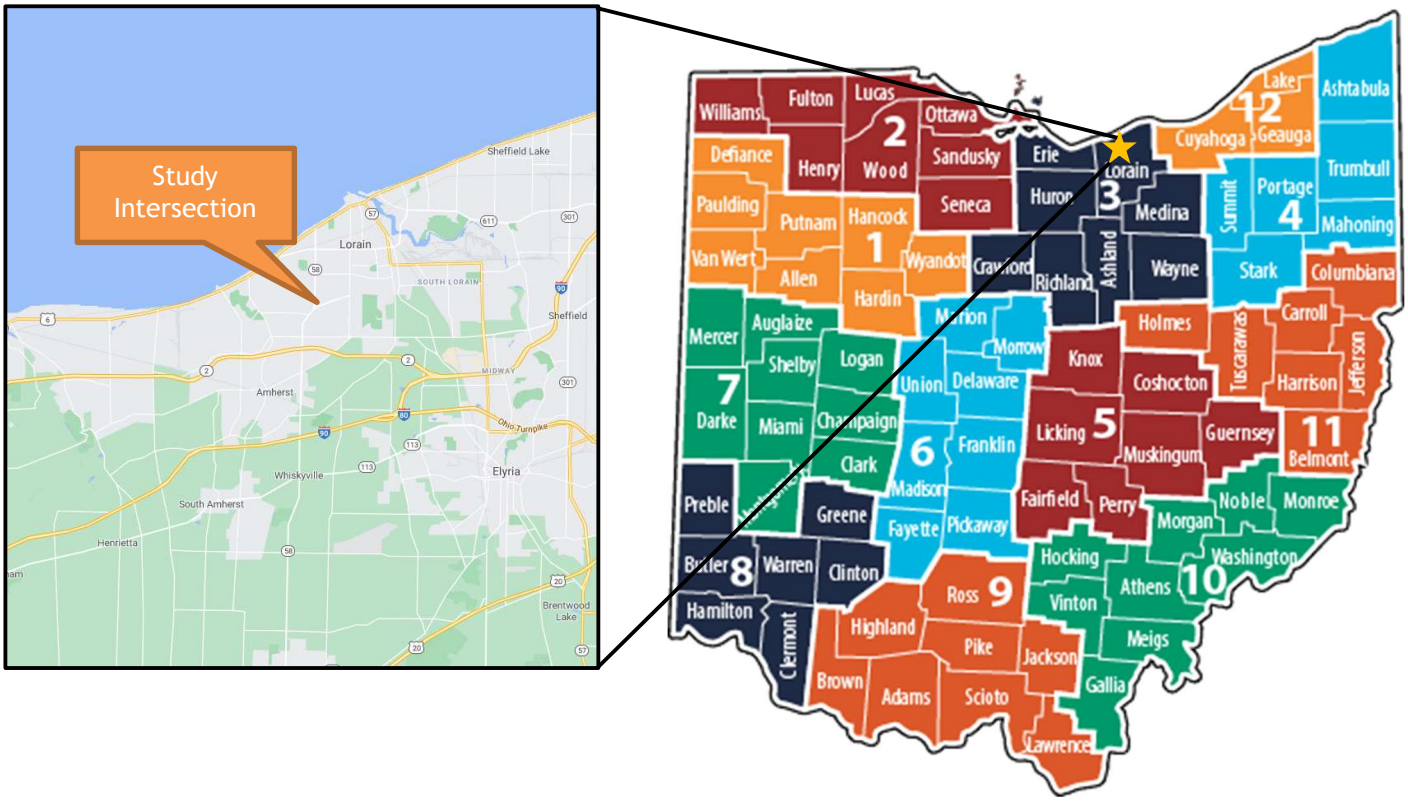

LOR-58-25.5 | Abbreviated Safety Study

SR 58 at Tower Boulevard

ODOT PID 112342

OHIO DEPARTMENT OF TRANSPORTATION

WOOLPERT

ARCHITECTURE | ENGINEERING | GEOSPATIAL

Mead&Hunt

THE CITY OF LORAIN 1834 EST. OHIO

March 2021

WOOLPERT

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WOOLPERT

I. OVERVIEW

A. Existing Conditions

The location for this study is at the intersection of Leavitt Road (SR 58) and Tower Boulevard (SLM 25.5) in the City of Lorain, Lorain County, Ohio (District 3). SR 58 is four-lane, north-south undivided roadway functionally classified as an urban minor arterial with a 40-mph posted speed limit. Tower Boulevard is four-lane, east-west roadway classified as an urban major collector with a posted speed limit of 35 mph. The ODOT reported 2019 annual average daily traffic (AADT) was 23,946 vehicles per day (vpd) for SR 58 and 5,996 vpd for Tower Boulevard. The ODOT 2020 (post COVID-19 pandemic) traffic counts were conducted in the area of the studied intersection and resulted in a decrease of 14% in the traffic volumes along SR 58. The 2020 reported AADT was 20,397 vpd.

Tower Boulevard intersects SR 58 as a four-legged, uncoordinated-actuated, signalized intersection approximately 1.1 miles north of the interchange with SR 2. The fourth (west) leg of the intersection consists of a private drive for the Lighthouse Village retail development. The intersection is typically congested in the weekday and weekend peak hours due to traffic generation from the retail development. The surrounding area is primarily heavy commercial to the south of the intersection and residential to the north and east.

All four legs have exclusive left turn lanes with protected/permitted phasing. The northbound approach of SR 58 and the eastbound Lighthouse Village drive have exclusive right turn lanes. Right-turn-on-red is permitted for all approaches. Construction of a gas station and car wash was recently completed on the southeast corner. Crosswalks are not provided for any approaches, though one is planned by the City across the north leg. Residential areas to the north and east generate bicycle and pedestrian traffic at the intersection, with bike lanes provided on both sides of SR 58, though no crossing facilities are provided at the intersection. The city also plans to repave the roadway in 2021, which may present an opportunity for re-striping.

The intersection is located within a 1,250-foot radius left-hand curve (heading north) on SR 58, which corresponds to a maximum speed of 58 mph per ODOT's Location and Design Manual Figure 202-2. The curve appears to meet the design speed and sight distance requirements, but visibility is somewhat restricted around the curve due to utility poles along the west side of the curve. Northbound drivers turning left into Lighthouse Village may have limited sight distance to approaching vehicles.

Tower Boulevard is a wide, four lane boulevard with a 33-foot grass median and curves to meet SR 58, though visibility appears to be acceptable. Lighthouse Village drive is a commercial access with a landscaped median near the SR 58 intersection. The sight distance turning right on red out of Lighthouse Village is somewhat limited by the utility poles on SR 58 and parking at adjacent retailers.

Figure 1: SR 58 Curvature and Visibility

Figure 2: Tower Boulevard Curvature

The City of Lorain identified the intersection as a priority location for safety improvements. Between 2014 and 2018, the intersection generated the second highest number of collisions within the City. In 2018, the intersection was ranked 178 on ODOT's Highway Safety Improvement Program Priority List, with an expected excess crash frequency of 8.11 crashes per year compared to similar intersections. The purpose of this study is to identify any contributing factors and provide recommendations to address them.

A turning movement count was completed at the intersection on Tuesday, January 12th, 2021. Based on the count data, the AM peak occurs between 7:00 AM and 8:00 AM, the midday peak occurs between 12:00 PM and 1:00 PM, and the PM Peak occurs between 4:15 PM and 5:15 PM. The count report is included in **Appendix A**. The count shows the movements heading to and from SR 2 to the south were the heaviest, including:

- Northbound and southbound through
- Northbound left and right
- Eastbound right
- Westbound left

Intersection capacity analysis was performed for the intersection using Highway Capacity Software (HCS7) for the AM, midday, and PM Peak hours. All peak hours operate at a Level of Service (LOS) C using the ODOT balanced approach delay methodology with existing signal timings provided by the City. The results of the capacity analysis are summarized in Table 1 below and in **Appendix B**.

Table 1: Capacity Analysis Results

Peak Period	EB Delay-LOS	WB Delay-LOS	NB Delay-LOS	SB Delay-LOS	Overall Delay-LOS
AM Peak	23.7-C	23.6-C	21.7-C	24.6-C	23.2-C
Midday Peak	25.0-C	25.8-C	22.3-C	25.2-C	24.2-C
PM Peak	26.3-C	27.0-C	24.4-C	26.4-C	25.7-C

Clearance intervals were also analyzed for the intersection. The current signal timings show 4.0 seconds for the yellow clearance interval on the eastbound and westbound through movements, 3.0 seconds on north and southbound through moves, and 3.0 seconds for the yellow clearance interval for all other phases. The ODOT Traffic Engineering Manual formulas showed that the northbound and southbound through movements should have a 4.0 second yellow clearance interval and all left turn phases should have a 3.5 second yellow clearance interval. The existing 2.0 second all red clearance interval for all phases meets the standard. Additional yellow clearance time would allow left turning vehicles to clear the intersection. The clearance interval calculations are included in **Appendix C**.

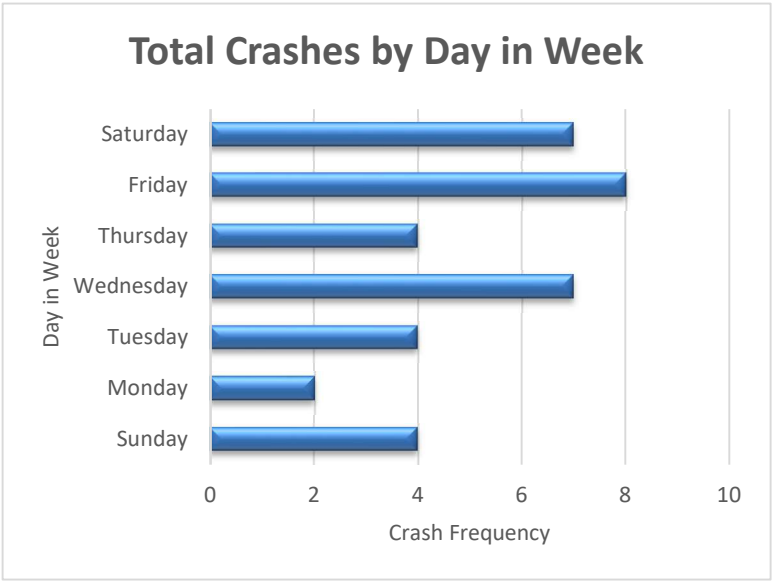
B. Crash Data and Analysis

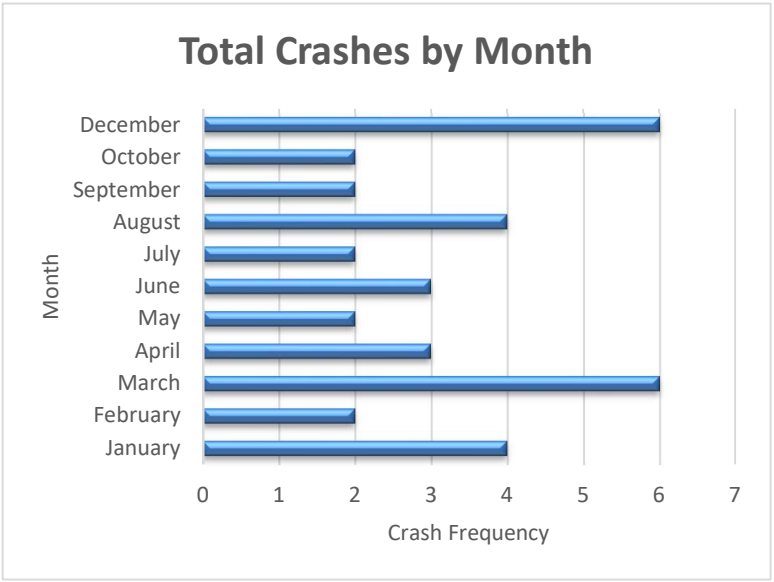
A total of 36 crashes occurred at the intersection between 2017 and 2019. Crash data for 2020 was omitted due to the implications of the COVID-19 pandemic and potentially reduced volumes. The crash reports were reviewed and removed or corrected as necessary. An overview of the crash data is shown in the tables and graphs below.

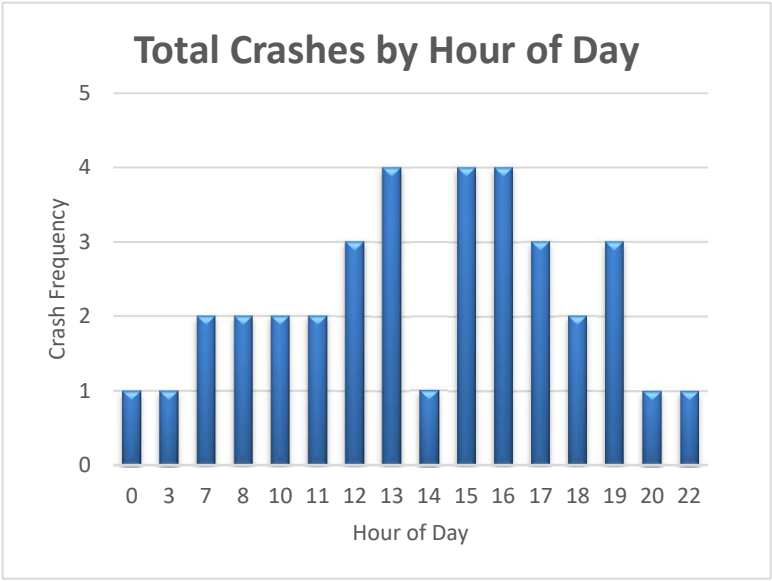
Year	Total Crashes	Fatalities	Serious Injuries
2017	10	0	0
2018	16	0	3
2019	10	0	0
Grand Total	36	0	3

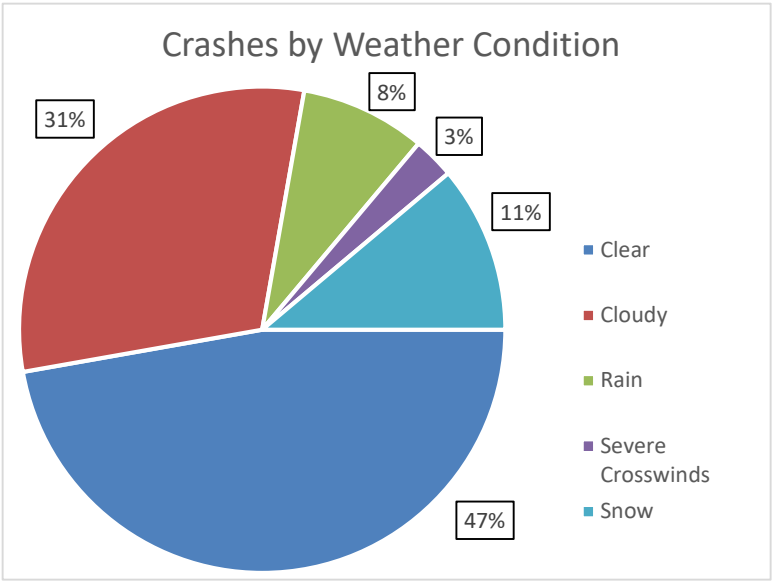
Contributing Circumstances	Total Crashes	Fatalities	Serious Injuries
Following too Close / ACDA	13	0	2
Failure to Yield	5	0	0
Improper Turn	5	0	0
Other Improper Action	5	0	1
Ran Red Light	5	0	0
Swerving to Avoid	1	0	0
None	1	0	0
Improper Lane Change	1	0	0
Grand Total	36	0	3

Crash Type	PDO/No Injury	Injury Possible	Minor Injury Suspected	Serious Injury Suspected	Grand Total
Rear End	9	1	2	1	13
Angle	3	3	1	0	7
Left Turn	2	3	1	0	6
Sideswipe - Passing	4	0	0	0	4
Right Turn	2	1	0	0	3
Fixed Object	2	0	0	0	2
Head On	0	0	0	1	1
Grand Total	22	8	4	2	36









The collision diagram for the intersection is shown below and in **Appendix D**. Rear end crashes (36%), angle crashes (19%), and left turn crashes (17%) accounted for most of the collisions. The crashes show no correlation with the day of the week, month, or weather and show slight correlation to the hour of day. Crash frequency increased slightly during the midday and PM peaks, which can likely be attributed to increased congestion. Turning movements taken in January 2021 show the midday peak hour beginning at 12:00 PM and the PM peak hour beginning at 4:15 PM, which align with the increased crash numbers.

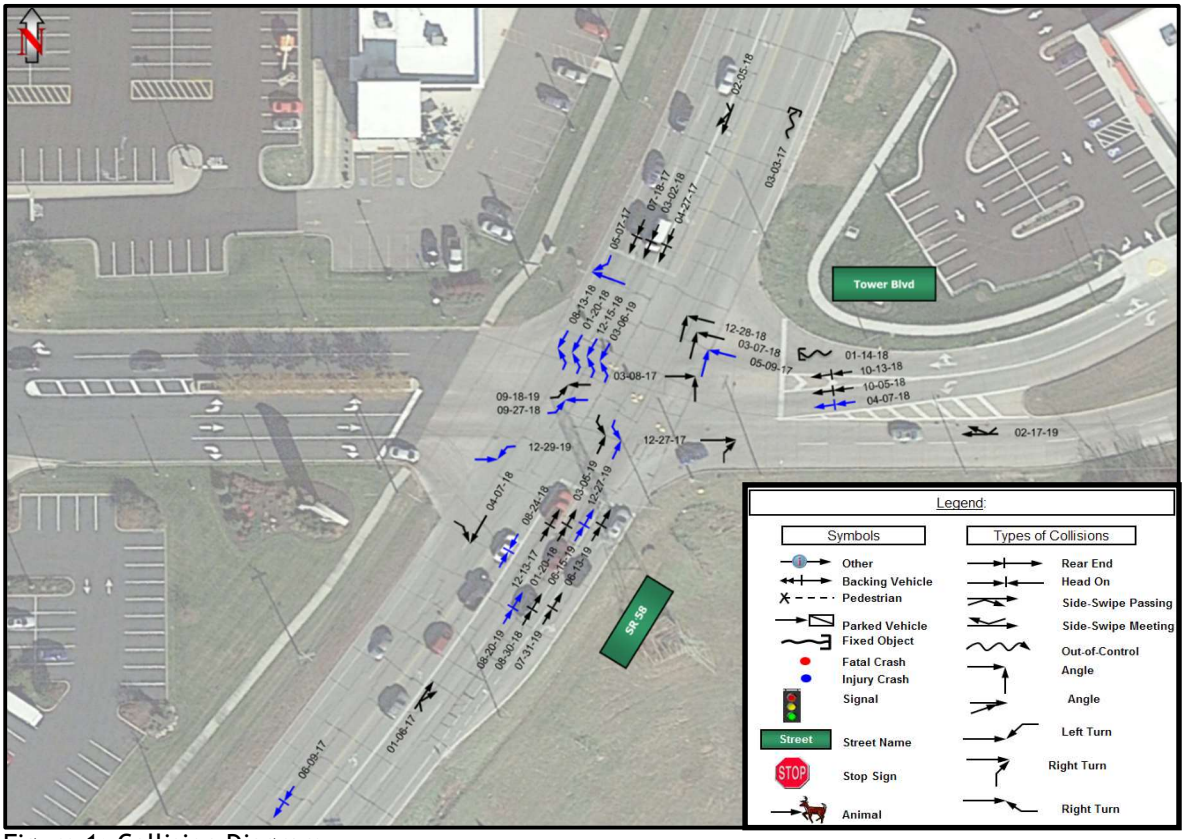


Figure 1: Collision Diagram

C. Probable Causes and Potential Countermeasures

Rear end crashes are typically resultant from congestion, but could also be caused by several other factors:

- Potential speeding along the SR 58 and Tower Boulevard corridors, combined with unexpected signal changes due to a lack of dilemma zone detection, could be causing sudden stops.
- Signal visibility resulting from insufficient number of signal heads, poor signal head placement or difficult background or clutter. The number of signal heads (two per approach) meets MUTCD requirements but does not meet ODOT recommendations for number and placement of signal heads for similar 5 lane roadways. Backplates would also be recommended to improve visibility of the signals and help stand out from visual background clutter.
- Sight distance issues from roadway curvature and intersection skew angle could mean drivers aren't seeing stopped vehicles in advance.

Left turn and angle crashes at the intersection may be the result of the following concerns:

- Protected/permissive phasing for left turn movements creating additional conflicts in traffic flow between left turning vehicles and opposing through vehicles.
- Insufficient clearance intervals or phase timings, leading to red light running
- Sight distance issues from roadway curvature and intersection skew angle could limit sight distance to approaching through vehicles.
- The roadway width, curvature and intersection skew results in a rather large intersection, particularly for left turning traffic, increasing exposure for conflicts with oncoming traffic.

Figure 4: Southbound Approach Curvature

Figure 5: Westbound Approach Curvature

Figure 6: Signal Head Visibility

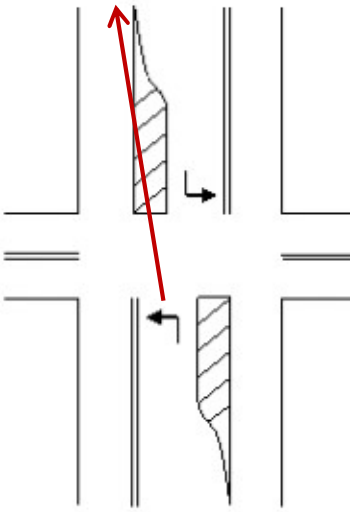
Figure 7: Northbound Approach Curvature

II. IMPLEMENTATION PLAN

1. Short Term Countermeasures (<1 Year)
   a. Install backplates on all signals to improve visibility*
   b. Install additional signal head for each direction and reposition as needed to improve visibility on northbound and southbound approaches*
   c. Add dilemma zone detection for the SR 58 northbound and southbound approaches
   d. Increase yellow clearance interval to 4 seconds for all through phases and to 3.5 seconds for all left turn phases to increase time for left turning vehicles to clear the intersection
   e. Increase minimum green time to 7 seconds for all left turn phases
   f. Convert northbound and southbound left turn phases to protected only with replacement of signal heads and revised signal timing and phasing*
   i. Alternatively, the protected/permissive 5-section signal heads could be converted to Flashing Yellow Arrow (FYA) signal heads with associated signage and educational efforts.
   g. Construct pedestrian crossings and signal timing changes for crossings with associated ADA compliant curb ramps
   h. Install advance warning signage on northbound, southbound, and westbound approaches
   i. Add dotted lines ("cat tracks") through the intersection to delineate left turn paths.

*Additional weight to existing span wire may require replacement of existing span wire supports. Further analysis would be required.

2. Medium Term Countermeasures (1 to 5 Years)
   a. Re-stripe pavement markings on SR 58 to provide a **positive offset** within the median to offset left turn lanes to the left, increasing sight distance around oncoming left turn vehicles within the curved roadway. If the City proceeds with planned repaving in 2021, restriping could occur simultaneously.
   b. Coordinate signal with intersection at Jaeger Road to the south to reduce congestion and reduce frequency of stopping and rear end crashes for northbound vehicles.
3. Long Term Countermeasures (>5 Years)
   a. Removal of northbound right turn lane to eliminate vehicles crossing the bike lane may be considered. Preliminary capacity analysis indicated the intersection would operate at acceptable conditions with the removal of the turn lane. The intersection site visit showed vehicles aren't utilizing the full turn lane, if at all. Removing the turn lane would reduce confusion for cyclists and remove conflicts with minimal effect on intersection capacity – the approach and overall intersection both operate at LOS C in the PM peak hour, with or without the northbound right turn lane. Alternatively, the lane could be lengthened, and proper bike lane striping employed.



   b. Major realignment of Tower Boulevard and Lighthouse Village drive to intersect SR 58 at right angles should be pursued if permitted by future redevelopment.

ECAT analysis was performed at the study intersection to perform a Benefit to Cost analysis on the proposed improvements. Table 2 provides a summary of the Benefit to Cost ratio for the intersection improvements. Cost estimates and cost benefit analysis are included in **Appendices E and F**, respectively. For short-term countermeasures, it was assumed a full signal rebuild would be required.

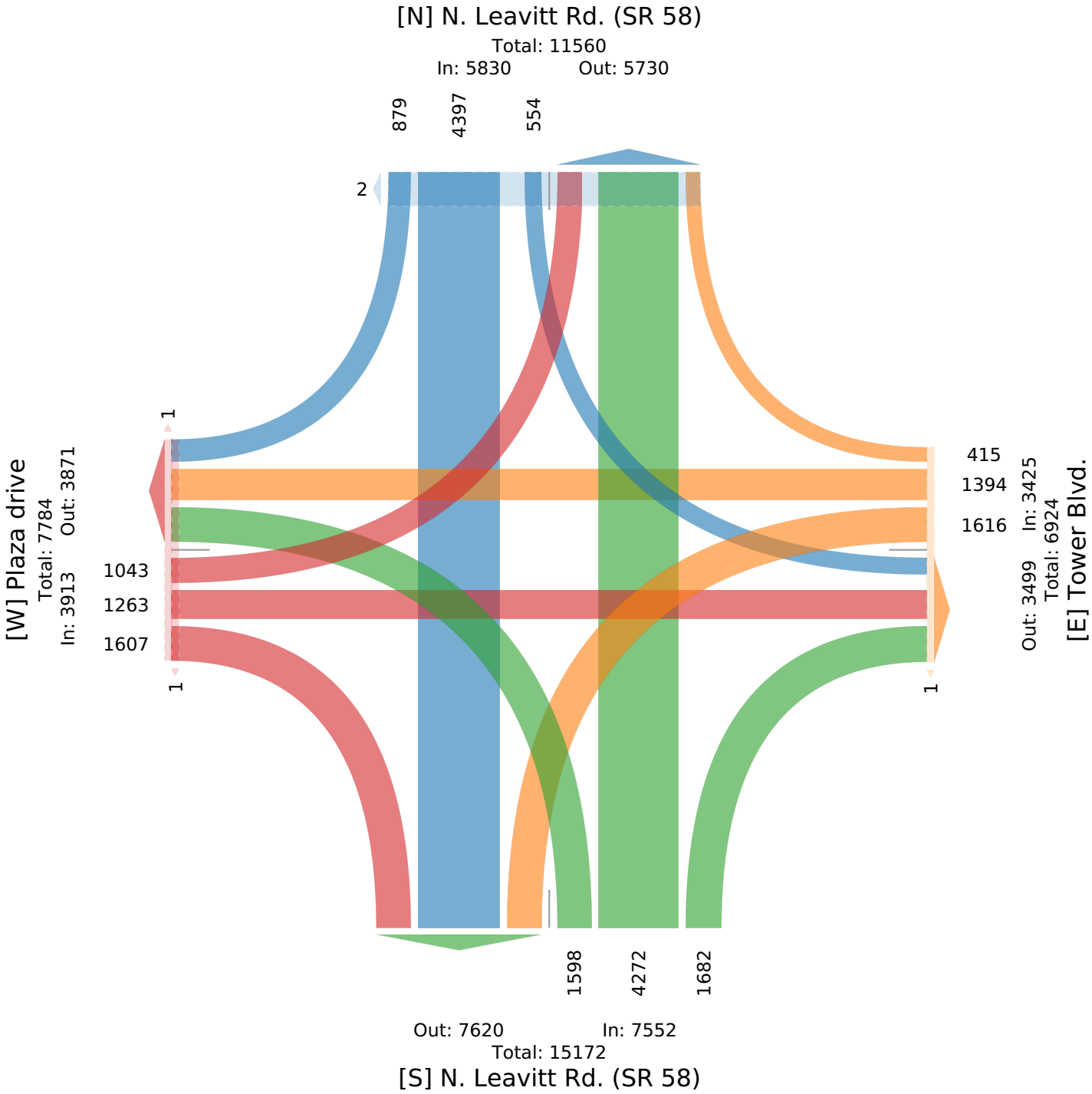
Table 2: Capacity Analysis Results

Countermeasures	Net Present Value of Project	Net Present Value of Safety Benefits	Benefit to Cost Ratio
Short Term	$260,000	$1,322,141.74	5.09
Medium Term	$162,500	$1,148,649.65	7.07
Long Term	$2,860,000	$414,185.09	0.14

Appendix A
Turning Movement Counts

N. Leavitt Rd. & Tower Blvd. - TMC
Tue Jan 12, 2021
Full Length (6 AM-7 PM)
All Classes (Lights, Articulated Trucks, Buses and Single-Unit Trucks, Pedestrians)
All Movements
ID: 808899, Location: 41.42901, -82.203031

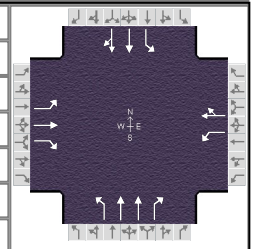
Provided by: Loukas Engineering
232 19th St. NW, Canton, OH, 44709, US



Appendix B
Intersection Capacity Analysis

HCS7 Signalized Intersection Results Summary

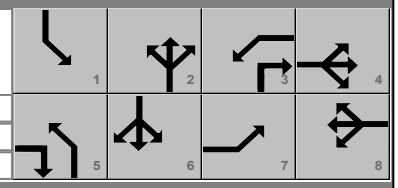
General Information				Intersection Information	
Agency				Duration, h	0.250
Analyst		Analysis Date	2/10/2021	Area Type	Other
Jurisdiction		Time Period		PHF	0.92
Urban Street	N Leavitt Road	Analysis Year	2021	Analysis Period	1> 7:00
Intersection	Tower Blvd	File Name	AM Peak Hour.xus		
Project Description	AM Peak Hour				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	16	23	54	106	32	41	50	278	114	47	361	14

Signal Information			
Cycle, s	100.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	7.0	33.0	13.0	26.0	0.0	0.0	
Yellow	3.0	3.0	3.0	4.0	0.0	0.0	
Red	2.0	2.0	2.0	2.0	0.0	0.0	



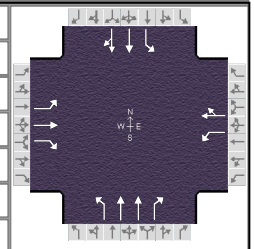
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	7	4	3	8	5	2	1	6
Case Number	1.1	3.0	1.1	4.0	1.1	3.0	1.1	4.0
Phase Duration, s	18.0	32.0	18.0	32.0	12.0	38.0	12.0	38.0
Change Period, ($Y+R_c$), s	5.0	6.0	5.0	6.0	5.0	5.0	5.0	5.0
Max Allow Headway (*MAH*), s	3.1	3.2	3.1	3.2	3.1	3.0	3.1	3.0
Queue Clearance Time (g_s), s	2.6	4.6	6.2	5.6	3.9	8.1	3.7	10.2
Green Extension Time (g_e), s	0.0	0.3	0.1	0.2	0.0	1.6	0.0	1.6
Phase Call Probability	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Out Probability	0.00	0.00	0.01	0.00	0.91	0.00	0.73	0.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	7	4	14	3	8	18	5	2	12	1	6	16
Adjusted Flow Rate (*v*), veh/h	17	25	59	115	79		54	302	124	51	205	203
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1795	1900	1598	1795	1726		1795	1809	1598	1810	1885	1860
Queue Service Time (g_s), s	0.6	1.0	2.6	4.2	3.6		1.9	6.1	4.5	1.7	8.2	8.2
Cycle Queue Clearance Time (g_c), s	0.6	1.0	2.6	4.2	3.6		1.9	6.1	4.5	1.7	8.2	8.2
Green Ratio (*g/C*)	0.39	0.26	0.33	0.39	0.26		0.40	0.33	0.46	0.40	0.33	0.33
Capacity (*c*), veh/h	577	494	527	627	449		422	1194	735	471	622	614
Volume-to-Capacity Ratio (*X*)	0.030	0.051	0.111	0.184	0.177		0.129	0.253	0.169	0.108	0.329	0.331
Back of Queue (*Q*), ft/ln (50 th percentile)	6	10.9	23.5	42.3	36		18.9	63.1	39.7	17.5	88.8	87.3
Back of Queue (*Q*), veh/ln (50 th percentile)	0.2	0.4	0.9	1.7	1.4		0.7	2.5	1.6	0.7	3.5	3.5
Queue Storage Ratio (*RQ*) (50 th percentile)	0.02	0.00	0.16	0.00	0.00		0.08	0.00	0.40	0.10	0.00	0.00
Uniform Delay (d_1), s/veh	18.9	27.7	23.3	19.9	28.7		19.1	24.5	15.8	18.9	25.2	25.2
Incremental Delay (d_2), s/veh	0.0	0.0	0.0	0.1	0.1		0.1	0.0	0.0	0.0	0.1	0.1
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (*d*), s/veh	19.0	27.8	23.3	20.0	28.8		19.2	24.5	15.8	18.9	25.3	25.3
Level of Service (LOS)	B	C	C	B	C		B	C	B	B	C	C
Approach Delay, s/veh / LOS	23.7	C		23.6	C		21.7	C		24.6	C	
Intersection Delay, s/veh / LOS	23.2						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.44	B	2.29	B	1.92	B	2.11	B
Bicycle LOS Score / LOS	0.65	A	0.81	A	0.88	A	0.87	A

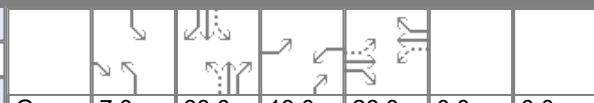
HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	0.250
Analyst		Analysis Date	2/10/2021	Area Type	Other
Jurisdiction		Time Period		PHF	0.92
Urban Street	N Leavitt Road	Analysis Year	2021	Analysis Period	1> 7:00
Intersection	Tower Blvd	File Name	Midday Peak Hour.xus		
Project Description	Midday Peak Hour				

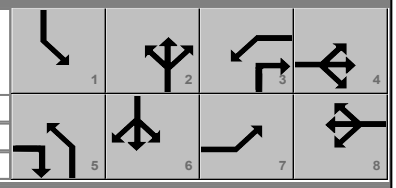


Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	91	101	147	134	119	36	149	343	118	35	332	76

Signal Information			
Cycle, s	100.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	7.0	33.0	13.0	26.0	0.0	0.0
Yellow	3.0	3.0	3.0	4.0	0.0	0.0
Red	2.0	2.0	2.0	2.0	0.0	0.0



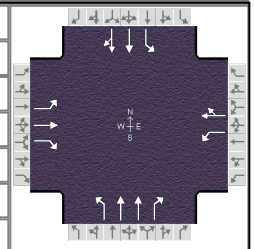
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	7	4	3	8	5	2	1	6
Case Number	1.1	3.0	1.1	4.0	1.1	3.0	1.1	4.0
Phase Duration, s	18.0	32.0	18.0	32.0	12.0	38.0	12.0	38.0
Change Period, ($Y+R_c$), s	5.0	6.0	5.0	6.0	5.0	5.0	5.0	5.0
Max Allow Headway (*MAH*), s	3.1	3.1	3.1	3.1	3.1	3.0	3.1	3.0
Queue Clearance Time (g_s), s	5.6	9.4	7.4	9.5	7.9	9.7	3.3	11.4
Green Extension Time (g_e), s	0.1	0.8	0.1	0.6	0.0	1.9	0.0	1.9
Phase Call Probability	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Out Probability	0.00	0.00	0.05	0.06	1.00	0.00	0.31	0.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	7	4	14	3	8	18	5	2	12	1	6	16
Adjusted Flow Rate (*v*), veh/h	99	110	160	146	168		162	373	128	38	227	217
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1795	1900	1598	1795	1824		1795	1809	1598	1810	1885	1764
Queue Service Time (g_s), s	3.6	4.5	7.4	5.4	7.5		5.9	7.7	4.7	1.3	9.2	9.4
Cycle Queue Clearance Time (g_c), s	3.6	4.5	7.4	5.4	7.5		5.9	7.7	4.7	1.3	9.2	9.4
Green Ratio (*g/C*)	0.39	0.26	0.33	0.39	0.26		0.40	0.33	0.46	0.40	0.33	0.33
Capacity (*c*), veh/h	507	494	527	557	474		404	1194	735	438	622	582
Volume-to-Capacity Ratio (*X*)	0.195	0.222	0.303	0.261	0.355		0.401	0.312	0.175	0.087	0.365	0.372
Back of Queue (*Q*), ft/ln (50 th percentile)	36	50.4	68.8	54.6	80.6		60.2	79.6	41.2	13	99.7	94.7
Back of Queue (*Q*), veh/ln (50 th percentile)	1.4	2.0	2.7	2.2	3.2		2.4	3.2	1.6	0.5	4.0	3.8
Queue Storage Ratio (*RQ*) (50 th percentile)	0.14	0.00	0.46	0.00	0.00		0.24	0.00	0.41	0.07	0.00	0.00
Uniform Delay (d_1), s/veh	20.2	29.1	24.9	20.5	30.2		20.6	25.0	15.9	18.9	25.5	25.6
Incremental Delay (d_2), s/veh	0.1	0.1	0.1	0.1	0.2		0.2	0.1	0.0	0.0	0.1	0.1
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (*d*), s/veh	20.3	29.1	25.1	20.6	30.3		20.8	25.1	15.9	18.9	25.7	25.7
Level of Service (LOS)	C	C	C	C	C		C	C	B	B	C	C
Approach Delay, s/veh / LOS	25.0	C		25.8	C		22.3	C		25.2	C	
Intersection Delay, s/veh / LOS	24.2						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.44	B	2.29	B	1.92	B	2.11	B
Bicycle LOS Score / LOS	1.10	A	1.01	A	1.03	A	0.88	A

HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	0.250
Analyst		Analysis Date	2/10/2021	Area Type	Other
Jurisdiction		Time Period		PHF	0.92
Urban Street	N Leavitt Road	Analysis Year	2021	Analysis Period	1> 7:00
Intersection	Tower Blvd	File Name	PM Peak Hour.xus		
Project Description	PM Peak Hour				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	150	187	171	155	163	37	188	552	216	54	436	111

Signal Information			
Cycle, s	100.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

							1	2	3	4
Green	7.0	33.0	13.0	26.0	0.0	0.0	5	6	7	8
Yellow	3.0	3.0	3.0	4.0	0.0	0.0				
Red	2.0	2.0	2.0	2.0	0.0	0.0				

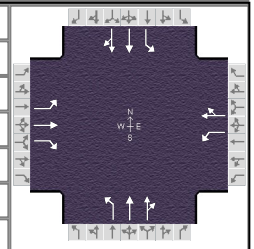
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	7	4	3	8	5	2	1	6
Case Number	1.1	3.0	1.1	4.0	1.1	3.0	1.1	4.0
Phase Duration, s	18.0	32.0	18.0	32.0	12.0	38.0	12.0	38.0
Change Period, ($Y+R_c$), s	5.0	6.0	5.0	6.0	5.0	5.0	5.0	5.0
Max Allow Headway (*MAH*), s	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Queue Clearance Time (g_s), s	8.1	10.9	8.3	11.9	9.0	15.3	4.0	15.2
Green Extension Time (g_e), s	0.1	1.0	0.1	0.7	0.0	3.0	0.0	3.0
Phase Call Probability	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Out Probability	0.13	0.00	0.17	0.35	1.00	0.02	1.00	0.02

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	7	4	14	3	8	18	5	2	12	1	6	16
Adjusted Flow Rate (*v*), veh/h	163	203	186	168	217		204	600	235	59	306	288
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1795	1900	1598	1795	1839		1795	1809	1598	1810	1885	1753
Queue Service Time (g_s), s	6.1	8.9	8.8	6.3	9.9		7.0	13.3	9.3	2.0	13.0	13.2
Cycle Queue Clearance Time (g_c), s	6.1	8.9	8.8	6.3	9.9		7.0	13.3	9.3	2.0	13.0	13.2
Green Ratio (*g/C*)	0.39	0.26	0.33	0.39	0.26		0.40	0.33	0.46	0.40	0.33	0.33
Capacity (*c*), veh/h	470	494	527	485	478		346	1194	735	346	622	579
Volume-to-Capacity Ratio (*X*)	0.347	0.411	0.353	0.347	0.455		0.591	0.503	0.319	0.170	0.493	0.498
Back of Queue (*Q*), ft/ln (50 th percentile)	61.8	98.5	81.5	64.1	107.1		81.6	137.8	81.3	20.3	141.5	132.6
Back of Queue (*Q*), veh/ln (50 th percentile)	2.5	3.9	3.2	2.5	4.3		3.2	5.5	3.2	0.8	5.6	5.3
Queue Storage Ratio (*RQ*) (50 th percentile)	0.25	0.00	0.54	0.00	0.00		0.33	0.00	0.81	0.12	0.00	0.00
Uniform Delay (d_1), s/veh	21.3	30.7	25.4	21.2	31.1		23.0	26.9	17.1	19.9	26.8	26.9
Incremental Delay (d_2), s/veh	0.2	0.2	0.1	0.2	0.3		1.9	0.1	0.1	0.1	0.2	0.2
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (*d*), s/veh	21.5	30.9	25.5	21.4	31.3		24.8	27.0	17.2	20.0	27.0	27.1
Level of Service (LOS)	C	C	C	C	C		C	C	B	B	C	C
Approach Delay, s/veh / LOS	26.3	C		27.0	C		24.4	C		26.4	C	
Intersection Delay, s/veh / LOS	25.7						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.44	B	2.29	B	1.92	B	2.11	B
Bicycle LOS Score / LOS	1.40	A	1.12	A	1.34	A	1.03	A

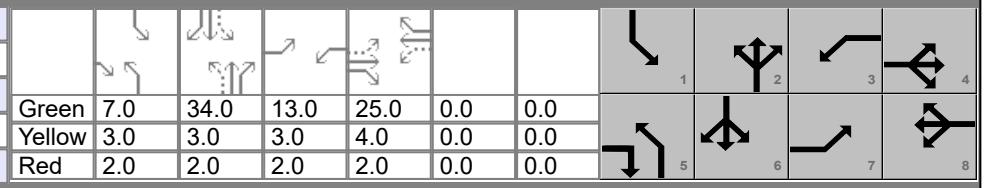
HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	0.250
Analyst		Analysis Date	2/10/2021	Area Type	Other
Jurisdiction		Time Period		PHF	0.92
Urban Street	N Leavitt Road	Analysis Year	2021	Analysis Period	1> 7:00
Intersection	Tower Blvd	File Name	PM Peak Hour No NBR.xus		
Project Description	PM Peak Hour				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	150	187	171	155	163	37	188	552	216	54	436	111

Signal Information			
Cycle, s	100.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	7.0	34.0	13.0	25.0	0.0	0.0
Yellow	3.0	3.0	3.0	4.0	0.0	0.0
Red	2.0	2.0	2.0	2.0	0.0	0.0

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	7	4	3	8	5	2	1	6
Case Number	1.1	3.0	1.1	4.0	1.1	4.0	1.1	4.0
Phase Duration, s	18.0	31.0	18.0	31.0	12.0	39.0	12.0	39.0
Change Period, ($Y+R_c$), s	5.0	6.0	5.0	6.0	5.0	5.0	5.0	5.0
Max Allow Headway (*MAH*), s	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Queue Clearance Time (g_s), s	8.2	11.0	8.4	12.1	9.0	21.8	4.0	15.0
Green Extension Time (g_e), s	0.1	1.0	0.1	0.7	0.0	2.5	0.0	2.8
Phase Call Probability	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Out Probability	0.14	0.00	0.19	0.37	1.00	0.11	1.00	0.02

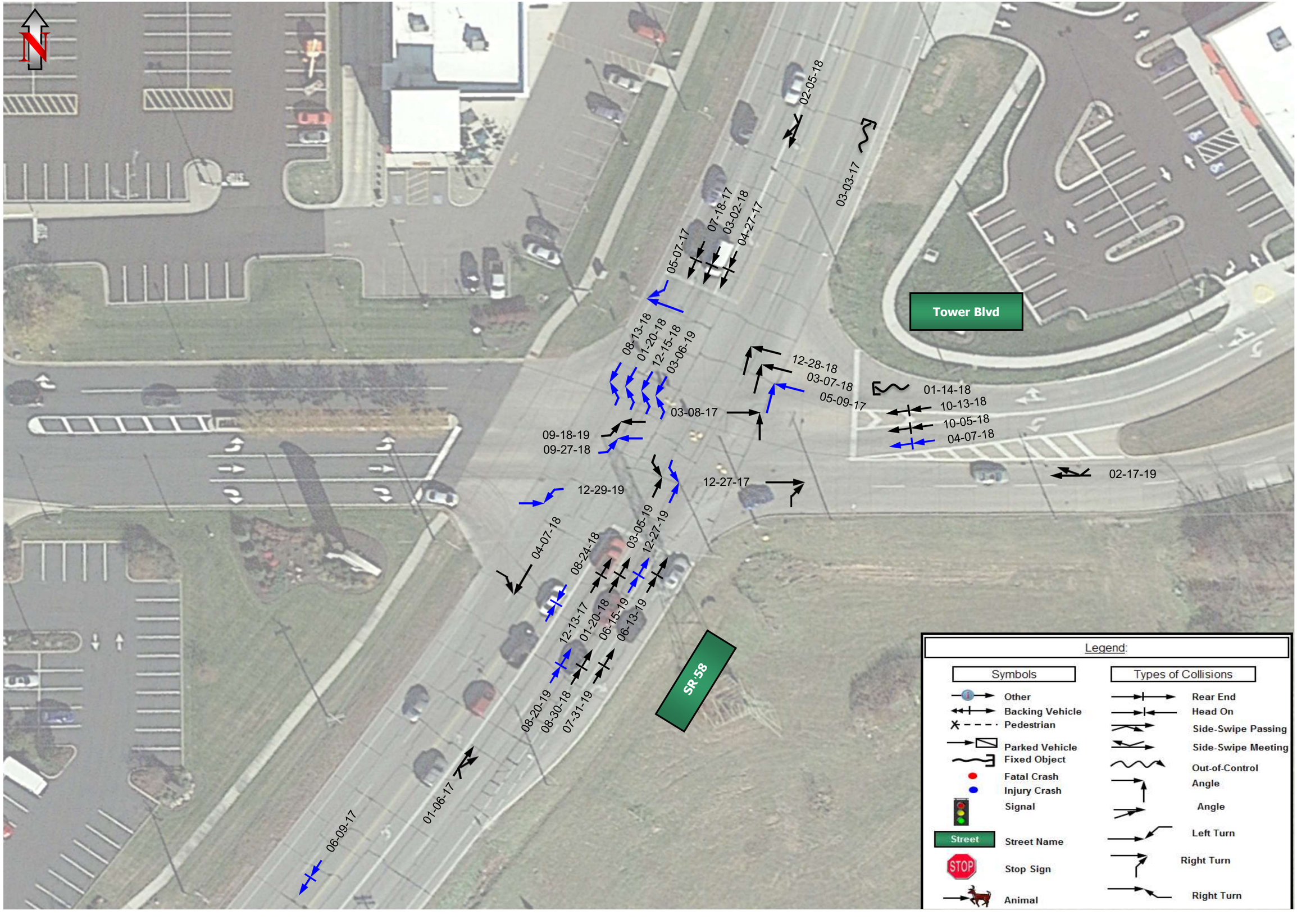
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	7	4	14	3	8	18	5	2	12	1	6	16
Adjusted Flow Rate (*v*), veh/h	163	203	186	168	217		204	438	397	59	306	288
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1795	1900	1598	1795	1839		1795	1900	1717	1810	1885	1753
Queue Service Time (g_s), s	6.2	9.0	9.0	6.4	10.1		7.0	19.8	19.8	2.0	12.8	13.0
Cycle Queue Clearance Time (g_c), s	6.2	9.0	9.0	6.4	10.1		7.0	19.8	19.8	2.0	12.8	13.0
Green Ratio (*g/C*)	0.38	0.25	0.32	0.38	0.25		0.41	0.34	0.34	0.41	0.34	0.34
Capacity (*c*), veh/h	457	475	511	472	460		355	646	584	280	641	596
Volume-to-Capacity Ratio (*X*)	0.357	0.428	0.364	0.357	0.473		0.575	0.678	0.679	0.210	0.478	0.483
Back of Queue (*Q*), ft/ln (50 th percentile)	63.1	100.1	82.9	65.4	108.8		79.2	223.5	205.4	20	138.9	130.2
Back of Queue (*Q*), veh/ln (50 th percentile)	2.5	4.0	3.3	2.6	4.4		3.1	8.9	8.2	0.8	5.5	5.2
Queue Storage Ratio (*RQ*) (50 th percentile)	0.25	0.00	0.55	0.00	0.00		0.32	0.00	0.00	0.11	0.00	0.00
Uniform Delay (d_1), s/veh	22.0	31.5	26.2	21.9	31.9		22.0	28.3	28.3	20.6	26.0	26.1
Incremental Delay (d_2), s/veh	0.2	0.2	0.2	0.2	0.3		1.5	2.4	2.6	0.1	0.2	0.2
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (*d*), s/veh	22.2	31.7	26.3	22.1	32.2		23.5	30.7	31.0	20.7	26.2	26.3
Level of Service (LOS)	C	C	C	C	C		C	C	C	C	C	C
Approach Delay, s/veh / LOS	27.1	C		27.8	C		29.4	C		25.8	C	
Intersection Delay, s/veh / LOS	27.8						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.29	B	2.29	B	1.92	B	2.11	B
Bicycle LOS Score / LOS	1.40	A	1.12	A	1.34	A	1.03	A

Appendix C
Clearance Interval Calculations

ASSOCIATED PHASE	DIRECTION	MOVEMENT	TRAFFIC SIGNAL														PEDESTRIAN													
			FACTORS *(TEM 403-2)								CALCULATED (TEM 403-2)			FINAL CLEARANCE							OMUTCD 4E.06-12	OMUTCD 4E.06-07		3 fps CHECKS (OMUTCD 4E.06, 01-14)				FINAL PED TIMING	
			POSTED SPEED LIMIT	PERCEPTION/REACTION TIME (1s TYP)	YELLOW CHANGE APPROACH SPEED*	RED APPROACH SPEED*	DECELERATION RATE (10 fps TYP)	WIDTH OF INTERSECTION*	LENGTH OF VEHICLE (20 ft TYP)	APPROACH GRADE	YELLOW	RED	Y + R	YELLOW	RED	Y + R	PED MOVEMENT	ASSOCIATED PHASE	CROSSWALK LENGTH	PUSHBUTTON PROVIDED	DISTANCE TO PUSHBUTTON FROM CURB	WALK INTERVAL (4-7s TYP)	CALCULATED PED CLEARANCE	PED CHANGE INTERVAL (FDW)	(L+P)/(3 fps) (NOTE: P=6 IF NO PUSHBUTTON)	WALK + PED CHANGE INTERVALS	IS Y>=X?	ADDITIONAL WALK INTERVAL REQUIRED	FINAL WALK INTERVAL	FINAL PED CHANGE INTERVAL (FDW)
				t	V_Y	V_R	a	W	L	g	Y	R	TOTAL	Y (3-6s TYP)	R (1-6s TYP)	TOTAL			L		P		= 3.5 fps WALK TIME	= 3.5 fps WALK TIME - 3 sec BUFFER	X	Y				
			MPH	SEC	MPH	MPH	FPS	FT	FT	%	SEC	SEC	SEC	SEC	SEC	SEC			FT		FT	SEC	SEC	SEC	SEC	SEC		SEC	SEC	SEC
1	SB LT	LEFT TURN	40	1	35	25	10	120	20	0	3.6	2.8	6.4	4	2	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	NB	THROUGH/RT	40	1	47	47	10	92	20	0	4.5	0.6	5.1	4	2	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	WB LT	LEFT TURN	35	1	30	25	10	130	20	0	3.2	3.1	6.3	4	2	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	EB	THROUGH/RT	25	1	32	32	10	130	20	0	3.4	2.2	5.6	4	2	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	NB LT	LEFT TURN	40	1	35	25	10	125	20	0	3.6	2.9	6.5	4	2	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	SB	THROUGH/RT	40	1	47	47	10	120	20	0	4.5	1.0	5.5	4	2	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	EB LT	LEFT TURN	25	1	20	25	10	130	20	0	2.5	3.1	5.6	4	2	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	WB	THROUGH/RT	35	1	42	42	10	130	20	0	4.1	1.4	5.5	4	2	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix D
Collision Diagram


N
Tower Blvd
SR 58
02-05-18
03-03-17
07-18-17
03-02-18
04-27-17
05-07-17
08-13-18
01-20-18
12-15-18
03-06-19
12-28-18
03-07-18
05-09-17
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12-29-19
04-07-18
08-24-18
03-05-19
12-27-19
12-13-17
01-20-18
06-15-19
06-13-19
08-20-19
08-30-18
07-31-19
01-06-17
06-09-17
Legend:
Symbols
Other
Backing Vehicle
Pedestrian
Parked Vehicle
Fixed Object
Fatal Crash
Injury Crash
Signal
Street
Street Name
STOP
Stop Sign
Animal
Types of Collisions
Rear End
Head On
Side-Swipe Passing
Side-Swipe Meeting
Out-of-Control
Angle
Angle
Left Turn
Right Turn
Right Turn

Appendix E
Cost Estimates

Project Cost Estimate

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Engineering Design %	10%
Contingency %	20%

Countermeasures	Construction Costs	Right of Way Costs	Engineering Design Costs	Contingency Amount	Total Cost of Countermeasure	Annual Maintenance & Energy Costs	Salvage Value
Site Characteristic Improvements (i.e. Lane widening)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Lighting)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Signal Phasing)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Added Right Turn Lane)			$0.00	$0.00	**$0.00**		
CMF 1 - Add additional signal and upgrade to 12-inch lenses	$200,000.00		$20,000.00	$40,000.00	**$260,000.00**		
CMF 2 - Add 3-inch yellow retroreflective sheeting to signal backplates			$0.00	$0.00	**$0.00**		
CMF 3 - Modify change plus clearance interval to ITE 1985 Proposed Recommended Practice (4-leg signalized)			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
Totals	**$200,000.00**	**$0.00**	**$20,000.00**	**$40,000.00**	**$260,000.00**	**$0.00**	**$0.00**

Inflation %	

Final Costruction Cost:	**$260,000.00**

*Final construction cost should match the Project Cost Estimate

Project Cost Estimate

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Engineering Design %	10%
Contingency %	20%

Countermeasures	Construction Costs	Right of Way Costs	Engineering Design Costs	Contingency Amount	Total Cost of Countermeasure	Annual Maintenance & Energy Costs	Salvage Value
Site Characteristic Improvements (i.e. Lane widening)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Lighting)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Signal Phasing)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Added Right Turn Lane)			$0.00	$0.00	**$0.00**		
CMF 1 - Introducing zero or positive offset left-turn lane on crossing roadway (Signalized Only)	$25,000.00		$2,500.00	$5,000.00	**$32,500.00**		
CMF 2 - Coordinate arterial signals	$100,000.00		$10,000.00	$20,000.00	**$130,000.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
Totals	**$125,000.00**	**$0.00**	**$12,500.00**	**$25,000.00**	**$162,500.00**	**$0.00**	**$0.00**

Inflation %	

Final Costruction Cost:	**$162,500.00**

*Final construction cost should match the Project Cost Estimate

Project Cost Estimate

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Engineering Design %	10%
Contingency %	20%

Countermeasures	Construction Costs	Right of Way Costs	Engineering Design Costs	Contingency Amount	Total Cost of Countermeasure	Annual Maintenance & Energy Costs	Salvage Value
Site Characteristic Improvements (i.e. Lane widening)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Lighting)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Signal Phasing)			$0.00	$0.00	**$0.00**		
Site Characteristic Improvements (i.e. Added Right Turn Lane)			$0.00	$0.00	**$0.00**		
CMF 1 - Change intersection skew angle	$2,000,000.00	$200,000.00	$220,000.00	$440,000.00	**$2,860,000.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
			$0.00	$0.00	**$0.00**		
Totals	**$2,000,000.00**	**$200,000.00**	**$220,000.00**	**$440,000.00**	**$2,860,000.00**	**$0.00**	**$0.00**

Inflation %	

Final Costruction Cost:	**$2,860,000.00**

*Final construction cost should match the Project Cost Estimate

Appendix F
Cost Benefit Analysis

Safety Benefit - Cost Analysis

ECAT Economic Crash Analysis Tool

General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Select Site Types to be used in Benefit-Cost Analysis:

All Sites

Comments:

Countermeasure Service Lives, Costs, and Safety Benefits

Countermeasures	Service Life (Years)	Initial Cost of Countermeasure	Annual Maintenance & Energy Costs	Salvage Value	Net Present Cost of Countermeasure	Total Cost of Countermeasures	Summary of Annual Crash Modifications	Net Present Value of Safety Benefits
Site Characteristic Improvements (i.e. Lane widening)		$0.00			$0.00	$0.00	-0.556	$219,084
Site Characteristic Improvements (i.e. Lighting)		$0.00			$0.00	$0.00		
Site Characteristic Improvements (i.e. Signal Phasing)		$0.00			$0.00	$0.00		
Site Characteristic Improvements (i.e. Added Right Turn Lane)		$0.00			$0.00	$0.00		
CMF 1 - Add additional signal and upgrade to 12-inch lenses	20	$260,000.00			$260,000.00	$260,000.00	-1.503	$595,516
CMF 2 - Add 3-inch yellow retroreflective sheeting to signal backplates	20	$0.00			$0.00	$0.00	-1.101	$436,157
CMF 3 - Modify change plus clearance interval to ITE 1985 Proposed Recommended Practice (4-leg signalized)	5	$0.00			$0.00	$0.00	0.119	$71,385
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
Totals		**$260,000.00**	**$0.00**	**$0.00**	**$260,000.00**	**$260,000.00**	**-3.041**	**$1,322,142**

Safety Benefit - Cost Analysis

ECAT Economic Crash Analysis Tool

General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Benefit - Cost Calculator

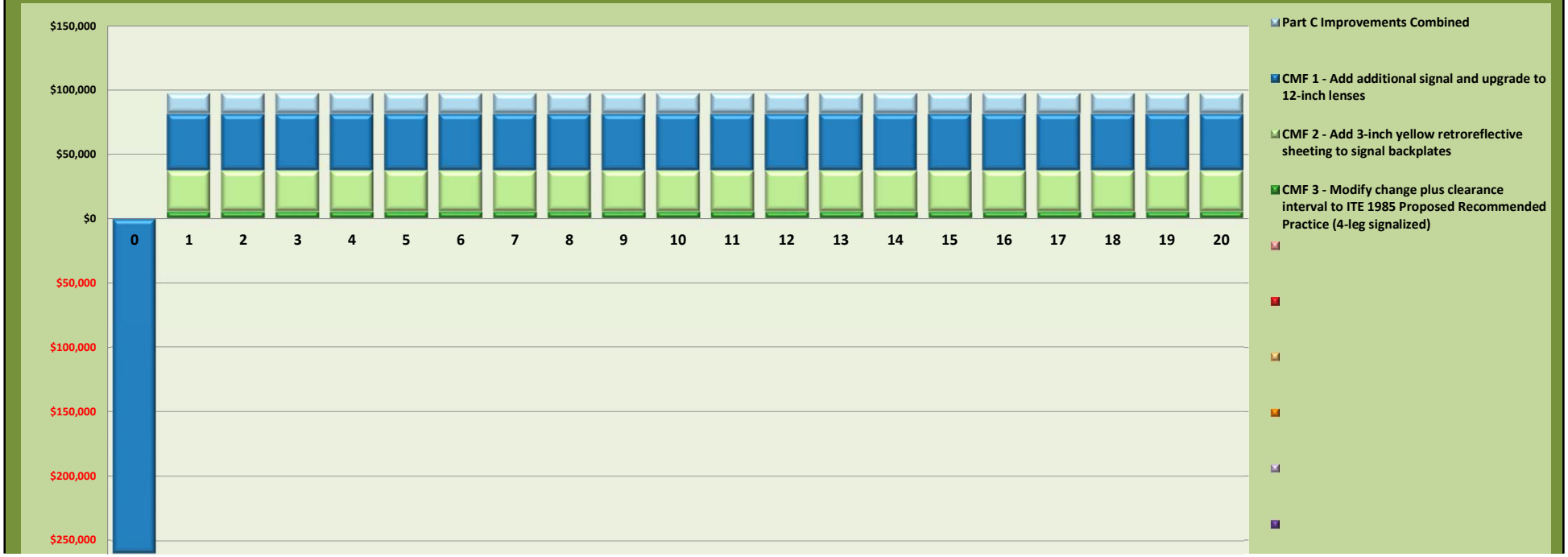
Net Present Value of Project	$260,000.00
Net Present Value of Safety Benefits	$1,322,141.74
Net Benefit	$1,062,141.74
Benefit / Cost Ratio	5.09

Expected Annual Crash Adjustment

Number of Fatal & Incapacitating Injury Crashes	-0.086
Number of Injury Crashes	-0.939
Number of Total Crashes	-3.041

Comments:

Safety Benefits and Project Costs Combined Cash Flows By Countermeasure Per Year



Safety Benefit - Cost Analysis

ECAT Economic Crash Analysis Tool

General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Safety Benefit - Cost Analysis

General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Project Costs Only Cash Flows By Countermeasure Per Year

Return on Investment (Safety Benefits and Project Investments)

First year to observe a positive return on investiment: Unknown (3 years)

Percentage of Service Life to observe a continuous Positive Return on Investment: 90.00%

Safety Benefit - Cost Analysis

ECAT Economic Crash Analysis Tool

General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Select Site Types to be used in Benefit-Cost Analysis:

All Sites

Comments:

Countermeasure Service Lives, Costs, and Safety Benefits

Countermeasures	Service Life (Years)	Initial Cost of Countermeasure	Annual Maintenance & Energy Costs	Salvage Value	Net Present Cost of Countermeasure	Total Cost of Countermeasures	Summary of Annual Crash Modifications	Net Present Value of Safety Benefits
Site Characteristic Improvements (i.e. Lane widening)		$0.00			$0.00	$0.00	0.514	($202,912)
Site Characteristic Improvements (i.e. Lighting)		$0.00			$0.00	$0.00		
Site Characteristic Improvements (i.e. Signal Phasing)		$0.00			$0.00	$0.00		
Site Characteristic Improvements (i.e. Added Right Turn Lane)		$0.00			$0.00	$0.00		
CMF 1 - Introducing zero or positive offset left-turn lane on crossing roadway (Signalized Only)	20	$32,500.00			$32,500.00	$32,500.00	-1.685	$667,329
CMF 2 - Coordinate arterial signals	20	$130,000.00			$130,000.00	$130,000.00	-1.728	$684,233
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
Totals		**$162,500.00**	**$0.00**	**$0.00**	**$162,500.00**	**$162,500.00**	**-2.899**	**$1,148,650**

Safety Benefit - Cost Analysis

General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Benefit - Cost Calculator

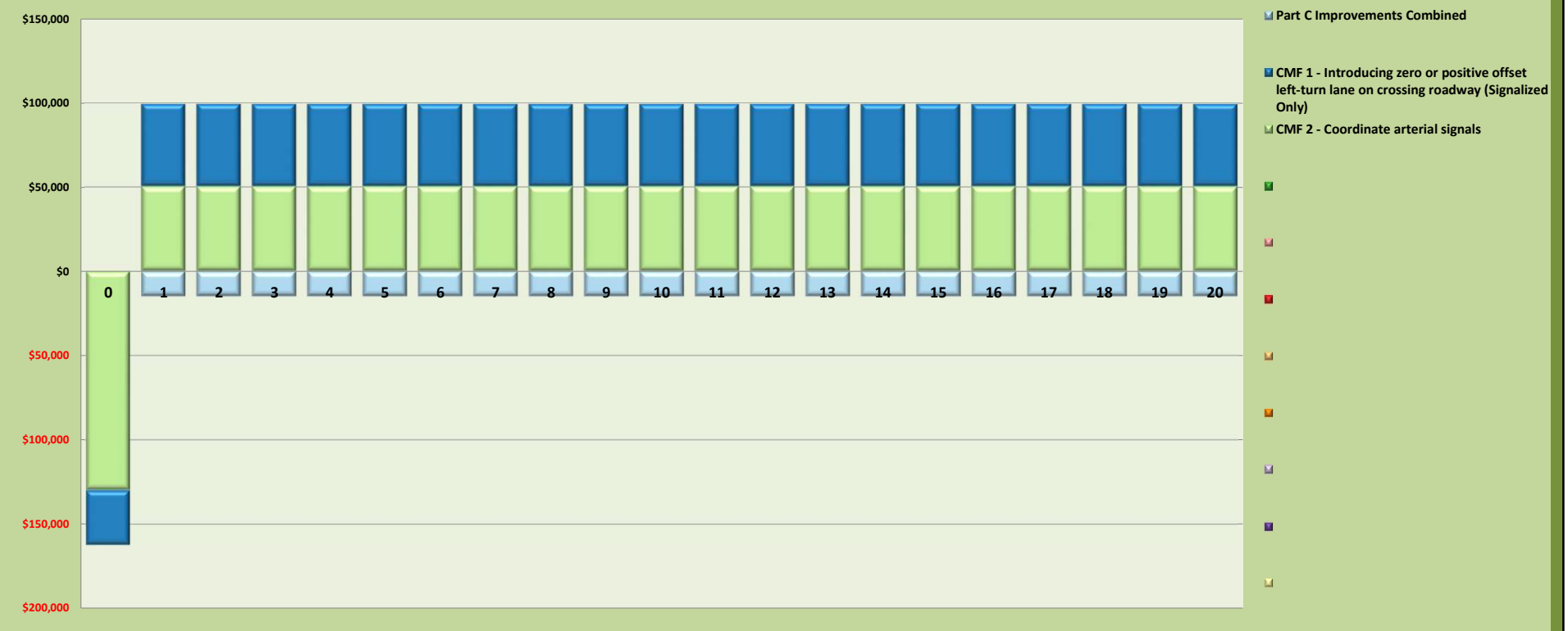
Net Present Value of Project	$162,500.00
Net Present Value of Safety Benefits	$1,148,649.65
Net Benefit	$986,149.65
Benefit / Cost Ratio	7.07

Expected Annual Crash Adjustment

Number of Fatal & Incapacitating Injury Crashes	-0.068
Number of Injury Crashes	-0.824
Number of Total Crashes	-2.899

Comments:

Safety Benefits and Project Costs Combined Cash Flows By Countermeasure Per Year

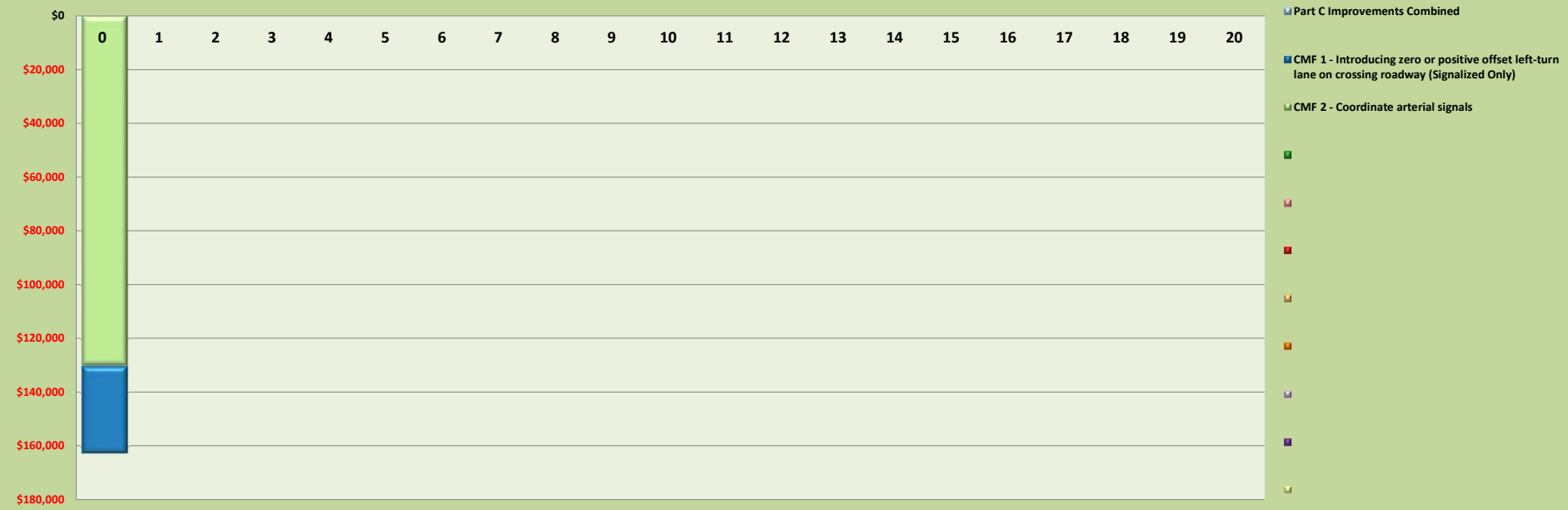


Safety Benefit - Cost Analysis

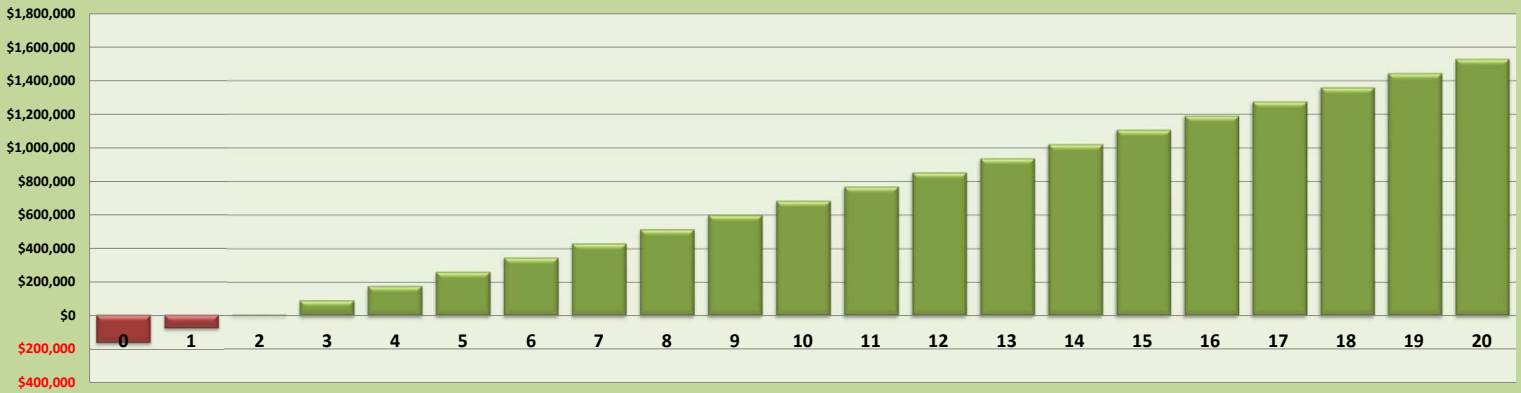
General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Project Costs Only Cash Flows By Countermeasure Per Year



Return on Investment (Safety Benefits and Project Investments)



First year to observe a positive return on investiment: Unknown (2 years)

Percentage of Service Life to observe a continuous Positive Return on Investment: 95.00%

Safety Benefit - Cost Analysis

General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Select Site Types to be used in Benefit-Cost Analysis:

All Sites

Comments:

Countermeasure Service Lives, Costs, and Safety Benefits

Countermeasures	Service Life (Years)	Initial Cost of Countermeasure	Annual Maintenance & Energy Costs	Salvage Value	Net Present Cost of Countermeasure	Total Cost of Countermeasures	Summary of Annual Crash Modifications	Net Present Value of Safety Benefits
Site Characteristic Improvements (i.e. Lane widening)		$0.00			$0.00	$0.00	0.816	($409,171)
Site Characteristic Improvements (i.e. Lighting)		$0.00			$0.00	$0.00		
Site Characteristic Improvements (i.e. Signal Phasing)		$0.00			$0.00	$0.00		
Site Characteristic Improvements (i.e. Added Right Turn Lane)		$0.00			$0.00	$0.00		
CMF 1 - Change intersection skew angle	30	$2,860,000.00			$2,860,000.00	$2,860,000.00	-1.634	$823,356
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
		$0.00			$0.00	$0.00	0.000	$0
Totals		**$2,860,000.00**	**$0.00**	**$0.00**	**$2,860,000.00**	**$2,860,000.00**	**-0.818**	**$414,185**

Safety Benefit - Cost Analysis

General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Benefit - Cost Calculator

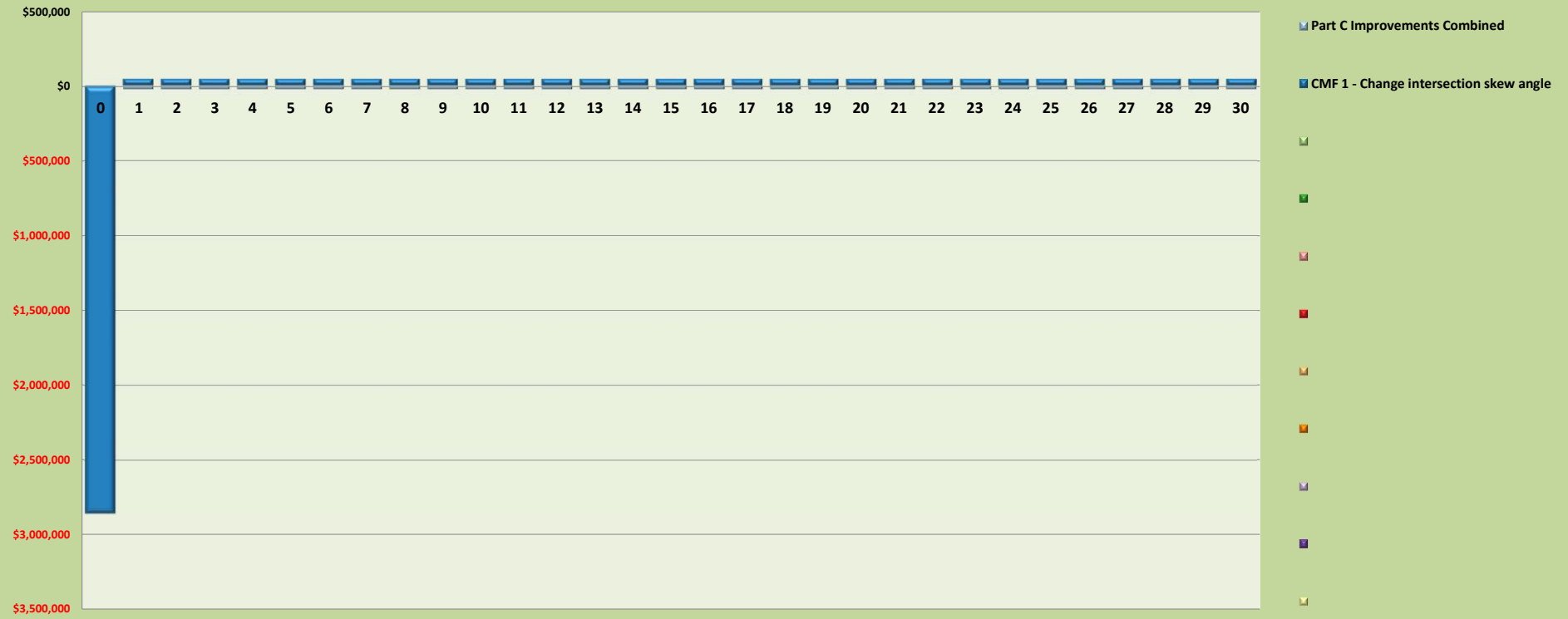
Net Present Value of Project	$2,860,000.00
Net Present Value of Safety Benefits	$414,185.09
Net Benefit	($2,445,814.91)
Benefit / Cost Ratio	0.14

Expected Annual Crash Adjustment

Number of Fatal & Incapacitating Injury Crashes	-0.019
Number of Injury Crashes	-0.233
Number of Total Crashes	-0.818

Comments:

Safety Benefits and Project Costs Combined Cash Flows By Countermeasure Per Year



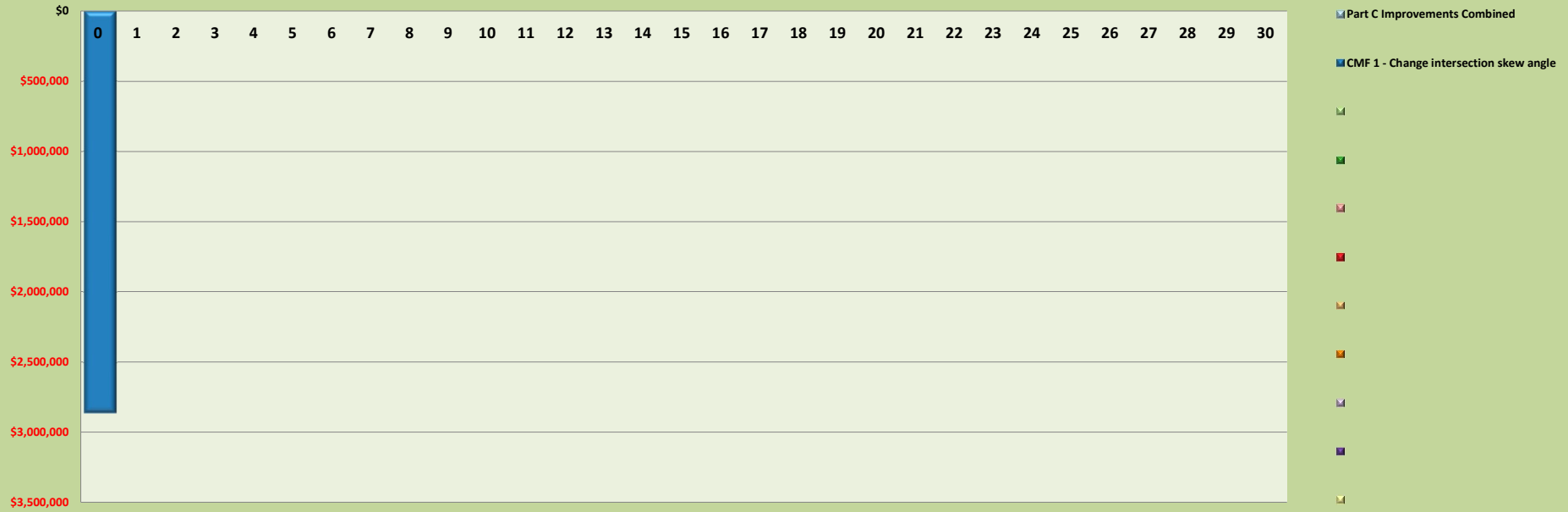
Safety Benefit - Cost Analysis

ECAT Economic Crash Analysis Tool

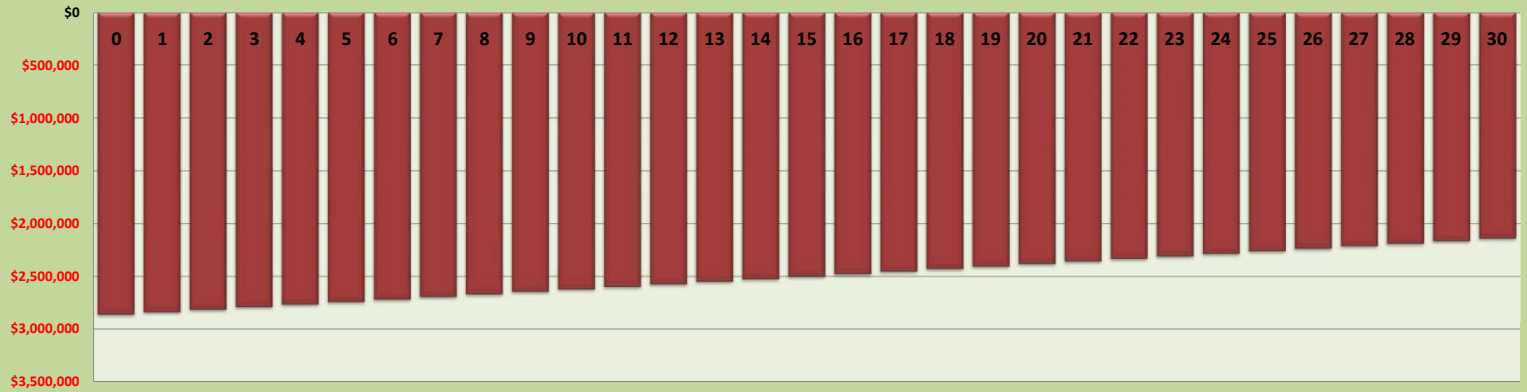
General Information

Project Name	STW Safety Design	Contact Email	
Project Description	SR 58 and Tower Blvd Safety Study	Contact Phone	
Reference Number	112342	Date Performed	2.12.2021
Analyst	Keegan Anderson	Analysis Year	2017-2019
Agency/Company	Woolpert, Inc.		

Project Costs Only Cash Flows By Countermeasure Per Year



Return on Investment (Safety Benefits and Project Investments)



First year to observe a positive return on investiment: Unknown (31 years)

Percentage of Service Life to observe a continuous Positive Return on Investment: 00.00%