



March 21, 2017

Atkins North America, Inc.
7604 Technology Way, Suite 400
Denver, Colorado 80237

Attention: Mr. Matt Aguirre, PE
Transportation Engineer

Subject: Life Cycle Cost Analysis, North I-25 Reconstruction Project – Additional Request Element No. 3 Segment, Approximately 2,500 feet South of Larimer County Road 16 (LCR 16)) to LCR 16, Larimer County, Colorado, CDOT Project No. IM 0253-255(21506), RockSol Project Number 292.05

Dear Mr. Aguirre:

RockSol Consulting Group, Inc. (RockSol) has performed a Life Cycle Cost Analysis (LCCA) for the subject project as part of the pavement design evaluation. Per Section 13.2 of the 2017 CDOT ME Pavement Design Manual (PDM), a Life Cycle Cost Analysis (LCCA) comparing asphalt and concrete should be prepared for all surface treatment projects with more than \$2,000,000 initial pavement cost where both pavement types are considered feasible alternatives as determined by the CDOT Regional Materials Engineer.

This LCCA is based on proposed pavement construction for northbound and southbound I-25 between approximate Mile Post (MP) 253.7 to MP 254.2, located approximately ½-mile south of LCR 16 to LCR 16 (Project Station No. 3264+00 to 3291+00). The proposed I-25 mainline configuration for the Additional Requested Elements number three (ARE#3) area includes widening to the inside median area for express lane construction as well as outside areas as needed for the 2-plus-1 lane configuration.

Table 1 lists the approximate widths and lengths based on information provided in the project plans (*Exhibit 1-C3: ARE #3, Extend the Express Lane from Just North of LCR 16 to Approximately 2500 Feet South*, dated 1/26/2017) where new pavement is constructed over new subgrade and where new pavement is constructed over existing pavement (overlay section) are proposed in the ARE#3 Segment project limits. The term "overlay" is used in this LCCA only to indicate new pavement construction over existing pavement structure. Design life of 20 years for new flexible pavement and 30 years for new rigid pavement was used for design of new pavements for ARE#3.

For this project, two pavement types were considered for the LCCA; rigid pavement consisting of portland cement concrete pavement (PCCP) and flexible pavement consisting of hot mix asphalt (HMA) and stone matrix asphalt (SMA). An Annual Growth Rate of 2.6 percent was used for pavement thickness designs. A summary of evaluated pavement sections is presented in Tables 2A and 2B.

Table 1 – ARE#3 South Segment Project Area Description

Station No.	New Pavement over New Subgrade				Overlay Section – New Pavement over Existing Pavement			
	Average Width (ft)	Length (ft)	Area (SF)	Area (SY)	Average Width (ft)	Length (ft)	Area (SF)	Area (SY)
3264+00 to 3291+00	50	2,700	135,000	15,000	74	2,700	199,800	22,200

Table 2A – Evaluated Pavement Section Summary (New Pavement Construction)

North I-25 Mainline ARE#3 Segment Station and Mile Post	Full Depth Pavement Section (20 year SMA/HMA and 30 Year PCCP)		
Station No. 3264+00 to 3291+00 MP 253.7 to MP 254.2	SMA over HMA (inches) (Note 1)	ABC (inches)	R-40 (inches)
	12.5	6.0	24
	PCCP (inches)	ABC (inches)	R-40 (inches)
	12.0	6.0	24

Note 1: 2 inches of SMA over 10.5 inches of new HMA.

ABC = CDOT Class 6 Aggregate Base Course. R-40 = R-Value of subgrade material for the minimum designed depth beneath ABC.

Table 2B – Evaluated Pavement Section Summary (Overlay Pavement Construction)

North I-25 Mainline ARE#3 Segment Station and Mile Post	Overlay Pavement Section (20 year SMA/HMA and 30 Year PCCP)		
Station No. 3264+00 to 3291+00 MP 253.7 to MP 254.2	SMA over HMA (inches) (Note 1)	Remaining of Existing HMA after Milling (inches)	Minimum Rubblized Existing Concrete (inches)
	4.0	4.0	8.0
	PCCP (inches)	Remaining of Existing HMA after Milling (inches)	Minimum Rubblized Existing Concrete (inches)
	13.5	4.0	8.0

Note 1: 2 inches of SMA over 2 inches of new HMA.

All PCCP pavement sections presented in Tables 2A and 2B include ¼ inch allowance for future diamond grinding.

This LCCA is based on phasing for the initial pavement construction to be completed off the inside shoulder median area of northbound and southbound I-25, then traffic will be shifted onto the newly constructed pavement so overlay pavement can be constructed for northbound and

southbound I-25. RockSol understands that two lanes of traffic will be required to remain open for northbound and southbound I-25 during construction for this project. Initial pavement construction near overpasses will be governed by the construction phasing of the proposed bridge structures within the limits of the LCCA site. The estimate length of time for pavement construction is estimated to be significantly less than the estimated length of time for the construction of the proposed bridge structures planned for this project. A construction phasing schedule was not developed at the time of this LCCA.

Based on recent construction projects and traffic control permitting requirements for Region 4 along I-25, a workzone speed limit of 65 miles per hour (mph) and a workzone length of 0.5 miles (full project limit) was used for initial construction for long term traffic control purposes. A workzone speed limit of 55 mph and a workzone length of 0.5 miles was used for rehabilitation construction for short term operations.

LCCA Input Summary

The LCCA was performed using a 40-year analysis period and a 30-year design life period for rigid pavement, assuming an initial/base construction year of 2020. Based on Section 13.3.3 of the 2017 CDOT ME PDM, a triangular distribution with the most likely value of 27 years (2047) was used for the first rigid pavement rehabilitation cycle. The rigid pavement rehabilitation analysis included a ½ percent slab replacement in the travel lanes and 100 percent diamond grinding of ¼ inch and longitudinal and transverse joint resealing.

The LCCA was performed using a 40-year analysis period and a 20-year design life period for flexible pavement, assuming an initial/base construction year of 2020. Rehabilitation of the flexible pavement included a 2-inch mill and overlay with 2 inches of SMA and 1.5 inches of HMA at year 2034 and a 2-inch mill and overlay with 2 inches of SMA and 2 inches of HMA at year 2047. The rehabilitation time periods are based on Table 13.1 in the 2017 CDOT ME PDM and discussions with CDOT Region 4 Materials.

Additional factors used in the LCCA for both flexible and rigid pavements include a discount rate of 2.22 percent, Cost of Engineering (CE) of 22.1 percent, Traffic Control Cost of 15 percent for the initial construction and rehabilitation operations. A Preliminary Engineering (PE) cost of 10 percent was used for the rehabilitation operations.

Annual maintenance costs used for the LCCA are \$1,027 per lane mile for HMA and \$640 per lane mile for PCCP per Section 13.5.3 of the 2017 CDOT PDM.

Sources for evaluation of material costs and production rates included:

- 1) 2017 CDOT Pavement Design Manual (Chapter 13).
- 2) CDOT Colorado Construction Cost Index Report, Calendar Year 2016, Second Quarter.
- 3) 2013 through 2016 CDOT Cost Data Information and Bid Tabs.
- 4) Discussions with CDOT Region 4.
- 5) Discussions with representatives from the Colorado Asphalt Pavement Association (CAPA) and American Concrete Pavement Association (ACPA).
- 6) CDOT Engineering Estimates and Marketing Analysis information.
- 7) Recent E-470 Asphalt Paving Material Prices

Pricing for PCCP was evaluated with CDOT data for large projects considered appropriate for comparison and a plot of that price data is attached. Most of the price data was for PCCP ranging from 10 to 12 inches. Also evaluated was Table 13.19 of the 2017 CDOT M-E PDM which lists prices for PCCP, 12 or greater inches, with a normalized average price per square yard of \$38.36. This value is slightly higher than the price indicated in the price plot attached.

Also strongly considered was a recent PCCP paving project, I-25 from Lincoln to County Line that included PCCP which was 13-inches thick and was for nearly 75,000 square yards. For that project three bidders provided costs for the PCCP which were \$38.50, \$49.50, and \$52.00 per square yard (\$2.96, \$3.81, and \$4.00 per square yard-inch, respectively). ACPA has provided an estimated unit price of PCCP of \$3.50 to \$3.75 per square yard-inch. Based on this range of PCCP pricing, RockSol is using PCCP pricing that is consistent with the I-25 Lincoln to County Line bidding prices and the ACPA pricing estimate.

Pricing for SMA and S mix asphalt was evaluated using prices for projects bid after 2012 and a plot of the price data is included in Appendix A. Tack coat (emulsified asphalt – slow setting) was included as a cost item for this LCCA. Of the projects evaluated for cost, most listed tack coat as a separate cost item but some did not. Where tack coat was not listed as a separate cost item in the cost data, it was included in the SMA/ HMA cost data. To appropriately compare SMA/HMA costs for all projects evaluated, where tack coat was included in the HMA/SMA costs, an average cost for tack coat per ton of HMA/SMA was subtracted from the HMA/SMA unit costs for this LCCA.

Table 3 presents the basic material, construction and rehabilitation costs, and production rates.

Table 3 - Material, Construction and Rehabilitation Costs and Production Rates

Operation/Material	Production Rate	Minimum Cost (\$)	Most Likely Cost (\$)	Maximum Cost (\$)
10.5-inches - HMA Grading S (100) PG 64-22 (price per ton)	2,200 tons/day (75%) 1,800 tons/day (25%)	60.00	65.00	70.00
2-inches - SMA (Fiber)	1,800 tons/day (75%) 1,500 tons/day (25%)	90.00	95.00	100.00
Planing/Milling (HMA) SY	2 days ahead of paving operations	2.04	2.27	2.50
Tack Coat Material (Emulsified Asphalt – Slow Setting) (SY)	Performed ahead of paving operations (same day/night)	0.28	0.38	0.48
Rigid Pavement 12 to 13.5 inches (price per SY-in)	5,500 (75%)(SY/day) 2,880 (25%) (SY/day) [Production rate includes time required to achieve strength and sealing]	3.25	3.50	3.75
Rigid Slab Replacement (SY) (includes removal/replacement)	5 Panels per day/night	125	150	175
Grinding Concrete Pavement (SY)	7,040 SY/day	3.00	3.50	4.00
Sawing and Sealing Concrete Joints (linear feet)	10,000 LF/day	2.25	2.75	3.25

The area for ARE#3 Segment is approximately 37,200 square yards (SY). Using the production rates of 5,500 SY per day for normal production (75 percent of the time) and 2,880 SY per day for lower production (25 percent of the time), the initial construction for the rigid alternative was determined to be 8 days.

A total of 4,092 tons of SMA and 11,105 tons of HMA was determined based on the total area and design thicknesses. Tack coat placement was based on total project square yardage, number of lifts for HMA/SMA placement, and an application rate of 0.1 gallons per square yard. Based on 25 percent of the total tons for low production days, 75 percent for normal production

days and the production rates listed in Table 3 for SMA and HMA material types, a total of 7 days was determined for initial construction of the flexible alternative.

User costs are included in the LCCA for both pavement alternatives for initial pavement construction and for their respective rehabilitation operations. User cost information from the LCCA is attached.

LCCA Output Summary

Based on the results of the LCCA, the probabilistic analysis indicates the rigid pavement option is less costly than the flexible pavement option by a difference of 17.7 percent at the 75 percentile as shown in Table 4. CDOT uses the 75 percentile as the basis for comparison of pavement alternatives. The output results for CDOT User Cost Website and RealCost are included in Appendix B.

Table 4 – Probabilistic LCCA Results (40 Year Analysis)

Statistics	Alternative 1 – Flexible Pavement			Alternative 2 – Rigid Pavement		
	LCCAOutput: Alternative 1: Agency Cost	LCCAOutput: Alternative 1: User Cost	Flexible Pavement Total	LCCAOutput: Alternative 2: Agency Cost	LCCAOutput: Alternative 2: User Cost	Rigid Pavement Total
Probability Function	(Thousands)	(Thousands)	(Thousands)	(Thousands)	(Thousands)	(Thousands)
Minimum	2371.46	255.45	2626.91	2199.27	245.44	2444.71
Maximum	3395.37	273.78	3669.15	2727.41	279.34	3006.75
Mean	2963.00	267.17	3230.17	2516.80	264.96	2781.76
Median	2982.62	267.73	3250.35	2518.28	266.83	2785.10
Standard Deviation	188.30	3.69	191.99	96.57	7.84	104.40
Percentile (5%)	2625.12	260.67	2885.79	2357.17	250.72	2607.90
Percentile (25%)	2851.99	265.12	3117.11	2448.90	259.03	2707.93
Percentile (75%)	3096.79	269.82	3366.61	2588.25	271.08	2859.33
Percentile (95%)	3233.51	272.24	3505.76	2665.19	274.64	2939.83

The cost and duration indicated on the User Cost output sheets are based on the total pavement area (new and overlay pavement sections) as outlined in Table 1 for the ARE#3 Segment Project limits.

Based on the CDOT User Cost website, user costs for initial and rehabilitation construction operations for the flexible and rigid pavement alternatives are outlined in Table 5.

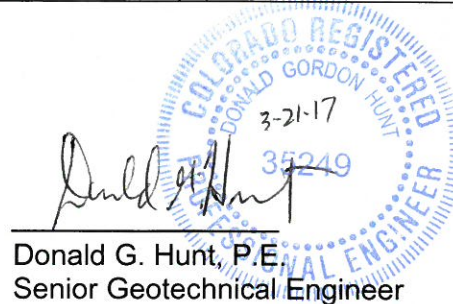
Table 5 – LCCA User Costs Summary

Operation	Flexible Pavement	Rigid Pavement
Initial Construction (2020)	\$242,185	\$242,185
Rehabilitation 2034	\$13,982	----
Rehabilitation 2047	\$27,361	\$49,144
Total	\$283,528	\$291,329

Prepared by:
RockSol Consulting Group, Inc.



Ryan Lepro
Engineering Geologist



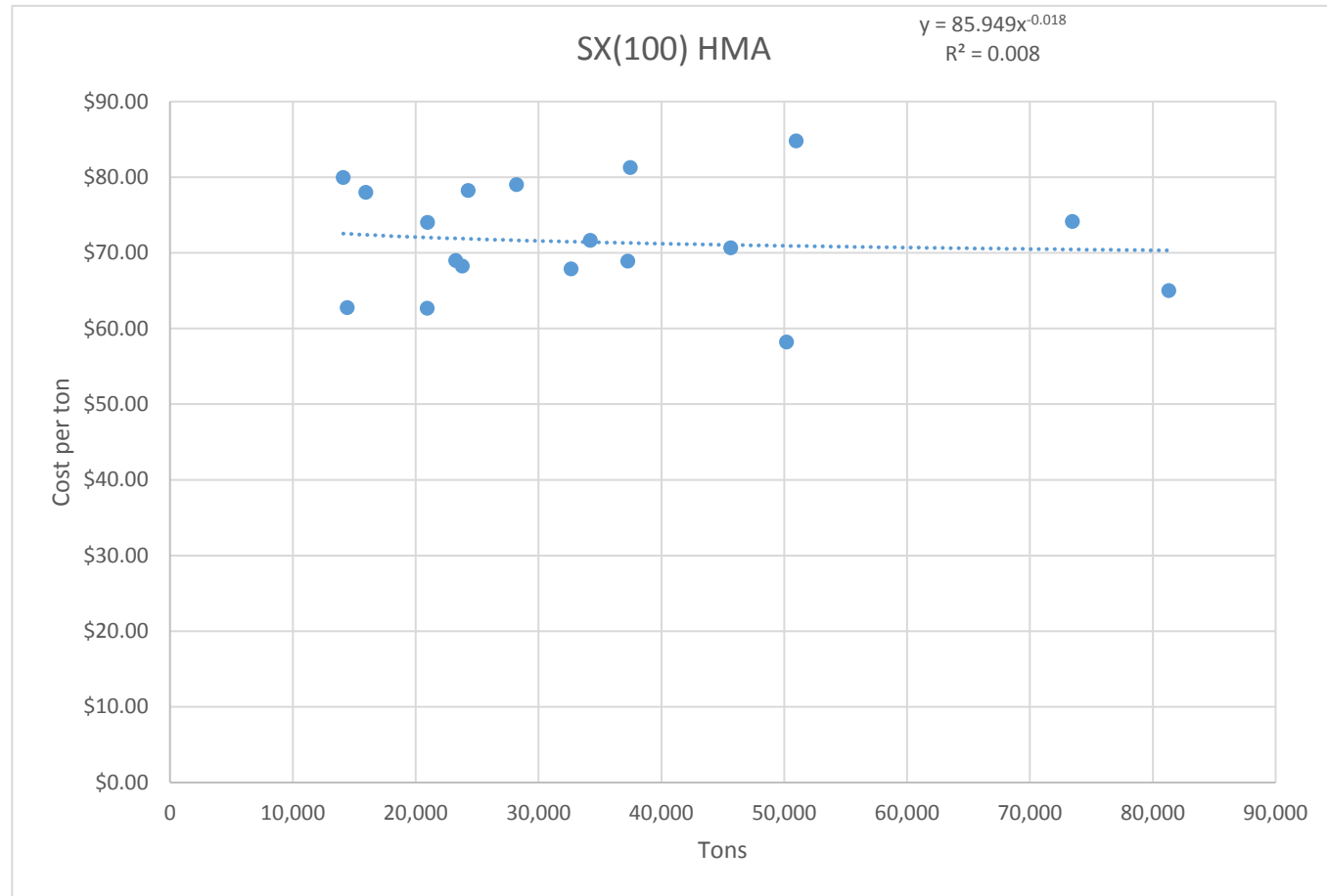
Donald G. Hunt, P.E.
Senior Geotechnical Engineer

Attachments

- Appendix A: SMA, HMA, PCCP Unit Cost Information
- Appendix B: LCCA Input and Output Summary Sheets

APPENDIX A

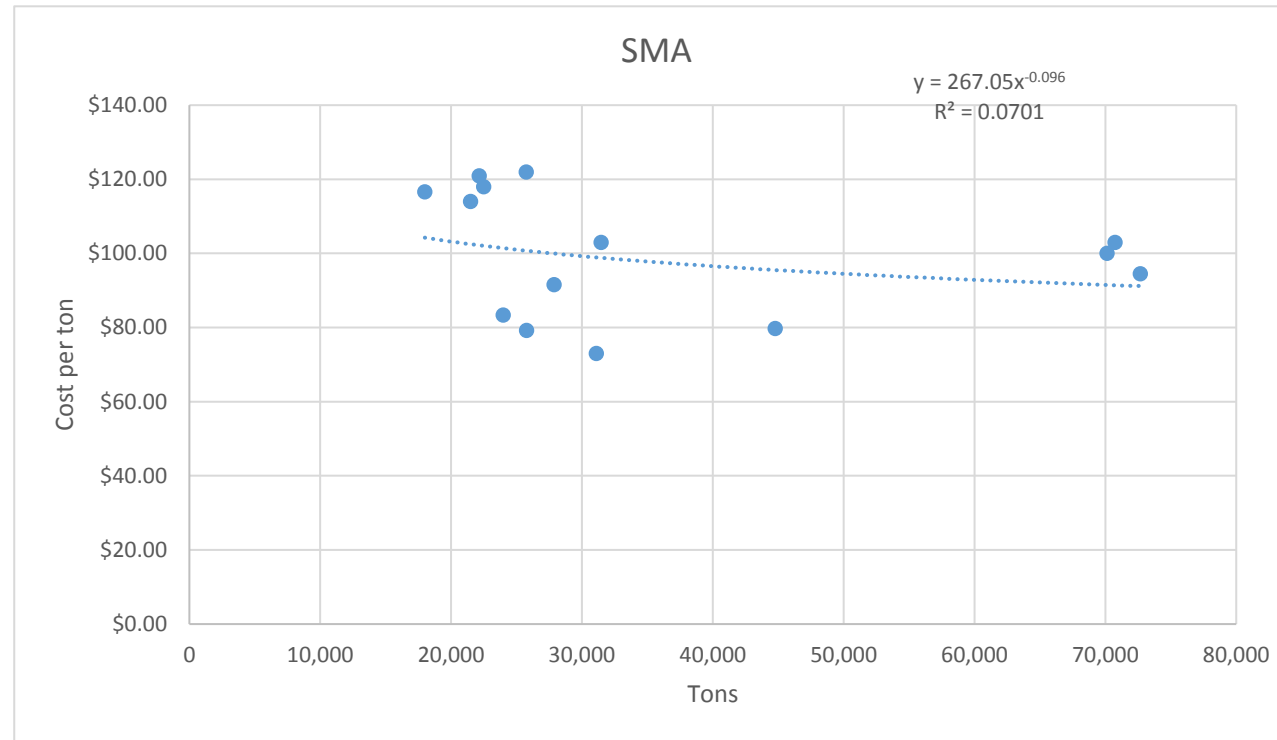
SMA, HMA, PCCP UNIT COST INFORMATION



HMA
300000 tons

Unit Price
\$ per ton **\$68.49**

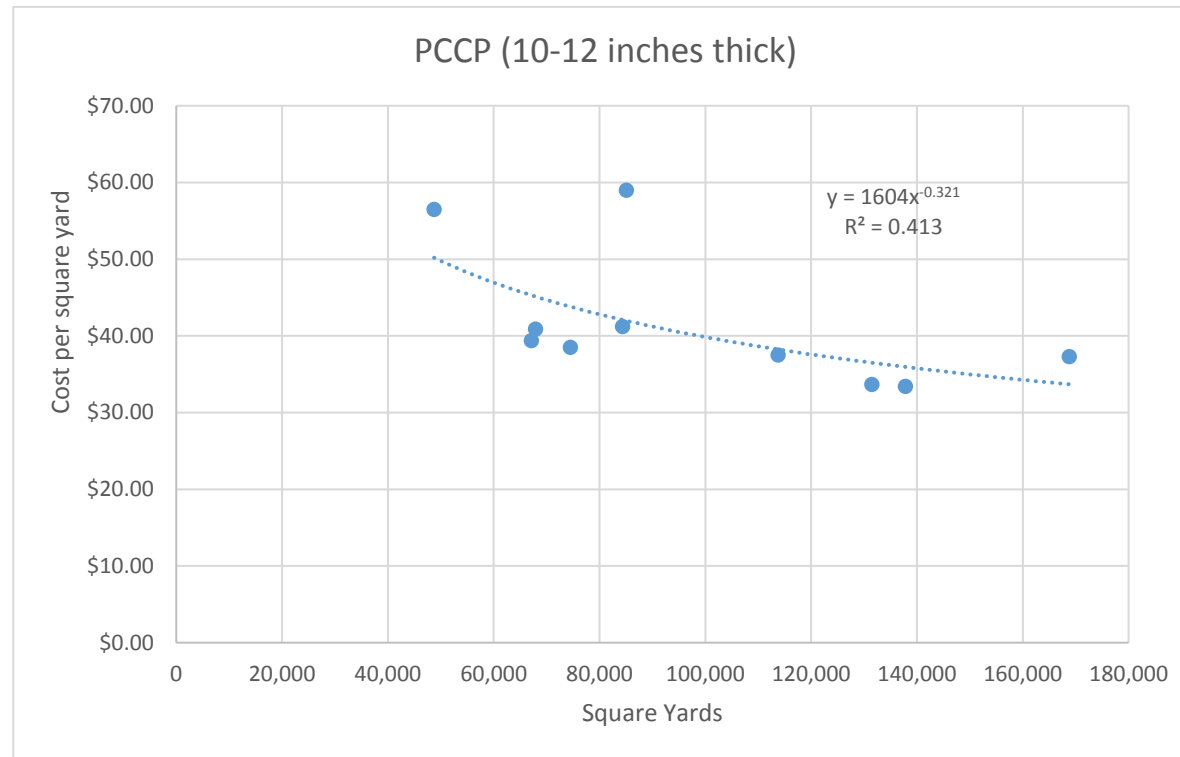
Bid Date	Contract ID	Location	Awarded To	Quantity (tons)	Unit Cost (\$/ton)	Total Cost (\$)	Unit Price Tack Coat (\$)	Quantity (gal)	Total Cost Tack Coat (\$)
FEB 07 2013	C18825	US 50, LA JUNTA # EAST, 4-LANE	MARTIN MARIETTA MATERIALS	50,170	\$58.21	\$2,920,396	\$2.81	21,522.00	\$60,477
MAR 28 2013	C19014	I 25A, MIDWAY NORTH, Site 1, Site 2, Site 3, and	SCHMIDT CONSTRUCTION COMPANY	37,258	\$68.90	\$2,567,076	\$2.51	13,283.00	\$33,340
APR 18 2013	C18736	SH30: FLORIDA TO 1ST & SH83: JEWELL TO	BRANNAN SAND AND GRAVEL, LLC	23,247	\$69.00	\$1,604,043	\$3.09	8,050.00	\$24,875
MAR 13 2014	C19655	I-25, BUTTE CREEK SOUTH (MP 50-59)	APC SOUTHERN CONSTRUCTION COMPANY, LLC	73,458	\$74.14	\$5,446,195	\$2.85	22,012.00	\$62,734
MAR 13 2014	C19655	I-25, BUTTE CREEK SOUTH (MP 50-59)	APC SOUTHERN CONSTRUCTION COMPANY, LLC	14,104	\$79.97	\$1,127,897	\$2.85	4,224.00	\$12,038
Apr-14		I-25 SANTA FE ALAMEDA INTERCHANGE (S(100))	HAMON INFRASTRUCTURE, INC.	28,199	\$79.00	\$2,227,721			\$0
Mar-15	C19456	SH58 Resurfacing	APC CONSTRUCTION CO., LLC	14,412	\$62.74	\$904,209	\$4.93	8,736.10	\$43,069
		US 50 Wills to Purcell (S(100) PG64-22))		20,957	\$74.00	\$1,550,818			\$0
FEB 12 2015	C19654	SH 47 FROM DILLION DR TO PCCP SECTION, MP	MARTIN MARIETTA MATERIALS	34,200	\$71.63	\$2,449,761	\$4.89	11,736.00	\$57,389
MAR 12 2015	C20225	SH 16 & SH 21 SYRACUSE TO BRADLEY	ROCKY MOUNTAIN MATERIALS & ASPHALT, INC.	32,631	\$67.89	\$2,215,319	\$5.24	14,731.00	\$77,190
APR 16 2015	C20365	S85 FY15 OVERLAY BRIGHTON TO FT LUPTON	AGGREGATE INDUSTRIES - WCR, INC.	24,274	\$78.25	\$1,899,441			\$0
APR 23 2015	C20487	US 71 from M.P. 18.9 to M.P. 27	A and S CONSTRUCTION CO.	15,937	\$78.00	\$1,243,056	\$4.00	15,088.00	\$60,352
FEB 04 2016	C20519	I25 from Aguilar North	APC SOUTHERN CONSTRUCTION COMPANY, LLC	45,632	\$70.65	\$3,223,926	\$2.90	18,192.00	\$52,757
FEB 18 2016	C19626	I-25 120th to SH7 S(100) PG64-22 Mix	HAMON INFRASTRUCTURE, INC.	81,292	\$65.00	\$5,283,980	\$6.00	26,904.00	\$161,424
MAR 03 2016	C21267	I-76: EAST OF BRUSH TO MERINO	SIMON CONTRACTORS	37,462	\$81.25	\$3,043,788			\$0
MAR 24 2016	C20846	C-470 RESURFACING: S. ROONEY RD TO KEN	APC CONSTRUCTION CO., LLC	20,931	\$62.66	\$1,311,536	\$4.64	12,240.00	\$56,794
April 11 2016		I-25 Arapahoe Rd. Interchange S(100) PG64-22	EKS	50,960	\$84.80	\$4,321,408	\$3.18	13,338.95	\$42,418
MAR 24 2016	C20655	US 85 RESURFACING MP 240-246 SOUTHBOUND	COULSON EXCAVATING COMPANY	23,794	\$68.25	\$1,623,941			\$0



SMA
50000 tons

Unit Price
\$ per ton **\$94.51**

Bid Date	Contract ID	Location	Awarded To	Quantity (tons)	Unit Cost (\$/ton)	Total Cost (\$)	Unit Price Tack Coat (\$)	Quantity (gal)	Total Cost Tack Coat (\$)
MAR 14 2013	C18449	C470: SANTA FE TO WADSWORTH RE	APC CONSTRUCTION CO., LLC	25,776	\$79.25	\$2,042,748	\$5.74	4,939.35	\$28,352
02/14/13	C19258	I-76 Resurfacing	MARTIN MARIETTA MATERIALS	23,977	\$83.34	\$1,998,243	\$2.56	9,018.00	\$23,086
APR 18 2013	C19314	I-70 WEST OF FLAGLER	MARTIN MARIETTA MATERIALS	72,667	\$94.50	\$6,867,032	\$2.40	25,652.00	\$61,565
FEB 27 2014	C17800S	I-25 RUBBLIZATION HARMONY ROAD	AGGREGATE INDUSTRIES - WCR, INC.	21,483	\$114.00	\$2,449,062			\$0
04/10/14	C17890	Arapahoe Road Resurfacing (2014)	Hamon	31,476	\$103.00	\$3,242,028	\$3.00	10,857.56	\$32,573
03/05/15	C19456	SH 58 US6-SH93 to I-70 (2015)	APC CONSTRUCTION CO., LLC	27,872	\$91.55	\$2,551,682	\$4.93	16,882.92	\$83,233
02/18/16	C19626	I-25: 120th Ave to SH7	Hamon	70,138	\$100.00	\$7,013,800	\$6.00	22,211.32	\$133,268
03/24/16	C20846	C470: Resurfacing (2016) STU4701-129	APC CONSTRUCTION CO., LLC	44,772	\$79.75	\$3,570,567	\$4.64	26,145.52	\$121,315
		E470		70,731	\$102.98	\$7,283,878			\$0
04/14/16	C20836	I-25, NHPP0252-445	Brannan Sand and Gravel	25,750	\$122.00	\$3,141,500	\$2.00	16,521.00	\$33,042
02/11/16	C20583	I-25 Climbing Lane (2016)	SEMA	22,500	\$118.00	\$2,655,000	\$3.90	7,490.88	\$29,214
04/11/16		I-25 Arapahoe Road Interchange	EKS	17,994	\$116.60	\$2,098,100	\$3.18	4,711.05	\$14,981
JUN 02 2016	C20929	I 25 OVERLAY, MLK BYPASS NORTH	SCHMIDT CONSTRUCTION COMPANY	22,135	\$120.94	\$2,677,007	\$3.25	8,355.00	\$27,154
DEC 22 2016	C20902	I-70 MP 158.5 TO 168	OLDCASTLE SW GROUP, INC.	31,096	\$73.00	\$2,270,008	\$2.00	21,447.00	\$42,894



PCCP
140000 square yards

Unit Price
\$ per Sq
yd

\$35.75

Bid Date	Contract ID	Location	Awarded To	Quantity (SQ YD)	Sq Yd- In (\$)	Total Cost
JAN 24 2013	C15402	Ft. Morgan to Brush (Phase III)	CASTLE ROCK CONST. CO. OF COLO, LLC	137,818	\$33.40	\$4,603,121
JAN 17 2013	C19303	I-70 GLENWOOD CANYON PCCP PHASE 4	INTERSTATE HIGHWAY CONSTRUCTION	84,334	\$41.23	\$3,477,091
AUG 15 2013	C16259-	I-70 TOWER TO COLFAX	AMES CONSTRUCTION, INC.	113,731	\$37.50	\$4,264,913
JUL 17 2014	C19273	SH86:I-25 TO WOODLANDS BLVD.	CONCRETE WORKS OF COLORADO INC.	48,733	\$56.50	\$2,753,415
MAY 03 2012	C17757	SH 85 IN GREELEY 5TH TO US 34	CASTLE ROCK CONST. CO. OF COLO, LLC	131,455	\$33.67	\$4,426,090
JAN 24 2013	C15402	Ft. Morgan to Brush (Phase III)	CASTLE ROCK CONST. CO. OF COLO, LLC	168,771	\$37.30	\$6,295,158
JUN 26 2014	C16602	I-25 LINCOLN TO COUNTY LINE (12.5")	INTERSTATE HIGHWAY CONSTRUCTION	67,134	\$39.40	\$2,645,080
		I-25 at Crossroads (12.5")		85,064	\$59.00	\$5,018,776
		I-25: Lincoln to County Line (13")	INTERSTATE HIGHWAY CONSTRUCTION	74,487	\$38.50	\$2,867,750
FEB 19 2015	C19029	I-70 SEIBERT-EAST	CASTLE ROCK CONST. CO. OF COLO, LLC	67,876	\$40.90	\$2,776,128

APPENDIX B

LCCA INPUT AND OUTPUT SUMMARY SHEETS

LCCA Initial and Rehab Costs - IM 0253-255 (21506) - ARE#3 Segment
RockSol Project No. 292.05_March 16_2017

Initial Construction Cost (Year 2020)	Area (SY)	Thickness	Directions	PE (%)	CE (%)	Traffic (%)	Minimum Cost (SQ YD-IN)	Most Likely Cost (SQ YD-IN)	Maximum Cost (SQ YD-IN)	Minimum Total	Most Likely Total	Maximum Total
13.5" PCCP Mainline I-25	22,200	13.5 in	both	0	0.221	0.15	\$3.25	\$3.50	\$3.75	\$1,335,388	\$1,438,110	\$1,540,833
12" PCCP Mainline I-25	15,000	12 in	both	0	0.221	0.15	\$3.25	\$3.50	\$3.75	\$802,035	\$863,730	\$925,425
									Initial Total	\$2,137,423	\$2,301,840	\$2,466,258

Rehabilitation Cost (Year 2047)		Directions	PE (%)	CE (%)	Traffic (%)	Minimum Cost	Most Likely Cost	Maximum Cost	Minimum Total	Most Likely Total	Maximum Total
1/2 % Slab Replacement	186 SY	both	0.1	0.221	0.15	\$125.00	\$150.00	\$175.00	\$34,201	\$41,041	\$47,881
100% Grinding	37,200 SY	both	0.1	0.221	0.15	\$3.00	\$3.50	\$4.00	\$164,164	\$191,524	\$218,885
Joint Restoration Transverse	22,320 LF	both	0.1	0.221	0.15	\$2.25	\$2.75	\$3.25	\$73,874	\$90,290	\$106,706
Joint Restoration Longitudinal	24,300 LF	both	0.1	0.221	0.15	\$2.25	\$2.75	\$3.25	\$80,427	\$98,300	\$116,172
								Rehab Total	\$352,665	\$421,155	\$489,644

LCCA Initial and Rehab Costs - IM 0253-255 (21506) - ARE#3 Segment
RockSol Project No. 292.05_March 16_2017

Initial Construction Costs (Year 2020)	Total	Units	Directions	PE (%)	CE (%)	Traffic Cost (%)	Minimum Cost	Most Likely Cost	Maximum Cost	Minimum Total	Most Likely Total	Maximum Total	
SMA	4,092	tons	both	0	0.221	0.15	\$90.00	\$95.00	\$100.00	\$504,912	\$532,963	\$561,013	
HMA S(100)PG 64-22	11,105	tons	both	0	0.221	0.15	\$60.00	\$65.00	\$70.00	\$913,497	\$989,622	\$1,065,747	
Tack Coat	89,400	SY	both	0	0.221	0.15	\$0.28	\$0.38	\$0.48	\$34,319	\$46,576	\$58,832	
										Total	\$1,452,728	\$1,569,160	\$1,685,592
Rehabilitation Costs (Years 2034 and 2047)													
2034 SMA	4,092	tons	both	0.1	0.221	0.15	\$90.00	\$95.00	\$100.00	\$541,740	\$571,837	\$601,933	
2034 HMA	3,069	tons	both	0.1	0.221	0.15	\$60.00	\$65.00	\$70.00	\$270,870	\$293,442	\$316,015	
Tack Coat	74,400	SY	both	0.1	0.221	0.15	\$0.28	\$0.38	\$0.48	\$30,644	\$41,588	\$52,532	
Milling (2034)	37,200	SY	both	0.1	0.221	0.15	\$2.04	\$2.27	\$2.50	\$111,631	\$124,217	\$136,803	
										Total	\$954,885	\$1,031,084	\$1,107,283
2047 SMA	4,092	tons	both	0.1	0.221	0.15	\$90.00	\$95.00	\$100.00	\$541,740	\$571,837	\$601,933	
2047 HMA	4,092	tons	both	0.1	0.221	0.15	\$60.00	\$65.00	\$70.00	\$361,160	\$391,257	\$421,353	
Tack Coat	74,400	SY	both	0.1	0.221	0.15	\$0.28	\$0.38	\$0.48	\$30,644	\$41,588	\$52,532	
Milling (2047)	37,200	SY	both	0.1	0.221	0.15	\$2.04	\$2.27	\$2.50	\$111,631	\$124,217	\$136,803	
										Total	\$1,045,175	\$1,128,898	\$1,212,622

Probabilistic Life Cycle Cost Analysis Worksheet

INPUT WORKSHEET			
1. Economic Variables			
Value of Time for Passenger Cars (\$/hour)	\$18.50		
Value of Time for Single Unit Trucks (\$/hour)	\$43.50		
Value of Time for Combination Trucks (\$/hour)	\$49.50		
2. Analysis Options			
Include User Costs in Analysis	Yes		
Include User Cost Remaining Life Value	Yes		
Use Differential User Costs	Yes		
User Cost Computation Method	Specified		
Include Agency Cost Remaining Life Value	Yes		
Traffic Direction	Both		
Analysis Period (Years)	40		
Beginning of Analysis Period	2020		
Discount Rate (%)	2.2		
Number of Alternatives	2		
3. Project Details			
State Route	025A		
Project Name	North I-25 ARE#3 Segment		
Region	Region 4		
County	Larimer and Weld Counties		
Analyzed By	RockSol Consulting Group, Inc.		
Mileposts			
Begin	253.70		
End	254.20		
Length of Project (miles)	0.50		
Comments	LCCA Analysis - March 16, 2017		
4. Traffic Data			
AADT Construction Year (total for both directions)	90,675		
Cars as Percentage of AADT (%)	90.0		
Single Unit Trucks as Percentage of AADT (%)	2.0		
Combination Trucks as Percentage of AADT (%)	8.0		
Annual Growth Rate of Traffic (%)	2.6		
Speed Limit Under Normal Operating Conditions (mph)	75		
No of Lanes in Each Direction During Normal Conditions	2		
Free Flow Capacity (vphpl)	2095		
Rural or Urban Hourly Traffic Distribution	Rural		
Queue Dissipation Capacity (vphpl)	2057		
Maximum AADT (total for both directions)	224,256		
Maximum Queue Length (miles)	5.0		
5. Construction			

Probabilistic Life Cycle Cost Analysis Worksheet

Alternative 1	Flexible Alternative		
Number of Activities	3		
Activity 1	Initial Flexible Construction Completed 2020		
Agency Construction Cost (\$1000)	\$1,569.16		
User Work Zone Costs (\$1000)	\$242.19		
Work Zone Duration (days)	7		
No of Lanes Open in Each Direction During Work Zone	2		
Activity Service Life (years)	13.7		
Activity Structural Life (years)	20.0		
Maintenance Frequency (years)	1		
Agency Maintenance Cost (\$1000)	1.027		
Work Zone Length (miles)	0.50		
Work Zone Speed Limit (mph)	65		
Work Zone Capacity (vphpl)	1750		
Traffic Hourly Distribution	Week Day 1		
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)			
<i>Inbound</i>	Start	End	
First period of lane closure			
Second period of lane closure			
Third period of lane closure			
<i>Outbound</i>	Start	End	
First period of lane closure			
Second period of lane closure			
Third period of lane closure			
Activity 2	2034 Flex Rehab 2" Mill and 2.0" SMA & 1.5		
Agency Construction Cost (\$1000)	\$1,031.08		
User Work Zone Costs (\$1000)	\$13.98		
Work Zone Duration (days)	6		
No of Lanes Open in Each Direction During Work Zone	2		
Activity Service Life (years)	13.3		
Activity Structural Life (years)	10.0		
Maintenance Frequency (years)	1		
Agency Maintenance Cost (\$1000)	1.027		
Work Zone Length (miles)	0.50		
Work Zone Speed Limit (mph)	55		
Work Zone Capacity (vphpl)	1400		
Traffic Hourly Distribution	Week Day 1		
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)			
<i>Inbound</i>	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			
<i>Outbound</i>	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			

Probabilistic Life Cycle Cost Analysis Worksheet

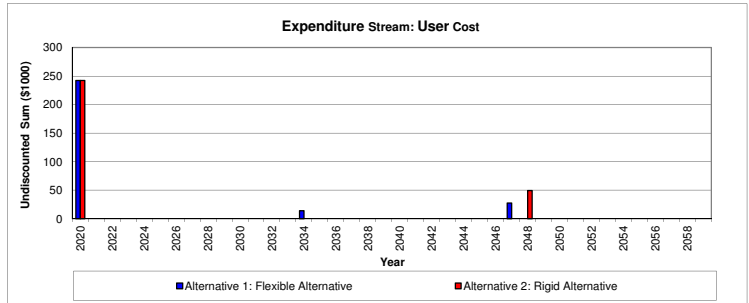
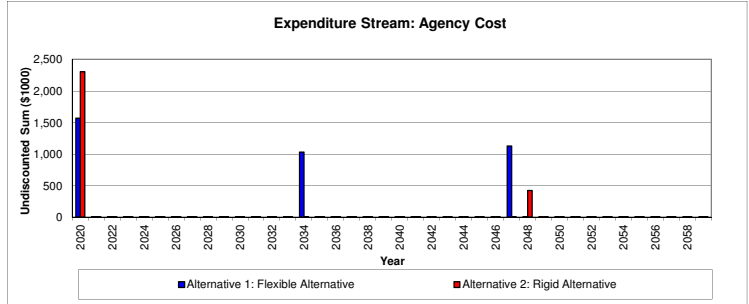
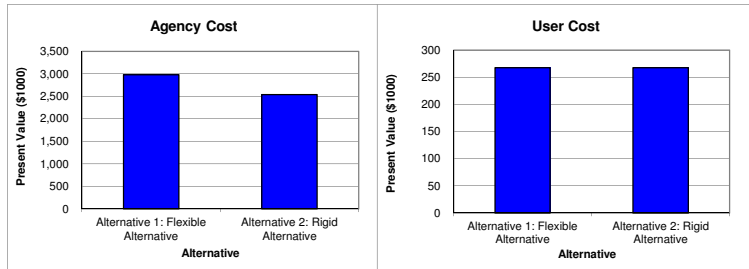
Activity 3	2047 Flex Rehab 2" Mill and 2.0" SMA + 2.0"		
Agency Construction Cost (\$1000)	\$1,128.90		
User Work Zone Costs (\$1000)	\$27.36		
Work Zone Duration (days)	6		
No of Lanes Open in Each Direction During Work Zone	2		
Activity Service Life (years)	13.3		
Activity Structural Life (years)	10.0		
Maintenance Frequency (years)	1		
Agency Maintenance Cost (\$1000)	1.027		
Work Zone Length (miles)	0.50		
Work Zone Speed Limit (mph)	55		
Work Zone Capacity (vphpl)	1400		
Traffic Hourly Distribution	Week Day 1		
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)			
<i>Inbound</i>	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			
<i>Outbound</i>	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			

Probabilistic Life Cycle Cost Analysis Worksheet

Alternative 2	Rigid Alternative	
Number of Activities	2	
Activity 1	Initial Rigid Construction Completed 2020	
Agency Construction Cost (\$1000)	\$2,301.84	
User Work Zone Costs (\$1000)	\$242.19	
Work Zone Duration (days)	8	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	27.7	
Activity Structural Life (years)	30.0	
Maintenance Frequency (years)	1	
Agency Maintenance Cost (\$1000)	0.64	
Work Zone Length (miles)	0.50	
Work Zone Speed Limit (mph)	65	
Work Zone Capacity (vphpl)	1750	
Traffic Hourly Distribution	Week Day 1	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
<i>Inbound</i>	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
<i>Outbound</i>	Start	End
First period of lane closure		
Second period of lane closure		
Third period of lane closure		
Activity 2	2047 Rigid Rehab 1/2% Slab, 100% Grinding	
Agency Construction Cost (\$1000)	\$421.15	
User Work Zone Costs (\$1000)	\$49.14	
Work Zone Duration (days)	10	
No of Lanes Open in Each Direction During Work Zone	2	
Activity Service Life (years)	13.0	
Activity Structural Life (years)	13.0	
Maintenance Frequency (years)	1	
Agency Maintenance Cost (\$1000)	0.64	
Work Zone Length (miles)	0.50	
Work Zone Speed Limit (mph)	55	
Work Zone Capacity (vphpl)	1400	
Traffic Hourly Distribution	Week Day 1	
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)		
<i>Inbound</i>	Start	End
First period of lane closure	20	24
Second period of lane closure	0	6
Third period of lane closure		
<i>Outbound</i>	Start	End
First period of lane closure	20	24
Second period of lane closure	0	6
Third period of lane closure		

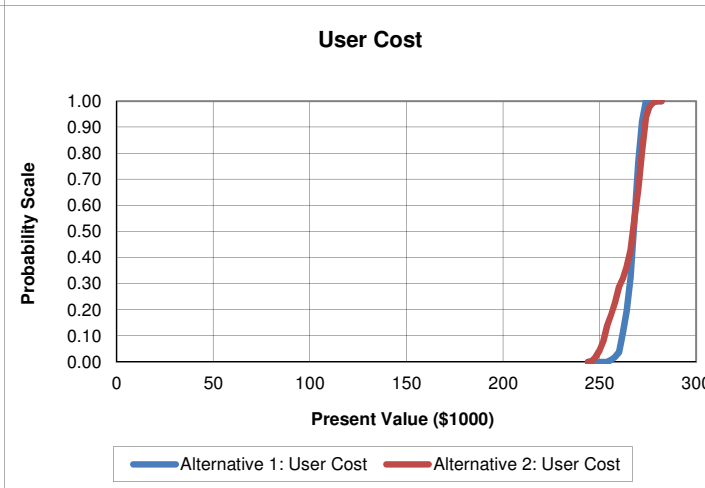
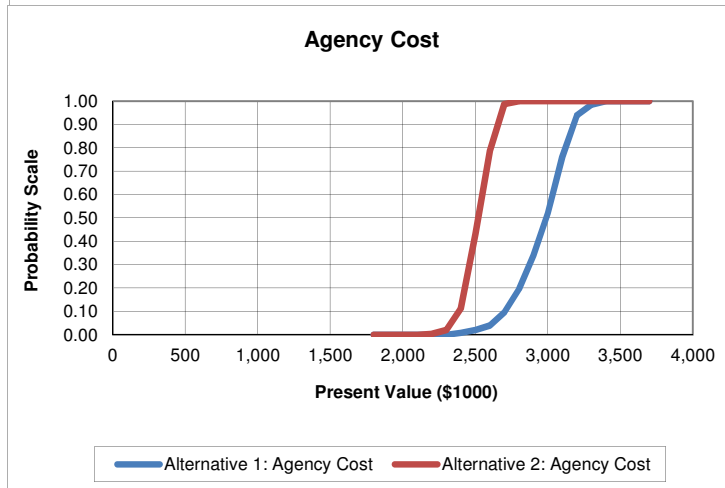
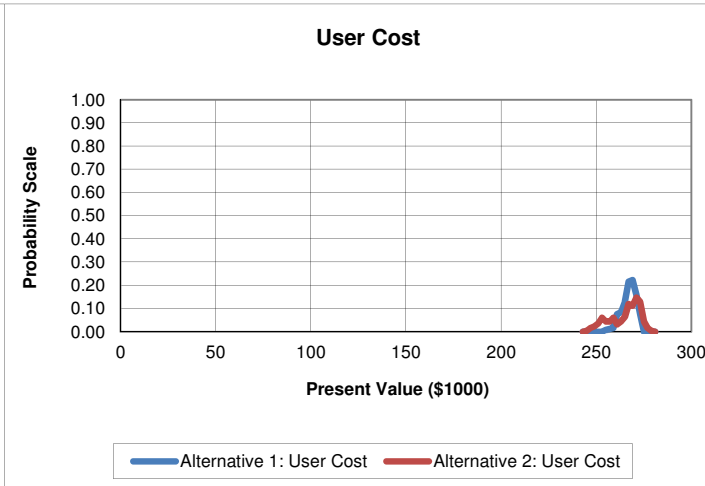
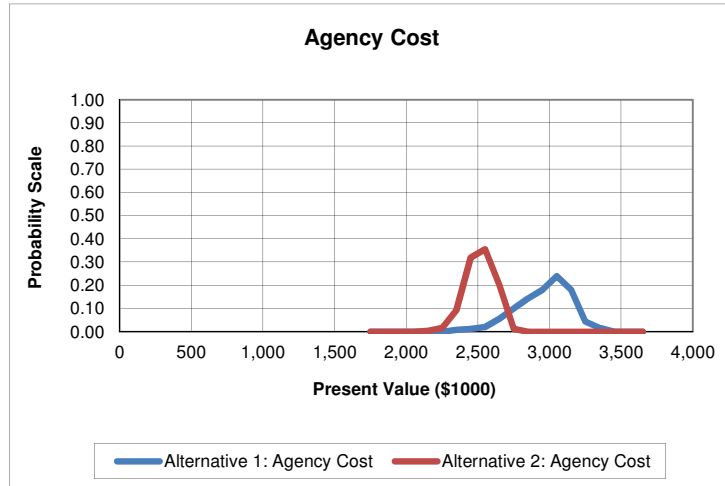
Deterministic Results

Update Results				
Total Cost				
Total Cost	Alternative 1: Flexible Alternative		Alternative 2: Rigid Alternative	
	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)
Undiscounted Sum	\$3,767.14	\$283.53	\$2,725.71	\$288.81
Present Value	\$2,976.67	\$267.59	\$2,536.84	\$267.71
EUAC	\$113.06	\$10.16	\$96.35	\$10.17
Lowest Present Value Agency Cost	Alternative 2: Rigid Alternative			
Lowest Present Value User Cost	Alternative 1: Flexible Alternative			
Expenditure Stream				
Year	Alternative 1: Flexible Alternative		Alternative 2: Rigid Alternative	
	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)
2020	\$1,569.16	\$242.18	\$2,301.84	\$242.18
2021	\$1.03		\$0.64	
2022	\$1.03		\$0.64	
2023	\$1.03		\$0.64	
2024	\$1.03		\$0.64	
2025	\$1.03		\$0.64	
2026	\$1.03		\$0.64	
2027	\$1.03		\$0.64	
2028	\$1.03		\$0.64	
2029	\$1.03		\$0.64	
2030	\$1.03		\$0.64	
2031	\$1.03		\$0.64	
2032	\$1.03		\$0.64	
2033	\$1.03		\$0.64	
2034	\$1,031.08	\$13.98	\$0.64	
2035	\$1.03		\$0.64	
2036	\$1.03		\$0.64	
2037	\$1.03		\$0.64	
2038	\$1.03		\$0.64	
2039	\$1.03		\$0.64	
2040	\$1.03		\$0.64	
2041	\$1.03		\$0.64	
2042	\$1.03		\$0.64	
2043	\$1.03		\$0.64	
2044	\$1.03		\$0.64	
2045	\$1.03		\$0.64	
2046	\$1.03		\$0.64	
2047	\$1,128.90	\$27.36	\$0.64	
2048	\$1.03		\$421.15	\$49.14
2049	\$1.03		\$0.64	
2050	\$1.03		\$0.64	
2051	\$1.03		\$0.64	
2052	\$1.03		\$0.64	
2053	\$1.03		\$0.64	
2054	\$1.03		\$0.64	
2055	\$1.03		\$0.64	
2056	\$1.03		\$0.64	
2057	\$1.03		\$0.64	
2058	\$1.03		\$0.64	
2059	\$1.03		\$0.64	
2060			(\$21.60)	(\$2.52)



Probabilistic Results

Total Cost				
Total Cost (Present Value)	Alternative 1: Flexible Alternative		Alternative 2: Rigid Alternative	
	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)
Mean	\$2,963.00	\$267.17	\$2,516.80	\$264.96
Standard Deviation	\$188.30	\$3.69	\$96.57	\$7.84
Minimum	\$2,371.46	\$255.45	\$2,199.27	\$245.44
Maximum	\$3,395.37	\$273.78	\$2,727.41	\$279.34



Output Distributions

Alternative 1: Agency Cost

Bin	Mid Point	Rel. Freq.	Cum. Rel. Freq.
1800	1750	0.00	0.00
1900	1850	0.00	0.00
2000	1950	0.00	0.00
2100	2050	0.00	0.00
2200	2150	0.00	0.00
2300	2250	0.00	0.00
2400	2350	0.01	0.01
2500	2450	0.01	0.02
2600	2550	0.02	0.04
2700	2650	0.06	0.10
2800	2750	0.10	0.20
2900	2850	0.14	0.34
3000	2950	0.18	0.52
3100	3050	0.24	0.76
3200	3150	0.18	0.94
3300	3250	0.04	0.98
3400	3350	0.02	1.00
3500	3450	0.00	1.00
3600	3550	0.00	1.00
3700	3650	0.00	1.00

Alternative 1: User Cost

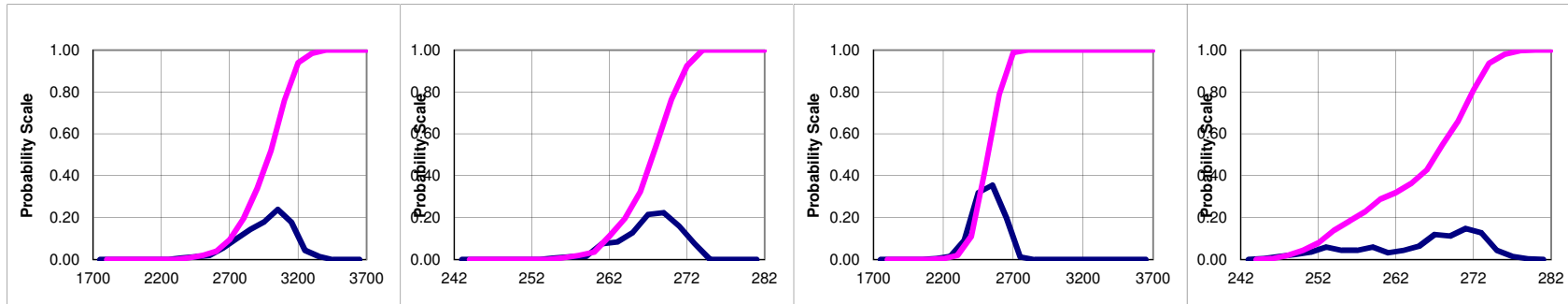
Bin	Mid Point	Rel. Freq.	Cum. Rel. Freq.
244	243	0.00	0.00
246	245	0.00	0.00
248	247	0.00	0.00
250	249	0.00	0.00
252	251	0.00	0.00
254	253	0.00	0.00
256	255	0.01	0.01
258	257	0.01	0.02
260	259	0.02	0.04
262	261	0.08	0.11
264	263	0.08	0.20
266	265	0.13	0.32
268	267	0.22	0.54
270	269	0.22	0.76
272	271	0.16	0.92
274	273	0.08	1.00
276	275	0.00	1.00
278	277	0.00	1.00
280	279	0.00	1.00
282	281	0.00	1.00

Alternative 2: Agency Cost

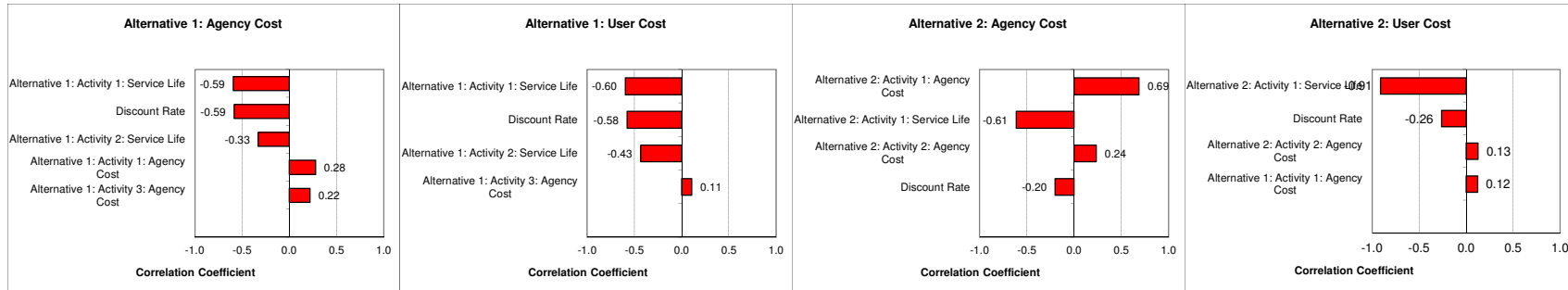
Bin	Mid Point	Rel. Freq.	Cum. Rel. Freq.
1800	1750	0.00	0.00
1900	1850	0.00	0.00
2000	1950	0.00	0.00
2100	2050	0.00	0.00
2200	2150	0.00	0.00
2300	2250	0.02	0.02
2400	2350	0.09	0.11
2500	2450	0.32	0.43
2600	2550	0.36	0.79
2700	2650	0.20	0.99
2800	2750	0.01	1.00
2900	2850	0.00	1.00
3000	2950	0.00	1.00
3100	3050	0.00	1.00
3200	3150	0.00	1.00
3300	3250	0.00	1.00
3400	3350	0.00	1.00
3500	3450	0.00	1.00
3600	3550	0.00	1.00
3700	3650	0.00	1.00

Alternative 2: User Cost

Bin	Mid Point	Rel. Freq.	Cum. Rel. Freq.
244	243	0.00	0.00
246	245	0.00	0.00
248	247	0.02	0.02
250	249	0.02	0.04
252	251	0.04	0.08
254	253	0.06	0.14
256	255	0.04	0.18
258	257	0.04	0.23
260	259	0.06	0.29
262	261	0.03	0.32
264	263	0.04	0.36
266	265	0.06	0.43
268	267	0.12	0.55
270	269	0.11	0.66
272	271	0.15	0.81
274	273	0.13	0.94
276	275	0.04	0.98
278	277	0.02	1.00
280	279	0.00	1.00
282	281	0.00	1.00



Tornado Graphs



Alternative 1: Agency Cost		Alternative 1: User Cost		Alternative 2: Agency Cost		Alternative 2: User Cost	
Input Variable	Corr. Coeff.	Input Variable	Corr. Coeff.	Input Variable	Corr. Coeff.	Input Variable	Corr. Coeff.
Alternative 1: Activity 1: Service Life	-0.59	Alternative 1: Activity 1: Service Life	-0.60	Alternative 2: Activity 1: Agency Cost	0.69	Alternative 2: Activity 1: Service Life	-0.91
Discount Rate	-0.59	Discount Rate	-0.58	Alternative 2: Activity 1: Service Life	-0.61	Discount Rate	-0.26
Alternative 1: Activity 2: Service Life	-0.33	Alternative 1: Activity 2: Service Life	-0.43	Alternative 2: Activity 2: Agency Cost	0.24	Alternative 2: Activity 2: Agency Cost	0.13
Alternative 1: Activity 1: Agency Cost	0.28	Alternative 1: Activity 3: Agency Cost	0.11	Discount Rate	-0.20	Alternative 1: Activity 1: Agency Cost	0.12
Alternative 1: Activity 3: Agency Cost	0.22						

Extreme Tail Analysis

Input Variable		Alternative 1: Agency Cost				Alternative 1: User Cost				Alternative 2: Agency Cost				Alternative 2: User Cost			
Name	Probability Function	5%	25%	75%	95%	5%	25%	75%	95%	5%	25%	75%	95%	5%	25%	75%	95%
Discount Rate	LCCALOGNORMAL(2.22,0.38)	0.32	0.83	-0.77	-0.82	0.31	0.78	-0.67	-0.82	0.07	0.20	-0.39	-0.35	0.09	0.16	-0.54	-0.54
Annual Average Daily Traffic	LCCATRIANG(1.6,2.6,3.6)	-0.92	0.03	-0.01	0.14	-0.92	0.00	-0.02	-0.02	0.24	-0.01	-0.10	-0.39	0.59	0.04	-0.01	0.12
Alternative 1: Activity 1: Agency Co	LCCATRIANG(1452.728,1569.16,	-1.51	-0.12	0.54	0.99	-0.18	0.00	-0.01	0.03	-0.46	-0.02	0.03	-0.28	-0.46	-0.12	0.27	0.03
Alternative 2: Activity 1: Agency Co	LCCATRIANG(2137.423,2301.84,	-0.25	-0.01	-0.02	-0.12	-0.10	0.06	0.11	-0.09	-1.81	-0.95	0.88	1.25	-0.06	0.01	0.14	0.14
Alternative 1: Activity 1: Service Lif	LCCATRIANG(6,14,21)	1.20	0.66	-0.83	-1.62	1.20	0.68	-0.82	-1.52	-0.13	-0.16	0.00	0.00	-0.14	-0.05	0.14	0.27
Alternative 2: Activity 1: Service Lif	LCCATRIANG(16,27,40)	-0.36	-0.17	-0.19	0.05	0.22	-0.14	0.24	-0.28	1.64	1.15	-0.48	-0.55	1.91	1.40	-0.89	-1.27
Alternative 1: Activity 2: Agency Co	LCCATRIANG(954.885,1031.084,	-0.57	-0.23	0.05	0.23	-0.76	-0.01	-0.10	-0.25	0.27	-0.25	-0.12	-0.29	-0.13	-0.12	0.04	0.23
Alternative 2: Activity 2: Agency Co	LCCATRIANG(352.665,421.155,4,	0.43	-0.07	-0.07	-0.34	-0.03	-0.07	0.07	-0.18	-0.58	-0.16	0.55	1.03	-0.06	-0.06	0.24	0.03
Alternative 1: Activity 2: Service Lif	LCCATRIANG(6,13,21)	1.07	0.91	-0.17	-0.95	1.20	0.91	-0.25	-0.95	0.13	-0.11	0.01	0.41	-0.20	-0.03	0.01	0.30
Alternative 1: Activity 3: Agency Co	LCCATRIANG(1045.175,1128.898,	-0.95	-0.37	0.19	0.39	-0.08	-0.47	-0.03	0.19	0.60	0.18	-0.12	-0.10	0.53	0.14	-0.10	-0.10
Alternative 2: Activity 3: Agency Co	LCCATRIANG(1839.841,2197.822,	0.02	0.05	0.09	0.09	0.08	0.06	0.17	0.09	-0.18	-0.20	0.17	0.48	-0.18	0.02	-0.03	-0.82
Alternative 1: Activity 3: Service Lif	LCCATRIANG(6,13,21)	0.04	-0.02	0.05	0.15	0.61	0.06	0.15	-0.11	0.29	0.26	-0.02	-0.35	0.31	0.26	-0.11	-0.48
Alternative 1: Activity 4: Agency Co	LCCATRIANG(5455.233,5791.167,	-0.52	-0.05	0.03	0.44	-0.52	-0.07	0.07	0.09	0.25	0.00	-0.07	-0.04	-0.41	0.05	-0.09	-0.09
Alternative 1: Activity 4: Service Lif	LCCATRIANG(6,14,21)	0.76	0.07	-0.07	0.06	0.43	0.10	-0.06	-0.22	-0.28	0.01	0.01	-0.55	0.14	-0.21	0.09	0.28

Probability Function

Variable Name: Annual Average Daily Traffic

Probability Distribution: Triangular

Minimum: 1.6

Most Likely: 2.6

Maximum: 3.6

Ok Cancel

RealCost – Annual Average Daily Traffic Triangular Probability Distribution

NOTE: Following Table 13.7 of the PDM, RockSol used an Annual Growth Rate of 1.6% (minimum), 2.6% (most likely) and 3.6% (maximum) in the RealCost Triangular Probability Function.

Traffic Data X

AADT at Beginning of Analysis Peiod (total both directions):

Single Unit Trucks as Percentage of AADT (%):


Combination Trucks as Percentage of AADT (%):

Annual Growth Rate of Traffic (%):

Speed Limit Under Normal Operating Conditions (mph):

Lanes Open in Each Direction Under Normal Conditions:

Free Flow Capacity (vphpl):

Free Flow Capacity Calculator 

Queue Dissipation Capacity (vphpl):

Maximum AADT (total for both directions):

Maximum Queue Length (miles):

Rural or Urban Hourly Traffic Distribution:

RealCost – Traffic Data

Free Flow Capacity Calculation

Number of Lanes in Each Direction:

Lane Width (ft):

Proportion of Trucks and Buses (%):

Upgrade (%):

Upgrade Length (miles):

Obstruction on Two Sides:

Distance to Obstruction / Shoulder Width (ft):

Calculate

Free Flow Capacity (vphpl):

Copy to Free Flow Capacity Field Cancel

RealCost – Free Flow Capacity Calculation (12 ft Lane Width)

Free Flow Capacity Calculation

Number of Lanes in Each Direction:

Lane Width (ft):

Proportion of Trucks and Buses (%):

Upgrade (%):

Upgrade Length (miles):

Obstruction on Two Sides:

Distance to Obstruction / Shoulder Width (ft):

Calculate

Free Flow Capacity (vphpl):

Copy to Free Flow Capacity Field Cancel

RealCost – Free Flow Capacity Calculation (11 ft Lane Width)

The screenshot shows a dialog box titled "Probability Function" with a close button (X) in the top right corner. The dialog contains the following fields:

- Variable Name: Alternative 1: Activity 1: Agency Cost
- Probability Distribution: Triangular
- Minimum: 1452.728
- Most Likely: 1569.16
- Maximum: 1685.592

At the bottom of the dialog are two buttons: "Ok" and "Cancel".

RealCost – Agency Cost for Initial Flexible Pavement Construction (Alternative 1: Activity 1)

The screenshot shows a dialog box titled "Probability Function" with a close button (X) in the top right corner. The dialog contains the following fields:

- Variable Name: Alternative 1: Activity 1: Service Life
- Probability Distribution: Triangular
- Minimum: 6
- Most Likely: 14
- Maximum: 21

At the bottom of the dialog are two buttons: "Ok" and "Cancel".

RealCost – Service Life for Initial Flexible Pavement Construction (Alternative 1: Activity 1)

Probability Function

Variable Name: Alternative 1: Activity 2: Agency Cost

Probability Distribution: Triangular

Minimum: 954.885

Most Likely: 1031.084

Maximum: 1107.283

Ok Cancel

RealCost – Agency Cost for SMA and HMA Pavement Rehabilitation at 2034
(Alternative 1: Activity 2)

Probability Function

Variable Name: Alternative 1: Activity 3: Agency Cost

Probability Distribution: Triangular

Minimum: 1045.175

Most Likely: 1128.898

Maximum: 1212.622

Ok Cancel

RealCost – Agency Cost for SMA and HMA Pavement Rehabilitation at 2047
(Alternative 1: Activity 3)

The screenshot shows a dialog box titled "Probability Function" with a close button (X) in the top right corner. The dialog contains the following fields:

- Variable Name: Alternative 1: Activity 2: Service Life
- Probability Distribution: Triangular (selected from a dropdown menu)
- Minimum: 6
- Most Likely: 13
- Maximum: 21

At the bottom of the dialog are two buttons: "Ok" and "Cancel".

RealCost – Service Life for SMA and HMA Pavement Rehabilitation 2034 and 2047
(Alternative 1: Activities 2 and 3)

The screenshot shows a dialog box titled "Probability Function" with a close button (X) in the top right corner. The dialog contains the following fields:

- Variable Name: Alternative 2: Activity 1: Agency Cost
- Probability Distribution: Triangular (selected from a dropdown menu)
- Minimum: 2137.423
- Most Likely: 2301.84
- Maximum: 2466.258

At the bottom of the dialog are two buttons: "Ok" and "Cancel".

RealCost – Agency Cost for Initial Rigid Pavement Construction (Alternative 2: Activity 1)

Probability Function

Variable Name: Alternative 2: Activity 1: Service Life

Probability Distribution: Triangular

Minimum: 16

Most Likely: 27

Maximum: 40

Ok Cancel

RealCost – Service Life for Initial Rigid Pavement Construction (Alternative 2: Activity 1)

Probability Function

Variable Name: Alternative 2: Activity 2: Agency Cost

Probability Distribution: Triangular

Minimum: 352.665

Most Likely: 421.155

Maximum: 489.644

Ok Cancel

RealCost – Agency Cost for Rigid Pavement Rehabilitation at 2047 (Alternative 2: Activity 2)



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CDOT Report - Summary Input and Output for the Crossover Strategy

Project Code	21506	
Project Name	North I-25 - ARE#3	
Freeway Name	025A	
Input Filename	PCCP_2020.WZM	
Project Start Date	2020	
Project End Date	2020	
Design Speed	75 mph	
Speed Limit	75 mph	
Workzone Speed Limit	65 mph	
Grade	2.0 %	
Workzone Length	0.50 miles	
Functional Class	Rural Interstate (Weekday)	
	PRIMARY	SECONDARY
Total Number of Lanes	2	2
Number of Open Lanes	2	2
Number of Temporary Lanes	0	0
AADT	45,338	45,338
Percentage of Single Unit Trucks	2.0 %	2.0 %
Percentage of Combination Trucks	8.0 %	8.0 %

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	PRIMARY COST	SECONDARY COST	DURATION
412-Concrete Pavement <= 14.0 inch	\$121,092.61	\$121,092.61	8
TOTAL ADDL. USER COST	\$121,092.61	\$121,092.61	8

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 8 DAYS : INBOUND = \$207,982.40 OUTBOUND = \$207,982.40

Disclaimer:

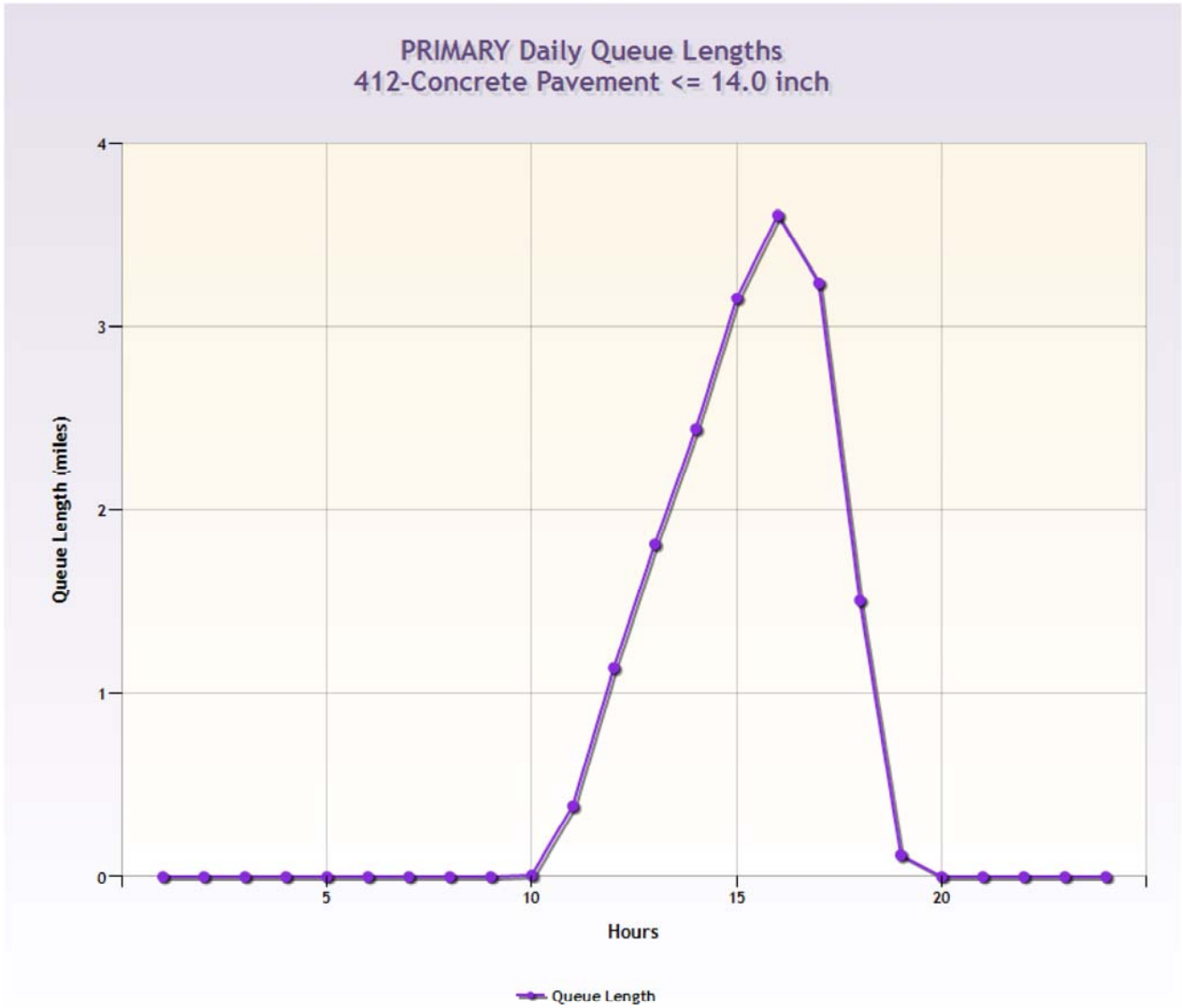
The values presented in this program are intended to provide guidelines only. Engineering judgement must be applied to use these values. No one but the user can assure that these results are properly applied



User Cost Queue Graph

PRIMARY SECONDARY

Type of Work: 412-Concrete Pavement <= 14.0 inch





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CDOT Report - Summary Input and Output for the Single Lane Closure Strategy

Project Code 21506
 Project Name North I-25 - ARE#3
 Freeway Name 025A
 Input Filename PCCP_2047.WZM
 Project Start Date 2047
 Project End Date 2047
 Design Speed 75 mph
 Speed Limit 75 mph
 Workzone Speed Limit 55 mph
 Grade 2.0 %
 Workzone Length 0.50 miles
 Functional Class Rural Interstate (Weekday)

Total Number of Lanes 2
 Number of Open Lanes 1
 Number of Temporary Lanes 1
 AADT, Directional 79,560
 Percentage of Single Unit Trucks 2.0 %
 Percentage of Combination Trucks 8.0 %
 Work in Both Directions NO

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	COST	DURATION
202-Removal of Concrete (Diamond Grinding)	\$20,212.48	5
412-Routing & Sealing PCCP Cracks	\$28,931.83	5
TOTAL ADDL. USER COST	\$49,144.31	10

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
 FOR A DURATION OF 10 DAYS = \$87,046.77

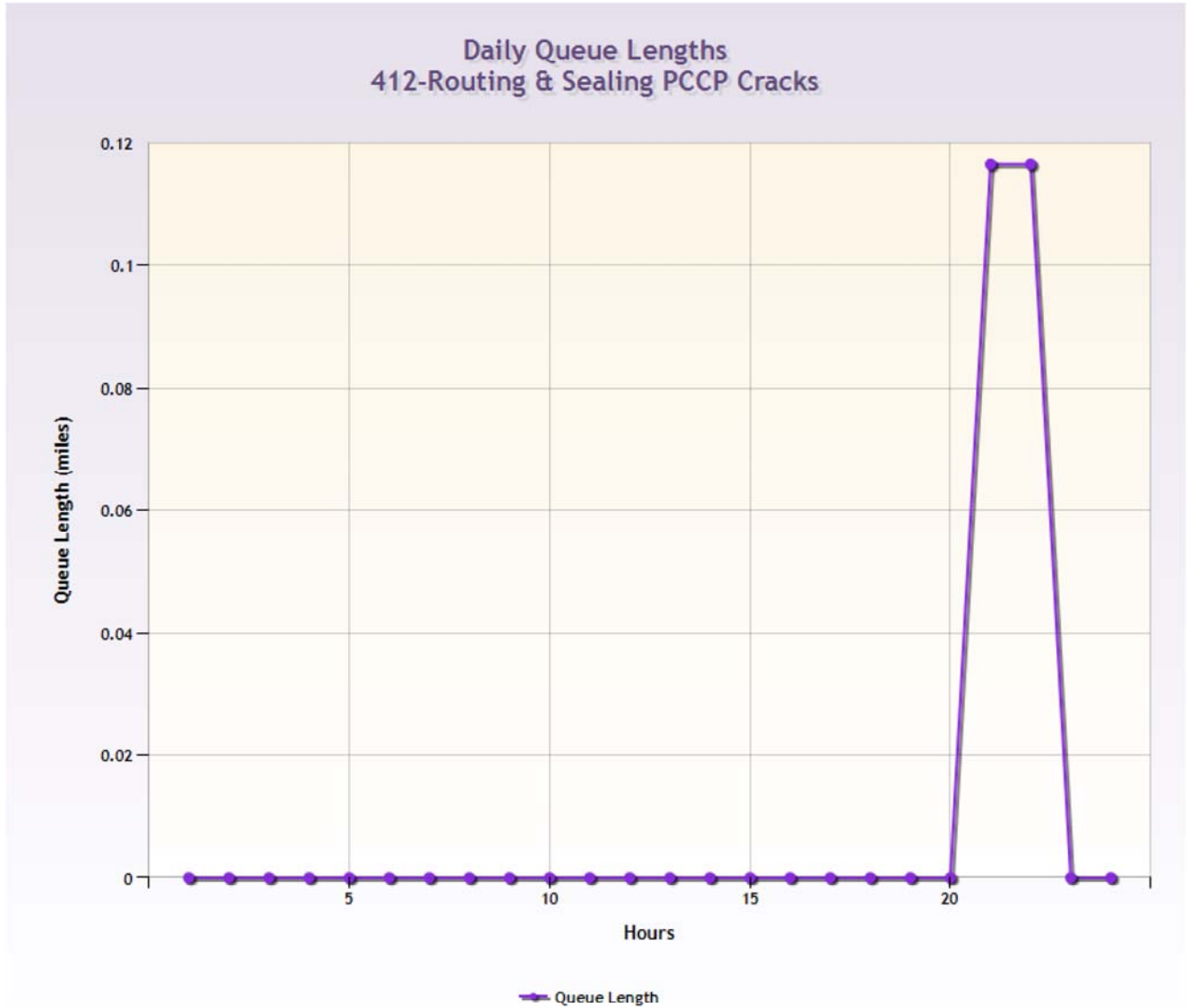
Disclaimer:

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User Cost Queue Graph

Type of Work:





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CDOT Report - Summary Input and Output for the Crossover Strategy

Project Code	21506	
Project Name	North I-25 - ARE#3	
Freeway Name	025A	
Input Filename	Flex 2020.WZM	
Project Start Date	2020	
Project End Date	2020	
Design Speed	75 mph	
Speed Limit	75 mph	
Workzone Speed Limit	65 mph	
Grade	2.0 %	
Workzone Length	0.50 miles	
Functional Class	Rural Interstate (Weekday)	
	PRIMARY	SECONDARY
Total Number of Lanes	2	2
Number of Open Lanes	2	2
Number of Temporary Lanes	0	0
AADT	45,338	45,338
Percentage of Single Unit Trucks	2.0 %	2.0 %
Percentage of Combination Trucks	8.0 %	8.0 %

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	PRIMARY COST	SECONDARY COST	DURATION
403-HMA (2-in SMA & 10.5-in HMA)	\$121,092.61	\$121,092.61	7
TOTAL ADDL. USER COST	\$121,092.61	\$121,092.61	7

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 7 DAYS : INBOUND = \$181,984.60 OUTBOUND = \$181,984.60

Disclaimer:

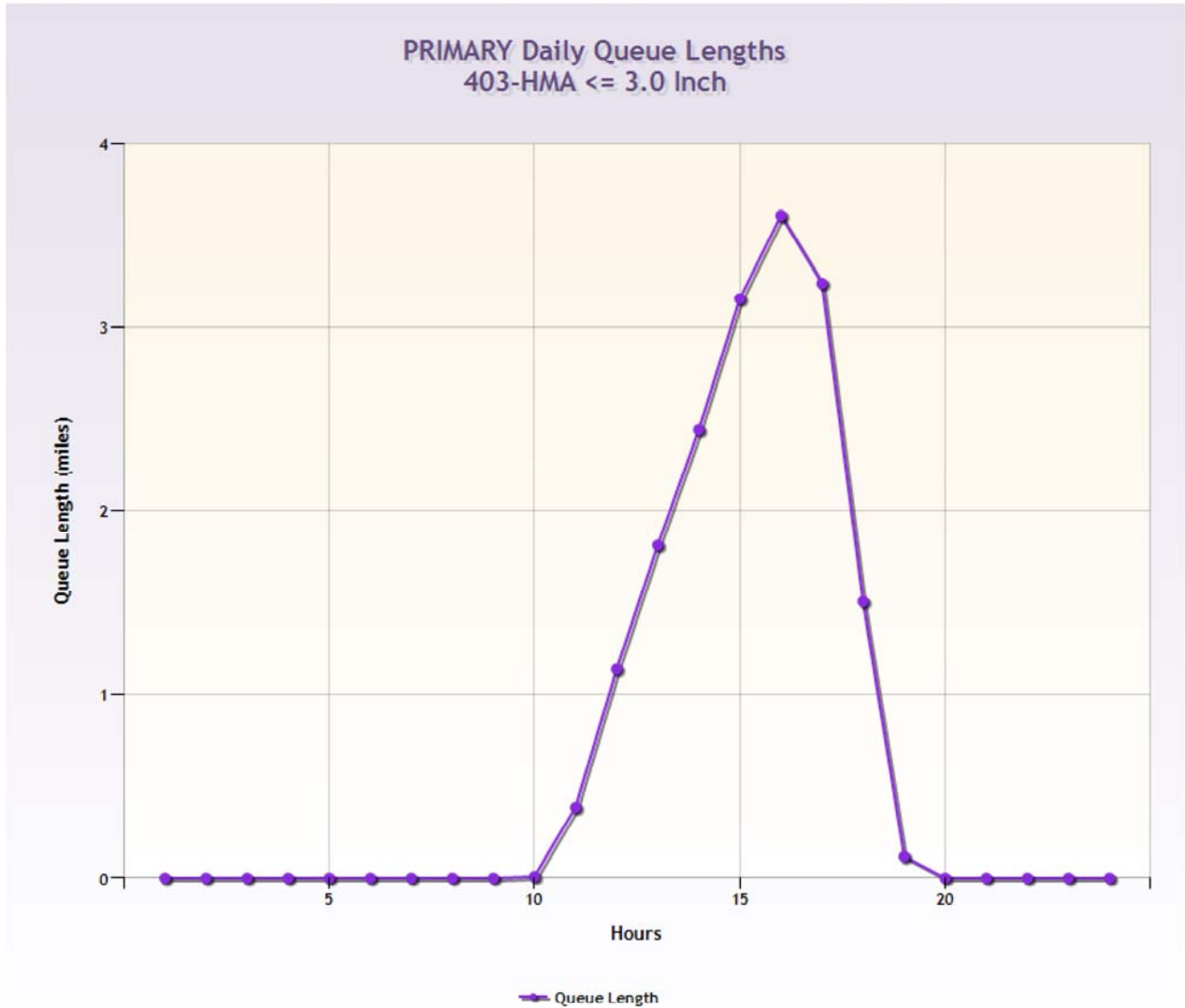
The values presented in this program are intended to provide guidelines only. Engineering judgement must be applied to use these values. No one but the user can assure that these results are properly applied



User Cost Queue Graph

PRIMARY SECONDARY

Type of Work: 403-HMA <= 3.0 Inch





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CDOT Report - Summary Input and Output for the Single Lane Closure Strategy

Project Code	21506
Project Name	North I-25 - ARE#3
Freeway Name	025A
Input Filename	Flex_2034.WZM
Project Start Date	2034
Project End Date	2034
Design Speed	75 mph
Speed Limit	75 mph
Workzone Speed Limit	55 mph
Grade	2.0 %
Workzone Length	0.50 miles
Functional Class	Rural Interstate (Weekday)

Total Number of Lanes	2
Number of Open Lanes	1
Number of Temporary Lanes	1
AADT, Directional	63,083
Percentage of Single Unit Trucks	2.0 %
Percentage of Combination Trucks	8.0 %
Work in Both Directions	NO

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	COST	DURATION
202-Removal of Asphalt (Planing)	\$4,613.72	2
403-HMA (2-in SMA & 1.5-in HMA)	\$9,368.09	4
TOTAL ADDL. USER COST	\$13,981.82	6

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 6 DAYS = \$41,446.20

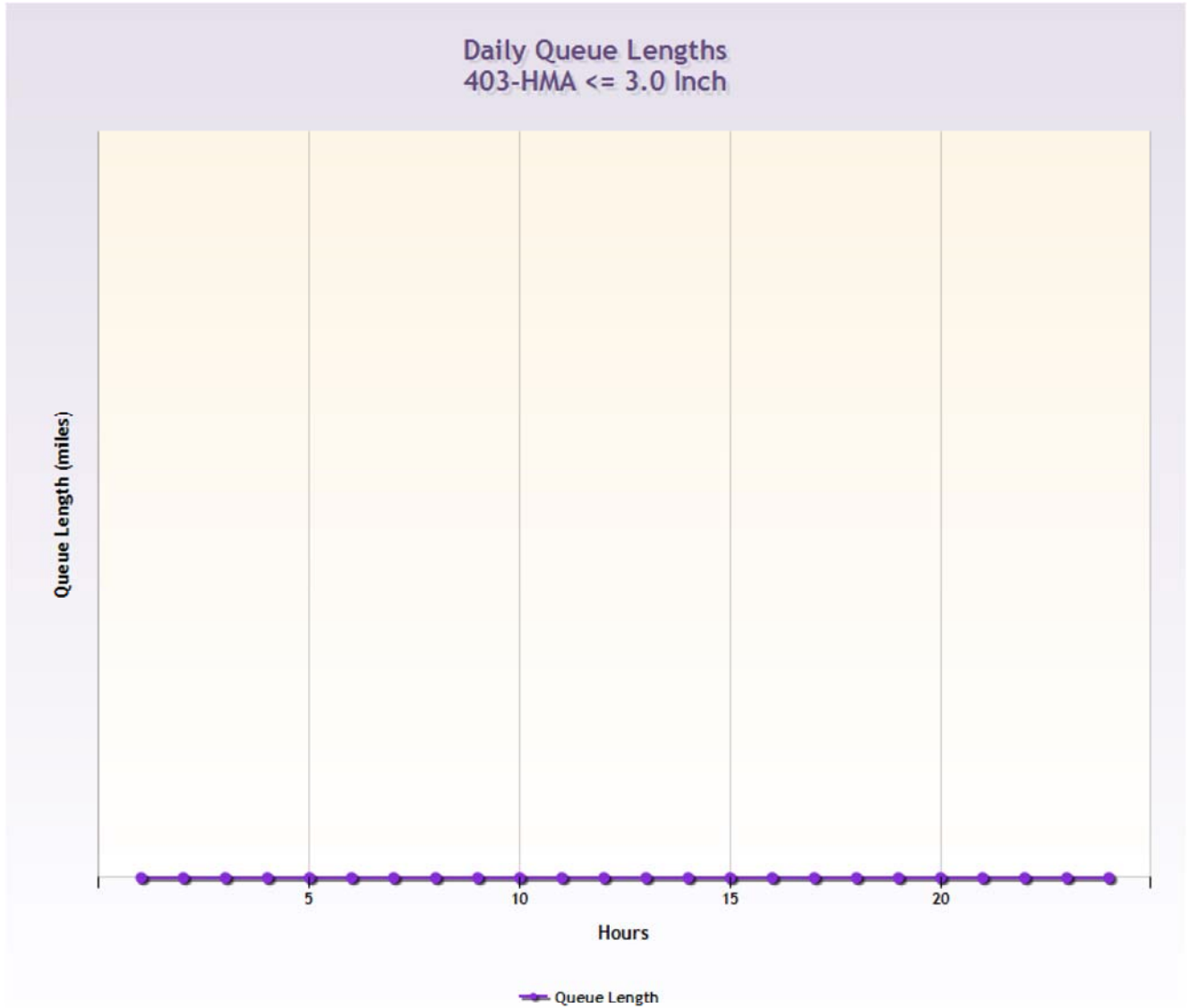
Disclaimer:

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User Cost Queue Graph

Type of Work:





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CDOT Report - Summary Input and Output for the Single Lane Closure Strategy

Project Code	21506
Project Name	North I-25 - ARE#3
Freeway Name	025A
Input Filename	Flex 2047.WZM
Project Start Date	2047
Project End Date	2047
Design Speed	75 mph
Speed Limit	75 mph
Workzone Speed Limit	55 mph
Grade	2.0 %
Workzone Length	0.50 miles
Functional Class	Rural Interstate (Weekday)

Total Number of Lanes	2
Number of Open Lanes	1
Number of Temporary Lanes	1
AADT, Directional	79,560
Percentage of Single Unit Trucks	2.0 %
Percentage of Combination Trucks	8.0 %
Work in Both Directions	NO

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	COST	DURATION
202-Removal of Asphalt (Planing)	\$8,084.99	2
403-HMA (2-in SMA & 2-in HMA)	\$19,276.13	4
TOTAL ADDL. USER COST	\$27,361.12	6

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 6 DAYS = \$52,228.06

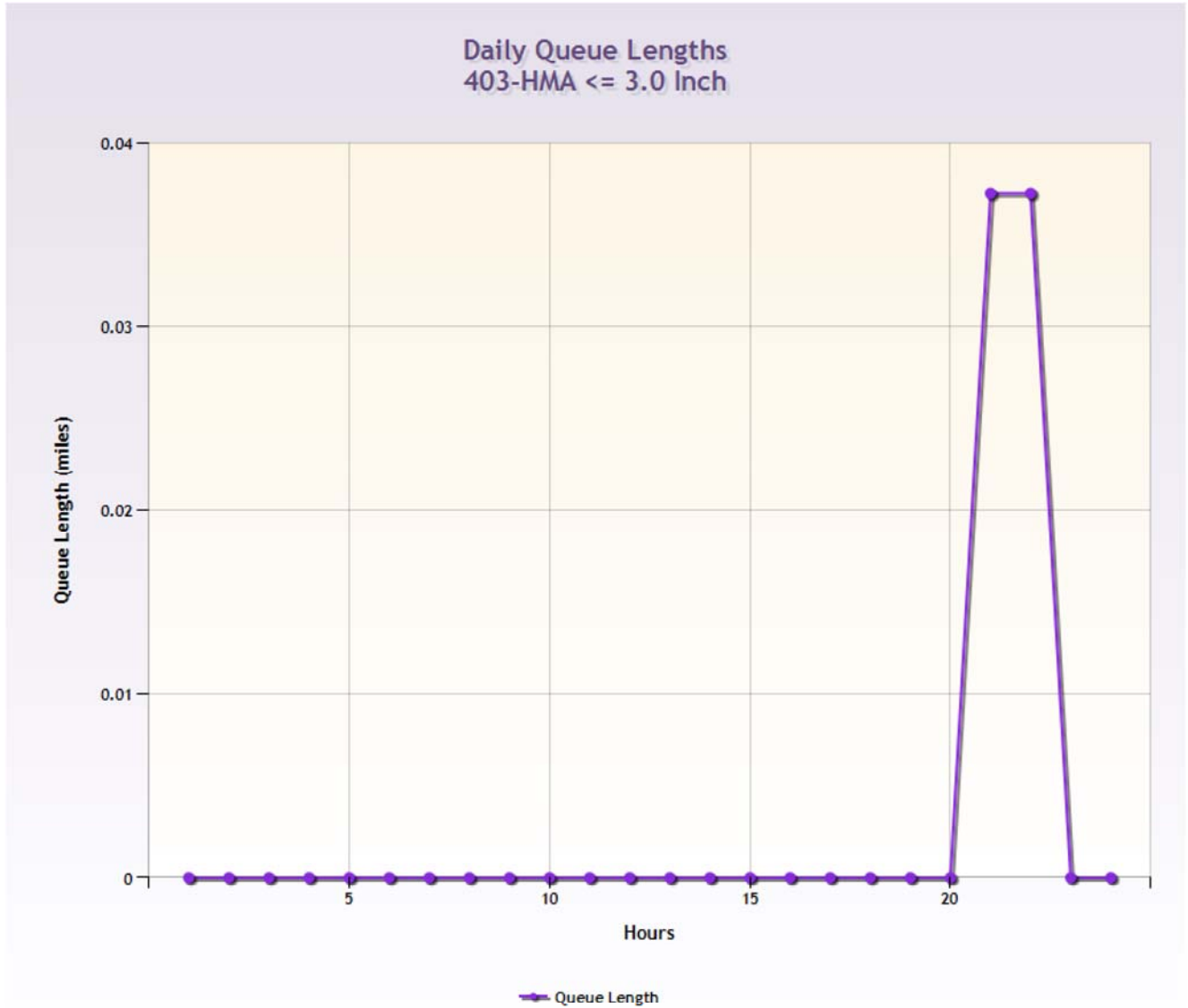
Disclaimer:

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User Cost Queue Graph

Type of Work:



Select File to Open: File Open: PCCP 2020.WZM
Last Modified: 02-17-17

Project Code:	<input type="text" value="21506"/>	Freeway Name:	<input type="text" value="025A"/>
Name of the Project:	<input type="text" value="North I-25 - ARE#3"/>	Region:	<input type="text" value="R4"/>
Project Start Date:	<input type="text" value="2020"/>	Project End Date:	<input type="text" value="2020"/>
Author & Comments:	<input type="text" value="RockSol Consulting Group, Inc."/>	Design Speed:	<input type="text" value="75"/> mph
Length of Closure:	<input type="text" value="0.50"/> miles	Speed Limit:	<input type="text" value="75"/> mph
Percent Grade:	<input type="text" value="2"/>	Work Zone Speed Limit:	<input type="text" value="65"/> mph

Type of Closure: Single Lane Cross Over

Primary Direction			Secondary Direction		
Total Number of Lanes:	<input type="text" value="2"/>		Total Number of Lanes:	<input type="text" value="2"/>	
Number of Open Lanes:	<input type="text" value="2"/>	<input type="text" value="0"/>	Number of Open Lanes:	<input type="text" value="2"/>	<input type="text" value="0"/>
Single Unit Trucks [%]:	<input type="text" value="2.00"/> %	<input type="text" value="8.00"/> %	Single Unit Trucks [%]:	<input type="text" value="2.00"/> %	<input type="text" value="8.00"/> %
AADT:	<input type="text" value="45338"/>		AADT:	<input type="text" value="45338"/>	

Type of Work	Function Class:	<input type="text" value="Rural Interstate (Weekday)"/>
<ul style="list-style-type: none"> 202-Removal of Concrete 202-Removal of Concrete (Diamond Grinding) 202-Removal of Asphalt 202-Removal of Asphalt (Planing) 203-Unclassified Excavation 203-Unclassified Excavation (C.I.P.) 203-Embankment Material 203-Embankment Material (C.I.P.) 203-Muck Excavation 203-Rolling 	Total Duration (days):	<input type="text" value="8"/>
	Normal Capacity per Lane:	<input type="text" value="1789.0"/> Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Primary Capacity per Lane	Secondary Capacity per Lane	
412-Concrete Pavement <= 14.0 inch	<input type="text" value="8"/>	<input type="text" value="N/A"/>	<input type="text" value="1750"/>	<input type="text" value="1750"/>	✘

Select File to Open: File Open: PCCP 2047.WZM
Last Modified: 02-14-17

Project Code:	<input type="text" value="21506"/>	Freeway Name:	<input type="text" value="025A"/>
Name of the Project:	<input type="text" value="North I-25 - ARE#3"/>	Region:	<input type="text" value="R4"/>
Project Start Date:	<input type="text" value="2047"/>	Project End Date:	<input type="text" value="2047"/>
Author & Comments:	<input type="text" value="RockSol"/>	Design Speed:	<input type="text" value="75"/> mph
Length of Closure:	<input type="text" value="0.50"/> miles	Speed Limit:	<input type="text" value="75"/> mph
Percent Grade:	<input type="text" value="2"/>	Work Zone Speed Limit:	<input type="text" value="55"/> mph

Type of Closure: Single Lane Cross Over

Enter The Following Data Per Direction

Total Number of Lanes:	<input type="text" value="2"/>	Number of Open Lanes:	<input type="text" value="1"/>
Single Unit Trucks [%]:	<input type="text" value="2.00"/> %	Number of Temporary Lanes:	<input type="text" value="1"/>
Combination Trucks [%]:	<input type="text" value="8.00"/> %	Average Annual Daily Traffic:	<input type="text" value="79560"/>
<input type="checkbox"/> Work on Both Directions		<input type="checkbox"/> Pilot Car Operation	Please select stop time: <input type="text" value="15 Minutes"/>

Type of Work	Function Class:	<input type="text" value="Rural Interstate (Weekday)"/>
<ul style="list-style-type: none"> 202-Removal of Concrete 202-Removal of Concrete (Diamond Grinding) 202-Removal of Asphalt 202-Removal of Asphalt (Planing) 203-Unclassified Excavation 203-Unclassified Excavation (C.I.P.) 203-Embankment Material 203-Embankment Material (C.I.P.) 203-Muck Excavation 203-Rolling 	Total Duration (days):	<input type="text" value="10"/>
	Normal Capacity per Lane:	<input type="text" value="1789.0"/> Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Work Zone Capacity per Lane	
202-Removal of Concrete (Diamond Grinding)	<input type="text" value="5"/>	<input type="text" value="N/A"/>	<input type="text" value="1459"/>	✘
412-Routing & Sealing PCCP Cracks	<input type="text" value="5"/>	<input type="text" value="N/A"/>	<input type="text" value="1366"/>	✘

Select File to Open: File Open: 2020Flex.WZM
Last Modified: 03-16-17

Project Code:	<input type="text" value="21506"/>	Freeway Name:	<input type="text" value="025A"/>
Name of the Project:	<input type="text" value="North I-25 - ARE#3"/>	Region:	<input type="text" value="R4"/>
Project Start Date:	<input type="text" value="2020"/>	Project End Date:	<input type="text" value="2020"/>
Author & Comments:	<input type="text" value="RockSol Consulting Group, Inc."/>	Design Speed:	<input type="text" value="75"/> mph
Length of Closure:	<input type="text" value="0.50"/> miles	Speed Limit:	<input type="text" value="75"/> mph
Percent Grade:	<input type="text" value="2"/>	Work Zone Speed Limit:	<input type="text" value="65"/> mph

Type of Closure: Single Lane Cross Over

Primary Direction			Secondary Direction		
Total Number of Lanes:	<input type="text" value="2"/>		Total Number of Lanes:	<input type="text" value="2"/>	
Number of Open Lanes:	<input type="text" value="2"/>	<input type="text" value="0"/> Number of Temporary Lanes	Number of Open Lanes:	<input type="text" value="2"/>	<input type="text" value="0"/> Number of Temporary Lanes
Single Unit Trucks [%]:	<input type="text" value="2.00"/> %	<input type="text" value="8.00"/> % Combination Trucks [%]	Single Unit Trucks [%]:	<input type="text" value="2.00"/> %	<input type="text" value="8.00"/> % Combination Trucks [%]
AADT:	<input type="text" value="45338"/>		AADT:	<input type="text" value="45338"/>	

Type of Work	Function Class:	<input type="text" value="Rural Interstate (Weekday)"/>
<ul style="list-style-type: none"> 202-Removal of Concrete 202-Removal of Concrete (Diamond Grinding) 202-Removal of Asphalt 202-Removal of Asphalt (Planing) 203-Unclassified Excavation 203-Unclassified Excavation (C.I.P.) 203-Embankment Material 203-Embankment Material (C.I.P.) 203-Muck Excavation 203-Rolling 	Total Duration (days):	<input type="text" value="7"/>
	Normal Capacity per Lane:	<input type="text" value="1789.0"/> Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Primary Capacity per Lane	Secondary Capacity per Lane	
403-HMA (2-in SMA & 10.5-in HMA)	<input type="text" value="7"/>	<input type="text" value="12.50"/>	<input type="text" value="1750"/>	<input type="text" value="1750"/>	✘

Initial Construction (2020) UserCost Screenshot for Flexible Pavement Alternative

Select File to Open: File Open: Flex 2034.WZM
Last Modified: 02-14-17

Project Code:	<input type="text" value="21506"/>	Freeway Name:	<input type="text" value="025A"/>
Name of the Project:	<input type="text" value="North I-25 - ARE#3"/>	Region:	<input type="text" value="R4"/>
Project Start Date:	<input type="text" value="2034"/>	Project End Date:	<input type="text" value="2034"/>
Author & Comments:	<input type="text" value="RockSol Consulting Group, Inc."/>	Design Speed:	<input type="text" value="75"/> mph
Length of Closure:	<input type="text" value="0.50"/> miles	Speed Limit:	<input type="text" value="75"/> mph
Percent Grade:	<input type="text" value="2"/>	Work Zone Speed Limit:	<input type="text" value="55"/> mph

Type of Closure: Single Lane Cross Over

Enter The Following Data Per Direction

Total Number of Lanes:	<input type="text" value="2"/>	Number of Open Lanes:	<input type="text" value="1"/>
Single Unit Trucks [%]:	<input type="text" value="2.00"/> %	Number of Temporary Lanes:	<input type="text" value="1"/>
Combination Trucks [%]:	<input type="text" value="8.00"/> %	Average Annual Daily Traffic:	<input type="text" value="63083"/>
<input type="checkbox"/> Work on Both Directions		<input type="checkbox"/> Pilot Car Operation	Please select stop time: <input type="text" value="15 Minutes"/>

Type of Work	Function Class:	<input type="text" value="Rural Interstate (Weekday)"/>
<ul style="list-style-type: none"> 202-Removal of Concrete 202-Removal of Concrete (Diamond Grinding) 202-Removal of Asphalt <li style="background-color: #e0e0e0;">202-Removal of Asphalt (Planing) 203-Unclassified Excavation 203-Unclassified Excavation (C.I.P.) 203-Embankment Material 203-Embankment Material (C.I.P.) 203-Muck Excavation 203-Rolling 	Total Duration (days):	<input type="text" value="6"/>
	Normal Capacity per Lane:	<input type="text" value="1789.0"/> Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Work Zone Capacity per Lane	
202-Removal of Asphalt (Planing)	<input type="text" value="2"/>	<input type="text" value="N/A"/>	<input type="text" value="1459"/>	✘
403-HMA (2-in SMA & 1.5-in HMA)	<input type="text" value="4"/>	<input type="text" value="3.50"/>	<input type="text" value="1408"/>	✘

Select File to Open: File Open: 2047Flex.WZM
Last Modified: 03-16-17

Project Code:	<input type="text" value="21506"/>	Freeway Name:	<input type="text" value="025A"/>
Name of the Project:	<input type="text" value="North I-25 - ARE#3"/>	Region:	<input type="text" value="R4"/>
Project Start Date:	<input type="text" value="2047"/>	Project End Date:	<input type="text" value="2047"/>
Author & Comments:	<input type="text" value="RockSol Consulting Group, Inc."/>	Design Speed:	<input type="text" value="75"/> mph
Length of Closure:	<input type="text" value="0.50"/> miles	Speed Limit:	<input type="text" value="75"/> mph
Percent Grade:	<input type="text" value="2"/>	Work Zone Speed Limit:	<input type="text" value="55"/> mph

Type of Closure: Single Lane Cross Over

Enter The Following Data Per Direction

Total Number of Lanes:	<input type="text" value="2"/>	Number of Open Lanes:	<input type="text" value="1"/>
Single Unit Trucks [%]:	<input type="text" value="2.00"/> %	Number of Temporary Lanes:	<input type="text" value="1"/>
Combination Trucks [%]:	<input type="text" value="8.00"/> %	Average Annual Daily Traffic:	<input type="text" value="79560"/>
<input type="checkbox"/> Work on Both Directions		<input type="checkbox"/> Pilot Car Operation	Please select stop time: <input type="text" value="15 Minutes"/>

Type of Work	Function Class:	<input type="text" value="Rural Interstate (Weekday)"/>
<ul style="list-style-type: none"> 202-Removal of Concrete 202-Removal of Concrete (Diamond Grinding) 202-Removal of Asphalt 202-Removal of Asphalt (Planing) 203-Unclassified Excavation 203-Unclassified Excavation (C.I.P.) 203-Embankment Material 203-Embankment Material (C.I.P.) 203-Muck Excavation 203-Rolling 	Total Duration (days):	<input type="text" value="6"/>
	Normal Capacity per Lane:	<input type="text" value="1789.0"/> Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Work Zone Capacity per Lane	
202-Removal of Asphalt (Planing)	<input type="text" value="2"/>	<input type="text" value="N/A"/>	<input type="text" value="1459"/>	✘
403-HMA (2-in SMA & 2-in HMA)	<input type="text" value="4"/>	<input type="text" value="4.00"/>	<input type="text" value="1408"/>	✘

UserCost Screenshot for Flexible Pavement 2047 Rehabilitation

For Future Rehabilitations

Edit Hourly Traffic Distribution Factors
Current Functional Class: Rural Interstate (Weekday)

Hour 0 - 1:	0.0165	Hour 12 - 13:	0.0000
Hour 1 - 2:	0.0137	Hour 13 - 14:	0.0000
Hour 2 - 3:	0.0128	Hour 14 - 15:	0.0000
Hour 3 - 4:	0.0136	Hour 15 - 16:	0.0000
Hour 4 - 5:	0.0166	Hour 16 - 17:	0.0000
Hour 5 - 6:	0.0232	Hour 17 - 18:	0.0000
Hour 6 - 7:	0.0000	Hour 18 - 19:	0.0000
Hour 7 - 8:	0.0000	Hour 19 - 20:	0.0000
Hour 8 - 9:	0.0000	Hour 20 - 21:	0.0298
Hour 9 - 10:	0.0000	Hour 21 - 22:	0.0256
Hour 10 - 11:	0.0000	Hour 22 - 23:	0.0212
Hour 11 - 12:	0.0000	Hour 23 - 24:	0.0175

Sum of Hourly Distribution: 0.1905

OK Cancel

For Initial Construction

Edit Hourly Traffic Distribution Factors
Current Functional Class: Rural Interstate (Weekday)

	Primary	Secondary		Primary	Secondary
Hour 0 - 1:	0.0165	0.0165	Hour 12 - 13:	0.0675	0.0675
Hour 1 - 2:	0.0137	0.0137	Hour 13 - 14:	0.0681	0.0681
Hour 2 - 3:	0.0128	0.0128	Hour 14 - 15:	0.0683	0.0683
Hour 3 - 4:	0.0136	0.0136	Hour 15 - 16:	0.0656	0.0656
Hour 4 - 5:	0.0166	0.0166	Hour 16 - 17:	0.0602	0.0602
Hour 5 - 6:	0.0232	0.0232	Hour 17 - 18:	0.0523	0.0523
Hour 6 - 7:	0.0380	0.0380	Hour 18 - 19:	0.0435	0.0435
Hour 7 - 8:	0.0495	0.0495	Hour 19 - 20:	0.0359	0.0359
Hour 8 - 9:	0.0590	0.0590	Hour 20 - 21:	0.0298	0.0298
Hour 9 - 10:	0.0648	0.0648	Hour 21 - 22:	0.0256	0.0256
Hour 10 - 11:	0.0683	0.0683	Hour 22 - 23:	0.0212	0.0212
Hour 11 - 12:	0.0685	0.0685	Hour 23 - 24:	0.0175	0.0175

Sum of Hourly Distribution: Primary: 1.0000 / Secondary: 1.0000

OK Cancel

UserCost Screenshot for Hourly Traffic Distribution Factors for Initial and Rehabilitation Pavement Construction Operations