HDR ONE COMPANY | *Many Solutions*®

UTAH DEPARTMENT OF TRANSPORTATION

U.S. 40 MP 106-109 PASSING LANES

TIGER DISCRETIONARY GRANTS PROGRAM

APRIL 24, 2014

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY 3
2. INTRODUCTION 6
3. METHODOLOGICAL FRAMEWORK 6
4. CAL-B/C CORRIDOR 7
5. PROJECT OVERVIEW 8

Base Case and Alternatives 8
Project Cost and Schedule 9
Effects on Long-Term Outcomes 9

6. ECONOMIC ASSUMPTIONS 10

Value of Time 11
Vehicle Operating Costs 11
Value of Statistical Life 12
Injury Costs 12
Property Damage Due to Accidents 13
Emissions Costs 13
Traffic Projections 14

7. BENEFIT MEASUREMENT, DATA AND ASSUMPTIONS 15

Safety 15
Quality of Life 16
Economic Competitiveness 18
Environmental Sustainability 19
State of Good Repair 20

8. SUMMARY OF FINDINGS AND BCA OUTCOMES 21
9. SUPPLEMENTARY DATA TABLES 22

Annual Estimates of Total Project Benefits and Costs, 2013 dollars 23
Safety: Annual Accident Cost Savings Estimates, 2013 dollars 24
Quality of Life: Annual Benefit Estimates, 2013 dollars 25
Economic Competitiveness: Annual Benefit Estimates, 2013 dollars 26
Environmental Sustainability: Annual Benefit Estimates, 2013 dollars 27

8403 Colesville Road, Silver Spring, Maryland 20910 USA
Telephone: (240) 485-2600 • Fax: (240) 485-2635 • http://www.hdrinc.com

LIST OF TABLES

Table 1: Construction Cost and Schedule, 2013 dollars 9
Table 2: Expected Effects on Long-Term Outcomes and Benefit Categories 10
Table 3: Recommended Hourly Values of Travel Time Savings, 2013 dollars 11
Table 4: Vehicle Operating and Fuel Costs 12
Table 5: Relative Disutility Factors by Injury Severity Level 12
Table 6: KABCO-AIS Conversion Table 12
Table 7: Summary of Accident Costs, 2013 dollars 13
Table 8: Social Cost of CO_2, 2011 to 2050 (in 2013 dollars) 14
Table 9: Summary of Emissions Costs, 2013 dollars 14
Table 10: Summary of Average Annual Daily Trips 15
Table 11: Monetized Accident Cost Savings, Millions of 2013 dollars 16
Table 12: Current and Forecasted Automobile Speeds, Miles per hour 17
Table 13: Monetized Automobile Generalized Cost of Travel, Millions of 2013 dollars 18
Table 14: Current and Forecasted Truck Speeds, Miles per hour 19
Table 15: Truck Generalized Cost of Travel Savings, Millions of 2013 dollars 19
Table 16: Emissions Benefits, Millions of 2013 dollars 20
Table 17: Overall Results of the Benefit Cost Analysis, Millions of 2013 Dollars 21
Table 18: Benefit Estimates by Long-Term Outcome, Millions of 2013 dollars 21

1. Executive Summary

The Utah Department of Transportation (UDOT) U.S. 40 mile point (MP) 106-109 Passing Lane project consists of the construction of passing lanes in both the northbound and southbound directions along U.S. 40 outside of Myton, Utah. The project will expand U.S. 40 from a three-lane facility to a five-lane facility that includes two lanes in each direction plus a center turning lane. In recent years, the rural Northeast Utah region has experienced an oil boom, resulting in rapid economic growth in the area. This growth has enhanced business activity around the Uintah Basin, which has increased truck volumes along U.S. 40. The additional traffic has resulted in lower travel speeds and accident rates that are higher than the state and county averages. The construction of passing lanes is expected to enable safer passing of slow-moving vehicles, improve travel speeds for road users, and expand roadway capacity for future growth. The summary of improvements and benefits associated with the project are summarized in Table ES-1 below.

Table ES-1: Summary of Improvements and Associated Benefits

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternatives	Type of Impacts	Population Affected by Impacts	Benefits	Summary of Results (millions of $2013)
Rapid growth of Uintah Basin in Northeast Utah has increased heavy truck traffic along U.S. 40. The addition of passing lanes in both directions will enable more passing opportunities for faster moving vehicles and increase roadway capacity.	Additional passing lanes will be constructed in the northbound and southbound direction along MP 106-109 of U.S. 40.	Reduce travel time for existing travelers. Potentially attract new travelers and lower accident rates.	Existing travelers	Monetized value of reduced travel times and accident cost savings	Overall estimated savings in generalized cost of travel in the region and accident cost savings for all road users.

The Benefit-Cost Analysis (BCA) lasts 24 years, beginning in 2014 and ending in 2037. The analysis includes four years of construction and 20 years of operations. Construction is expected to end in 2017 and the opening year of benefits is 2018. The total project costs are $20.3 million with $5.3 million coming from TIGER funding requests and $15 million from matching support. The anticipated project costs by year of expenditure are displayed in Table ES-2.

Table ES-2: Project Cost by Year of Expenditure, 2013 dollars

Year	Total Project Cost
2014	$2,438,000
2015	$500,000
2016	$50,000
2017	$17,312,000
Total	$20,300,000

The project analysis was conducted using the Cal-B/C Corridor model which is a nationally recognized sketching planning tool that supports the analysis of transportation projects. The inputs used in the analysis are presented in the rest of this report, and include parameters outlined in the TIGER BCA Resource Guide and assumptions from the Cal-B/C Corridor Model. A summary of the each of the benefit categories compared to the long-term outcomes described in the Notice of Funding Availability (NOFA) for the TIGER program is presented in Table ES-3.

Table ES-3: Total Benefits by Long Term Outcome, Millions of 2013 dollars

Long-Term Outcomes	Benefit Categories	Benefits (Millions of 2013 dollars)	
		7% Discount Rate	3% Discount Rate
Safety	Accident Cost Savings	$23.4	$38.6
Quality of Life	Auto Travel Time Savings	$16.6	$28.0
	Auto Vehicle Operating Cost Savings	($5.4)	($8.8)
Economic Competitiveness	Truck Travel Time Savings	$4.2	$7.0
	Truck Vehicle Operating Cost Savings	($0.3)	($0.6)
Environmental Sustainability	Emissions	($1.0)	($1.7)
State of Good Repair	Improved Pavement Quality	Not Monetized	Not Monetized
Total Benefit Estimates		$37.5	$62.4

A summary of the annual project costs and benefits discounted at 7 percent are presented in Table ES-4. Based on the BCA presented in the rest of this document, the project is expected to generate $37.5 million in discounted benefits and $17.1 million in discounted cost, using a 7-percent real discount rate. Therefore, the project is expected to generate a net present value (NPV) of $20.4 million and a benefit-cost ratio of 2.2. Under an alternative analysis at a 3-percent real discount rate, the NPV is $43.6 million and the benefit-cost ratio is 3.3.

Table ES-4: Summary of Quantifiable Benefits, Project Costs at 7-Percent Discount Rate, 2013 dollars

Calendar Year	Project Year	Total Project Costs	Total Benefits	Safety Benefits	Quality of Life	Economic Competitiveness	Environmental Sustainability
2014	1	$2,438,000					
2015	2	$467,290					
2016	3	$43,672					
2017	4	$14,131,749					
2018 (opening)	5		$2,208,357	$1,481,619	$577,513	$206,662	-$57,438
2019	6		$2,192,147	$1,459,338	$583,275	$207,159	-$57,625
2020	7		$2,170,493	$1,433,631	$587,419	$207,107	-$57,665
2021	8		$2,144,092	$1,405,042	$590,063	$206,559	-$57,571
2022	9		$2,113,579	$1,374,058	$591,316	$205,563	-$57,358
2023	10		$2,079,528	$1,341,114	$591,285	$204,164	-$57,036
2024	11		$2,042,458	$1,306,601	$590,071	$202,404	-$56,617
2025	12		$2,006,506	$1,270,863	$587,769	$200,320	-$52,445
2026	13		$1,964,646	$1,234,209	$584,470	$197,949	-$51,982
2027	14		$1,921,044	$1,196,912	$580,261	$195,323	-$51,452
2028	15		$1,876,047	$1,159,212	$575,222	$192,474	-$50,861
2029	16		$1,829,966	$1,121,323	$569,430	$189,429	-$50,216
2030	17		$1,783,078	$1,083,430	$562,958	$186,213	-$49,524
2031	18		$1,735,633	$1,045,696	$555,875	$182,853	-$48,791
2032	19		$1,687,853	$1,008,262	$548,244	$179,368	-$48,021
2033	20		$1,639,936	$971,250	$540,126	$175,779	-$47,220
2034	21		$1,592,058	$934,766	$531,578	$172,105	-$46,392
2035	22		$1,544,373	$898,899	$522,653	$168,364	-$45,542
2036	23		$1,497,020	$863,724	$513,399	$164,569	-$44,673
2037	24		$1,450,117	$829,304	$503,865	$160,737	-$43,789
Total		**$17,080,711**	**$37,478,929**	**$23,419,252**	**$11,286,793**	**$3,805,101**	**-$1,032,217**

8403 Colesville Road, Silver Spring, Maryland 20910 USA
Telephone: (240) 485-2600 • Fax: (240) 485-2635 • http://www.hdrinc.com

2. Introduction

This document provides detailed technical information on the economic analyses conducted in support of the TIGER VI Grant Application for the Utah Department of Transportation (UDOT) U.S. 40 MP 106-109 Passing Lanes project. After this introduction, Section 3 introduces the conceptual framework used in the Benefit-Cost Analysis (BCA). Section 4 provides an overview of the Cal B/C Corridor model used for the analysis. Section 5, Project Overview, provides a description of the project, including a brief overview of existing conditions and proposed alternatives. It also provides a summary of cost estimates, the project schedule, and a description of the benefits the U.S. 40 MP 106-109 Passing Lane project is expected to generate. Section 6, discusses the general assumptions used in the estimation of project costs and benefits, while assumptions pertaining to the long-term outcome selection criteria are presented along with associated benefit estimates in Section 7. Estimates of the project's Net Present Value (NPV), its Benefit/Cost ratio (BCR) and other project evaluation metrics are covered in Section 8. Additional data tables are provided in Section 9, Supplementary Data Tables, including annual estimates of benefits and costs, as well as intermediate values to assist DOT in its review of the application.[1]

3. Methodological Framework

Benefit-Cost Analysis (BCA) is a conceptual framework that quantifies as many of the costs and benefits of a project as possible in monetary terms. Benefits are broadly defined. They represent the extent to which people impacted by the project are made better-off, as measured by their own willingness-to-pay. In other words, central to BCA is the idea that people are best able to judge what is "good" for them (i.e., what improves their well-being or welfare).

BCA is also based on the view that a net increase in welfare (as measured by the summation of individual welfare changes) is a good thing, even if some groups within society are made worse-off. A project or proposal would be rated positively if the benefits to some are large enough to compensate the losses of others.

Finally, BCA is typically a forward-looking exercise, seeking to anticipate the welfare impacts of a project or proposal over its entire lifecycle. Future welfare changes are weighted against today's changes through discounting, which is meant to reflect society's general preference for the present, as well as broader inter-generational concerns.

The specific methodology developed for this application was developed using the above BCA principles and is consistent with the TIGER guidelines. In particular, the methodology involves:

- Establishing existing and future conditions under the Build and No Build scenarios;
- Assessing benefits with respect to each of the five long-term outcomes identified in the Notice of Funding Availability (NOFA);

[1] While the models and software themselves do not accompany this appendix, greater detail can be provided, including spreadsheets presenting additional interim calculations and discussions on model mechanics and coding are available upon request.

- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using DOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practices for the valuation of other effects;
- Discounting future benefits and costs with real discount rates recommended by the DOT (7 percent, and 3 percent for sensitivity analysis); and
- Conducting a sensitivity analysis to assess the impacts of changes in key estimating assumptions.

4. Cal-B/C Corridor

The benefit-cost analysis was conducted using the corridor version of the California Lifecycle Benefit/Cost Analysis Model (Cal-B/C v5.1 Corridor), which is a nationally recognized sketch planning model. The California Department of Transportation (Caltrans) developed the original Cal-B/C model in the mid-1990s. It has been used to evaluate capital projects proposed for the California State Transportation Improvement Program (STIP) since 1996. As part of a 2009 Cal-B/C revision, Caltrans developed a suite of tools for conducting benefit-cost analysis. While the original model retains a sketch planning format, Cal-B/C Corridor supports BCA after transportation user impacts are modeled in a planning or engineering tool.

Cal-B/C Corridor estimates benefits using changes in vehicle-miles traveled (VMT) and vehicle-hours traveled (VHT) measured in travel demand or simulation models. The model has a flexible design that supports a variety of input data. Cal-B/C Corridor uses analysis methods consistent with Cal-B/C and produces comparable results. The model is also consistent with the procedures outlined in the Federal Highway Administration's (FHWA's) *Economic Analysis Primer (2003)*. Caltrans recently developed an updated version of Cal-B/C Corridor. The new version includes the ability to account for increases in the value of time, consistent with the latest Federal guidance.

For this TIGER VI Discretionary Grant Application, the standard Cal-B/C Corridor assumptions and economic values were modified to adhere to the requirements stipulated 79 FR 11854 (2014-03-3). The resulting values are also consistent with the guidance found in the supplemental TIGER BCA Resource Guide (March 28, 2014). Cal-B/C Corridor was run in order to monetize the costs and benefits estimated using traffic projections provided by UDOT.

Using Cal-B/C Corridor, the following four primary categories of user benefits were quantified for the U.S. 40 MP 106-109 Passing Lanes project: accident cost savings, travel time savings, Vehicle operating cost reductions, and emission reductions (including greenhouse gases).

Cal-B/C Corridor estimates annual user benefits over the 20-year lifecycle in constant dollars for each benefit category. Future benefits are discounted to present values using a real discount rate. Benefits are estimated separately for different user groups defined as part of the analysis. Typically, user groups are defined by factors, such as mode, facility, type of vehicle, and time of day.

Cal-B/C Corridor estimates project costs annually from the start of construction to 20 years after the project opens. Project costs include right-of-way, construction, and project support costs.

Cal-B/C Corridor also includes the ability to estimate reductions in CO_2 emissions (in US short tons) and monetize the global benefits of reducing US CO_2 emissions. The methodology for monetizing greenhouse gas emissions is consistent with the guidance issued by the Interagency Working Group on Social Cost of Carbon (Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, May 2013, revised November 2013). This guidance lays out a range of values to use in monetizing the social cost of carbon at various future years. The version of Cal-B/C Corridor modified for this TIGER grant application uses the values described in the TIGER BCA Resource Guide, which correspond to the middle set of values in the Interagency Working Group report.

Extensive documentation for the Cal-B/C and Cal-B/C Corridor is available on the Caltrans website. Cal-B/C Corridor, in particular, is discussed in Volume 3 of the Cal-B/C technical documentation.

5. Project Overview

The Utah Department of Transportation (UDOT) is preparing an application to the TIGER VI Discretionary Grant Program to help fund the construction of passing lanes on U.S. 40 between miles 106 and 109, outside Myton, Utah. U.S. 40 is heavily used by trucks supporting the oil and gas industry in the Uintah Basin. Commensurate with the growth in energy extraction, U.S. 40 has experienced rapid growth in vehicle use over the past decade. The addition of passing lanes in both the northbound and southbound directions is expected to improve average travel speeds by allowing vehicles to pass slow-moving trucks and address future traffic demands in this rapidly growing region in Northeast Utah. The project will expand U.S. 40 from a three-lane facility to a five-lane facility that includes two lanes in each direction plus a center turning lane. The improvements are expected to generate safety benefits, improve travel speeds and relieve congestion by adding roadway capacity.

Base Case and Alternatives

The No Build scenario does not include any improvements and maintains the existing roadway conditions along U.S. 40. Consistent with the trend over the previous decade, traffic is anticipated to grow by 4.4 percent each year in both the No Build and Build scenario. Current accidents rates along this section of U.S. 40 are assumed to remain constant over the duration of the analysis. The analysis also assumes that U.S. 40 will remain a three-lane facility in this section and travel speeds are expected to remain unchanged in the No Build scenario (despite the growth in traffic).

The Build scenario includes the construction of the passing lane, resulting in the expansion of U.S. 40 from a three-lane to five-lane facility. Travel speeds are expected to improve with faster moving vehicles being able to pass heavy trucks. The additional roadway capacity is expected to improve traffic conditions and reduce the number and severity of accidents.

Project Cost and Schedule

The total project cost is expected to be $20.3 million with $5.3 million coming from funding requests and the additional $15 million coming from matching support. Construction is expected to last 3.5 years, beginning in 2014 and ending in mid-2017. Since Cal-B/C Corridor calculates benefits and costs in whole years, the length of the construction schedule is set to four years in the model so user benefits start in 2018. This overestimation of the construction period further discounts the user benefits, leading to a more conservative estimate of the benefits for the BCA.

Table 1 provides a summary of the expected annual project spending by cost category.

Table 1: Construction Cost and Schedule, 2013 dollars

Year	Task	Total Cost*
2014	Kickoff	$2,438,000
	Scoping	
	Geometry Review	
	Plan in Hand	
	Plans, Specifications & Estimates	
2015	Right of Way Acquisition	$500,000
2016	Advertise	$50,000
	Contractor Selection	
2017	Construction Complete	$17,312,000
Total		$20,300,000

**Note: Values displayed are in undiscounted 2013 dollars.*

Effects on Long-Term Outcomes

The project is expected to improve traffic conditions and reduce vehicle accidents along U.S. 40. Table 2 groups these benefits and others associated with the project according to the five long-term outcome criteria described in the NOFA.

Table 2: Expected Effects on Long-Term Outcomes and Benefit Categories

Long-Term Outcomes	Benefit or Impact Categories	Description	Quantified	Qualitative
Safety	Accident Reduction	Reductions in property losses, injuries and deaths due to additional roadway capacity from the passing lane	Yes	Yes
Economic Competitiveness	Truck Cost Savings Per Trip	Changes in travel time savings and operating costs for trucks, reducing cost per trip and improving access to the Uintah Basin	Yes	Yes
Quality of Life	Automobile Cost Savings Per Trip	Reduction in total automobile trip cost increasing connectivity to jobs, major destinations of study area	Yes	Yes
Environmental Sustainability	Reductions in Air Emissions	Changes in pollutants and greenhouse gasses due to changes in vehicle speeds relative to base case	Yes	Yes
State of Good Repair	Pavement Maintenance Savings	Improved pavement conditions due to new construction and additional roadway capacity reducing use on existing lanes	No	Yes

6. Economic Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of construction and continuing through 20 years of operations. The monetized benefits and costs are estimated in 2013 dollars with future dollars discounted in compliance with TIGER requirements using a 7-percent real rate and sensitivity testing at 3 percent.

The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically, the methodology includes the following elements:

- Input prices are expressed in 2013 dollars.
- The period of analysis begins in 2014 and ends in 2036. It includes project development and construction years (2014 - 2017) and 20 years of operations (2018 - 2037).
- A constant 7-percent real discount rate is assumed throughout the period of analysis. A 3-percent real discount rate is used for sensitivity analysis.
- Opening year demand is an input to the BCA and is assumed to be fully realized in Year 1 (no ramp-up).

This section summarizes the economic assumptions added to Cal-B/C Corridor to comply with the guidelines outlined in the TIGER BCA Resource Guide. Where the TIGER VI Discretionary Grant Guidelines did not specify values, the standard Cal-B/C assumptions were retained. All benefits and costs are valued in 2013 dollars. All values shown in the TIGER BCA Resource Guide have been updated to 2013 dollars using the GDP deflator.

Value of Time

The analysis uses values of time following United States Department of Transportation (USDOT) *Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis (Revision 3 – corrected)* and presented in the TIGER BCA Resource Guide. The value of time was assumed to grow 1.6 percent in real terms annually, consistent with USDOT guidance. Table 3 shows the values per person-hour provided in the latest USDOT guidance in 2013 dollars. The travel time benefits in the BCA are calculated using an average vehicle occupancy (AVO) of 1.15 for peak period travel and 1.30 for non-peak period travel.

Table 3: Recommended Hourly Values of Travel Time Savings, 2013 dollars

Variable Name	Unit	Value	Source
Travel Time Cost – All Purposes	Dollars per hour	$12.98	HDR Calculation
Travel Time Cost – Personal Travel	Dollars per hour	$12.42	USDOT Revised Departmental Guide on Valuation of Travel Time in Economic Analysis (updated April 18, 2014)
Travel Time Cost – Business Travel	Dollars per hour	$25.23	
Share of Personal Travel	Percentage	95.4%	
Share of Business Travel	Percentage	4.6%	
Truck drivers	Dollars per hour	$25.75	
Real Annual Growth Rate of Value of Time	Percentage	1.6%	

Vehicle Operating Costs

Cal-B/C Corridor includes a combination of fuel and non-fuel vehicle operating costs. Non-fuel operating costs include vehicle wear and tear as well as depreciation. For these costs, the benefit-cost analysis uses the standard Cal-B/C values updated by the GDP deflator to 2013 dollars. As described in the Cal-B/C technical documentation, these figures are derived from research by the American Automobile Association (AAA) for automobiles and the American Transportation Research Institute (ATRI) for trucks. The fuel cost for gasoline and diesel is held constant throughout the analysis based on the real cost per gallon published by EIA in their 2013 Annual Energy Outlook. Both the vehicle operating and fuel costs used in analysis are presented in Table 4.

Table 4: Vehicle Operating and Fuel Costs

Vehicle	Non-Fuel Operating Cost Per Mile	Fuel Cost Per Gallon
Auto	$0.30	$2.93
Truck	$0.36	$2.99

Value of Statistical Life

The USDOT *Guidance on Treatment of the Economic Value of a Statistical Life in the U.S. Department of Transportation Analysis (2014)* provides a value of statistical life (VSL) of $9.2 million in 2013 dollars.

Injury Costs

The USDOT guidance and TIGER BCA Resource Guide provide a method for estimating the value of injury reduction. The value is calculated using a fraction of VSL that depends on the severity of injury. Table 5 shows the fractions provided in the TIGER BCA Resource Guide.

Table 5: Relative Disutility Factors by Injury Severity Level

AIS Level	Severity	Fraction of VSL	Unit Value (2013$)
AIS 1	Minor	0.003	$27,600
AIS 2	Moderate	0.047	$432,400
AIS 3	Serious	0.105	$966,000
AIS 4	Severe	0.266	$2,447,200
AIS 5	Critical	0.593	$5,455,600
AIS 6	Unsurvivable	1	$9,200,000

As shown in Table 6, the conversion table provides the percentage of injuries in each ANSI (or KABCO) category that correspond to each AIS category.

Table 6: KABCO-AIS Conversion Table

	O	C	B	A	K	Injured	Unknown
	No Injury	Poss. Inj.	Non-Incap.	Incapac-itating	Killed	Severity Unknown	If Injured
AIS 0	0.9253	0.2344	0.0835	0.0344	0.0000	0.2154	0.4368
AIS 1	0.0726	0.6895	0.7684	0.5545	0.0000	0.6273	0.4174
AIS 2	0.0020	0.0639	0.1090	0.2091	0.0000	0.1040	0.0887
AIS 3	0.0001	0.0107	0.0319	0.1444	0.0000	0.0386	0.0482
AIS 4	0.0000	0.0014	0.0062	0.0399	0.0000	0.0044	0.0062
AIS 5	0.0000	0.0001	0.0010	0.0178	0.0000	0.0103	0.0028
Fatality	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000

By taking the weighted average of the AIS unit values shown in Table 5 and using the appropriate percentages for each ANSI column found in Table 6, the following (rounded) unit injury values were derived for use in the BCA:

- Severe Injury (A) = $439,990
- Moderate Injury (B) = $119,839
- Minor Injury (C) = $61,194.

Property Damage Due to Accidents

The USDOT provides a recommended monetization value for vehicle property damage of $3,927 per vehicle crash in 2013 dollars. This value comes from TIGER BCA Resource Guide, and is based on *The Economic and Societal Impact of Motor Vehicle Crashes (2010)*. A summary of all accident costs by severity is shown in Table 7.

Table 7: Summary of Accident Costs, 2013 dollars

Accident Type	Cost Per Accident
Fatal	$9,200,000
Severe Injury	$439,990
Moderate Injury	$119,839
Minor Injury	$61,194
Property Damage Only	$3,927

Cal-B/C estimates accident costs using accidents classified as fatal, injury, or property damage only (PDO) rather than accident events (i.e., fatality, injury and property damage). The values for the individual fatal, injury and property damage events are combined to estimate values for fatal, injury, and PDO accidents using statewide statistics on the distribution of events per typical accident.

Emissions Costs

Cal-B/C Corridor includes emissions rates estimated from the California Air Resources Board (CARB) EMFAC2011 model for on-road vehicles and other CARB sources for other modes. The Cal-B/C Corridor emission rates have not been updated to be consistent with MOBILE6, but the estimated emissions benefits should be within an order of magnitude of the benefits estimated using MOBILE6.

The emissions are monetized using values consistent with those found in NHTSA's *Final Regulatory Impact Analysis of the CAFE for MY 2012-MY2016 Passenger Cars and Light Trucks* and in the TIGER BCA Resource Guide (March 28, 2014). Since Cal-B/C Corridor estimates impacts in US short tons, the monetization values for US short tons have been used. The analysis uses a value per ton of carbon dioxide equivalent (CO_2e) consistent with the guidance in the Federal Register. The TIGER BCA Resource Guide (March 28, 2014) recommends using the monetization values shown in Table 8.

Table 8: Social Cost of CO_2 Per Metric Ton, 2011 to 2050 (in 2013 dollars)

Year	3% Social Cost of Carbon (2013 $)	Year	3% Social Cost of Carbon (2013 $)
2011	$37	2031	$58
2012	$38	2032	$59
2013	$39	2033	$60
2014	$40	2034	$61
2015	$42	2035	$62
2016	$43	2036	$63
2017	$44	2037	$65
2018	$45	2038	$66
2019	$46	2039	$67
2020	$47	2040	$68
2021	$48	2041	$69
2022	$49	2042	$70
2023	$50	2043	$70
2024	$51	2044	$71
2025	$53	2045	$72
2026	$53	2046	$73
2027	$54	2047	$74
2028	$55	2048	$76
2029	$56	2049	$77
2030	$57	2050	$78

These values correspond to one of four scenarios assessed by *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (May 2013; revised November 2013) with a discount rate of 3 percent. Cal-B/C and EMFAC estimate CO_2e in US short tons. The social cost of CO_2e was converted from metric tons to US short tons (multiplied by 2000/2205) and rounded to $39 per US short ton of CO_2e in the opening year of analysis. These values increase by 2.2 percent per year, so the CO_2e uprater (or escalation factor) in Cal-B/C Corridor is set to 2.2 percent. A summary of the emissions costs used in the model is available in Table 9.

Table 9: Summary of Emissions Costs, 2013 dollars

Emissions	Cost Per US Short Ton
CO	$0
CO_2e	$44 in 2018, increasing 2.2% annually
NO_X	$7,147
PM_{10}	$326,935
SO_X	$42,240
VOC	$1,813

8403 Colesville Road, Silver Spring, Maryland 20910 USA
Telephone: (240) 485-2600 • Fax: (240) 485-2635 • http://www.hdrinc.com

Traffic Projections

In a traffic report provided by UDOT, forecasted traffic was estimated based on an average annual growth rate of 4.4 percent, consistent with the trend over the previous decade in the region. In 2014, average annual daily trips are projected to be 10,435. In 2037, the number is expected to increase to 26,930 trips per day. Currently, trucks make up about 41 percent of all traffic on U.S. 40. This proportion was assumed to remain constant throughout the period of analysis due to the expected continued growth of the Uintah Basin and the demand for automobile and truck trips. Traffic projections in the current, opening and forecasted year are displayed in Table 10.

Table 10: Summary of Average Annual Daily Trips

Year	AADT
Current Year (2014)	10,435
Opening Year (2018)	13,304
Forecasted Year (2037)	26,930

7. Benefit Measurement, Data and Assumptions

This section describes the measurement approach used for each benefit or impact category identified in Table 2 (Expected Effects on Long Term Outcomes and Benefit Categories) and provides an overview of the associated methodology, assumptions, and estimates.

Safety

The U.S. 40 MP 106-109 Passing Lanes project will add two additional lanes, expanding roadway capacity and enabling safer passing of slow-moving vehicles. The addition of passing lanes is likely to result in fewer vehicle-related accidents along this section of U.S 40, which has a higher accident rate than the statewide average. The safety benefits are quantified based on recent accident data between MP 106 and 109 along U.S. 40, average accident rates from both Duchesne and Uintah counties, and empirical research on accident reductions due to the construction of passing lanes.

7.1.1 Methodology

To quantify the safety benefits of the passing lanes, projected accidents are compared in the No Build and Build scenarios. In the No Build scenario, the accident rate is calculated based on the total accidents in the section of highway during a three-year period from 2010 to 2012. This accident rate is assumed to remain constant throughout the No Build scenario. Fatality rates along U.S. 40 MP 106-109 are higher than the average rate observed in Uintah and Duchesne counties in 2012.

In the Build scenario, the addition of passing lanes is expected to reduce accidents by enabling safer passing opportunities for faster vehicles. The reduction in accidents is based on research conducted in Michigan on the effects of passing lanes statewide in which fatal accidents decreased by 16 percent, injury accidents by 42 percent and property damage only accidents by

2 percent when passing lanes were added. More details on this study can be found in the Cal-B/C technical documentation. No further reductions in the fatality rate were included in order to provide a more conservative estimate of the benefits.

7.1.2 Assumptions

From 2010 to 2012, there were 32 total accidents between MP 106 and 109 along U.S. 40, including one fatal accident, nine injuries and 22 accidents involving property damage only. According to county averages, there were 1.76 total accidents per million vehicle miles traveled in Duchesne and Uintah counties in 2012. About 25 percent of these were accidents involving injuries and less than one percent of the accidents were fatal.

7.1.3 Benefit Estimates

The monetized safety benefits for the project are presented in Table 11. The safety benefits represent the accident cost savings that occur due to improved safety conditions along U.S. 40 from the construction of passing lanes in both directions. The figures represent the combined cost savings from the reduction in fatal, injury and property damage accidents. Over the 20-year period of analysis, accident cost savings are expected to be $23.4 million when discounted at 7 percent and $38.6 million when discounted at 3 percent.

Table 11: Monetized Accident Cost Savings, Millions of 2013 dollars

Benefit Categories	Benefits (Millions of 2013 dollars)	
	7% Discount Rate	3% Discount Rate
Accident Cost Savings	$23.4	$38.6

Quality of Life

People place a value on the level of connectivity, quality and accessibility to goods and services needed for daily living. All of these factors influence the perception of the quality of life in the area. The improvements to U.S. 40 will play a significant role in influencing the way residents interact and connect within their community. Improved travel speeds could encourage residents to travel who did not previously due to the heavy truck traffic along U.S. 40. The benefits quantified in this section include travel time savings and vehicle operating cost savings that accrue to drivers and passengers of automobiles. Since most automobile trips are residents of the region, these benefits are categorized as impacting quality of life.

7.1.4 Methodology

The calculation of travel time savings is based on the average speeds of traffic driving along MP 106-109 of U.S. 40. The speed in the No Build scenario is based on the *2013 UDOT MP 106-109 Myton-Bench Roadway Widening Concept Report*. This report estimates speeds for current conditions using the Highway Capacity Manual (HCM) 2010 methods for passing lanes. Without

the additional passing lanes, passing opportunities are likely to be limited further by the increase in traffic. Since the 2013 UDOT Concept Report did not estimate operating conditions for future traffic, the analysis assumes that speed remains constant over the analysis period in both the No Build and Build scenarios. Speeds are likely to be lower in the future because of increased traffic and the lack of additional roadway capacity. However, assuming that the speeds are the same in the current and forecasted conditions of the No Build scenario is a conservative estimate of the benefits in the absence of better data.

In the Build scenario, it is assumed that the various improvements allow the road to function as a 4-lane facility. The center turning lane accommodates the frequent turning movements that occur along the corridor, so automobiles are able to travel at speeds based on demand-to-capacity ratios. Using a standard BPR curve (incorporated into Cal-B/C and based on the 2010 HCM), it is estimated that adequate capacity exists for automobiles to travel at the designed, free-flow speed of 65 miles per hour (mph). The increase in travel speed is expected to create travel time savings for all users. However, due to the higher speeds, automobile users are expected to use more fuel and experience more wear and tear on their vehicles, increasing vehicle operating costs. The benefits from travel time savings heavily outweigh the additional vehicle operating costs and the project results in a lower generalized cost of travel per trip for automobile users.

7.1.5 Assumptions

According to the 2013 UDOT Concept Report, the average speed in the No Build scenario for automobiles is 51.3 miles per hour. The forecasted speed in the No Build scenario is assumed to stay the same throughout the period of analysis. In the Build scenario, the speed of automobiles is expected to increase from 51.3 under current conditions to the design speed of the road, which is 65 mph. The speeds for the No Build and Build conditions are shown in Table 12.

Table 12: Current and Forecasted Automobile Speeds, Miles per hour

Vehicle	Current Conditions	Forecasted
Automobile (No Build)	51.3	51.3
Automobile (Build)	65.0	65.0

7.1.6 Benefit Estimates

Quality of life benefits for automobile (travel time savings and vehicle operating costs) are quantified in Table 13. Over the period of analysis, there are expected to be about $11.3 million in the travel time and vehicle operating cost savings for automobile users when discounted at 7 percent and $19.1 million when discounted at 3 percent.

Table 13: Monetized Automobile Generalized Cost of Travel, Millions of 2013 dollars

Benefit Categories	Benefits (Millions of 2013 dollars)	
	7% Discount Rate	3% Discount Rate
Automobile Travel Time Savings	$16.6	$28.0
Automobile Vehicle Operating Cost Savings	($5.4)	($8.8)
Total Benefits*	$11.3	$19.1

**Note: values may not be additive due to rounding.*

Economic Competitiveness

Similar to the benefits for the Quality of Life criterion, the project is expected to decrease the generalized cost of travel for trucks utilizing U.S. 40. The decrease in trip costs comes from changes to travel time and vehicle operating cost savings for trucks. This decrease in the cost per trip may spur additional economic growth to the already rapidly growing Uintah Basin. Lower travel costs can result in additional investment from businesses as the cost to transport goods becomes more affordable. As a result of the improvements to U.S. 40, regional businesses could become more economically competitive or profitable. However, the BCA considers only the reduction in user costs for current truck users rather than consider the greater macro-economic impacts that could result.

The improvement in travel speed for trucks is expected to be less than that of automobiles because automobiles will benefit from passing slow moving vehicles, while only faster trucks will benefit from passing slower, heavier trucks.

7.1.7 Methodology

The benefits for trucks come from the change in travel speed due to the increased roadway capacity on U.S. 40. Despite trucks having a higher value of time than automobiles, the reduction in the generalized cost of travel is smaller for trucks than for automobiles because truck speed does not increase as much as the automobile speed.

7.1.8 Assumptions

According to the 2013 UDOT Concept Report, the average speed for truck traffic along this section of U.S. 40 is 51.3 mph under the current conditions. This speed is assumed for trucks throughout the No Build scenario. Speeds are likely to deteriorate in future years as traffic grows, but the assumption of constant speeds is conservative and the best assumption in the absence of better data. In the Build, trucks are assumed to have a slight improvement in speed (i.e., faster trucks can pass slower trucks) based on results in the 2013 UDOT Concept Report using HCM methods for passing lanes. As a result, the average speed of truck traffic is

estimated to increase to 53.8 mph in the Build. As with the No Build speeds, the estimated Build speeds are assumed to stay constant in future years of the Build scenario. The assumed speeds for trucks are shown in Table 14.

Table 14: Current and Forecasted Truck Speeds, Miles per hour

Vehicle	Current Conditions	Forecasted
Truck (No Build)	51.3	51.3
Truck (Build)	53.8	53.8

7.1.9 Benefit Estimates

The benefit estimates for economic competitiveness are the sum of the travel time savings and vehicle operating cost savings for trucks. Since the increase in travel speed is due to the ability to pass slower moving vehicles, fewer trucks than automobiles are expected to benefit from these savings. Even so, improved travel times along this corridor contribute to an increase in regional and national economic competitiveness due to the development of the region. The passing lanes are also expected to increase roadway capacity, which is critical to address the growing need for trucks serving the Uintah Basin. This benefit has not been included in the analysis. The project is expected to generate travel time savings for trucks worth $4.2 million at a 7-percent real discount rate and $7.0 million at a 3-percent real discount rate.

Table 15: Truck Generalized Cost of Travel Savings, Millions of 2013 dollars

Benefit Categories	Benefits (Millions of 2013 dollars)	
	7% Discount Rate	3% Discount Rate
Truck Travel Time Savings	$4.2	$7.0
Truck Vehicle Operating Cost Savings	($0.3)	($0.6)
Total Benefits*	$3.8	$6.4

**Note: Values may not be additive due to rounding*

Environmental Sustainability

Due to the increased travel speeds in the Build scenario, the project will generate negative emissions benefits. Emission rates are based solely on vehicle speeds and are generally higher when vehicles are traveling faster (beyond the inflection point in emissions around 40 to 45 mph). These negative benefits are small compared to the positive benefits expected from accident cost savings and travel time savings generated by the passing lanes. The quantified emissions benefits are displayed in Table 16. Increased emission rates are expected to result in negative benefits of $1.0 million when discounted at 7 percent and $1.7 million when

discounted at 3 percent. Nearly all of these negative benefits are due to increases in greenhouse gas emissions.

Table 16: Emissions Benefits, Millions of 2013 dollars

Benefit Categories	Benefits (Millions of 2013 dollars)	
	7% Discount Rate	3% Discount Rate
Emissions	($1.0)	($1.7)

State of Good Repair

State of good repair benefits are expected to come from pavement maintenance cost savings due to the addition of passing lanes, but they are not monetized for the BCA. Additional capacity results in less wear and tear on the pavement because more roadway is being used, resulting in less stress on each lane. However, the deterioration due to heavy trucks will continue. The creation of the passing lanes extends the usable life of the road in the Build scenario, thus saving pavement maintenance costs versus the No Build scenario.

8. Summary of Findings and BCA Outcomes

The tables below summarize the BCA findings. Annual costs and benefits are computed over the 24-year lifecycle of the project (4 construction years and 20 benefit years). As stated earlier, construction is expected to be completed by 2017. Benefits accrue during the full operation of the project.

Table 17: Overall Results of the Benefit Cost Analysis, Millions of 2013 Dollars

Category	7% Discount Rate	3% Discount Rate
Total Discounted Benefits	$37.5	$62.4
Total Discounted Costs	$17.1	$18.8
Net Present Value	$20.4	$43.6
Benefit / Cost Ratio	2.2	3.3
Internal Rate of Return (%)	16.8%	

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 16.8 percent. With a 7-percent real discount rate, the $17.1 million investment would result in $37.5 million in total benefits and a benefit/cost ratio of approximately 2.2.

With a 3-percent real discount rate, the net present value of the project would increase to $43.6 million, for a benefit/cost ratio of 3.3.

Table 18: Benefit Estimates by Long-Term Outcome, Millions of 2013 dollars

Long-Term Outcomes	Benefit Categories	Benefits (Millions of 2013 dollars)	
		7% Discount Rate	3% Discount Rate
Safety	Accident Cost Savings	$23.4	$38.6
Quality of Life	Automobile Travel Time Savings	$16.6	$28.0
	Automobile Vehicle Operating Cost Savings	($5.4)	($8.8)
Economic Competitiveness	Truck Travel Time Savings	$4.2	$7.0
	Truck Vehicle Operating Cost Savings	($0.3)	($0.6)
Environmental Sustainability	Emissions	($1.0)	($1.7)
State of Good Repair	Improved Pavement Quality	Not Monetized	Not Monetized
Total Benefit Estimates		$37.5	$62.4

9. Supplementary Data Tables

This section breaks down all benefits associated with the four long-term outcome criteria that were monetized in the analysis (i.e. safety, economic competiveness, quality of life, and environmental sustainability) in annual form for the U.S. 40 MP 106-109 Passing Lanes project.

Annual Estimates of Total Project Benefits and Costs, 2013 dollars

Calendar Year	Project Year	Total Benefits (7%)	Total Costs (7%)	Discounted Net Benefits (7%)	Total Benefits (3%)	Total Costs (3%)	Discounted Net Benefits (3%)
2014	1		$2,438,000	-$2,438,000		$2,438,000	-$2,438,000
2015	2		$467,290	-$467,290		$485,437	-$485,437
2016	3		$43,672	-$43,672		$47,130	-$47,130
2017	4		$14,131,749	-$14,131,749		$15,842,932	-$15,842,932
2018 (opening)	5	$2,208,357		$2,208,357	$2,571,908		$2,571,908
2019	6	$2,192,147		$2,192,147	$2,652,176		$2,652,176
2020	7	$2,170,493		$2,170,493	$2,727,958		$2,727,958
2021	8	$2,144,092		$2,144,092	$2,799,428		$2,799,428
2022	9	$2,113,579		$2,113,579	$2,866,758		$2,866,758
2023	10	$2,079,528		$2,079,528	$2,930,109		$2,930,109
2024	11	$2,042,458		$2,042,458	$2,989,639		$2,989,639
2025	12	$2,006,506		$2,006,506	$3,051,073		$3,051,073
2026	13	$1,964,646		$1,964,646	$3,103,437		$3,103,437
2027	14	$1,921,044		$1,921,044	$3,152,409		$3,152,409
2028	15	$1,876,047		$1,876,047	$3,198,126		$3,198,126
2029	16	$1,829,966		$1,829,966	$3,240,718		$3,240,718
2030	17	$1,783,078		$1,783,078	$3,280,312		$3,280,312
2031	18	$1,735,633		$1,735,633	$3,317,028		$3,317,028
2032	19	$1,687,853		$1,687,853	$3,350,985		$3,350,985
2033	20	$1,639,936		$1,639,936	$3,382,294		$3,382,294
2034	21	$1,592,058		$1,592,058	$3,411,064		$3,411,064
2035	22	$1,544,373		$1,544,373	$3,437,399		$3,437,399
2036	23	$1,497,020		$1,497,020	$3,461,399		$3,461,399
2037	24	$1,450,117		$1,450,117	$3,483,163		$3,483,163
Total		**$37,478,929**	**$17,080,711**	**$20,398,218**	**$62,407,380**	**$18,813,499**	**$43,593,881**

8403 Colesville Road, Silver Spring, Maryland 20910 USA
Telephone: (240) 485-2600 • Fax: (240) 485-2635 • http://www.hdrinc.com

Safety: Annual Accident Cost Savings Estimates, 2013 dollars

Calendar Year	Project Year	Accident Cost Savings Discounted Benefits (7%)	Accident Cost Savings Discounted Benefits (3%)
2018 (opening)	5	$1,481,619	$1,725,531
2019	6	$1,459,338	$1,765,585
2020	7	$1,433,631	$1,801,842
2021	8	$1,405,042	$1,834,489
2022	9	$1,374,058	$1,863,706
2023	10	$1,341,114	$1,889,665
2024	11	$1,306,601	$1,912,531
2025	12	$1,270,863	$1,932,461
2026	13	$1,234,209	$1,949,608
2027	14	$1,196,912	$1,964,117
2028	15	$1,159,212	$1,976,126
2029	16	$1,121,323	$1,985,770
2030	17	$1,083,430	$1,993,176
2031	18	$1,045,696	$1,998,466
2032	19	$1,008,262	$2,001,756
2033	20	$971,250	$2,003,160
2034	21	$934,766	$2,002,784
2035	22	$898,899	$2,000,730
2036	23	$863,724	$1,997,097
2037	24	$829,304	$1,991,978
Total		**$23,419,252**	**$38,590,577**

8403 Colesville Road, Silver Spring, Maryland 20910 USA
Telephone: (240) 485-2600 • Fax: (240) 485-2635 • http://www.hdrinc.com

Quality of Life: Annual Benefit Estimates, 2013 dollars

Calendar Year	Project Year	Auto Travel Time Savings Discounted Benefits (7%)	Auto Travel Operating Cost Savings Discounted Benefits (7%)	Total Discounted Benefits (7%)	Auto Travel Time Savings Discounted Benefits (3%)	Auto Operating Cost Savings Discounted Benefits (3%)	Total Discounted Benefits (3%)
2018 (opening)	5	$916,678	-$339,165	$577,513	$1,067,587	-$395,000	$672,587
2019	6	$917,340	-$334,065	$583,275	$1,109,846	-$404,169	$705,677
2020	7	$915,599	-$328,180	$587,419	$1,150,760	-$412,469	$738,291
2021	8	$911,698	-$321,635	$590,063	$1,190,356	-$419,943	$770,414
2022	9	$905,859	-$314,543	$591,316	$1,228,663	-$426,631	$802,033
2023	10	$898,287	-$307,001	$591,285	$1,265,709	-$432,573	$833,136
2024	11	$889,172	-$299,101	$590,071	$1,301,521	-$437,807	$863,714
2025	12	$878,689	-$290,920	$587,769	$1,336,126	-$442,370	$893,756
2026	13	$867,000	-$282,529	$584,470	$1,369,549	-$446,295	$923,254
2027	14	$854,252	-$273,991	$580,261	$1,401,817	-$449,616	$952,201
2028	15	$840,583	-$265,361	$575,222	$1,432,954	-$452,365	$980,589
2029	16	$826,118	-$256,688	$569,430	$1,462,987	-$454,573	$1,008,414
2030	17	$810,972	-$248,014	$562,958	$1,491,938	-$456,268	$1,035,669
2031	18	$795,251	-$239,376	$555,875	$1,519,832	-$457,479	$1,062,352
2032	19	$779,051	-$230,806	$548,244	$1,546,691	-$458,232	$1,088,459
2033	20	$762,460	-$222,334	$540,126	$1,572,540	-$458,554	$1,113,987
2034	21	$745,560	-$213,982	$531,578	$1,597,401	-$458,468	$1,138,933
2035	22	$728,424	-$205,772	$522,653	$1,621,295	-$457,997	$1,163,297
2036	23	$711,119	-$197,720	$513,399	$1,644,244	-$457,166	$1,187,079
2037	24	$693,705	-$189,840	$503,865	$1,666,270	-$455,994	$1,210,276
Total		**$16,647,816**	**-$5,361,023**	**$11,286,793**	**$27,978,086**	**-$8,833,970**	**$19,144,117**

8403 Colesville Road, Silver Spring, Maryland 20910 USA
Telephone: (240) 485-2600 • Fax: (240) 485-2635 • http://www.hdrinc.com

Economic Competitiveness: Annual Benefit Estimates, 2013 dollars

Calendar Year	Project Year	Truck Travel Time Savings Discounted Benefits (7%)	Truck Operating Cost Savings Discounted Benefits (7%)	Total Discounted Benefits (7%)	Truck Travel Time Savings Discounted Benefits (3%)	Truck Operating Cost Savings Discounted Benefits (3%)	Total Discounted Benefits (3%)
2018 (opening)	5	$228,706	-$22,043	$206,662	$266,356	-$25,672	$240,684
2019	6	$228,871	-$21,712	$207,159	$276,900	-$26,268	$250,632
2020	7	$228,436	-$21,329	$207,107	$287,107	-$26,807	$260,300
2021	8	$227,463	-$20,904	$206,559	$296,986	-$27,293	$269,693
2022	9	$226,006	-$20,443	$205,563	$306,544	-$27,728	$278,816
2023	10	$224,117	-$19,953	$204,164	$315,787	-$28,114	$287,673
2024	11	$221,843	-$19,439	$202,404	$324,721	-$28,454	$296,267
2025	12	$219,227	-$18,908	$200,320	$333,355	-$28,751	$304,604
2026	13	$216,311	-$18,362	$197,949	$341,694	-$29,006	$312,688
2027	14	$213,131	-$17,807	$195,323	$349,745	-$29,222	$320,523
2028	15	$209,720	-$17,246	$192,474	$357,513	-$29,400	$328,113
2029	16	$206,111	-$16,683	$189,429	$365,006	-$29,544	$335,462
2030	17	$202,332	-$16,119	$186,213	$372,229	-$29,654	$342,575
2031	18	$198,410	-$15,558	$182,853	$379,189	-$29,733	$349,456
2032	19	$194,368	-$15,001	$179,368	$385,890	-$29,782	$356,108
2033	20	$190,229	-$14,450	$175,779	$392,339	-$29,803	$362,537
2034	21	$186,013	-$13,907	$172,105	$398,542	-$29,797	$368,745
2035	22	$181,737	-$13,374	$168,364	$404,503	-$29,766	$374,737
2036	23	$177,420	-$12,850	$164,569	$410,229	-$29,712	$380,516
2037	24	$173,075	-$12,338	$160,737	$415,724	-$29,636	$386,088
Total		**$4,153,527**	**-$348,426**	**$3,805,101**	**$6,980,359**	**-$574,142**	**$6,406,218**

8403 Colesville Road, Silver Spring, Maryland 20910 USA
Telephone: (240) 485-2600 • Fax: (240) 485-2635 • http://www.hdrinc.com

Environmental Sustainability: Annual Benefit Estimates, 2013 dollars

Calendar Year	Project Year	Emissions Discounted Benefits (7%)	Emissions Discounted Benefits (3%)
2018 (opening)	5	-$57,438	-$66,894
2019	6	-$57,625	-$69,718
2020	7	-$57,665	-$72,475
2021	8	-$57,571	-$75,168
2022	9	-$57,358	-$77,797
2023	10	-$57,036	-$80,365
2024	11	-$56,617	-$82,873
2025	12	-$52,445	-$79,748
2026	13	-$51,982	-$82,113
2027	14	-$51,452	-$84,431
2028	15	-$50,861	-$86,703
2029	16	-$50,216	-$88,928
2030	17	-$49,524	-$91,109
2031	18	-$48,791	-$93,246
2032	19	-$48,021	-$95,339
2033	20	-$47,220	-$97,389
2034	21	-$46,392	-$99,398
2035	22	-$45,542	-$101,365
2036	23	-$44,673	-$103,292
2037	24	-$43,789	-$105,179
Total		**-$1,032,217**	**-$1,733,531**

8403 Colesville Road, Silver Spring, Maryland 20910 USA
Telephone: (240) 485-2600 • Fax: (240) 485-2635 • http://www.hdrinc.com