228,041,908
	-10%	-184,114,245	-163%	-114,020,954
	0%	**-70,093,290**	**0%**	**0**
	10%	43,927,664	163%	114,020,954
	20%	157,948,618	325%	228,041,908
	30%	271,969,572	488%	342,062,862

FIGURE 79: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, COOL-BAU1-EO



Cool-BAU2:

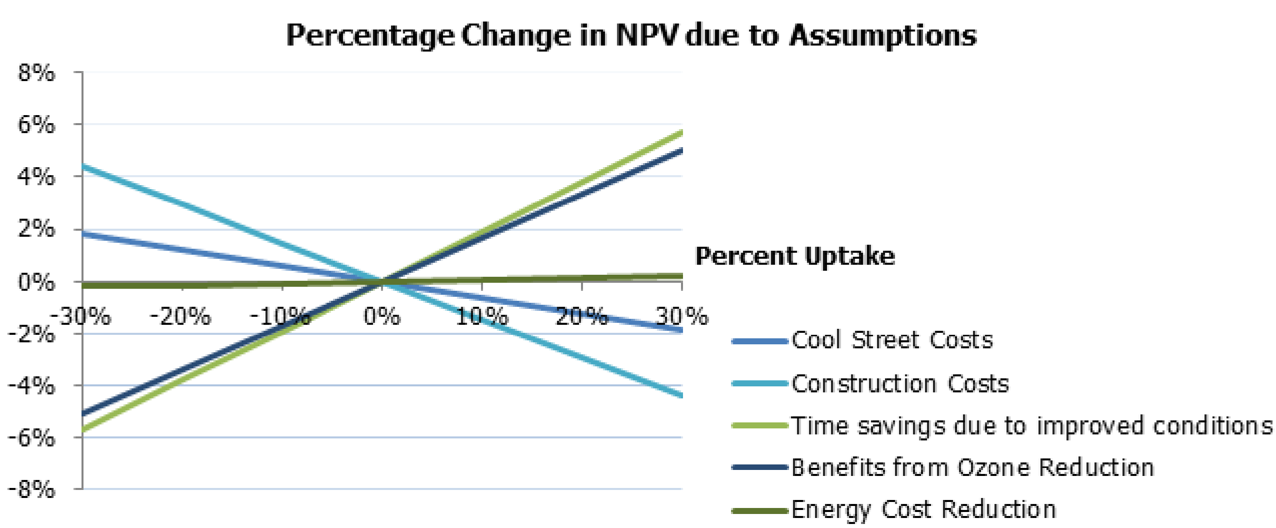
Similar to Cool-BAU1, in Cool-BAU2 time savings due to improved conditions and the benefits from ozone reduction had the largest effect on the net present value.

TABLE 76: PERCENT CHANGE IN COOL-BAU2 RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Cool Street Construction Costs	-30%	6,106,080,413	1.8%	110,798,210
	-20%	6,069,147,676	1.2%	73,865,474
	-10%	6,032,214,939	0.6%	36,932,737
	0%	**5,995,282,202**	**0.0%**	**0**
	10%	5,958,349,465	-0.6%	-36,932,737
	20%	5,921,416,729	-1.2%	-73,865,474
	30%	5,884,483,992	-1.8%	-110,798,210
Construction Costs	-30%	6,258,834,385	4.4%	263,552,183
	-20%	6,170,983,658	2.9%	175,701,455
	-10%	6,083,132,930	1.5%	87,850,728
	0%	**5,995,282,202**	**0.0%**	**0**
	10%	5,907,431,475	-1.5%	-87,850,728
	20%	5,819,580,747	-2.9%	-175,701,455
	30%	5,731,730,019	-4.4%	-263,552,183
	-30%	5,653,219,340	-5.7%	-342,062,862
	-20%	5,767,240,294	-3.8%	-228,041,908

Variable	% Change	NPV	% Change	Actual Change
Time savings due to improved conditions	-10%	5,881,261,248	-1.9%	-114,020,954
	0%	**5,995,282,202**	**0.0%**	**0**
	10%	6,109,303,156	1.9%	114,020,954
	20%	6,223,324,110	3.8%	228,041,908
	30%	6,337,345,065	5.7%	342,062,862
Benefits from Ozone Reduction	-30%	5,692,908,766	-5.0%	-302,373,437
	-20%	5,793,699,911	-3.4%	-201,582,291
	-10%	5,894,491,057	-1.7%	-100,791,146
	0%	**5,995,282,202**	**0.0%**	**0**
	10%	6,096,073,348	1.7%	100,791,146
	20%	6,196,864,493	3.4%	201,582,291
	30%	6,297,655,639	5.0%	302,373,437
Energy Cost Reduction	-30%	5,982,896,297	-0.2%	-12,385,906
	-20%	5,987,024,932	-0.1%	-8,257,270
	-10%	5,991,153,567	-0.1%	-4,128,635
	0%	**5,995,282,202**	**0.0%**	**0**
	10%	5,999,410,838	0.1%	4,128,635
	20%	6,003,539,473	0.1%	8,257,270
	30%	6,007,668,108	0.2%	12,385,906

FIGURE 80: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, COOL-BAU2



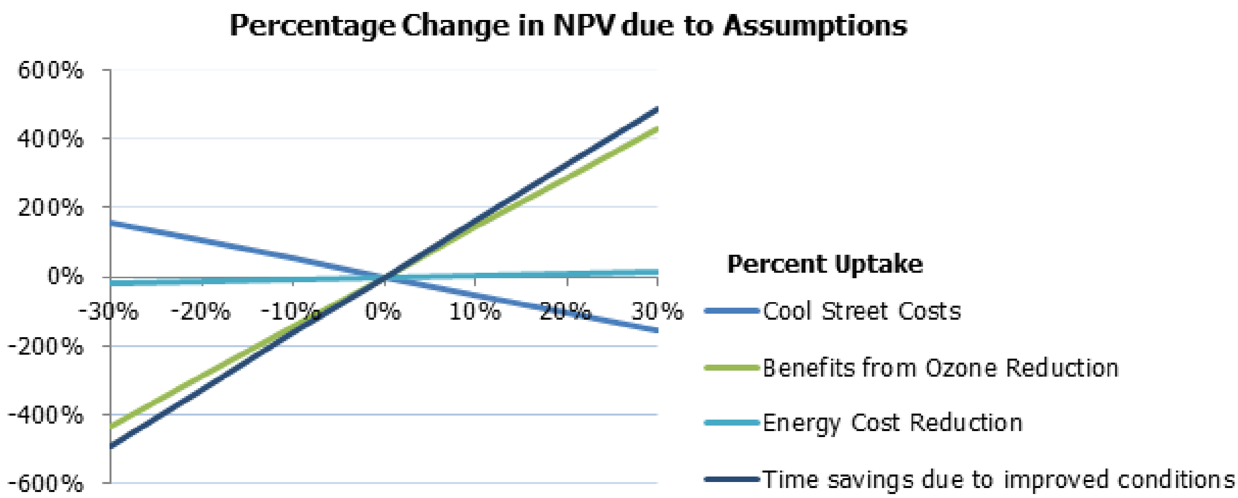
Cool-BAU2, Element Only (Cool-BAU2-EO):

As in the Cool-BAU2 scenario above, time savings due to improved conditions and the benefits from ozone reduction had the largest effect on the net present value. Notably, a 0.4% increase in either of these variables made the net present value positive for the implementation of Cool Street pavement.

Table 77: Percent change in Cool-BAU2-EO results due to change in variables

Variable	% Change	NPV	% Change	Actual Change
Cool Street Construction Costs	-30%	40,704,920	158.1%	110,798,210
	-20%	3,772,183	105.4%	73,865,474
	-10%	-33,160,554	52.7%	36,932,737
	0%	**-70,093,290**	**0.0%**	**0**
	10%	-107,026,027	-52.7%	-36,932,737
	20%	-143,958,764	-105.4%	-73,865,474
	30%	-180,891,501	-158.1%	-110,798,210
Benefits from Ozone Reduction	-30%	-372,466,727	-431.4%	-302,373,437
	-20%	-271,675,582	-287.6%	-201,582,291
	-10%	-170,884,436	-143.8%	-100,791,146
	0%	**-70,093,290**	**0.0%**	**0**
	10%	30,697,855	143.8%	100,791,146
	20%	131,489,001	287.6%	201,582,291
	30%	232,280,146	431.4%	302,373,437
Energy Cost Reduction	-30%	-82,479,196	-17.7%	-12,385,906
	-20%	-78,350,561	-11.8%	-8,257,270
	-10%	-74,221,926	-5.9%	-4,128,635
	0%	**-70,093,290**	**0.0%**	**0**
	10%	-65,964,655	5.9%	4,128,635
	20%	-61,836,020	11.8%	8,257,270
	30%	-57,707,385	17.7%	12,385,906
Time savings due to improved conditions	-30%	-412,156,153	-488.0%	-342,062,862
	-20%	-298,135,199	-325.3%	-228,041,908
	-10%	-184,114,245	-162.7%	-114,020,954
	0%	**-70,093,290**	**0.0%**	**0**
	10%	43,927,664	162.7%	114,020,954
	20%	157,948,618	325.3%	228,041,908
	30%	271,969,572	488.0%	342,062,862

FIGURE 81: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, COOL-BAU2-EO



A.5.3. Complete Street

Discount Rate:

Complete-BAU1:

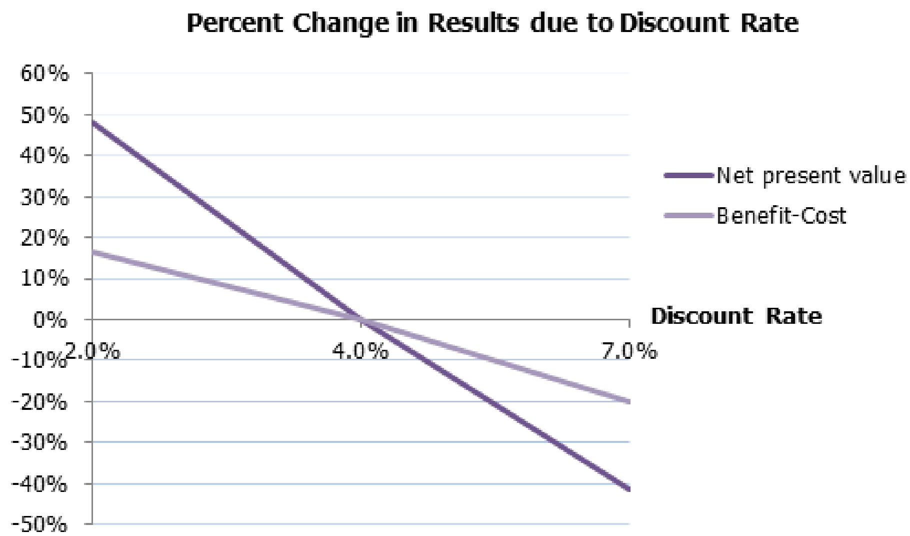
The sensitivity of the Complete-BAU1 results is similar to the Green and Cool -BAU1 results. In the case of Complete-BAU1, a 2% discount rate changes the net present value by 48% - compared to 45% for Green-BAU1 and 46% for Cool-BAU1. A 7% discount rate changes the net present value by 42% - compared to 42% for Green-BAU1 and 39% for Cool-BAU1. The tables and figure below display the results of a 2% and 7% discount rate, compared to 4% used in the analysis.

TABLE 78: PERCENT CHANGE IN COMPLETE-BAU1 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	10,797,996,216	48%	3,521,039,232
4%	**7,276,956,985**	**0%**	**0**
7%	4,252,477,683	-42%	-3,024,479,302

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	5.17	17%	0.73
4%	**4.44**	**0%**	**0.00**
7%	3.55	-20%	-0.89

FIGURE 82: PERCENT CHANGE IN COMPLETE-BAU1 RESULTS DUE TO DISCOUNT RATE

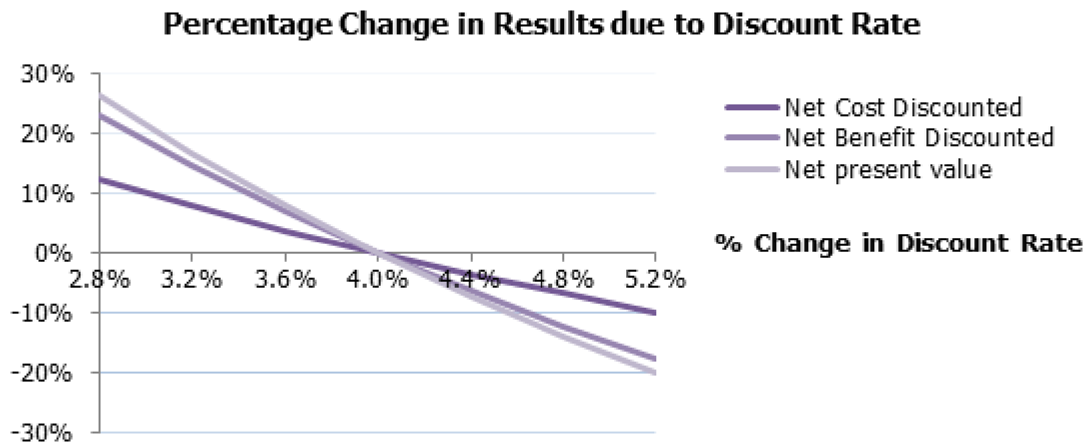


When the discount rate decreases 0.4%, the net present value increase by 8% (577 million dollars). When the discount rate increase 0.4%, the results decrease by 7% (527 million dollars). This incremental analysis of the change in the discount rate is shown in the table and figure below:

TABLE 79: PERCENT CHANGE IN COMPLETE-BAU1 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	9,185,716,015	26.2%	1,908,759,031
3.2%	8,488,830,698	16.7%	1,211,873,714
3.6%	7,854,733,515	7.9%	577,776,530
4.0%	**7,276,956,985**	**0.0%**	**0**
4.4%	6,749,764,210	-7.2%	-527,192,774
4.8%	6,268,060,616	-13.9%	-1,008,896,368
5.2%	5,827,316,915	-19.9%	-1,449,640,070

FIGURE 83: PERCENT CHANGE IN COMPLETE-BAU1 RESULTS DUE TO DISCOUNT RATE



Complete-BAU1, Element Only (Complete-BAU1-EO):

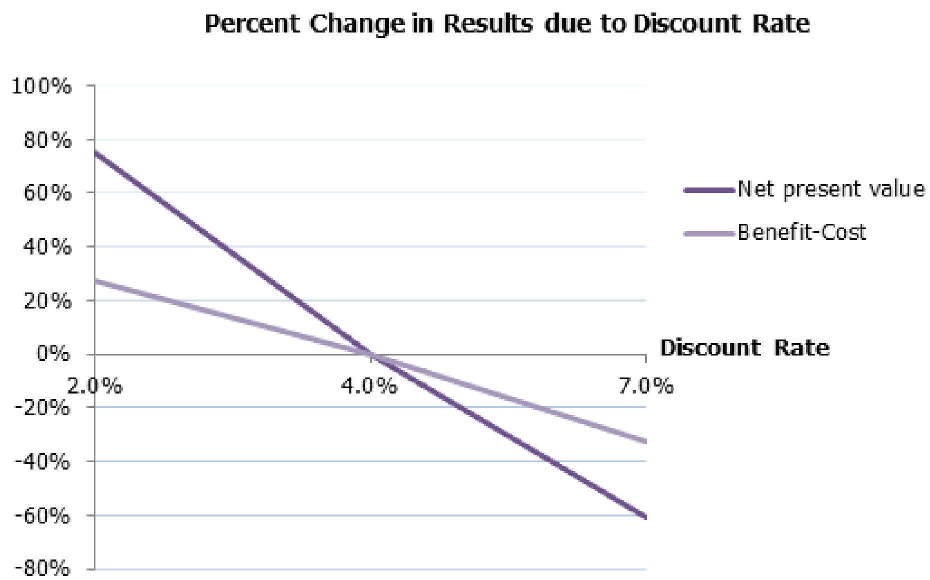
As in the Green and Cool scenarios, the Complete-BAU1-Element Only analysis - the results of the costs and benefits associated with the implementation of the Complete Street Element Only – are much more sensitive to the discount rate. As can be seen in the tables and figure below, a 2% discount rate changes the net present value by 75% and a 7% discount rate changes the net present value by 61%.

TABLE 80: CHANGE IN COMPLETE-BAU1-EO RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	1,612,524,005	75%	690,942,837
4%	**921,581,168**	**0%**	**0**
7%	362,837,663	-61%	-558,743,505

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	1.94	27.0%	0.27
4%	**1.67**	**0.0%**	**0.00**
7%	1.34	-32.6%	-0.33

FIGURE 84: PERCENT CHANGE IN COMPLETE-BAU1-EO RESULTS DUE TO DISCOUNT RATE

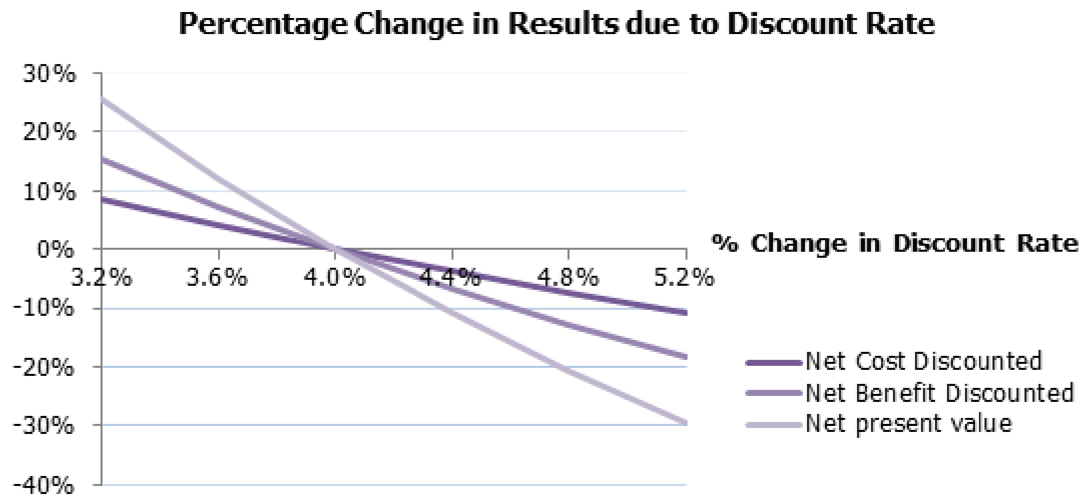


The incremental analysis also show similar results. An increase in the discount rate of 0.4% decreases the net present value by 11% (100 million dollars) – compared to only 7% in the Complete-BAU1 scenario. A decrease in the discount rate of 0.4% increases the net present value by nearly 12% (111 million dollars) – compared to only 8% in the Complete-BAU1 scenario.

TABLE 81: CHANGE IN COMPLETE-BAU1-EO RESULTS DUE TO CHANGE DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	1,291,998,266	40.2%	370,417,098
3.2%	1,155,507,081	25.4%	233,925,913
3.6%	1,032,530,622	12.0%	110,949,454
4.0%	**921,581,168**	**0.0%**	**0**
4.4%	821,348,669	-10.9%	-100,232,499
4.8%	730,678,225	-20.7%	-190,902,943
5.2%	648,550,554	-29.6%	-273,030,614

FIGURE 85: PERCENT CHANGE IN COMPLETE-BAU1-EO RESULTS DUE TO CHANGE DISCOUNT RATE



Complete-BAU2:

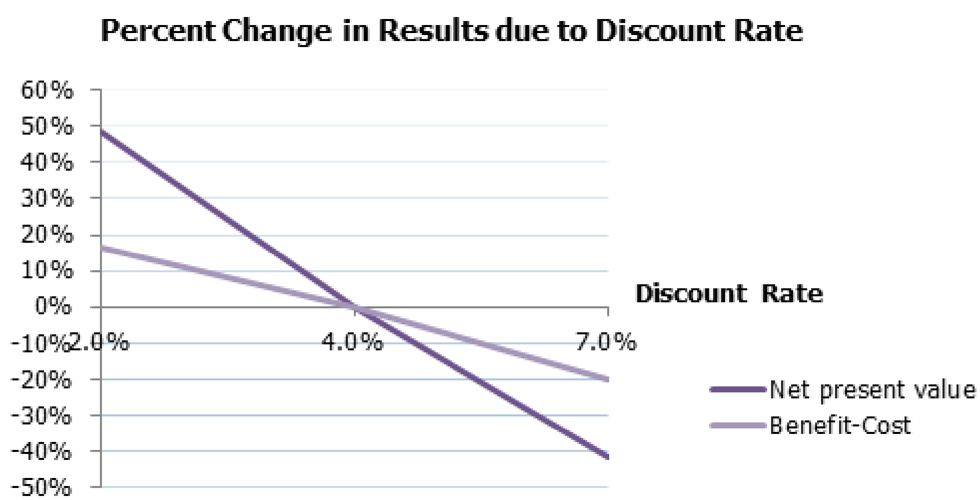
Similar to the Complete-BAU1 scenario, the sensitivity of the Complete-BAU2 results is similar to the Green and Cool –BAU2 results. In the case of Complete-BAU2, a 2% discount rate changes the net present value by 49% -compared to 47% for Green-BAU2 and 48% for Cool-BAU2. A 7% discount rate changes the net present value by 42% -compared to 40% for Green-BAU2 and 41% for Cool-BAU2. The tables and figure below display the results of the sensitivity of the Complete-BAU2 results to a 2% and 7% discount rate, compared to 4% used in the analysis.

TABLE 82: CHANGE IN COMPLETE-BAU2 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	10,802,030,039	49%	3,533,543,295
4%	**7,268,486,744**	**0%**	**0**
7%	4,222,064,438	-42%	-3,046,422,306

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	5.49	20.1%	0.92
4%	**4.57**	**0.0%**	**0.00**
7%	3.54	-22.7%	-1.04

FIGURE 86: PERCENT CHANGE IN COMPLETE-BAU2 RESULTS DUE TO DISCOUNT RATE

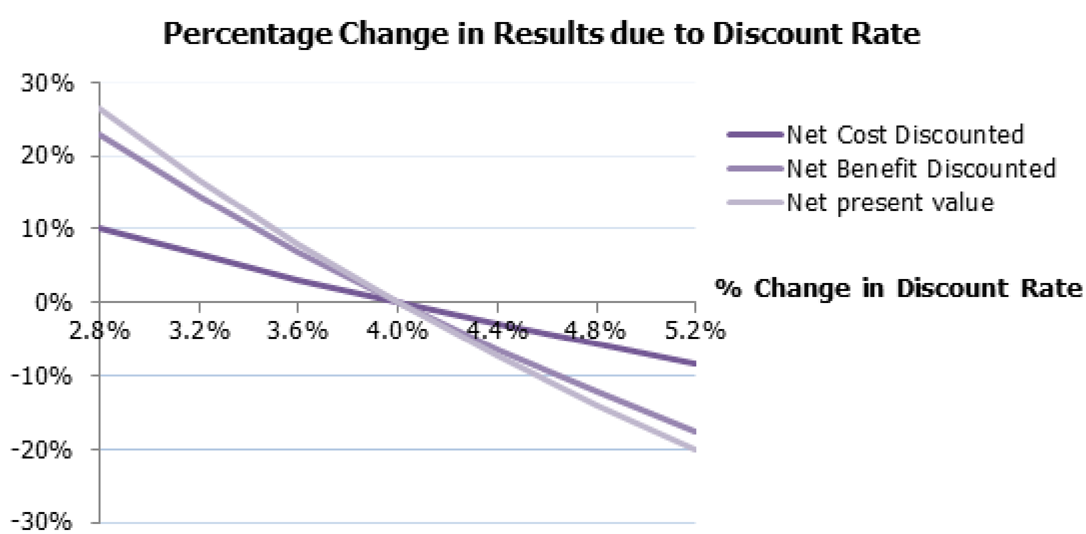


When the discount rate decrease 0.4%, the results increase by 8% (577 million dollars). When the discount rate increase 0.4%, the results decrease by 7% (527 million dollars). This incremental analysis is shown in the table and figure below:

TABLE 83: CHANGE IN COMPLETE-BAU2 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	9,185,778,513	26.4%	1,917,291,770
3.2%	8,486,269,010	16.8%	1,217,782,266
3.6%	7,849,294,731	8.0%	580,807,987
4.0%	**7,268,486,744**	**0.0%**	**0**
4.4%	6,738,186,896	-7.3%	-530,299,847
4.8%	6,253,362,950	-14.0%	-1,015,123,793
5.2%	5,809,534,399	-20.1%	-1,458,952,345

FIGURE 87: PERCENT CHANGE IN COMPLETE-BAU2 RESULTS DUE TO DISCOUNT RATE



Complete-BAU2, Element Only (Complete-BAU2-EO):

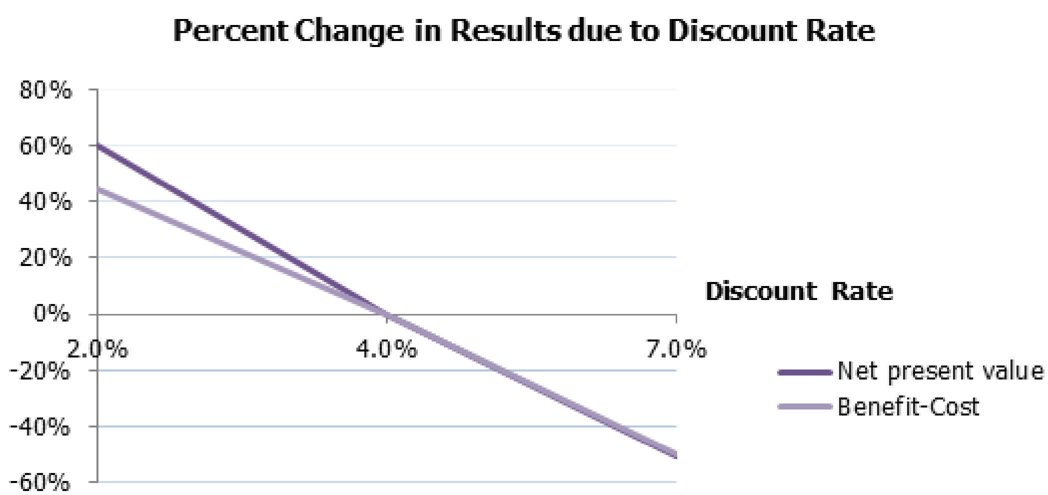
As in all previous scenarios, the Complete-BAU2-EO results are more sensitive to the discount rate than in the Complete-BAU2 scenario, when the street construction costs and benefits are included. In this scenario, a 2% discount rate changes the net present value by 60%, and a 7% discount rate changes the net present value by 51%.

TABLE 84: CHANGE IN COMPLETE-BAU2-EO RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	1,921,597,788	60%	718,486,537
4%	**1,203,111,251**	**0%**	**0**
7%	591,994,907	-51%	-611,116,344

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	2.70	44%	0.44
4%	**2.26**	**0%**	**0.00**
7%	1.76	-50%	-0.50

FIGURE 88: PERCENT CHANGE IN COMPLETE-BAU2-EO RESULTS DUE TO DISCOUNT RATE

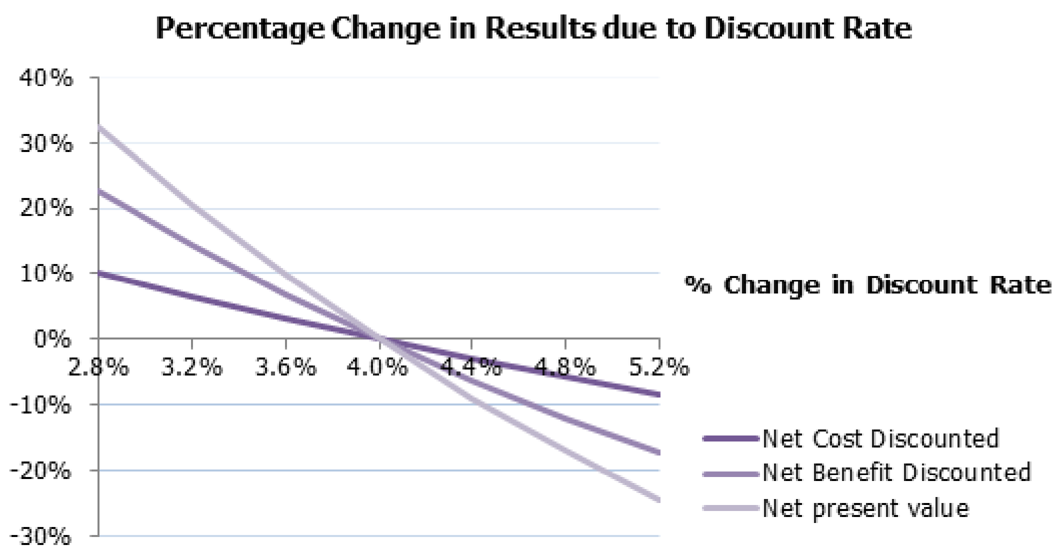


According to the analysis looking at incremental change in the discount rate on the results, a 0.4% increase in the discount rate results in nearly a 9% decrease in the net present value. A 0.4% decrease in the discount rate results in nearly a 10% increase in the net present value. The results of this analysis are shown in the table and figure below:

TABLE 85: CHANGE NET PRESENT VALUE DUE TO DISCOUNT RATE, COMPLETE-BAU2-EO

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	1,592,274,342	32.3%	389,163,091
3.2%	1,450,055,404	20.5%	246,944,154
3.6%	1,320,771,047	9.8%	117,659,796
4.0%	**1,203,111,251**	**0.0%**	**0**
4.4%	1,095,910,454	-8.9%	-107,200,797
4.8%	998,130,537	-17.0%	-204,980,714
5.2%	908,845,921	-24.5%	-294,265,330

FIGURE 89: PERCENT CHANGE IN NET PRESENT VALUE DUE TO DISCOUNT RATE, COMPLETE-BAU1-EO



Sensitivity Analysis on Variables:

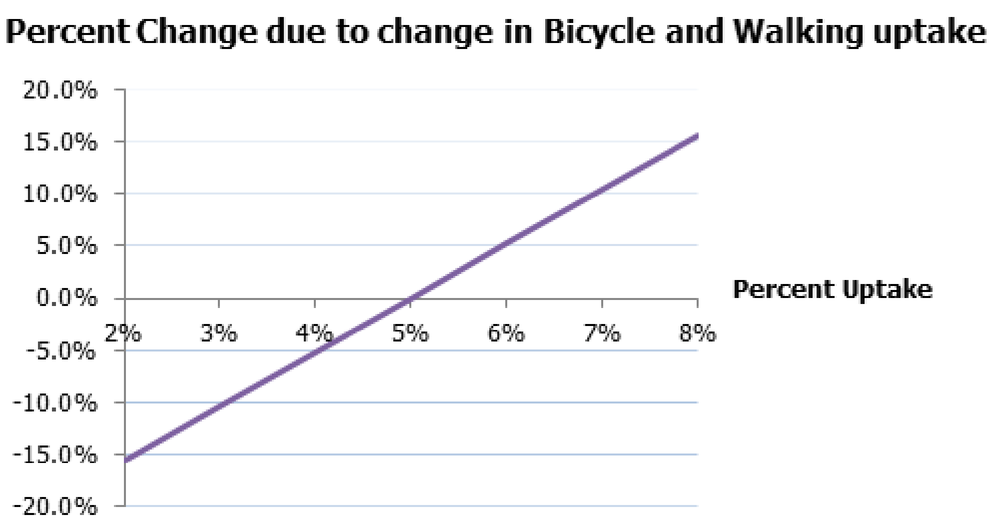
Complete-BAU1:

One of the main assumptions in the Complete Street analysis is the assumption on how the implementation of the complete elements will translate to people walking and cycling, rather than using their vehicle. In the study, and assumption of 5% was used. The following table and figure show how the results change if this assumption is increased and decreased. As can be seen in the results below, a 1% change in active transport changes the net present value by $378 million dollars (5%).

TABLE 86: CHANGE IN COMPLETE-BAU1 RESULTS DUE TO CHANGE IN ACTIVE TRANSPORT

Variable	% Change	NPV	% Change	Actual Change
Switch to Bicycle Riding and Walking	2%	6,142,106,667	-15.6%	-1,134,850,317
	3%	6,520,390,106	-10.4%	-756,566,878
	4%	6,898,673,545	-5.2%	-378,283,439
	5%	**7,276,956,985**	**0.0%**	**0**
	6%	7,655,240,424	5.2%	378,283,439
	7%	8,033,523,863	10.4%	756,566,878
	8%	8,411,807,302	15.6%	1,134,850,317

FIGURE 90: CHANGE IN NET PRESENT VALUE DUE CHANGE IN BICYCLING AND WALKING, COMPLETE-BAU1



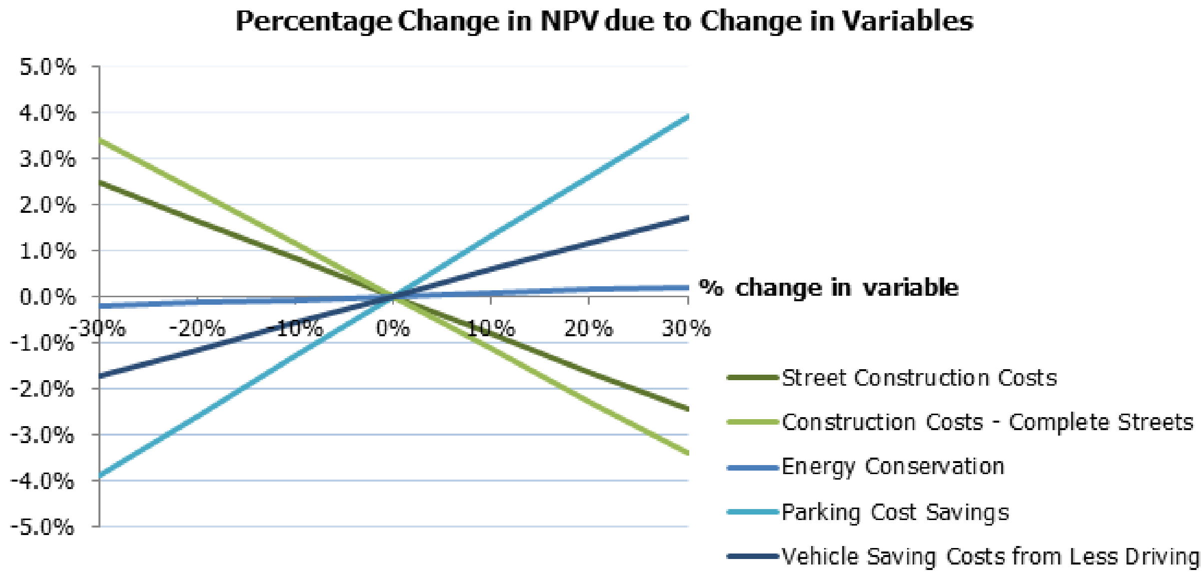
In addition to changes in active transport, various variables were analyzed to determine their impact on the results of the study. As can be seen in the table below, most of the variables analyzed had a relatively small effect on the overall results of the study. For example, changing the assumption on parking cost savings by 30% only changes the net present value by 3.9%. This is a smaller effect than increasing active transport, which had a larger effect on net present value for Complete-BAU1.

TABLE 87: CHANGE IN COMPLETE-BAU1 RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Street Construction Costs	-30%	7,456,056,136	2.5%	179,099,152
	-20%	7,396,356,419	1.6%	119,399,435
	-10%	7,336,656,702	0.8%	59,699,717
	0%	**7,276,956,985**	**0.0%**	**0**
	10%	7,217,257,267	-0.8%	-59,699,717
	20%	7,157,557,550	-1.6%	-119,399,435
	30%	7,097,857,833	-2.5%	-179,099,152
Construction Costs - Complete Streets	-30%	7,524,979,178	3.4%	248,022,193
	-20%	7,442,305,113	2.3%	165,348,129
	-10%	7,359,631,049	1.1%	82,674,064
	0%	**7,276,956,985**	**0.0%**	**0**
	10%	7,194,282,920	-1.1%	-82,674,064
	20%	7,111,608,856	-2.3%	-165,348,129
	30%	7,028,934,792	-3.4%	-248,022,193
Energy Conservation	-30%	7,261,455,965	-0.2%	-15,501,020
	-20%	7,266,622,971	-0.1%	-10,334,013
	-10%	7,271,789,978	-0.1%	-5,167,007
	0%	**7,276,956,985**	**0.0%**	**0**
	10%	7,282,123,991	0.1%	5,167,007
	20%	7,287,290,998	0.1%	10,334,013
	30%	7,292,458,004	0.2%	15,501,020
Parking Cost Savings	-30%	6,992,771,624	-3.9%	-284,185,360
	-20%	7,087,500,078	-2.6%	-189,456,907
	-10%	7,182,228,531	-1.3%	-94,728,453
	0%	**7,276,956,985**	**0.0%**	**0**
	10%	7,371,685,438	1.3%	94,728,453
	20%	7,466,413,892	2.6%	189,456,907
	30%	7,561,142,345	3.9%	284,185,360
	-30%	7,151,011,200	-1.7%	-125,945,785
	-20%	7,192,993,128	-1.2%	-83,963,856

Variable	% Change	NPV	% Change	Actual Change
Vehicle Saving Costs from Less Driving	-10%	7,234,975,056	-0.6%	-41,981,928
	0%	**7,276,956,985**	**0.0%**	**0**
	10%	7,318,938,913	0.6%	41,981,928
	20%	7,360,920,841	1.2%	83,963,856
	30%	7,402,902,769	1.7%	125,945,785

FIGURE 91: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, COMPLETE-BAU1



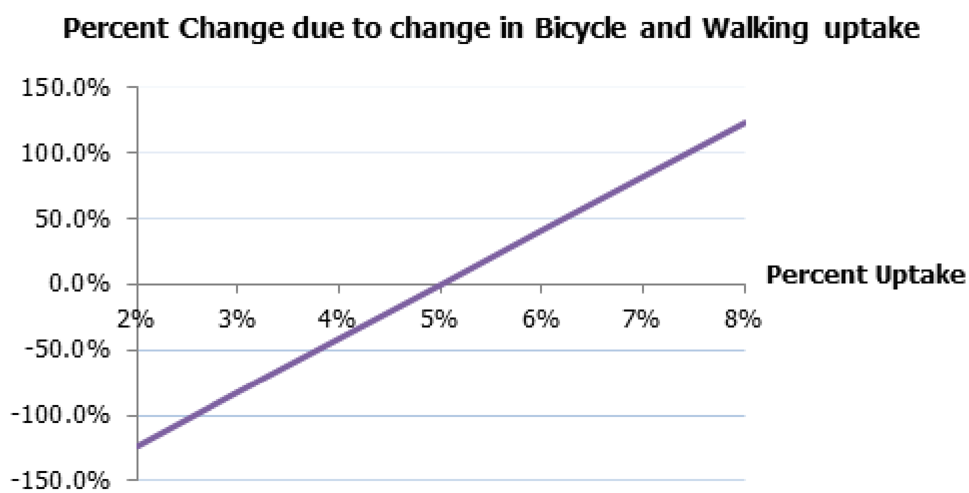
Complete-BAU1 (Element Only):

As in Complete-BAU1, one of the main assumptions in the Complete Street analysis is the assumption on how the implementation of the complete elements will translate to people walking and cycling, rather than using their vehicle. In the study, and assumption of 5% transfer from vehicle miles to active miles was used. The following table and figure show how the results change if this assumption is increased or decreased. As can be seen in the results below, a 1% change in active transport changes the net present value by $378 million dollars (41%).

TABLE 88: CHANGE IN COMPLETE-BAU1-EO RESULTS DUE TO CHANGE IN BICYCLING AND WALKING

Variable	% Change	NPV	% Change	Actual Change
Switch to Bicycle Riding and Walking	2%	-213,269,150	-123.1%	-1,134,850,317
	3%	165,014,290	-82.1%	-756,566,878
	4%	543,297,729	-41.0%	-378,283,439
	5%	**921,581,168**	**0.0%**	**0**
	6%	1,299,864,607	41.0%	378,283,439
	7%	1,678,148,046	82.1%	756,566,878
	8%	2,056,431,485	123.1%	1,134,850,317

FIGURE 92: CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN BICYCLING AND WALKING, COMPLETE-BAU2-EO



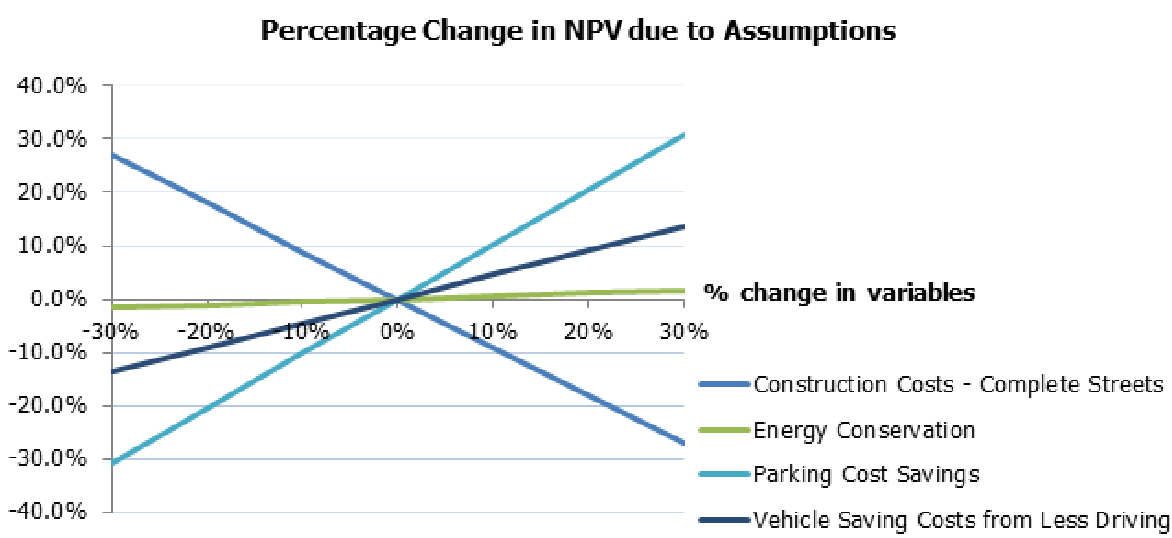
Several additional variables were analyzed to determine their impact on the results of the study. As can be seen in the table below, variance in the Complete Street construction costs significantly affects the overall results. Similarly, variance in the assumed parking cost savings has a significant effect on the results.

TABLE 89: CHANGE IN COMPLETE-BAU2-EO RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Construction Costs - Complete Streets	-30%	1,169,603,361	26.9%	248,022,193
	-20%	1,086,929,296	17.9%	165,348,129
	-10%	1,004,255,232	9.0%	82,674,064
	0%	**921,581,168**	**0.0%**	**0**
	10%	838,907,104	-9.0%	-82,674,064
	20%	756,233,039	-17.9%	-165,348,129
	30%	673,558,975	-26.9%	-248,022,193
Energy Conservation	-30%	906,080,148	-1.7%	-15,501,020
	-20%	911,247,155	-1.1%	-10,334,013
	-10%	916,414,161	-0.6%	-5,167,007
	0%	**921,581,168**	**0.0%**	**0**
	10%	926,748,174	0.6%	5,167,007
	20%	931,915,181	1.1%	10,334,013
	30%	937,082,187	1.7%	15,501,020

Variable	% Change	NPV	% Change	Actual Change
Parking Cost Savings	-30%	637,395,807	-30.8%	-284,185,360
	-20%	732,124,261	-20.6%	-189,456,907
	-10%	826,852,714	-10.3%	-94,728,453
	0%	**921,581,168**	**0.0%**	**0**
	10%	1,016,309,621	10.3%	94,728,453
	20%	1,111,038,075	20.6%	189,456,907
	30%	1,205,766,528	30.8%	284,185,360
Vehicle Saving Costs from Less Driving	-30%	795,635,383	-13.7%	-125,945,785
	-20%	837,617,311	-9.1%	-83,963,856
	-10%	879,599,240	-4.6%	-41,981,928
	0%	**921,581,168**	**0.0%**	**0**
	10%	963,563,096	4.6%	41,981,928
	20%	1,005,545,024	9.1%	83,963,856
	30%	1,047,526,953	13.7%	125,945,785

FIGURE 93: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, COMPLETE-BAU1-EO



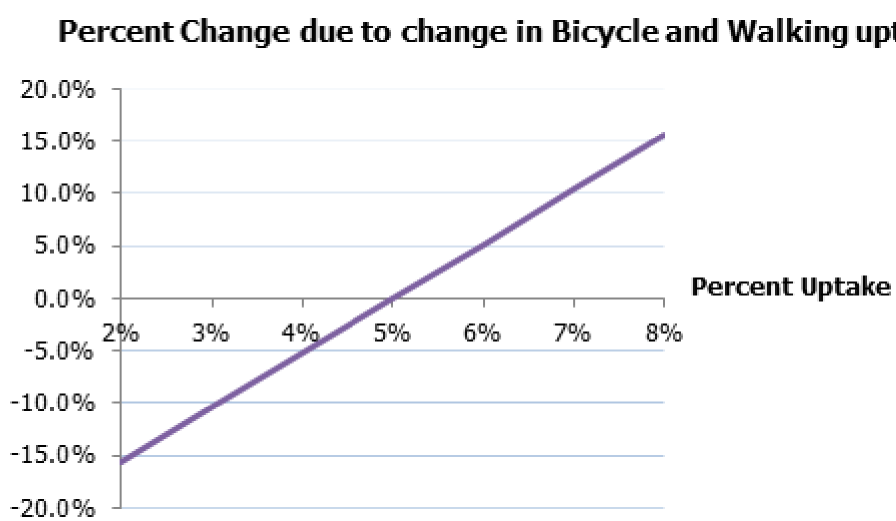
Complete-BAU2:

As in the BAU1 scenario, the assumption on how the implementation of the complete elements will translate to people walking and cycling, rather than using their vehicle, is one of the main assumptions made in the Complete Street scenario. In the study, an assumption of 5% transfer from vehicle miles travelled to active transport was used. The following table and figure show how the results change if this assumption is increased and decreased. As can be seen in the results below, a 1% change in active transport changes the net present value by $378 million dollars (5.2%).

TABLE 90: CHANGE IN COMPLETE-BAU1 RESULTS DUE TO CHANGE IN BICYCLING AND WALKING

Variable	% Change	NPV	% Change	Actual Change
Switch to Bicycle Riding and Walking	2%	6,133,636,426	-15.6%	-1,134,850,317
	3%	6,511,919,865	-10.4%	-756,566,878
	4%	6,890,203,304	-5.2%	-378,283,439
	5%	**7,268,486,744**	**0.0%**	**0**
	6%	7,646,770,183	5.2%	378,283,439
	7%	8,025,053,622	10.4%	756,566,878
	8%	8,403,337,061	15.6%	1,134,850,317

FIGURE 94: CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN BICYCLE AND WALKING, COMPLETE-BAU1



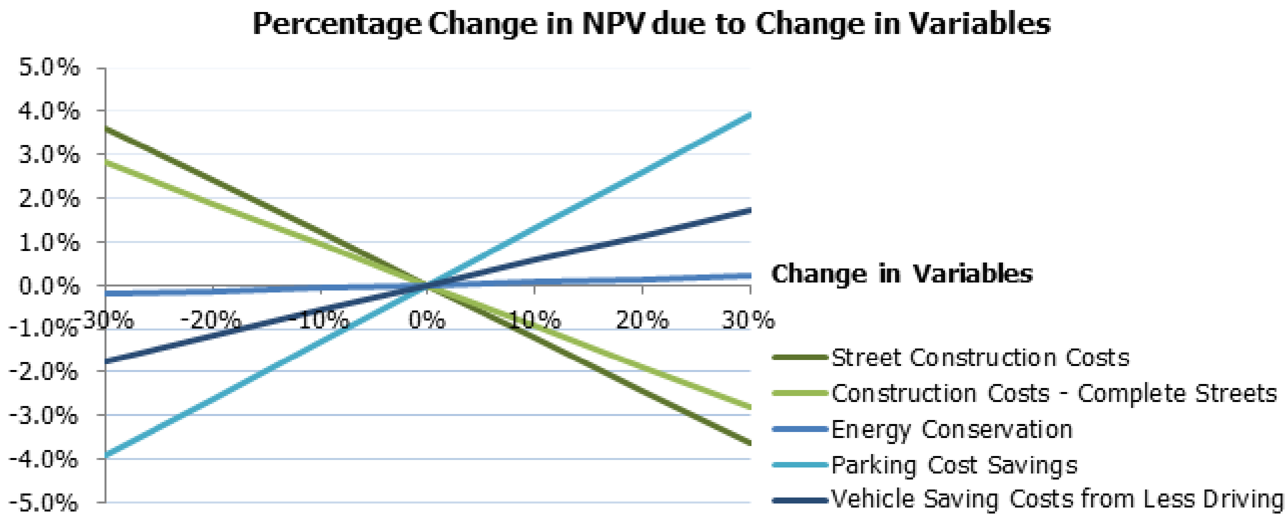
In addition to changes in active transport, various variables were analyzed to determine their impact on the results of the study. The assumption that had the largest effect on the results is parking cost savings; a 30% change in this variable changes the net present value by 3.9%.

TABLE 91: CHANGE IN COMPLETE-BAU2 RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Street Construction Costs	-30%	7,532,038,927	3.6%	263,552,183
	-20%	7,444,188,199	2.4%	175,701,455
	-10%	7,356,337,471	1.2%	87,850,728

Variable	% Change	NPV	% Change	Actual Change
	0%	**7,268,486,744**	**0.0%**	**0**
	10%	7,180,636,016	-1.2%	-87,850,728
	20%	7,092,785,288	-2.4%	-175,701,455
	30%	7,004,934,561	-3.6%	-263,552,183
Construction Costs - Complete Streets	-30%	7,473,769,115	2.8%	205,282,371
	-20%	7,405,341,658	1.9%	136,854,914
	-10%	7,336,914,201	0.9%	68,427,457
	0%	**7,268,486,744**	**0.0%**	**0**
	10%	7,200,059,287	-0.9%	-68,427,457
	20%	7,131,631,830	-1.9%	-136,854,914
	30%	7,063,204,372	-2.8%	-205,282,371
Energy Conservation	-30%	7,252,985,724	-0.2%	-15,501,020
	-20%	7,258,152,730	-0.1%	-10,334,013
	-10%	7,263,319,737	-0.1%	-5,167,007
	0%	**7,268,486,744**	**0.0%**	**0**
	10%	7,273,653,750	0.1%	5,167,007
	20%	7,278,820,757	0.1%	10,334,013
	30%	7,283,987,763	0.2%	15,501,020
Parking Cost Savings	0%	6,984,301,383	-3.9%	-284,185,360
	0%	7,079,029,837	-2.6%	-189,456,907
	0%	7,173,758,290	-1.3%	-94,728,453
	0%	**7,268,486,744**	**0.0%**	**0**
	0%	7,363,215,197	1.3%	94,728,453
	0%	7,457,943,651	2.6%	189,456,907
	0%	7,552,672,104	3.9%	284,185,360
Vehicle Saving Costs from Less Driving	-30%	7,142,540,959	-1.7%	-125,945,785
	-20%	7,184,522,887	-1.2%	-83,963,856
	-10%	7,226,504,815	-0.6%	-41,981,928
	0%	**7,268,486,744**	**0.0%**	**0**
	10%	7,310,468,672	0.6%	41,981,928
	20%	7,352,450,600	1.2%	83,963,856
	30%	7,394,432,528	1.7%	125,945,785

FIGURE 95: CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, COMPLETE-BAU2



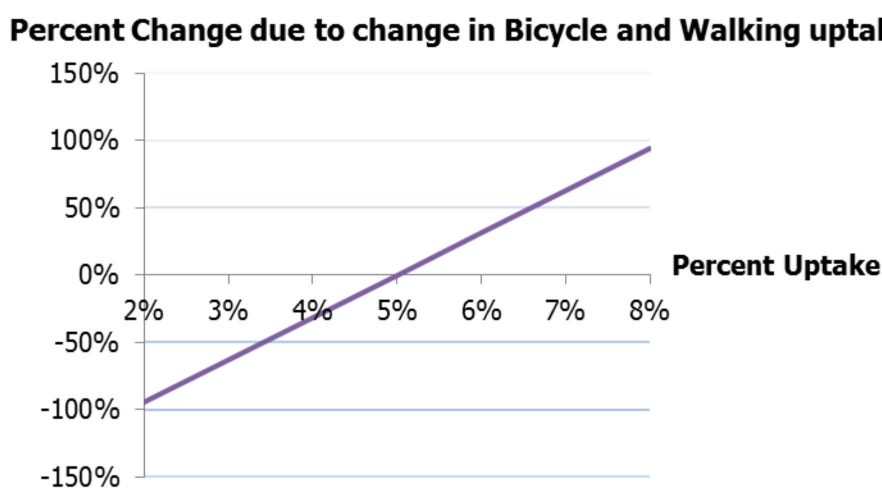
Complete-BAU2, Element Only (Complete-BAU2-EO):

The following table and figure show how the results change if the uptake in active transport is changes. As can be seen in the results below, a 1% change in active transport changes the net present value by $378 million dollars (31%).

TABLE 92: CHANGE IN COMPLETE-BAU2-EO RESULTS DUE TO CHANGE IN BICYCLING AND WALKING

Variable	% Change	NPV	% Change	Actual Change
Switch to Bicycle Riding and Walking	2%	68,260,933	-94%	-1,134,850,317
	3%	446,544,372	-63%	-756,566,878
	4%	824,827,812	-31%	-378,283,439
	5%	**1,203,111,251**	**0%**	**0**
	6%	1,581,394,690	31%	378,283,439
	7%	1,959,678,129	63%	756,566,878
	8%	2,337,961,568	94%	1,134,850,317

FIGURE 96: CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN BICYCLING AND WALKING, COMPLETE-BAU2-

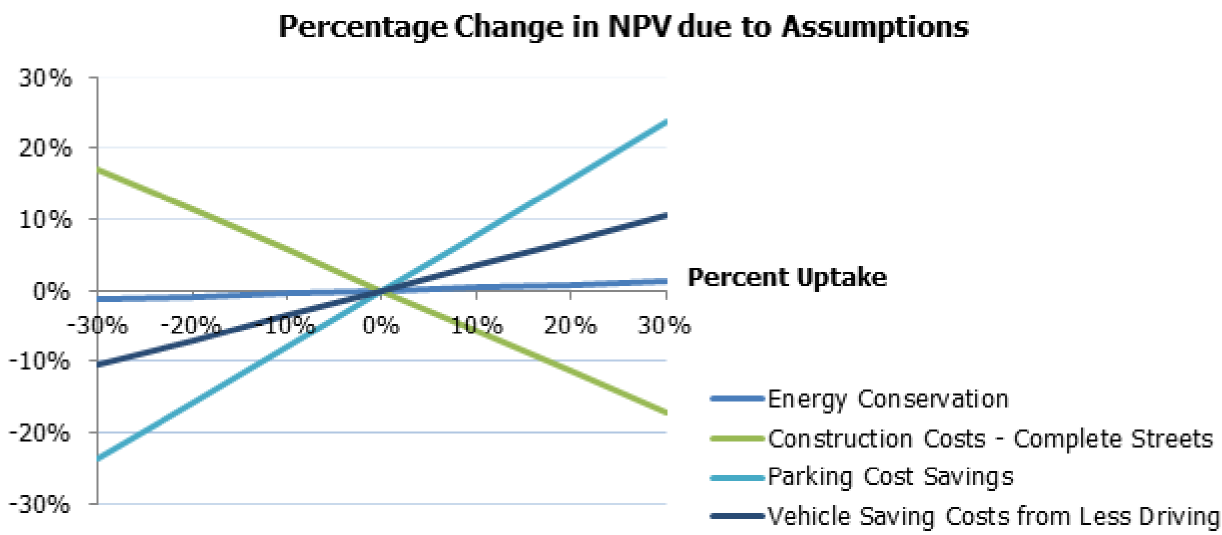


In addition, several other variables were analyzed to determine their effect on the net present value. As can be seen in the table and figure below, changes to parking cost savings and to the complete street construction cost assumptions have the largest effect on the results in this scenario.

TABLE 93: CHANGE IN COMPLETE-BAU2-EO RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Construction Costs - Complete Streets	-30%	1,408,393,622	17%	205,282,371
	-20%	1,339,966,165	11%	136,854,914
	-10%	1,271,538,708	6%	68,427,457
	0%	**1,203,111,251**	**0%**	**0**
	10%	1,134,683,794	-6%	-68,427,457
	20%	1,066,256,337	-11%	-136,854,914
	30%	997,828,880	-17%	-205,282,371
Energy Conservation	-30%	1,187,610,231	-1.3%	-15,501,020
	-20%	1,192,777,238	-0.9%	-10,334,013
	-10%	1,197,944,244	-0.4%	-5,167,007
	0%	**1,203,111,251**	**0.0%**	**0**
	10%	1,208,278,257	0.4%	5,167,007
	20%	1,213,445,264	0.9%	10,334,013
	30%	1,218,612,270	1.3%	15,501,020
Parking Cost Savings	-30%	918,925,890	-24%	-284,185,360
	-20%	1,013,654,344	-16%	-189,456,907
	-10%	1,108,382,797	-8%	-94,728,453
	0%	**1,203,111,251**	**0%**	**0**
	10%	1,297,839,704	8%	94,728,453
	20%	1,392,568,158	16%	189,456,907
	30%	1,487,296,611	24%	284,185,360
Vehicle Saving Costs from Less Driving	-30%	1,077,165,466	-10%	-125,945,785
	-20%	1,119,147,394	-7%	-83,963,856
	-10%	1,161,129,323	-3%	-41,981,928
	0%	**1,203,111,251**	**0%**	**0**
	10%	1,245,093,179	3%	41,981,928
	20%	1,287,075,107	7%	83,963,856
	30%	1,329,057,036	10%	125,945,785

FIGURE 97: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, COMPLETE-BAU2-EO



A.5.4. Living Street

Discount Rate:

Living-BAU1:

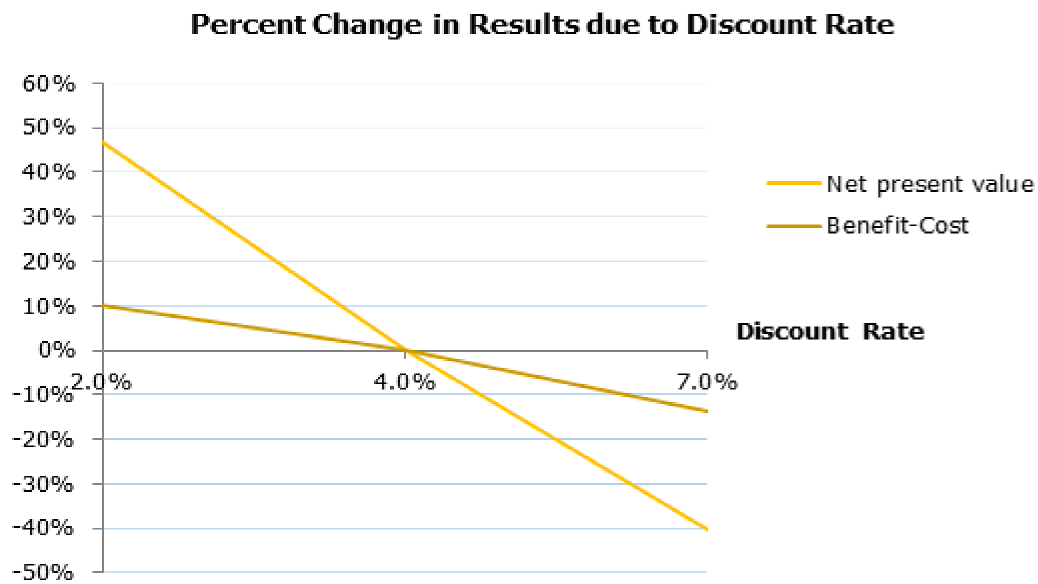
As in the previous scenarios, the effect of the discount rate on the net present value in the Living-BAU1 case was analyzed. Using a 2% discount rate, the net present value increases 47% ($4.27 Billion). Conversely, a 7% discount rate decreases the net present value by 40% ($3.69 Billion). These results are represented in the tables and figure below:

TABLE 94: CHANGE IN LIVING-BAU1 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	13,397,734,905	47%	4,265,398,502
4%	**9,132,336,403**	**0%**	**0**
7%	5,441,534,220	-40%	-3,690,802,183

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	4.14	10.1%	0.38
4%	**3.77**	**0.0%**	**0.00**
7%	3.25	-13.8%	-0.52

FIGURE 98: PERCENT CHANGE IN LIVING-BAU1 RESULTS DUE TO DISCOUNT RATE

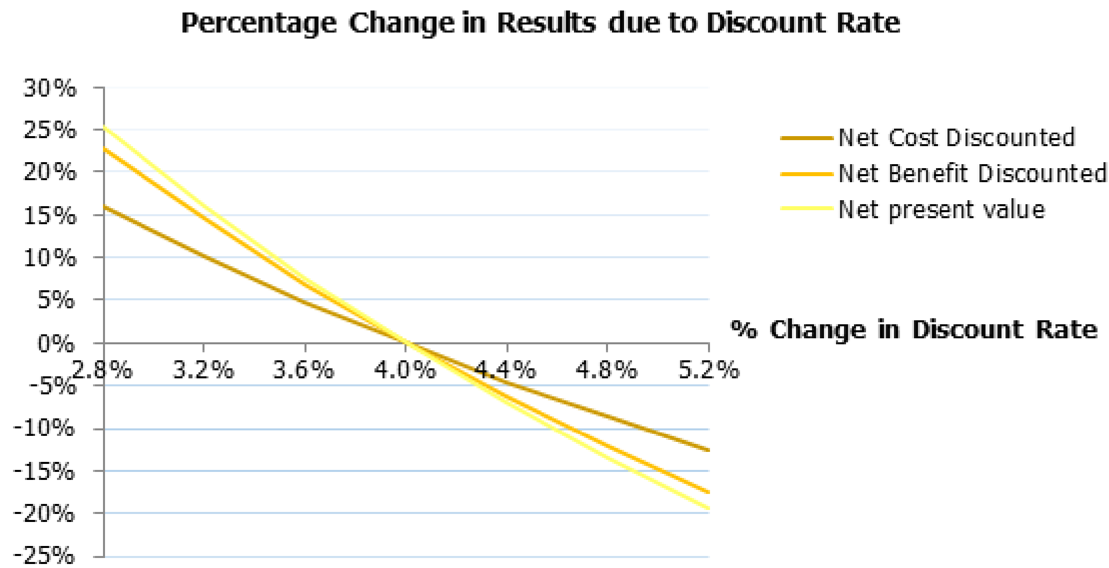


An incremental decrease of in the discount rate (0.4%) results in an 8% increase in the net present value ($701 Million). An incremental increase of in the discount rate (0.4%) results in a 7% decrease in the net present value ($641 Million).

TABLE 95: CHANGE IN LIVING-BAU1 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	11,447,945,573	25%	2,315,609,170
3.2%	10,603,515,562	16%	1,471,179,159
3.6%	9,834,196,021	8%	701,859,618
4.0%	**9,132,336,403**	**0%**	**0**
4.4%	8,491,141,280	-7%	-641,195,123
4.8%	7,904,568,055	-13%	-1,227,768,348
5.2%	7,367,237,563	-19%	-1,765,098,839

FIGURE 99: PERCENT CHANGE IN LIVING-BAU1 RESULTS DUE TO DISCOUNT RATE



Living-BAU1, Element Only (Living-BAU1-EO):

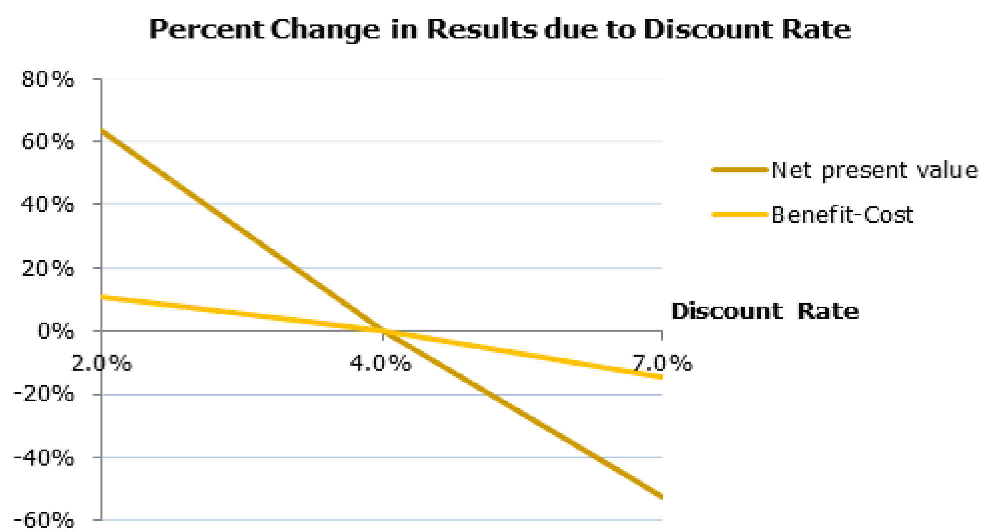
In the case of the Element Only analysis (Living-BAU1-EO), the discount rate affects the results more significantly than the Living-BAU1 results, similar to the previous scenarios. Using a 2% discount rate, the net present value increases 64%, compared to 47% in Living-BAU1 Conversely, a 7% discount rate decreases the net present value by 53%, compared to 40% in Living-BAU1. These results are represented in the tables and figure below:

TABLE 96: CHANGE IN LIVING-BAU1-EO RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	3,598,657,190	64%	1,397,652,638
4%	**2,201,004,552**	**0%**	**0**
7%	1,041,970,350	-53%	-1,159,034,201

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	1.91	11.0%	0.19
4%	**1.72**	**0.0%**	**0.00**
7%	1.47	-14.6%	-0.25

FIGURE 100: PERCENT CHANGE IN LIVING-BAU1-EO RESULTS DUE TO DISCOUNT RATE

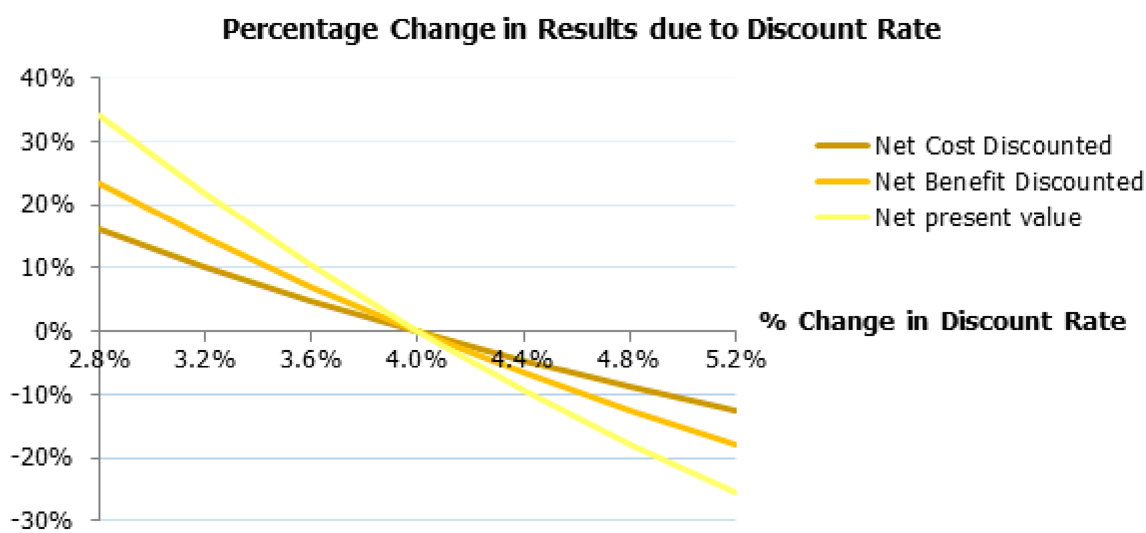


An incremental decrease of in the discount rate (0.4%) results in a 10% increase in the net present value (compared to 8% in Living-BAU1). An incremental increase of in the discount rate (0.4%) results in a 9% decrease in the net present value (compared to 7% in Living-BAU1).

TABLE 97: CHANGE NET PRESENT VALUE DUE TO DISCOUNT RATE, LIVING-BAU1-EO

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	2,953,897,793	34%	752,893,242
3.2%	2,677,557,728	22%	476,553,177
3.6%	2,427,529,014	10%	226,524,462
4.0%	**2,201,004,552**	**0%**	**0**
4.4%	1,995,503,447	-9%	-205,501,105
4.8%	1,808,830,622	-18%	-392,173,930
5.2%	1,639,041,683	-26%	-561,962,868

FIGURE 101: PERCENT CHANGE IN NET PRESENT VALUE DUE TO DISCOUNT RATE, LIVING-BAU1-EO



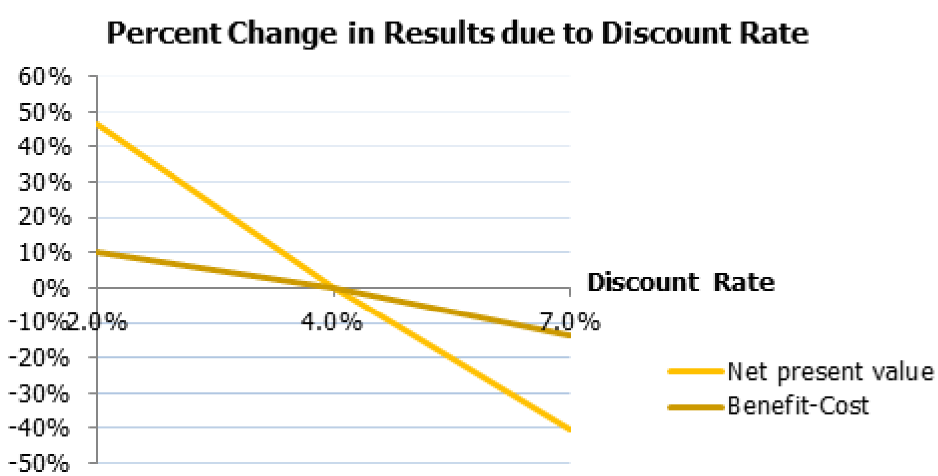
Living-BAU2:
When the discount rate is changed form 4% to 2%, the net present value in the Living-BAU2 case increased 49% (4.25 Billion). When the discount rate is changed form 4% to 2%, the net present value in the Living-BAU2 case increased 42% (3.66 Billion). This shows that the results are sensitive to the discount rate chosen. These results are shown in the tables and figure below:

Table 98: Change in Living-BAU2 results due to discount rate

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	12,927,116,899.90	49%	4,249,396,356
4%	**8,677,720,543.75**	**0.0%**	**$0**
7%	5,018,050,901.97	-42%	-3,659,669,642

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	4.14	10%	0.38
4%	**3.77**	**0%**	**0.00**
7%	3.25	-134%	-0.52

Figure 102: Percent change in Living-BAU2 results due to discount rate

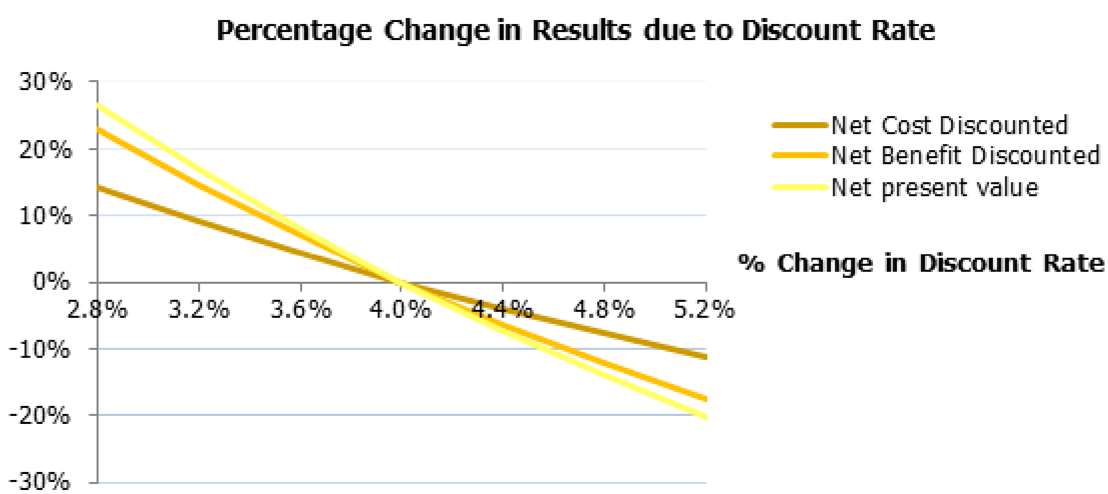


As can be seen from the table and figure below, the discount rate has a significant impact on the results of the study. When the discount rate decreases by 0.4%, the net present value increases by about 8% ($701 Million). When the discount rate increases by 0.4%, the net present value decreases by about 7% ($641 Million).

TABLE 99: CHANGE IN LIVING-BAU2 RESULTS DUE TO DISCOUNT RATE

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	11,447,945,573	25%	2,315,609,170
3.2%	10,603,515,562	16%	1,471,179,159
3.6%	9,834,196,021	8%	701,859,618
4.0%	**9,132,336,403**	**0%**	**0**
4.4%	8,491,141,280	-7%	-641,195,123
4.8%	7,904,568,055	-13%	-1,227,768,348
5.2%	7,367,237,563	-19%	-1,765,098,839

FIGURE 103: PERCENT CHANGE IN LIVING-BAU2 RESULTS DUE TO DISCOUNT RATE



Living-BAU2, Element Only (Living-BAU2-EO):

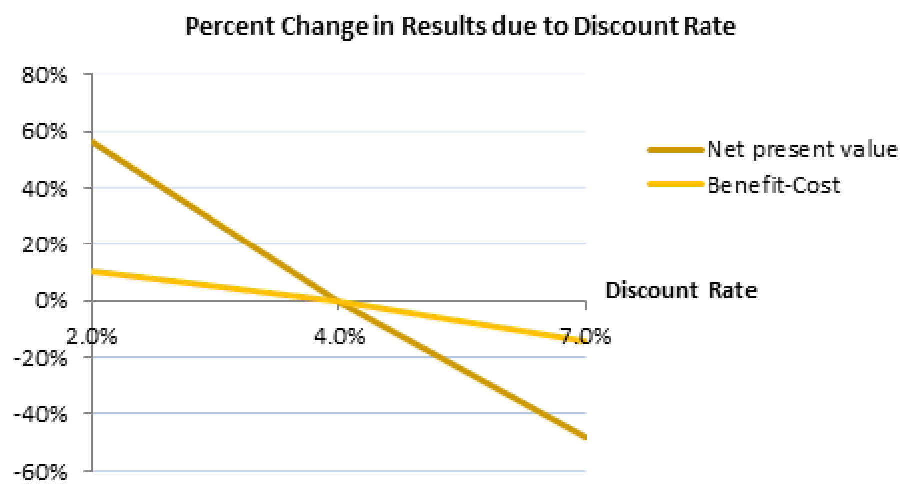
The discount rate affects the Living-BAU2-EO results more significantly than the Living-BAU2 results, similar to the previous scenarios. Using a 2% discount rate, the net present value increases 57%, compared to 49% in Living-BAU2 Conversely, a 7% discount rate decreases the net present value by 48%, compared to 42% in Living-BAU2. These results are represented in the tables and figure below:

Table 100: Change in Living-BAU2-EO results due to discount rate

Discount Rate	Net Present Value	Percent Change	Difference from Net Present Value in Study
2%	3,960,343,792.07	57%	1,429,041,915
4%	2,531,301,876.79	0%	0
7%	1,316,229,631.39	-48%	-1,215,072,245

Discount Rate	Benefit-Cost Ratio	Percent Change	Difference from Benefit-Costs Ratio in Study
2%	2.12	10.5%	0.20
4%	**1.92**	**0.0%**	**0.00**
7%	1.65	-14.1%	-0.27

FIGURE 104: PERCENT CHANGE IN LIVING-BAU2-EO RESULTS DUE TO DISCOUNT RATE

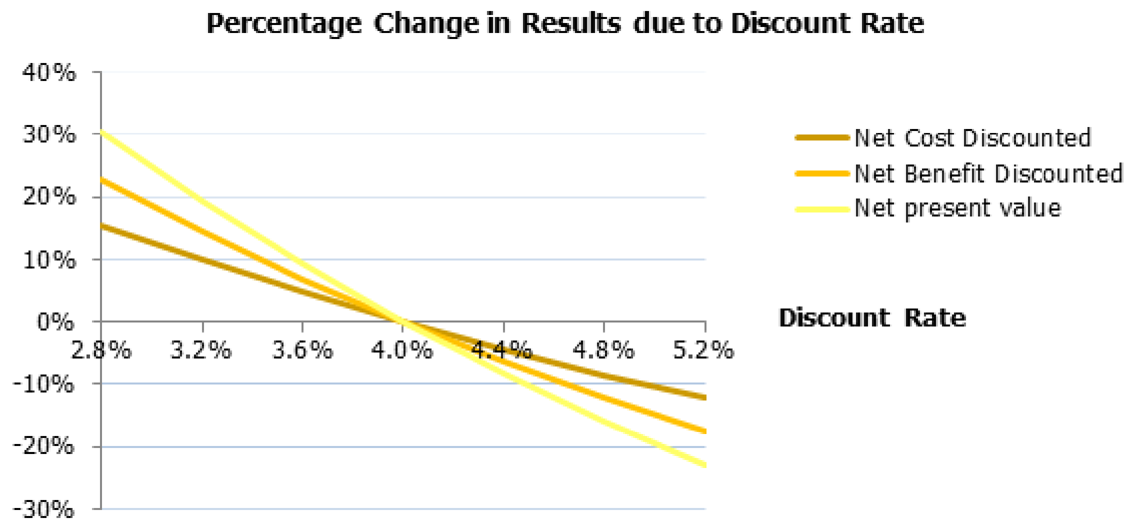


The following tables and figure show how an incremental change in discount rate affect the results. When the discount rate is increased 0.4%, the net present value decreased 8% (compared to 7% in Living-BAU2). When the discount rate is decreased 0.4%, the net present value increased 9% (compared to 8% in Living-BAU2).

TABLE 101: CHANGE NET PRESENT VALUE DUE TO DISCOUNT RATE, LIVING-BAU2-EO

Discount Rate	Net Present Value	Percent Change	Difference from Results in Study
2.8%	3,304,975,447	30.6%	773,673,571
3.2%	3,022,158,003	19.4%	490,856,126
3.6%	2,765,148,633	9.2%	233,846,756
4.0%	**2,531,301,877**	**0.0%**	**0**
4.4%	2,318,268,051	-8.4%	-213,033,826
4.8%	2,123,957,937	-16.1%	-407,343,940
5.2%	1,946,511,907	-23.1%	-584,789,970

FIGURE 105: PERCENT CHANGE IN NET PRESENT VALUE DUE TO DISCOUNT RATE, LIVING-BAU2-EO



Sensitivity Analysis on Variables:

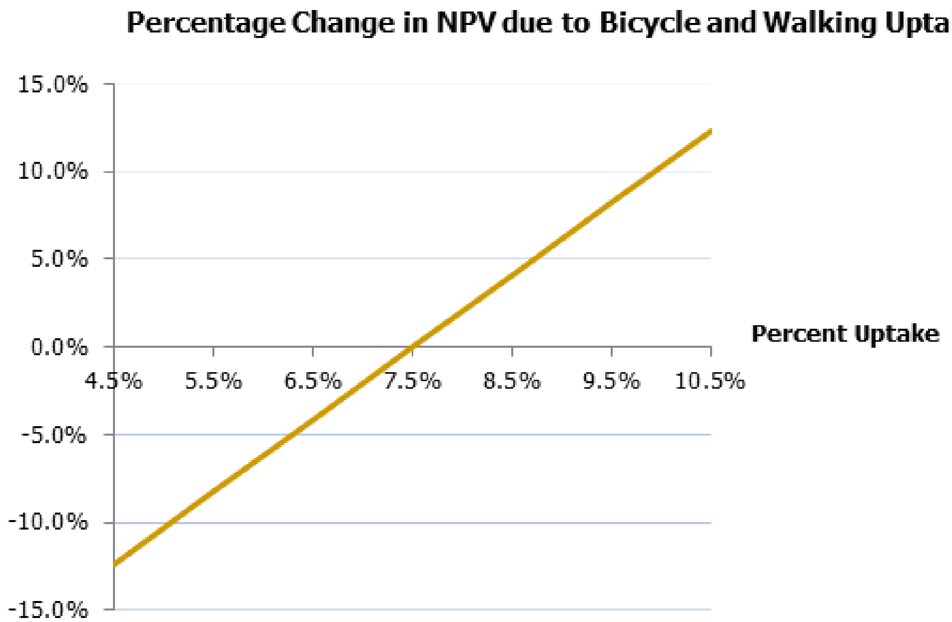
Living-BAU1:

As in the Complete Streets scenario, one of the most important assumptions for the Living Street scenario is the percentage of miles travelled that citizens choose to use active forms of transportation – namely, active transport – rather than using their car. In the Living Street scenario, the assumption was that 7.5% of vehicle miles travelled would be shifted to active transport. The following table and figure show how an adjustment in this assumption affects the net present value of the scenario. If that assumption is changed by 1%, the net present value changes 4.1% (376 million dollars).

TABLE 102: CHANGE IN LIVING-BAU1 RESULTS DUE TO CHANGE IN ACTIVE TRANSPORT

Variable	% Change	NPV	% Change	Actual Change
% of VMT transferred to active transport	4.5%	8,004,368,651	-12.4%	-1,127,967,751
	5.5%	8,380,357,902	-8.2%	-751,978,501
	6.5%	8,756,347,152	-4.1%	-375,989,250
	7.5%	**9,132,336,403**	**0.0%**	**0**
	8.5%	9,508,325,653	4.1%	375,989,250
	9.5%	9,884,314,904	8.2%	751,978,501
	10.5%	10,260,304,154	12.4%	1,127,967,751

FIGURE 106: PERCENT CHANGE IN NET PRESENT VALUE DUE CHANGE IN ACTIVE TRANSPORT, LIVING-BAU1

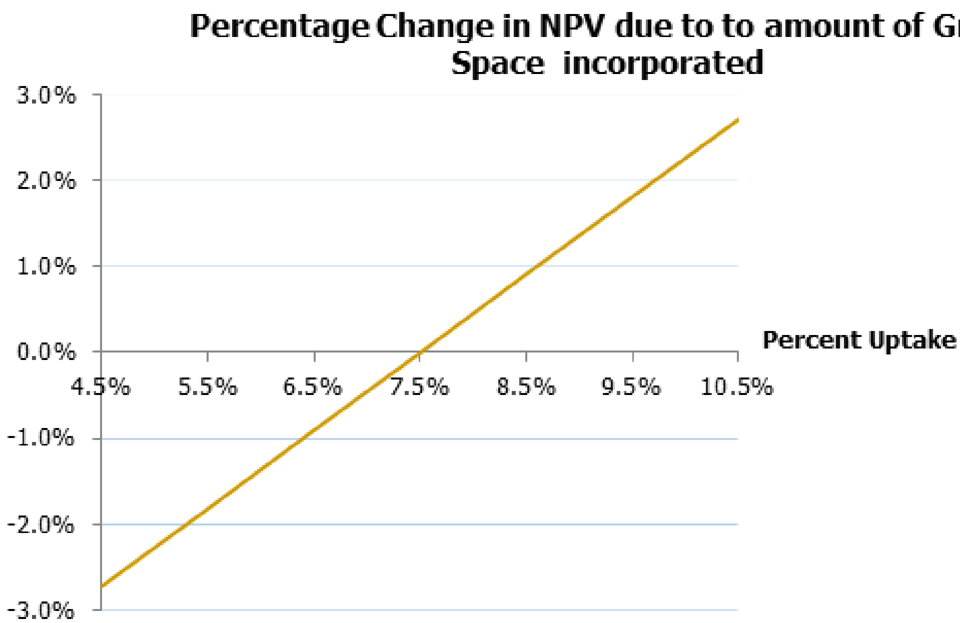


Just as in the Green Street scenarios, a major assumption in the Living Street scenario is the percentage of the street that is converted to green space. In the case of the Living Street design, the percentage of green space in the street and sidewalk space was 7.5% of the total space. The following table and figure show how the net present value is affected by a change in this assumption. A 1% change in the amount of green space affects the net present value by almost 1% ($82 Million). This shows that the net present value is less sensitive to this variable than to the assumed uptake in active transport, shown above.

TABLE 103: CHANGE IN LIVING-BAU1 RESULTS DUE TO CHANGE IN AMOUNT OF GREEN SPACE

Variable	% Change	NPV	% Change	Actual Change
Percentage of Green Space included in the Street	4.5%	8,884,156,036	-2.7%	-248,180,366
	5.5%	8,966,881,336	-1.8%	-165,455,067
	6.5%	9,049,611,104	-0.9%	-82,725,299
	7.5%	**9,132,336,403**	**0.0%**	**0**
	8.5%	9,215,061,702	0.9%	82,725,299
	9.5%	9,297,787,001	1.8%	165,450,598
	10.5%	9,380,512,300	2.7%	248,175,897

FIGURE 107: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN AMOUNT OF GREEN SPACE, LIVING-BAU1



Similar to the other scenarios, an analysis of the sensitivity to various variables was undertaken. As can be seen in the results below, change in the benefits associated with Vehicle Operating Costs Savings has the largest effect on the net present value. A 10% change in the value of Vehicle Operating Costs Savings changes the net present value more than 6%. The construction costs for Green Streets affected the results the least; a 10% change in the value of Green Street Construction Costs changes the net present value by 0.3%.

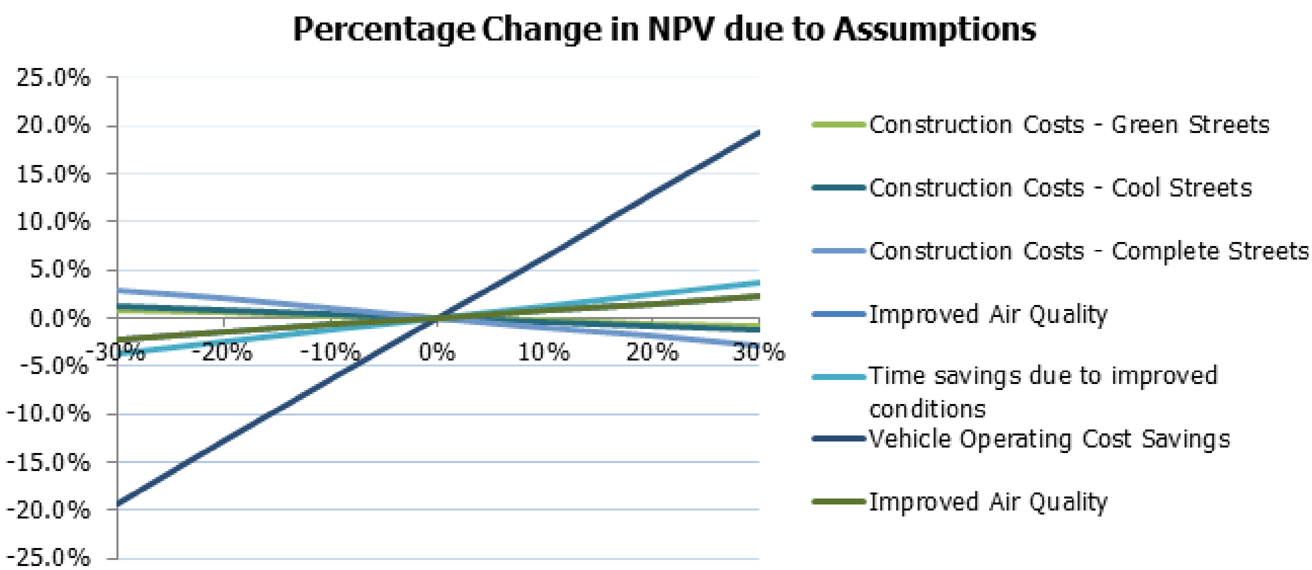
TABLE 104: CHANGE IN LIVING-BAU1 RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Construction Costs - Green Streets	-30%	9,209,667,693	0.8%	77,331,290
	-20%	9,183,890,596	0.6%	51,554,194
	-10%	9,158,113,499	0.3%	25,777,097
	0%	**9,132,336,403**	**0.0%**	**0**
	10%	9,106,559,306	-0.3%	-25,777,097
	20%	9,080,782,209	-0.6%	-51,554,194
	30%	9,055,005,112	-0.8%	-77,331,290
Construction Costs - Cool Streets	-30%	9,238,438,280	1.2%	106,101,877
	-20%	9,203,070,987	0.8%	70,734,585
	-10%	9,167,703,695	0.4%	35,367,292

Variable	% Change	NPV	% Change	Actual Change
	0%	**9,132,336,403**	**0.0%**	**0**
	10%	9,096,969,110	-0.4%	-35,367,292
	20%	9,061,601,818	-0.8%	-70,734,585
	30%	9,026,234,525	-1.2%	-106,101,877
Construction Costs - Complete Streets	-30%	9,397,574,416	2.9%	265,238,014
	-20%	9,309,161,745	1.9%	176,825,342
	-10%	9,220,749,074	1.0%	88,412,671
	0%	**9,132,336,403**	**0.0%**	**0**
	10%	9,043,923,731	-1.0%	-88,412,671
	20%	8,955,511,060	-1.9%	-176,825,342
	30%	8,867,098,389	-2.9%	-265,238,014
Improved Air Quality	-30%	8,930,533,704	-2.2%	-201,802,698
	-20%	8,997,801,270	-1.5%	-134,535,132
	-10%	9,065,068,837	-0.7%	-67,267,566
	0%	**9,132,336,403**	**0.0%**	**0**
	10%	9,199,603,969	0.7%	67,267,566
	20%	9,266,871,535	1.5%	134,535,132
	30%	9,334,139,101	2.2%	201,802,698
Time savings due to improved conditions	-30%	8,790,273,540	-3.7%	-342,062,862
	-20%	8,904,294,494	-2.5%	-228,041,908
	-10%	9,018,315,449	-1.2%	-114,020,954
	0%	**9,132,336,403**	**0.0%**	**0**
	10%	9,246,357,357	1.2%	114,020,954
	20%	9,360,378,311	2.5%	228,041,908
	30%	9,474,399,265	3.7%	342,062,862
Vehicle Operating Cost Savings	-30%	7,376,065,856	-19.2%	-1,756,270,546
	-20%	7,961,489,372	-12.8%	-1,170,847,031
	-10%	8,546,912,887	-6.4%	-585,423,515
	0%	**9,132,336,403**	**0.0%**	**0**
	10%	9,717,759,918	6.4%	585,423,515
	20%	10,303,183,433	12.8%	1,170,847,031
	30%	10,888,606,949	19.2%	1,756,270,546

Variable	% Change	NPV	% Change	Actual Change
Parking Cost Savings	-30%	8,930,533,704	-2.2%	-201,802,698
	-20%	8,997,801,270	-1.5%	-134,535,132
	-10%	9,065,068,837	-0.7%	-67,267,566
	0%	**9,132,336,403**	**0.0%**	**0**
	10%	9,199,603,969	0.7%	67,267,566
	20%	9,266,871,535	1.5%	134,535,132
	30%	9,334,139,101	2.2%	201,802,698

FIGURE 108: PERCENT CHANGE IN NET PRESENT VALUE, LIVING-BAU1



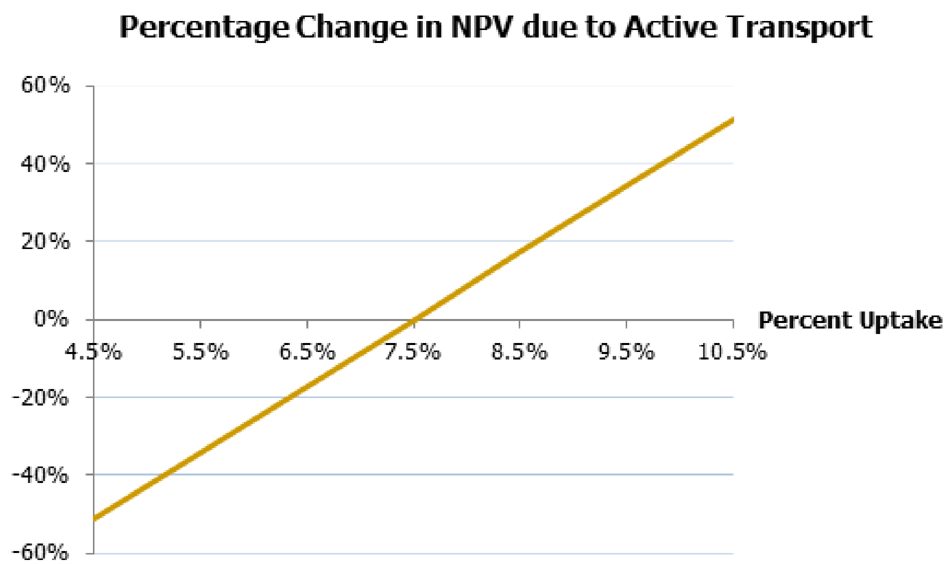
Living-BAU1, Element Only (Living-BUA1-EO):

In the Living Street scenario, the assumption was that 7.5% of vehicle miles travelled would be shifted to active transport. The following table and figure show how the net present value for the Living-BAU1-EO is affected by an adjustment in this assumption. If that assumption is changed by 1%, the net present value changes 17% (376 million dollars).

TABLE 105: CHANGE IN LIVING-BAU1-EO RESULTS DUE TO CHANGE IN ACTIVE TRANSPORT

Variable	% Change	NPV	% Change	Actual Change
% of VMT transferred to active transport	4.5%	1,073,036,800	-51.2%	-1,127,967,751
	5.5%	1,449,026,051	-34.2%	-751,978,501
	6.5%	1,825,015,301	-17.1%	-375,989,250
	7.5%	**2,201,004,552**	**0.0%**	**0**
	8.5%	2,576,993,802	17.1%	375,989,250
	9.5%	2,952,983,053	34.2%	751,978,501
	10.5%	3,328,972,303	51.2%	1,127,967,751

FIGURE 109: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN ACTIVE TRANSPORT, LIVING-BAU1-

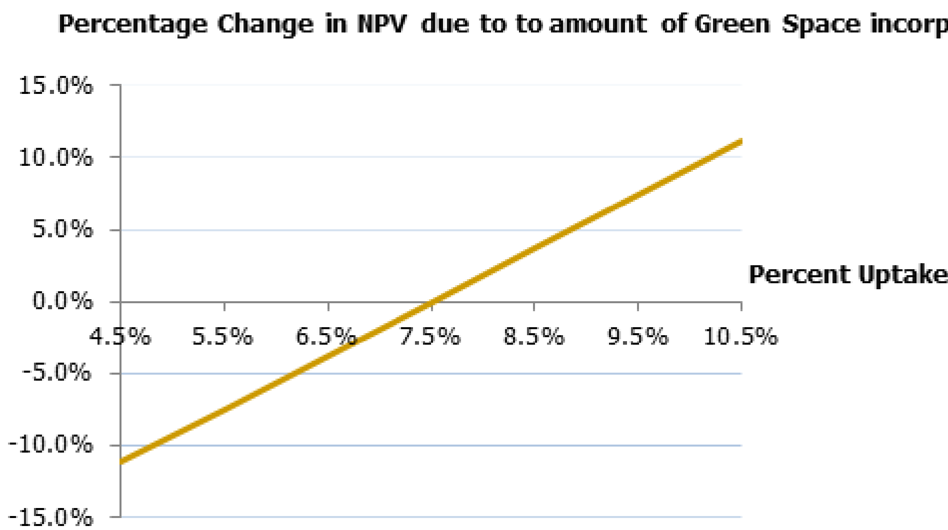


The following table and figure show how the net present value for the Living-BAU1-EO is affected by a change in the amount of green space implemented in the street. A 1% change in the amount of green space affects the net present value by 3.7%. This shows that the results are less sensitive to this variable than they are to the shift to active transport, shown above.

TABLE 106: CHANGE IN LIVING-BAU1-EO RESULTS DUE TO CHANGE IN AMOUNT OF GREEN SPACE

Variable	% Change	NPV	% Change	Actual Change
Percentage of Green Space included in the Street	4.5%	1,954,052,016	-11.2%	-246,952,536
	5.5%	2,036,368,038	-7.5%	-164,636,514
	6.5%	2,118,688,529	-3.7%	-82,316,022
	7.5%	**2,201,004,552**	**0.0%**	**0**
	8.5%	2,283,320,574	3.7%	82,316,022
	9.5%	2,365,636,596	7.5%	164,632,045
	10.5%	2,447,952,619	11.2%	246,948,067

FIGURE 110: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN AMOUNT OF GREEN SPACE, LIVING-BAU1-EO



An analysis of the sensitivity of the results to various assumptions was also undertaken. As can be seen in the results below, change in the benefits associated with Vehicle Operating Costs Savings has the largest effect on the net present value. Similarly, the Green Street construction costs has the least effect on the net present value.

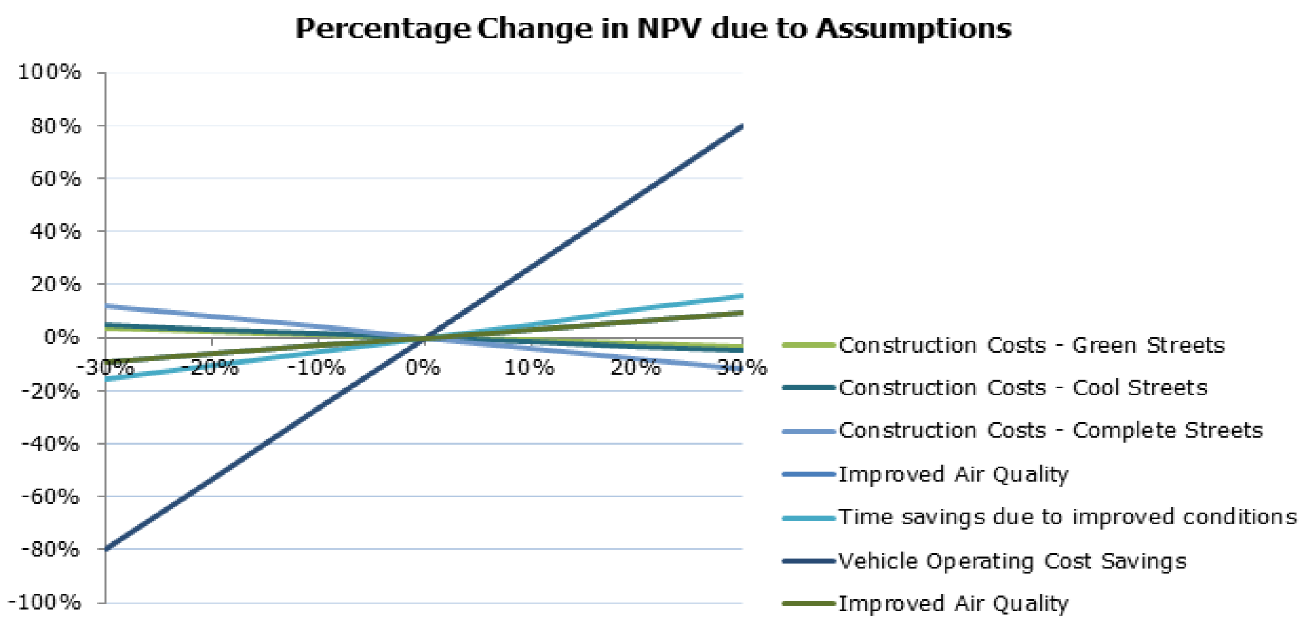
TABLE 107: CHANGE IN LIVING-BAU1-EO RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Construction Costs - Green Streets	-30%	2,278,335,842	3.5%	77,331,290
	-20%	2,252,558,745	2.3%	51,554,194
	-10%	2,226,781,648	1.2%	25,777,097
	0%	**2,201,004,552**	**0.0%**	**0**
	10%	2,175,227,455	-1.2%	-25,777,097
	20%	2,149,450,358	-2.3%	-51,554,194
	30%	2,123,673,261	-3.5%	-77,331,290
Construction Costs - Cool Streets	-30%	2,307,106,429	4.8%	106,101,877
	-20%	2,271,739,136	3.2%	70,734,585
	-10%	2,236,371,844	1.6%	35,367,292
	0%	**2,201,004,552**	**0.0%**	**0**

Variable	% Change	NPV	% Change	Actual Change
	10%	2,165,637,259	-1.6%	-35,367,292
	20%	2,130,269,967	-3.2%	-70,734,585
	30%	2,094,902,674	-4.8%	-106,101,877
Construction Costs - Complete Streets	-30%	2,466,242,565	12.1%	265,238,014
	-20%	2,377,829,894	8.0%	176,825,342
	-10%	2,289,417,223	4.0%	88,412,671
	0%	**2,201,004,552**	**0.0%**	**0**
	10%	2,112,591,880	-4.0%	-88,412,671
	20%	2,024,179,209	-8.0%	-176,825,342
	30%	1,935,766,538	-12.1%	-265,238,014
Improved Air Quality	-30%	1,999,201,853	-9.2%	-201,802,698
	-20%	2,066,469,419	-6.1%	-134,535,132
	-10%	2,133,736,986	-3.1%	-67,267,566
	0%	**2,201,004,552**	**0.0%**	**0**
	10%	2,268,272,118	3.1%	67,267,566
	20%	2,335,539,684	6.1%	134,535,132
	30%	2,402,807,250	9.2%	201,802,698
Time savings due to improved conditions	-30%	1,858,941,689	-15.5%	-342,062,862
	-20%	1,972,962,643	-10.4%	-228,041,908
	-10%	2,086,983,598	-5.2%	-114,020,954
	0%	**2,201,004,552**	**0.0%**	**0**
	10%	2,315,025,506	5.2%	114,020,954
	20%	2,429,046,460	10.4%	228,041,908
	30%	2,543,067,414	15.5%	342,062,862
Vehicle Operating Cost Savings	-30%	444,734,005	-79.8%	-1,756,270,546
	-20%	1,030,157,521	-53.2%	-1,170,847,031
	-10%	1,615,581,036	-26.6%	-585,423,515
	0%	**2,201,004,552**	**0.0%**	**0**
	10%	2,786,428,067	26.6%	585,423,515
	20%	3,371,851,582	53.2%	1,170,847,031
	30%	3,957,275,098	79.8%	1,756,270,546
Parking Cost Savings	-30%	1,999,201,853	-9.2%	-201,802,698
	-20%	2,066,469,419	-6.1%	-134,535,132

Variable	% Change	NPV	% Change	Actual Change
	-10%	2,133,736,986	-3.1%	-67,267,566
	0%	**2,201,004,552**	**0.0%**	**0**
	10%	2,268,272,118	3.1%	67,267,566
	20%	2,335,539,684	6.1%	134,535,132
	30%	2,402,807,250	9.2%	201,802,698

FIGURE 111: PERCENT CHANGE IN NET PRESENT VALUE, LIVING-BAU1-EO



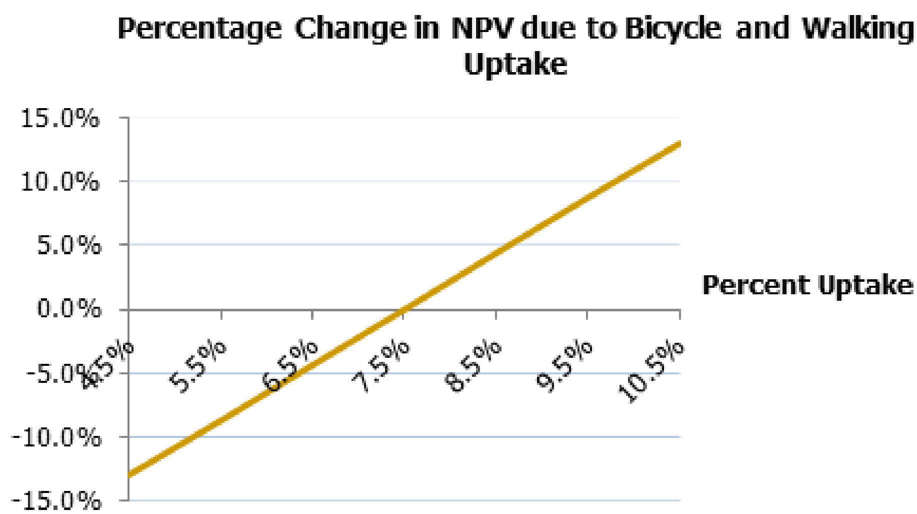
Living-BAU2:

One of the most important assumptions for the Living Street scenario, as in the Complete Streets scenario, is the percentage of miles travelled that citizens choose to shift from vehicles to more active forms of transport. In the Living Street scenario, this assumption was that 7.5% of vehicle miles travelled would be shifted to active transport. The following table and figure show how an adjustment in this assumption affects the net present value of the scenario. If that assumption is changed by 1%, the net present value changes 4.3%. This is very similar to the Living-BAU1 scenario, in which the results change 4.1%.

TABLE 108: CHANGE IN LIVING-BAU2 RESULTS DUE TO CHANGE IN ACTIVE TRANSPORT

Variable	% Change	NPV	% Change	Actual Change
% of VMT transferred to active transport	4.5%	7,549,752,792	-13.0%	-1,127,967,751
	5.5%	7,925,742,043	-8.7%	-751,978,501
	6.5%	8,301,731,293	-4.3%	-375,989,250
	7.5%	**8,677,720,544**	**0.0%**	**0**
	8.5%	9,053,709,794	4.3%	375,989,250
	9.5%	9,429,699,045	8.7%	751,978,501
	10.5%	9,805,688,295	13.0%	1,127,967,751

FIGURE 112: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN ACTIVE TRANSPORT, LIVING-BAU2

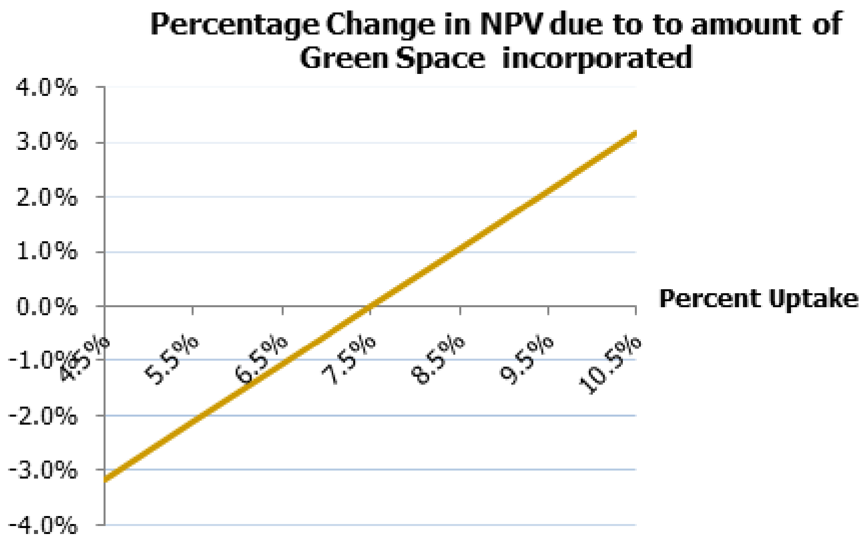


A major assumption in the Living Street scenario is the percentage of the street that is changed to green space, just as in the Green Street scenario. In the case of the Living Street design, the percentage of green space in the street and sidewalk space was assumed to be 7.5% of the total space. The following table and figure show how the net present value is affected by a change in this assumption. A 1% change in the amount of green space affects the net present value by 1.1%. This shows that the results are less sensitive to this variable than they are to the assumed shift to active transport, shown above.

TABLE 109: CHANGE IN LIVING-BAU2 RESULTS DUE TO CHANGE IN AMOUNT OF GREEN SPACE

Variable	% Change	NPV	% Change	Actual Change
Percentage of Green Space included in the Street	4.5%	8,401,107,582	-3.2%	-276,612,962
	5.5%	8,493,310,413	-2.1%	-184,410,131
	6.5%	8,585,517,713	-1.1%	-92,202,831
	7.5%	**8,677,720,544**	**0.0%**	**0**
	8.5%	8,769,923,375	1.1%	92,202,831
	9.5%	8,862,126,206	2.1%	184,405,662
	10.5%	8,954,329,037	3.2%	276,608,493

FIGURE 113: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN AMOUNT OF GREEN SPACE, LIVING-BAU2



Similar to the other scenarios, an analysis of the sensitivity of the results to different variables was undertaken. The variable which had the largest effect on the results was the change in the benefits associated with Vehicle Operating Costs Savings, as in the BAU1 case. A 10% change in the value of Vehicle Operating Costs Savings changes the net present value more than 6%. The construction costs for Green Streets affected the results the least; a 10% change in this value changes the net present value by 0.3%. These results are similar to the results above for Living-BAU1.

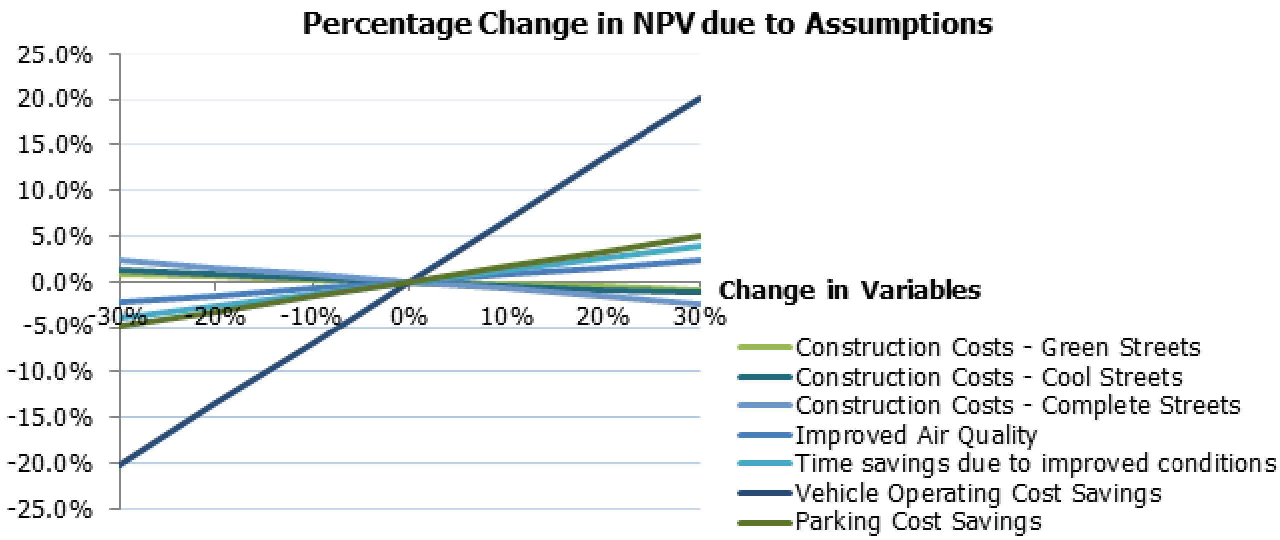
TABLE 110: CHANGE IN LIVING-BAU2 RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Construction Costs - Green Streets	-30%	8,749,676,806	0.8%	71,956,262
	-20%	8,725,691,385	0.6%	47,970,842
	-10%	8,701,705,965	0.3%	23,985,421
	0%	**8,677,720,544**	**0.0%**	**0**
	10%	8,653,735,123	-0.3%	-23,985,421
	20%	8,629,749,702	-0.6%	-47,970,842
	30%	8,605,764,281	-0.8%	-71,956,262
Construction Costs - Cool Streets	-30%	8,783,822,421	1.2%	106,101,877
	-20%	8,748,455,129	0.8%	70,734,585
	-10%	8,713,087,836	0.4%	35,367,292
	0%	**8,677,720,544**	**0.0%**	**0**

Variable	% Change	NPV	% Change	Actual Change
	10%	8,642,353,251	-0.4%	-35,367,292
	20%	8,606,985,959	-0.8%	-70,734,585
	30%	8,571,618,667	-1.2%	-106,101,877
Construction Costs - Complete Streets	-30%	8,883,002,915	2.4%	205,282,371
	-20%	8,814,575,458	1.6%	136,854,914
	-10%	8,746,148,001	0.8%	68,427,457
	0%	**8,677,720,544**	**0.0%**	**0**
	10%	8,609,293,087	-0.8%	-68,427,457
	20%	8,540,865,630	-1.6%	-136,854,914
	30%	8,472,438,173	-2.4%	-205,282,371
Improved Air Quality	-30%	8,475,917,845	-2.3%	-201,802,698
	-20%	8,543,185,412	-1.6%	-134,535,132
	-10%	8,610,452,978	-0.8%	-67,267,566
	0%	**8,677,720,544**	**0.0%**	**0**
	10%	8,744,988,110	0.8%	67,267,566
	20%	8,812,255,676	1.6%	134,535,132
	30%	8,879,523,242	2.3%	201,802,698
Time savings due to improved conditions	-30%	8,335,657,681	-3.9%	-342,062,862
	-20%	8,449,678,636	-2.6%	-228,041,908
	-10%	8,563,699,590	-1.3%	-114,020,954
	0%	**8,677,720,544**	**0.0%**	**0**
	10%	8,791,741,498	1.3%	114,020,954
	20%	8,905,762,452	2.6%	228,041,908
	30%	9,019,783,406	3.9%	342,062,862
Vehicle Operating Cost Savings	-30%	6,921,449,998	-20.2%	-1,756,270,546
	-20%	7,506,873,513	-13.5%	-1,170,847,031
	-10%	8,092,297,028	-6.7%	-585,423,515
	0%	**8,677,720,544**	**0.0%**	**0**
	10%	9,263,144,059	6.7%	585,423,515
	20%	9,848,567,575	13.5%	1,170,847,031
	30%	10,433,991,090	20.2%	1,756,270,546
Parking Cost Savings	-30%	8,251,442,503	-4.9%	-426,278,041
	-20%	8,393,535,183	-3.3%	-284,185,360

Variable	% Change	NPV	% Change	Actual Change
	-10%	8,535,627,864	-1.6%	-142,092,680
	0%	**8,677,720,544**	**0.0%**	**0**
	10%	8,819,813,224	1.6%	142,092,680
	20%	8,961,905,904	3.3%	284,185,360
	30%	9,103,998,584	4.9%	426,278,041

FIGURE 114: CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, LIVING-BAU2



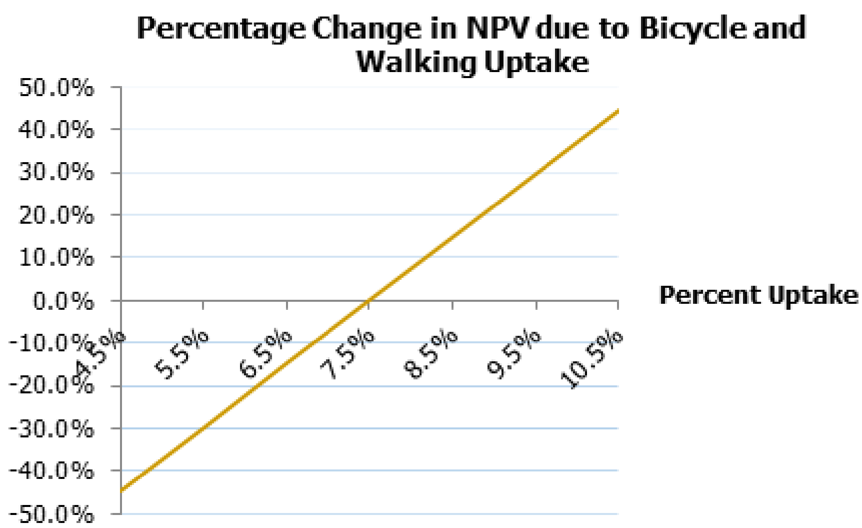
Living-BAU2, Element Only (Living-BAU2-EO):

The following table and figure show how the net present value for Living-BAU1-EO is affected by an adjustment in the assumed about of travels transferred from vehicles to active transport. If this assumption changes by 1%, the net present value changes 15% (376 million dollars).

TABLE 111: CHANGE IN LIVING-BAU2-EO RESULTS DUE TO CHANGE IN ACTIVE TRANSPORT

Variable	% Change	NPV	% Change	Actual Change
Switch to Bicycle Riding and Walking	4.5%	1,403,334,125	-45%	-1,127,967,751
	5.5%	1,779,323,376	-30%	-751,978,501
	6.5%	2,155,312,626	-15%	-375,989,250
	7.5%	**2,531,301,877**	**0%**	**0**
	8.5%	2,907,291,127	15%	375,989,250
	9.5%	3,283,280,378	30%	751,978,501
	10.5%	3,659,269,628	45%	1,127,967,751

FIGURE 115: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN ACTIVE TRANSPORT, LIVING-BAU2-

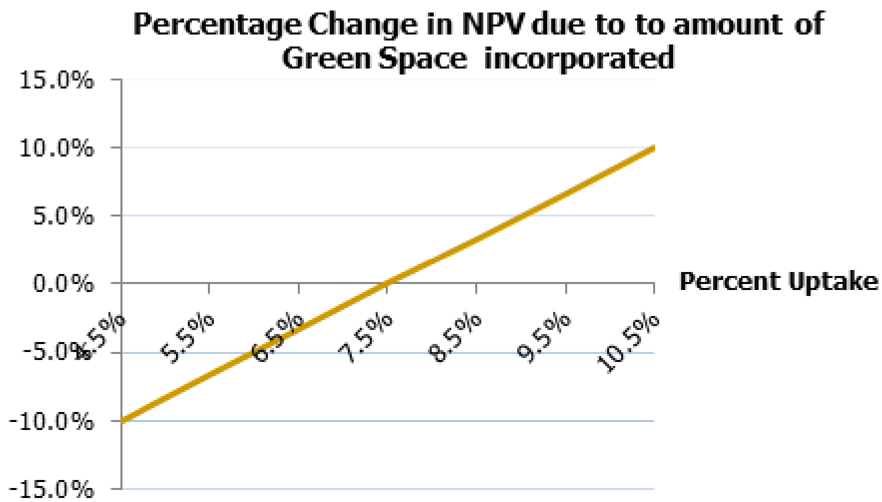


The following table and figure show how the net present value for the Living-BAU1-Element Only analysis is affected by a change in the amount of green space implemented in the street. A 1% change in the amount of green space affects the net present value by 3.4%. This is very similar to the Living-BAU1 scenario, which was 3.7%. The results are less sensitive to this variable than they are to the assumed change in active transport, shown above.

TABLE 112: CHANGE IN LIVING-BAU2-EO RESULTS DUE TO CHANGE IN AMOUNT OF GREEN SPACE

Variable	% Change	NPV	% Change	Actual Change
Percentage of Green Space included in the Street	4.5%	2,276,789,858	-10.1%	-254,512,019
	5.5%	2,361,625,708	-6.7%	-169,676,169
	6.5%	2,446,466,027	-3.4%	-84,835,850
	7.5%	**2,531,301,877**	**0.0%**	**0**
	8.5%	2,616,137,727	3.4%	84,835,850
	9.5%	2,700,973,577	6.7%	169,671,700
	10.5%	2,785,809,427	10.1%	254,507,550

FIGURE 116: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN AMOUNT OF GREEN SPACE, LIVING-BAU2-EO



An analysis of the sensitivity of the results to various assumptions was undertaken. A change in the benefits associated with Vehicle Operating Costs Savings has the largest effect on the net present value. This is similar to the results above for the full Living-BAU2 scenario.

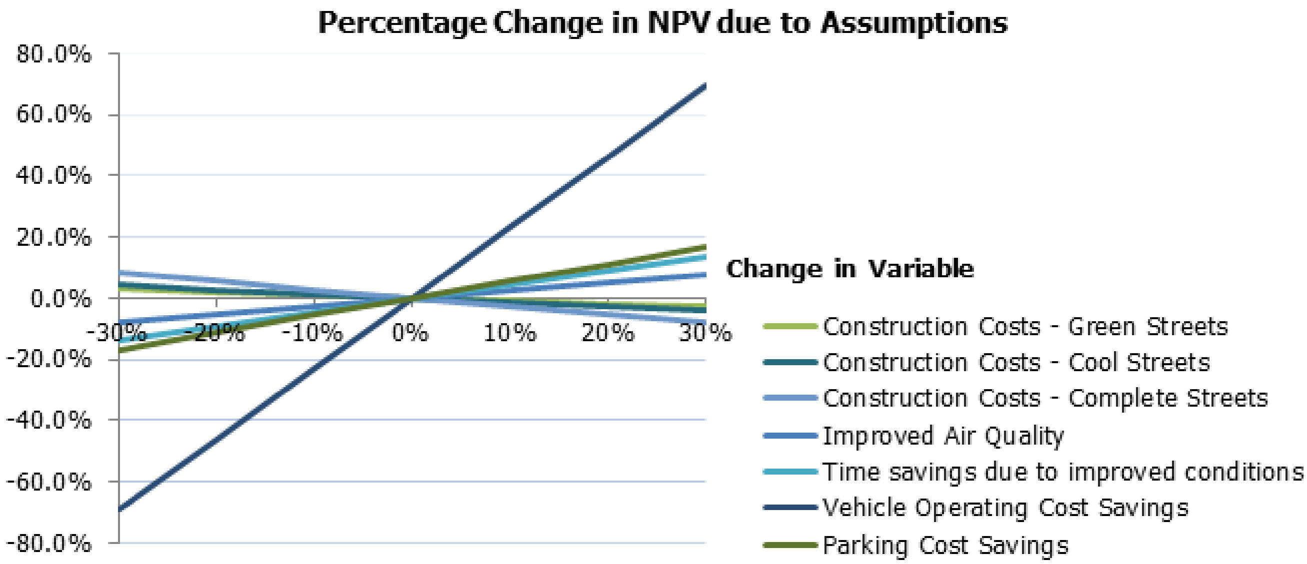
TABLE 113: CHANGE IN LIVING-BAU2-EO RESULTS DUE TO CHANGE IN VARIABLES

Variable	% Change	NPV	% Change	Actual Change
Construction Costs - Green Streets	-30%	2,603,258,139	2.8%	71,956,262
	-20%	2,579,272,718	1.9%	47,970,842
	-10%	2,555,287,298	0.9%	23,985,421
	0%	**2,531,301,877**	**0.0%**	**0**
	10%	2,507,316,456	-0.9%	-23,985,421
	20%	2,483,331,035	-1.9%	-47,970,842
	30%	2,459,345,614	-2.8%	-71,956,262
Construction Costs - Cool Streets	-30%	2,637,403,754	4.2%	106,101,877
	-20%	2,602,036,462	2.8%	70,734,585
	-10%	2,566,669,169	1.4%	35,367,292
	0%	**2,531,301,877**	**0.0%**	**0**
	10%	2,495,934,584	-1.4%	-35,367,292
	20%	2,460,567,292	-2.8%	-70,734,585
	30%	2,425,200,000	-4.2%	-106,101,877

Variable	% Change	NPV	% Change	Actual Change
Construction Costs - Complete Streets	-30%	2,736,584,248	8%	205,282,371
	-20%	2,668,156,791	5%	136,854,914
	-10%	2,599,729,334	3%	68,427,457
	0%	**2,531,301,877**	**0%**	**0**
	10%	2,462,874,420	-3%	-68,427,457
	20%	2,394,446,963	-5%	-136,854,914
	30%	2,326,019,506	-8%	-205,282,371
Improved Air Quality	-30%	2,329,499,179	-8%	-201,802,698
	-20%	2,396,766,745	-5%	-134,535,132
	-10%	2,464,034,311	-3%	-67,267,566
	0%	**2,531,301,877**	**0%**	**0**
	10%	2,598,569,443	3%	67,267,566
	20%	2,665,837,009	5%	134,535,132
	30%	2,733,104,575	8%	201,802,698
Time savings due to improved conditions	-30%	2,189,239,015	-14%	-342,062,862
	-20%	2,303,259,969	-9%	-228,041,908
	-10%	2,417,280,923	-5%	-114,020,954
	0%	**2,531,301,877**	**0%**	**0**
	10%	2,645,322,831	5%	114,020,954
	20%	2,759,343,785	9%	228,041,908
	30%	2,873,364,739	14%	342,062,862
Vehicle Operating Cost Savings	-30%	775,031,331	-69%	-1,756,270,546
	-20%	1,360,454,846	-46%	-1,170,847,031
	-10%	1,945,878,361	-23%	-585,423,515
	0%	**2,531,301,877**	**0%**	**0**
	10%	3,116,725,392	23%	585,423,515
	20%	3,702,148,908	46%	1,170,847,031
	30%	4,287,572,423	69%	1,756,270,546
Parking Cost Savings	-30%	2,105,023,836	-17%	-426,278,041
	-20%	2,247,116,516	-11%	-284,185,360
	-10%	2,389,209,197	-6%	-142,092,680
	0%	**2,531,301,877**	**0%**	**0**
	10%	2,673,394,557	6%	142,092,680

Variable	% Change	NPV	% Change	Actual Change
	20%	2,815,487,237	11%	284,185,360
	30%	2,957,579,917	17%	426,278,041

FIGURE 117: PERCENT CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN VARIABLES, LIVING-BAU2-EO



A.5.5. Effect of Discount Rate in the Overall Results

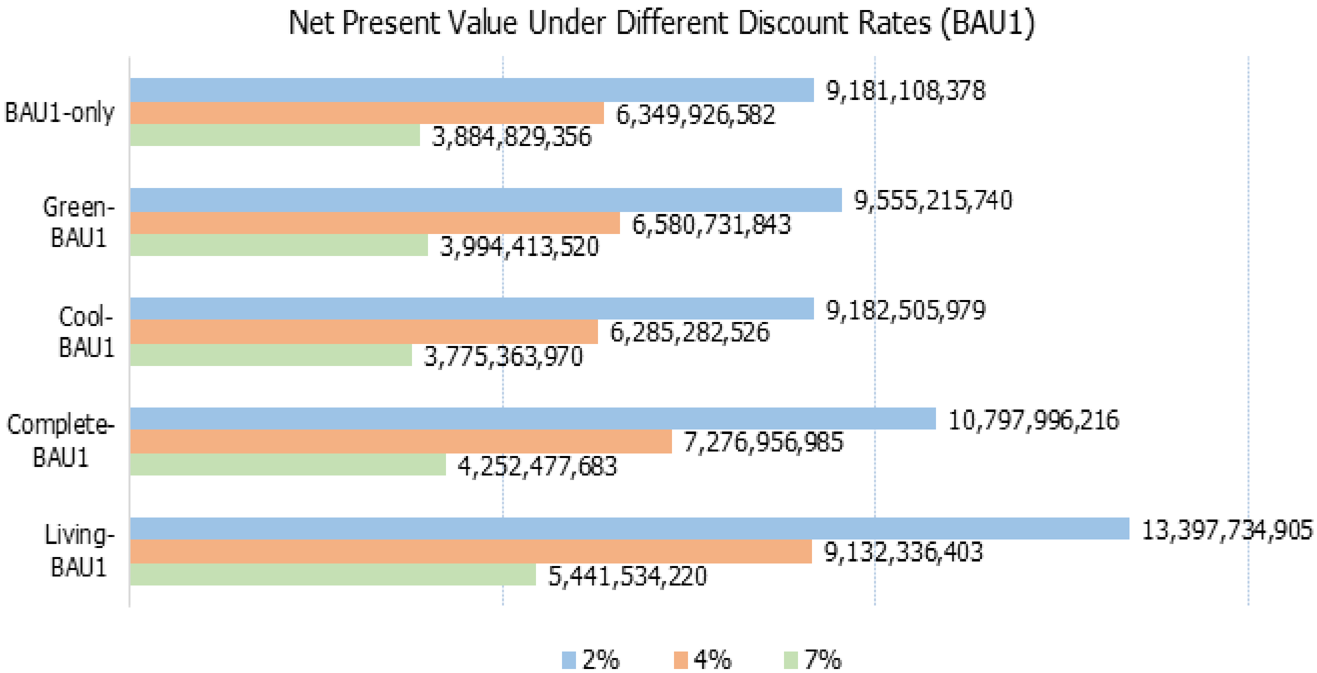
A.5.5.1. Business as Usual 1

As can be wee in the results below, the discount rate has a significant effect on the results of the study. Aside from the change in the magnitude of the results, the most significant change is the fact that, when the discount rate is 2%, the Cool-BAU1 scenario has a higher net present value than BAU1-Only, making it more desirable from an economic perspective. This is remarkably different from the results detailed in the report. This change happens due to the timing of the investments throughout the 35 year timespan analyzed in this study. When the economic costs and benefits in future years are discounted less, their values become more prominent in the net present value. Conversely, when the discount rate is increased to 7%, the difference between the net present value of BAU1-Only and Cool-BAU1 becomes even bigger (from 1% lower to 3% lower), making Cool-BAU1 even less desirable.

Table 114: Change in Overall Results due to Change in Discount Rate (BAU1)

	Action code	Total cost	Total benefit	Net present value	Pay back (years)	Benefit-Cost Ratio
2%	BAU1-only	870,998,240	10,052,106,618	9,181,108,378	3.0	11.5
	Green-BAU1	1,234,333,279	10,789,549,019	9,555,215,740	3.5	8.7
	Cool-BAU1	2,448,786,743	11,631,292,722	9,182,505,979	4.2	4.7
	Complete-BAU1	2,589,674,559	13,387,670,776	10,797,996,216	5.7	5.2
	Living-BAU1	4,260,546,845	17,658,281,749	13,397,734,905	4.6	4.1
4%	BAU1-only	738,677,265	7,088,603,848	6,349,926,582	3.0	9.6
	Green-BAU1	1,021,685,627	7,602,417,470	6,580,731,843	3.5	7.4
	Cool-BAU1	1,905,102,187	8,190,384,713	6,285,282,526	4.2	4.3
	Complete-BAU1	2,118,314,678	9,395,271,662	7,276,956,985	5.7	4.4
	Living-BAU1	3,301,975,358	12,434,311,761	9,132,336,403	4.6	3.8
7%	BAU1-only	605,413,037	4,490,242,393	3,884,829,356	3.0	7.4
	Green-BAU1	815,710,821	4,810,124,341	3,994,413,520	3.5	5.9
	Cool-BAU1	1,404,803,873	5,180,167,843	3,775,363,970	4.2	3.7
	Complete-BAU1	1,668,247,517	5,920,725,199	4,252,477,683	5.7	3.5
	Living-BAU1	2,423,122,349	7,864,656,569	5,441,534,220	4.6	3.2

FIGURE 118: CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN DISCOUNT RATE (BAU1)



A.5.5.2. Business as Usual 2

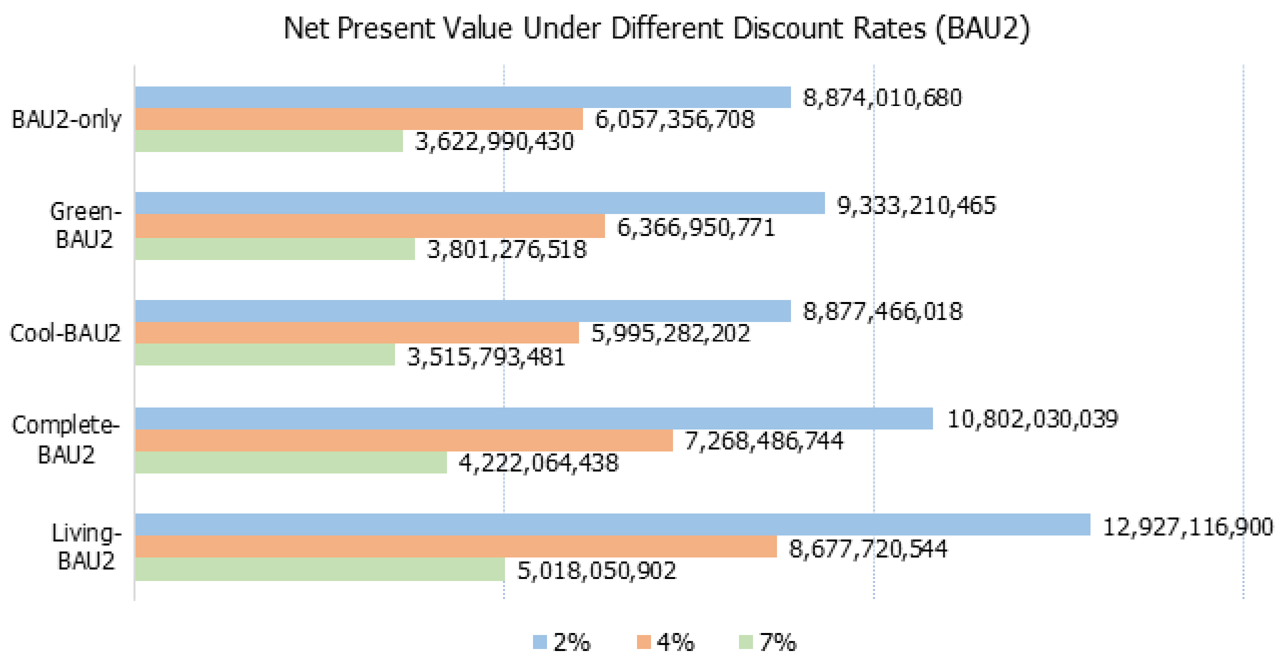
Similar to the BAU1 scenario, the table and figure below show that the discount rate has a significant effect on the results of the study. Aside from the change in the magnitude of the results, the most significant change is the prioritization of Cool Streets. When the discount rate is 2%, the Cool-BAU1 scenario has a higher net present value than BAU1-Only, making it more desirable from an economic perspective. Conversely, when the discount rate is increased to 7%, the difference between the net present value of BAU1-Only and Cool-BAU1 becomes even bigger, making Cool-BAU1 even less desirable.

TABLE 115: CHANGE IN OVERALL RESULTS DUE TO CHANGE IN DISCOUNT RATE (BAU1)

	Action code	Total cost	Total benefit	Net present value	Pay back (years)	Benefit-Cost Ratio
2%	BAU2-only	1,281,711,752	10,155,722,432	8,874,010,680	4.3	7.9
	Green-BAU2	1,545,711,156	10,878,921,622	9,333,210,465	4.5	7.0
	Cool-BAU2	2,857,442,518	11,734,908,535	8,877,466,018	5.4	4.1
	Complete-BAU2	2,403,855,550	13,205,885,588	10,802,030,039	6.1	5.5
	Living-BAU2	4,702,275,168	17,629,392,068	12,927,116,900	6.2	3.7
4%	BAU2-only	1,086,995,688	7,144,352,396	6,057,356,708	4.3	6.6
	Green-BAU2	1,285,372,720	7,652,323,491	6,366,950,771	4.5	6.0
	Cool-BAU2	2,250,851,059	8,246,133,262	5,995,282,202	5.4	3.7

	Complete-BAU2	2,034,655,649	9,303,142,393	7,268,486,744	6.1	4.6
	Living-BAU2	3,741,949,842	12,419,670,386	8,677,720,544	6.2	3.3
7%	BAU2-only	890,891,587	4,513,882,018	3,622,990,430	4.3	5.1
	Green-BAU2	1,031,946,425	4,833,222,943	3,801,276,518	4.5	4.7
	Cool-BAU2	1,688,013,986	5,203,807,467	3,515,793,481	5.4	3.1
	Complete-BAU2	1,664,609,572	5,886,674,010	4,222,064,438	6.1	3.5
	Living-BAU2	2,841,194,181	7,859,245,083	5,018,050,902	6.2	2.8

FIGURE 119: CHANGE IN NET PRESENT VALUE DUE TO CHANGE IN DISCOUNT RATE (BAU1)



Living Street is the best street paradigm to implement from an economic perspective, regardless of the discount rate used. In both the BAU1 and BAU2 cases, the Living Street had the highest net present value using 2%, 4% and 7% discount rates.