Benefit-Cost Analysis

Introduction

A benefit-cost analysis (BCA) for the US 395 North Spokane was completed with the intention of quantifying net benefits generated by the project. The BCA benefits quantified are safety, mobility and fuel. The quantified costs are right-of-way, engineering, construction and two rehabilitation cycles. Although these are the only benefits and costs that are used to calculate the BC ratio, this project has many societal benefits that are qualitative and are discussed below.

Methodology

When calculating the BCA, this project is assumed to be fully constructed in 2030 along with a 50 year lifecycle. Although the NSC will have a longer service life, 50 years was selected because it would require simple rehabilitation cycles to maintain. Traffic volumes were generated using the Spokane Regional Transportation Council model for the year 2030. These volumes were then estimated to grow at 2% annually. The volumes are then used to calculate monetary benefits for network safety, mobility and fuel consumption. Benefits were then discounted back to the present year value using the required 3 and 7 percent discount rates (per USDOT's – TIGER Guidelines[1]).

Safety

Safety benefits are the value associated with the reduction of fatalities, injuries and property damage. These benefits are a comparison between the year 2030 no-build scenario and the 2030 full-build scenario. Network safety was calculated by using vehicle miles traveled (VMT), collision rates and recommended monetized values. VMT's were generated by Spokane Regional Traffic Council using the traffic model VISUM. Collision rates were obtained by the 2010 Washington State Collision Data Summary for eastern Washington urban highways[2]. The recommended monetized value for fatal collisions is $6,200,000[3]. The value for injury collision is $652,550[4] and the value for property damages only is $3,285[5]. The Injury Collision value was obtained from averaging the cost of a minor, moderate, serious, and severe accident. Those values were $18,600, $291,400, $651,000, and $1,649,200 respectively. The annual results from

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[1] USDOT Tiger Grants. (2012) "BCA Resource Guide." Retrieved March 5th, 2012 from http://www.dot.gov/tiger/docs/tiger-12_bca-resourceGuide.pdf

[2] 2010 Washington State Collision Data Summary, "2010 Average Collision Rates By Functional Class Eastern Region (State Routes only)," pg 37, July, 2011

[3] Treatment of the Economic Value of a Statistical Life in Departmental Analyses (2008 revised guidance and 2011 update), July, 2011

[4] Treatment of the Economic Value of a Statistical Life in Departmental Analyses (2008 revised guidance and 2011 update), July, 2011

[5] The Economic Impact of Motor Vehicle Crashes 2000, "Summary of Unit Costs, 2000," pg 62, Table A-1, May, 2002

this analysis are $287 million at a 3% discount rate and $145 million at a 7% discount rate. These results can be seen in Table 1 below.

Mobility

Mobility is the value associated with travel time reduction. To calculate the mobility benefits, the 2030 no-build scenario is compared to the 2030 full build scenario. The difference between these two scenarios is the overall benefit. Mobility is calculated using network VMT's and speeds generated by VISUM. As expected with this facility, mobility has a very large benefit. The results from this benefit are $4.4 billion at a 3% discount rate and $2.5 billion at a 7% discount rate. These results can be seen in Table 1 as well.

Fuel

Fuel consumption is based off of project VMT and vehicle miles per gallon (MPG). Fuel is calculated as a non-benefit, because the 2030 Full Build has more VMT than the 2030 No-Build. Fuel usage was calculated for the entire network. Total 2030 gallons of fuel was calculated by dividing the total arterial and highway VMT by an average city (16.5) and highway (22.9) MPG[6]. These MPG values were obtained from www.fueleconomy.gov . Lastly, the total gallons were multiplied by today's national average fuel price of $3.76[7] to quantify the total cost of fuel.

TABLE 1: BCA Results

	3% Discount	7% Discount
Safety	$287,586,240	$144,853,886
Travel Time	$4,472,477,176	$2,252,735,377
Fuel Cost	($238,084,358)	($119,920,356)
Total Discounted Benefits	$4,521,979,058	$2,277,668,907
Cost	(1,900,000,000)	(1,900,000,000)
Maintenance & Rehab Costs @ Yr 16	($18,900,000)	($18,900,000)
Maintenance & Rehab Costs @ Yr 33	($18,900,000)	($18,900,000)
Total Cost	($1,937,800,000)	($1,937,800,000)
Benefit to Cost Ratio	2.33	1.18
Net Present Value	$2,584,179,058	$339,868,907

Safety and mobility benefits were derived for the entire region.

[6] Fuel Economy. (2012) "Download Fuel Economy Data, 2008 Datafile." Retrieved March 7th, 2012 from http://www.fueleconomy.gov/feg/download.shtml

[7] AAA's Daily Fuel Gauge Report. (2012) "National average prices." Retrieved March 7th, 2012 from http://www.fuelgaugereport.aaa.com/

Additional Benefits and Costs Not Included In the BCA

Fuel Consumption

This project proves to have a positive benefit on mobility as is shown in the table above. This positive benefit shows an increase in VMT of approximately 11%, according to the current Regional Transportation Model. However, due to the fact that this facility removes vehicle trips from local arterials onto the free flowing 60 mph freeway, the project provides a region wide average benefit of 6.5 % in fuel efficiency. For this reason, the resultant increase in fuel usage from the improved mobility is only 3%.

The added fuel associated with improved mobility is included in the BCA as a non-benefit. The improved mobility provides benefits of added productivity to industrial and commercial stakeholders and their employees. These are difficult to quantify with current economic analysis tools. These are known as "Agglomeration Benefits" and would balance the added fuel usage. Several studies suggest that these benefits are significantly higher than the costs[8]. However, since they are not easily quantifiable, benefits associated with the increased VMT are not quantified in the BCA.

Bike-Ped Path

The NSC provides a separated bicycle-pedestrian path which runs along the alignment. The costs of the path are small in comparison to the NSC. Much of the path grading work is simply accomplished as part of the overall grading work of the project. Of course there is some paving work and several structures. The benefit of having a multi-modal facility which allows access to non-vehicular modes is real but also not easily quantifiable. The cost of the path is captured in the BCA but the benefits are not. Therefore the BCA values are conservative.

Greenhouse Gasses and Emissions

In 2011, WSDOT used the EPA's mobile source emissions model (MOVES) to analyze this project for greenhouse gas emissions. To calculate the cost or benefit of CO_2 production, the metric tons of carbon produced from the 2030 No-Build must be subtracted from the 2030 Full-Build to see what NSC effects are created. The results can be seen in Table 2. From there it's seen that there is a net increase of 5 metric tons (3%) of CO_2. The social cost of carbon in year 2030 is only $32.80/metric ton. When the annual carbon cost is discounted back to present values, they have little to no impact on the BC ratio. Also, the FHWA considers an increase of less than 10% to be negligible. Therefore, these costs were not calculated for this BCA.

[8] Venables, Anthony J. "Evaluating Urban Transport Improvements: Cost-Benefit Analysis in the Presence of Agglomeration and Income Taxation." *Centre for Economic Performance* September 2004

TABLE 2: Greenhouse Gas Emissions and VMT[9]

Roadways	Emissions (MT CO_2e) VMT (miles) Existing	No Build	Build	Compare to Existing No Build	Build	Compare to No Build Build
North South Arterials	69	75	54	10%	-21%	-28%
	131,000	158,000	125,000	21%	-5%	-21%
East West Arterials	23	26	25 (o	13%	9%	-3%
	47,000	63,000	61,000	34%	30%	-3%
I-90	40	41	38	3%	-5%	-7%
	67,000	80,000	79,000	19%	18%	-1%
Subtotal	**131**	**142**	**117**	**8%**	**-11%**	**-18%**
	245,000	**301,000**	**265,000**	**23%**	**8%**	**-12%**
North Spokane Corridor		5	35			
		13,000	92,000			
Grand Total	131	147	152	12%	16%	3%
	245,000	314,000	357,000	28%	46%	14%

Notes: Numbers may not add due to rounding. Due to uncertainty associated with this type of analysis, scenarios with differences less than 10 percent should be considered negligible.

Conclusion

A BCA was completed for the NSC using safety, mobility and fuel as the benefits. The results of the analysis showed a BC ratio of 2.33 with a 3% discount rate and a BC ration of 1.18 with a 7% discount rate. This project has other benefits such as construction of non-motorized bicycle pedestrian facility, job creation, improved regional fuel efficiency and enhanced multi-modal transportation. Although these benefits are not monetized, their benefit to the community and this project cannot be overlooked.

[9] US Route 395 – North Spokane Corridor, "Greenhouse Gas Emissions Discipline Report – Final," pg 19. August 2011.

SAFETY SUMMARY

	No-Build	Full Build
North South Arterial VMT (Millions)	401	313
East West Arterial VMT (Millions)	154	153
Arterial VMT (Millions)	555	466
I-90 VMT (Millions)	186	198
NSC VMT (Millions)		198
Collision Rate (Interstate)	0.95	0.95
Collision Rate (Arterial)	2.62	2.62
Average Accident Costs - Arterial	$438,730	$438,730
Average Accident Costs - I-90	$361,869	$361,869
Average Accident Costs - NSC		$361,869
2030 Yearly Societal Cost - Arterial	$637,515,056	$535,312,103
2030 Yearly Societal Cost - I-90	$64,046,334	$68,046,944
2030 Yearly Societal Cost - NSC		$68,020,829
2030 Total Yearly Societal Cost	$701,561,390	$671,379,876
Projected Accidents per Million VMT	1630	1596
Money per accident	$430,385.12	$420,623.82
Difference	$9,761	
2030 Yearly Savings	$15,580,526	
2030 PV assuming 50 Year Life	($489,596,323)	
Present Value 2012 3% Discount	$287,586,240.23	
Present Value 2012 7% Discount	$144,853,885.64	

-To get the yearly societal cost for the arterials, I-90, and the NSC. Multiply the VMT's by the collision rate by the average accident cost. See the Safety Calc Sheet Tab on how to calculate the VMT and average accident cost.
-The yearly societal cost for the arterials, I-90 , and the NSC is then summed together for the total yearly societal cost.
-The total yearly societal cost is then broken down into a cost per accident. This is done by dividing the accidents per million VMT by the total yearly societal cost. See the Safety Calc Sheet Tab on how to calculate the accidents per million VMT.
-This procedure is done for both the No-Build and Full Build scenarios.
-The difference of the full build scenario and the no-build scenario is the yearly savings of the accidents.
-This value is then projected out 50 years using a compound uniform equation and then present valued back to the year 2030, assuming a growth rate of 2%
-The value is then present valued back to 2012 using discount rates of 3% and 7%.

Safety Calc Sheet Tab

	A	B	C	D	E	F	G	I	J	K	L	O	P	Q	R	S
1												Monetized Values				
2	Segments	Peak HR Directional Volume VMT	PHF	ADT VMT (B/C)	AADT VMT (D*250)	Mil Veh. Miles of Travel (E/1,000,000)	100 Mil Veh. Miles of Travel (F/100)	Collision Rate (F/Rate)	Property Damage Only Collision (F/Rate)	Injury Collision Rate (F/Rate)	Fatal Collision Rate (G/Rate)	Property Damage only Collision (Y4*J)	Injury Collision (Z4*K)	Fatal Collision (AA4*L)	SUM (O+P+Q)	Average Accident Cost (R/I)
3	**2030 Full Build**															
4	**NSC**	79146	0.1	791456	197863995	198	1.98	188	123	65	0.59	$587,080	$62,072,290	$5,361,459	$68,020,829	$361,869
5																
6	**North South Arterials**															
7	Maple/Ash	18450	0.1	184503	46125808	46	0.46	121	67	54	0.20	$322,282	$50,864,998	$1,833,123	$53,020,402	$438,730
8	Monroe	12628	0.1	126284	31571008	32	0.32	83	46	37	0.14	$220,587	$34,814,767	$1,254,689	$36,290,043	$438,730
9	Division/Ruby/US395	36752	0.1	367520	91879963	92	0.92	241	134	107	0.40	$641,966	$101,320,157	$3,651,476	$105,613,600	$438,730
10	US 2	11780	0.1	117802	29450458	29	0.29	77	43	34	0.13	$205,771	$32,476,341	$1,170,414	$33,852,526	$438,730
11	Hamilton/Nevada	13547	0.1	135474	33868575	34	0.34	89	49	39	0.15	$236,640	$37,348,397	$1,345,998	$38,931,036	$438,730
12	Crestline	3355	0.1	33555	8388723	8	0.08	22	12	10	0.04	$58,612	$9,250,621	$333,383	$9,642,616	$438,730
13	Greene/Market/Haven	12473	0.1	124729	31182303	31	0.31	82	46	36	0.14	$217,871	$34,386,124	$1,239,241	$35,843,236	$438,730
14	Argonne	16023	0.1	160233	40058205	40	0.40	105	58	46	0.18	$279,887	$44,173,980	$1,591,986	$46,045,853	$438,730
15				**Total VMT North South**		313		819				$2,183,616	$344,635,385	$12,420,310	$359,239,312	$438,730
16																
17	**East West Arterials**															
18	Riverside-Sprague	8835	0.1	88351	22087663	22	0.22	58	32	26	0.10	$154,327	$24,357,057	$877,804	$25,389,187	$438,730
19	Spokane Falls Blvd-Trent	12070	0.1	120705	30176218	30	0.30	79	44	35	0.13	$210,842	$33,276,669	$1,199,257	$34,686,768	$438,730
20	Maxwell-Mission	7695	0.1	76946	19236623	19	0.19	50	28	22	0.08	$134,407	$21,213,087	$764,498	$22,111,991	$438,730
21	Wellesley	7441	0.1	74407	18601645	19	0.19	49	27	22	0.08	$129,970	$20,512,869	$739,263	$21,382,102	$438,730
22	Francis-Bigelow Gulch	18648	0.1	186482	46620423	47	0.47	122	68	54	0.21	$325,737	$51,410,432	$1,852,780	$53,588,949	$438,730
23	Hawthorne	2307	0.1	23065	5766340	6	0.06	15	8	7	0.03	$40,289	$6,358,802	$229,165	$6,628,256	$438,730
24	Hastings-Farwell	2425	0.1	24247	6061708	6	0.06	16	9	7	0.03	$42,353	$6,684,517	$240,903	$6,967,773	$438,730
25	Mt Spokane Park (SR 206)	1851	0.1	18505	4626260	5	0.05	12	7	5	0.02	$32,324	$5,101,584	$183,856	$5,317,764	$438,730
26				**Total VMT East West**		153		401				$1,070,249	$168,915,016	$6,087,526	$176,072,791	$438,730
27																
28	**I 90**	79176	0.1	791760	197939960	198	1.98	188	123	65	0.59	$587,305	$62,096,122	$5,363,517	$68,046,944	$361,869
29																
30							NS Arterial	819								
31							EW Arterial	401								
32							I90	188								
33							NSC	188								
34						Full Build Total Collisions		1596								
35																
36	**2030 No-Build**															
37	**North South Arterials**															
38	Maple/Ash	22720	0.1	227198	56799595	57	0.57	149	83	66	0.25	$396,859	$62,635,462	$2,257,319	$65,289,640	$438,730
39	Monroe	15895	0.1	158946	39736603	40	0.40	104	58	46	0.17	$277,640	$43,819,335	$1,579,204	$45,676,179	$438,730
40	Division/Ruby/US395	43356	0.1	433559	108389868	108	1.08	284	158	126	0.48	$757,321	$119,526,371	$4,307,609	$124,591,301	$438,730
41	US 2	15022	0.1	150223	37555760	38	0.38	98	55	44	0.17	$262,403	$41,414,422	$1,492,534	$43,169,358	$438,730
42	Hamilton/Nevada	18377	0.1	183769	45942170	46	0.46	120	67	53	0.20	$320,998	$50,662,492	$1,825,825	$52,809,316	$438,730
43	Crestline	5963	0.1	59628	14907023	15	0.15	39	22	17	0.07	$104,156	$16,438,643	$592,432	$17,135,230	$438,730
44	Greene/Market/Haven	19168	0.1	191676	47918980	48	0.48	126	70	56	0.21	$334,810	$52,842,409	$1,904,387	$55,081,607	$438,730
45	Argonne	19760	0.1	197604	49400970	49	0.49	129	72	57	0.22	$345,165	$54,476,666	$1,963,284	$56,785,115	$438,730
46				**Total VMT North South**		401		1050				$2,799,353	$441,815,800	$15,922,594	$460,537,747	$438,730
47																
48	**East West Arterials**															
49	Riverside-Sprague	11308	0.1	113076	28269035	28	0.28	74	41	33	0.12	$197,516	$31,173,533	$1,123,463	$32,494,512	$438,730
50	Spokane Falls Blvd-Trent	12213	0.1	122135	30533715	31	0.31	80	45	35	0.13	$213,339	$33,670,898	$1,213,465	$35,097,702	$438,730
51	Maxwell-Mission	7981	0.1	79809	19952155	20	0.20	52	29	23	0.09	$139,406	$22,002,137	$792,935	$22,934,477	$438,730
52	Wellesley	6624	0.1	66240	16560030	17	0.17	43	24	19	0.07	$115,705	$18,261,488	$658,126	$19,035,319	$438,730
53	Francis-Bigelow Gulch	15009	0.1	150087	37521873	38	0.38	98	55	44	0.17	$262,166	$41,377,052	$1,491,187	$43,130,405	$438,730
54	Hawthorne	2447	0.1	24470	6117418	6	0.06	16	9	7	0.03	$42,742	$6,745,951	$243,117	$7,031,810	$438,730
55	Hastings-Farwell	3476	0.1	34762	8690540	9	0.09	23	13	10	0.04	$60,721	$9,583,448	$345,378	$9,989,547	$438,730
56	Mt Spokane Park (SR 206)	2528	0.1	25276	6319010	6	0.06	17	9	7	0.03	$44,151	$6,968,256	$251,129	$7,263,536	$438,730
57				**Total VMT East West**		154		403				$1,075,747	$169,782,763	$6,118,799	$176,977,309	$438,730
58																
59	**I 90**	74521	0.1	745211	186302693	186	1.86	177	116	61	0.56	$552,776	$58,445,372	$5,048,186	$64,046,334	$361,869
60																
61							NS Arterial	1050								
62							EW Arterial	403								
63							I90	177								
64																
65						No-Build Total Collisions		1630								

Safety Calc Sheet Tab

	T	U	V	W	X	Y	Z	AA	AB	AC	AD
1				Inflated Recommend Monetized Values ($2030)							
2				Property Damage only Collision	Injury Collision	Fatal Collision		Equation: PV=FV/((1+i)^t)			
3			$2011	$3,285	$652,550	$6,200,000					
4			$2030	$4,786	$950,642	$9,032,229					

-To get millions VMT's ,the Peak Hour Directional Volume VMT is obtained from the Travel Time 2030 No-Build and Full Build Tabs. This value is then multiplied by the peak hour factor of 0.1. This gives the daily VMT's. The daily VMT's is then multiplied by 250 working days to give annual VMT's. The value is then divided by 1,000,000 and 100,000,000 so this value can be used with collision rates.

-I-90 and the NSC used interstate collision rates while the arterials used principal arterial collision rates. The interstate rates are as follows: Collision rate=0.95, Property Damage Only Collision rate =0.62, Injury Collision rate =0.33, and Fatal Collision rate =0.30. The principal arterial rates are as follows: Collision rate=2.62, Property Damage Only Collision rate =1.46, Injury Collision rate =1.16, and Fatal Collision rate =0.44.

-The VMT's are then multiplied by these collision rates to determine the number of accidents per million VMT's. The Fatal Collisions rate is per 100 million VMT's.

-The recommended monetized value for fatal collisions is $6,200,000. The value for injury collision is $652,550 and the value for property damages only is $3,285. The Injury Collision value was obtained from averaging the cost of a minor, moderate, serious, and severe accident. Those values were $18,600, $291,400, $651,000, and $1,649,200 respectively. These values were then future valued to the year 2030 and multiplied by the number of accidents that occurred. The total dollars for each collision was then summed together and divided by the total number of collisions for the year to get the average accident cost.

TRAVEL TIMES SUMMARY

Column1	Off Peak	Peak
Arterial Average Speed in No Build	35.1	20.3
NSC Average Speed	60.0	53.1
NSC VMT	879137	79146
Savings	35284	2416
Total Travel Time Savings per day in hours	37700	
Yearly Savings (250 day per year)	9425113	
2009 Rate Per Hour	$ 18.00	
2030 Rate Per Hour	$25.71	
2030 Yearly savings	$242,304,879	
2030 PV assuming 50 Year Life	($7,614,093,010)	
Present Value 2012 values (3% Discount)	$4,472,477,176	
Present Value 2012 values (7% Discount)	$2,252,735,377	

-To get the daily travel time savings. Take the difference of the NSC Average Speed and the Arterial Average Speed in the No-Build scenario. This is done for both the Off Peak hours and the Peak hour. The NSC VMT's for the off peak hours and the peak hour are then divided by the difference of the average speed. These values are then summed together to get the Total Travel Time Savings per day in hours. See the Travel Time Tabs on how to calculate the average speeds and VMT's.
-The Total Travel Time Savings per day is then multiplied by 250 working days to give the yearly hourly savings.
-The recommended monetized value is $18.00 in 2009 dollars. This value is then future valued to the year 2030 at an inflation rate of 2%.
-The yearly hourly savings is multiplied by the 2030 a monetized value to get the yearly savings.
-This value is then projected out 50 years using a compound uniform equation and then present valued back to the year 2030, assuming a growth rate of 2%
-The value is then present valued back to 2012 using discount rates of 3% and 7%.

FUEL COST SUMMARY

	No-Build	Full Build
Average City MPG	16.5	
Average Highway MPG	22.9	
National Average Fuel Price (Regular $/gal)	$3.76	
2030 Arterial VMT	2,589,628	2,048,077
2030 I-90 VMT	1,096,864	1,137,364
2030 NSC VMT		958,282
Total 2030 Daily VMT	3,686,492	4,143,723
2030 Arterial Gallons Used Daily	156,905	124,093
2030 I-90 Gallons Used Daily	47,826	49,592
2030 NSC Gallons Used Daily		41,784
Total 2030 Gallons Used Daily	204,732	215,469
Cost of Gasoline	$769,791	$810,163
Cost per Mile	$0.20881	$0.19552
Efficiency	0.0637	
Gallons Spent per Day	13722	
Gallons Spent per Year	3430497	
2030 Cost per Year	($12,898,669)	
2030 PV assuming 50 Year Life	$405,322,683	
Present Value 3% Discount	($238,084,358)	
Present Value 7% Discount	($119,920,356)	

-To get the gallons of gasoline used in a day. Muliply the daily VMT's by the mpg, using the city mpg for the arterials and the highway mpg for I-90 and the NSC. These values are then summed together to get the total gallons of gasoline used daily.
-The total gallons is then multiplied by the National Average Fuel Price to cost of gasoline spent in a day. This value is then divided by the total daily VMT's to get a cost per mile.
-This procedure is done for the both the No-Build and Full Build scenarios.
-To get the efficiency. Take the difference of the No-Build cost per mile and the Full Build cost per mile. Then divide that by the No-Build cost per mile.
-Multiply the efficiency by the total gallons used daily to get the gallons spent per day. This is then multiplied by 250 working days to get gallons spent per year.
-This value is then multiplied by the National Average Fuel Price to get a cost per year.
-This value is then projected out 50 years using a compound uniform equation and then present valued back to the year 2030, assuming a growth rate of 2%
-The value is then present valued back to 2012 using discount rates of 3% and 7%.

BENEFIT COST RATIO

	3% Discount	7% Discount
Safety	$287,586,240	$144,853,886
Travel Time	$4,472,477,176	$2,252,735,377
Fuel Cost	($238,084,358)	($119,920,356)
Total Discounted Benefits	$4,521,979,058	$2,277,668,907
Cost	(1,900,000,000)	(1,900,000,000)
Maintenance & Rehab Costs @ Yr 16	($18,900,000)	($18,900,000)
Maintenance & Rehab Costs @ Yr 33	($18,900,000)	($18,900,000)
Total Cost	($1,937,800,000)	($1,937,800,000)
Benefit to Cost Ratio	2.33	1.18
Net Present Value	$2,584,179,058	$339,868,907

-Safety and Travel Time are counted towards Discounted Benefits and are added together to become the total Benefits.
-Cost is estimated at $1.9 billion which was obtained from 2008 CVEP
-Maintenance and Rehab Costs. Assume $250,000 per lane mile + $50,000 for maintenance. NSC averages 6 lanes for 10.5 miles = 63 lane miles. Multiply $300,000 by 63 lane miles = $18.9 million. Assuming two rehab cycles, this value is added toward the total cost of the project twice.
-Fuel Cost is also added to the Total Costs.
-The Benefit Cost Ratio is the Total Benefits over the Total Costs. This is done for both the 3% Discount and the 7% Discount
-The Net Present Value is obtained from subtracting the Total Discounted Benefits by the Total cost.