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February 2009
TEC PN – 08095-001

Intersection Safety Study
Milford Parkway & Chamber Drive
Milford, Ohio

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INTERSECTION SAFETY STUDY

Milford Parkway & Chamber Drive/River's Edge Road
Clermont County, Ohio

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I. EXECUTIVE SUMMARY

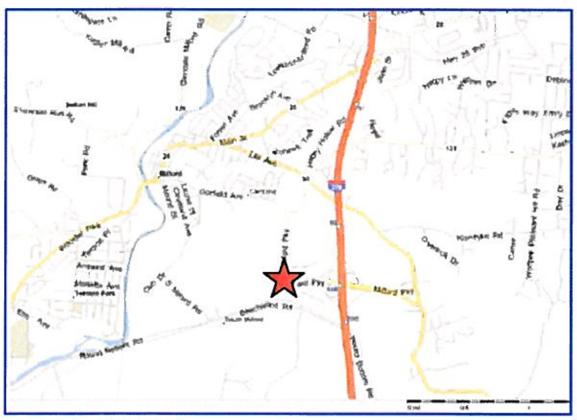
A. Purpose

The intersection of Milford Parkway and Chamber Drive/Rivers Edge Road had highest accident total in the City of Milford between 2005-2007. As a result, TEC Engineering, Inc. was retained to conduct a safety study of this intersection. The purpose of this study is to analyze the crashes and propose feasible countermeasures that will effectively reduce these crashes. This intersection was studied as part of a traffic impact study, completed by TEC Engineering, Inc. in 2008. The improvements recommended in that traffic impact study will be evaluated in this study.

B. Background

Milford Parkway is a major route connecting I-275 to the City of Milford. This intersection is a signalized intersection and is also the connection from I-275 to large shopping centers on either side of Milford Parkway. ***Figure 1*** shows a vicinity map and aerial photograph of the intersection.

Figure 1: Vicinity Map and Aerial Photograph



C. Crash Data and Analysis

This intersection was the location of 62 crashes during the most recent three year period (2005-2007). Four (4) of these accidents resulted in injury. There were no fatal accidents. The crash information provided was analyzed, and together with data gathered from traffic counts and field observations, used to determine potential safety issues at Milford Parkway and Chamber Drive. These safety issues are listed below:

- Driver Inattentiveness
- Excess Speeds
- Inadequate Signage
- Inadequate Storage Lanes

D. Recommended Countermeasures and Costs

Countermeasures were proposed to alleviate some of the safety issues listed above. These countermeasures are listed below:

- Review clearance intervals (Short Term)
- Install additional lane use signs-EB Chamber, NB Milford Parkway
- (Short Term)
- Review Speed limit sign location on NB Milford Parkway (Short Term)
- Install a "Prepare to stop when flashing" sign for EB Chamber Drive (Short Term)
- Restripe the WB approach to lengthen turn lane to recommended length (Short Term)

E. Rate of Return

The rate of return is a value used to quantify the benefits expected due to the implementation of improvements. The table below shows the rates of return for the proposed countermeasures.

Recommendation	Cost	ROR
Short Term Recommendations	$23,780	365%

II. EXISTING CONDITIONS

The intersection of Milford Parkway and Chamber Drive/River's Edge Road is located in the City of Milford in Clermont County, Ohio. The speed limit on Milford Parkway is 35 mph. The speed limit on Chamber Drive and River's Edge Road is 25 mph. Milford Parkway is categorized as an Urban Minor Arterial. Chamber Drive and River's Edge Road are local roads. Milford Parkway is a north/south road at this intersection and connects I-275 to the City of Milford. The ADT (Average Daily Traffic) at the intersection is 24,078 vehicles/day.

All approaches have both left and right turn lanes with northbound dual left turn lanes and eastbound dual right turn lanes. The pavement markings and signage near the intersection are in good condition. ***Figure 2*** shows the existing lane configuration. Intersection pictures are provided in ***Appendix A***.

A speed analysis was conducted at the intersection. On Chamber Drive, the average speed is 27.2 mph. The 85^{th} percentile speed is 32.3 mph. This is slightly higher than the posted speed limit of 25 mph. On River's Edge the average speed is 31 mph and the 85^{th} percentile speed is 36.2 mph. On northbound Milford Parkway, the average speed is 39.5 mph and the 85^{th} percentile speed is 44.4 mph, which is well above the 35 mph speed limit. Nearly 80% of the vehicles were traveling over the speed limit. The average speed for southbound vehicles is 32.8 mph and the 85^{th} percentile is 39.7 mph.

There is currently a plan to develop the outlets on the east side of Chamber Drive, across from the existing Wal-Mart development. The additional volumes predicted for this development have been taken into account in the capacity analysis portion of this study.

Figure 3 shows the existing peak hour turning movement volumes at the intersection. Full traffic count data is provided in ***Appendix B***.

Figure 2: Existing Conditions

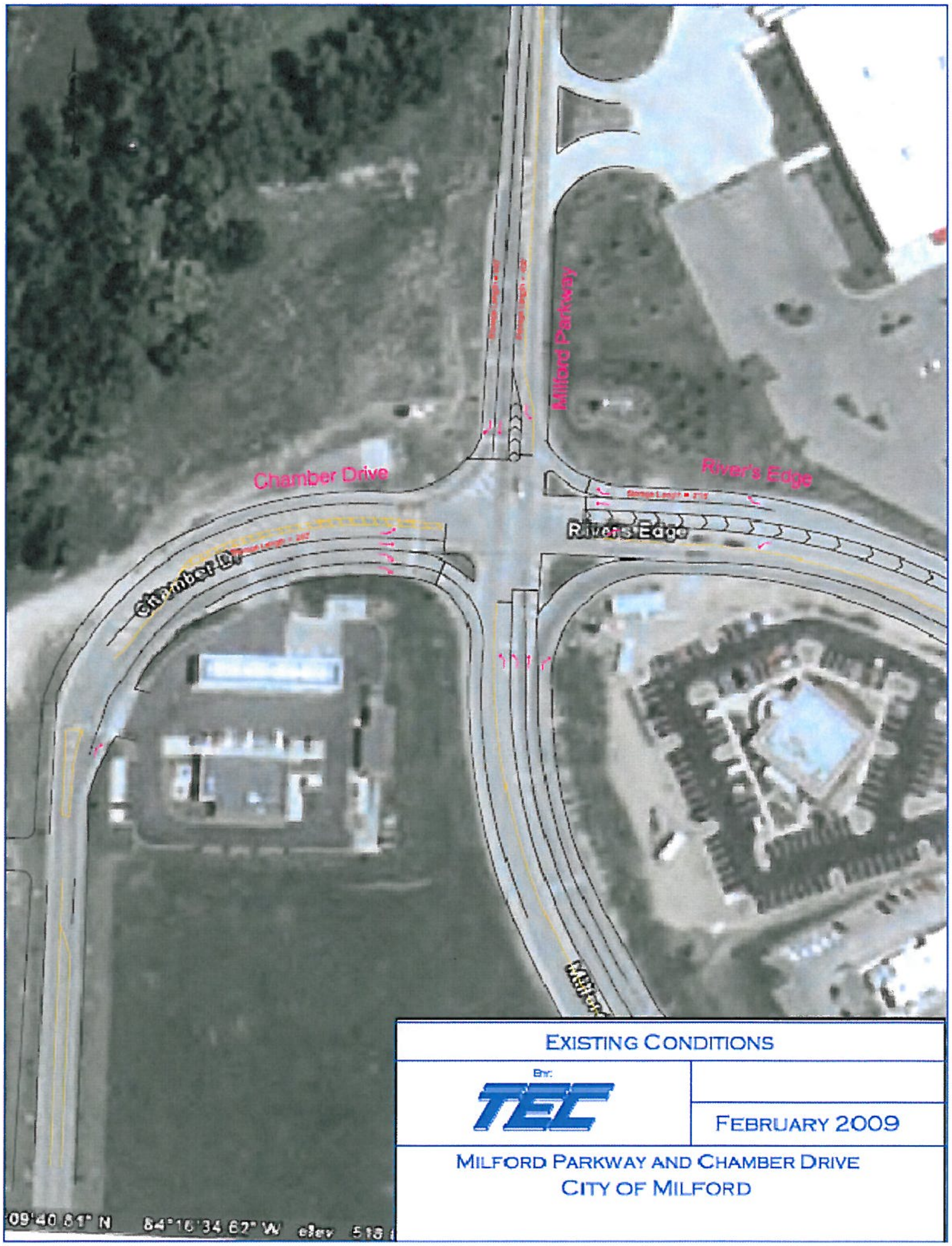
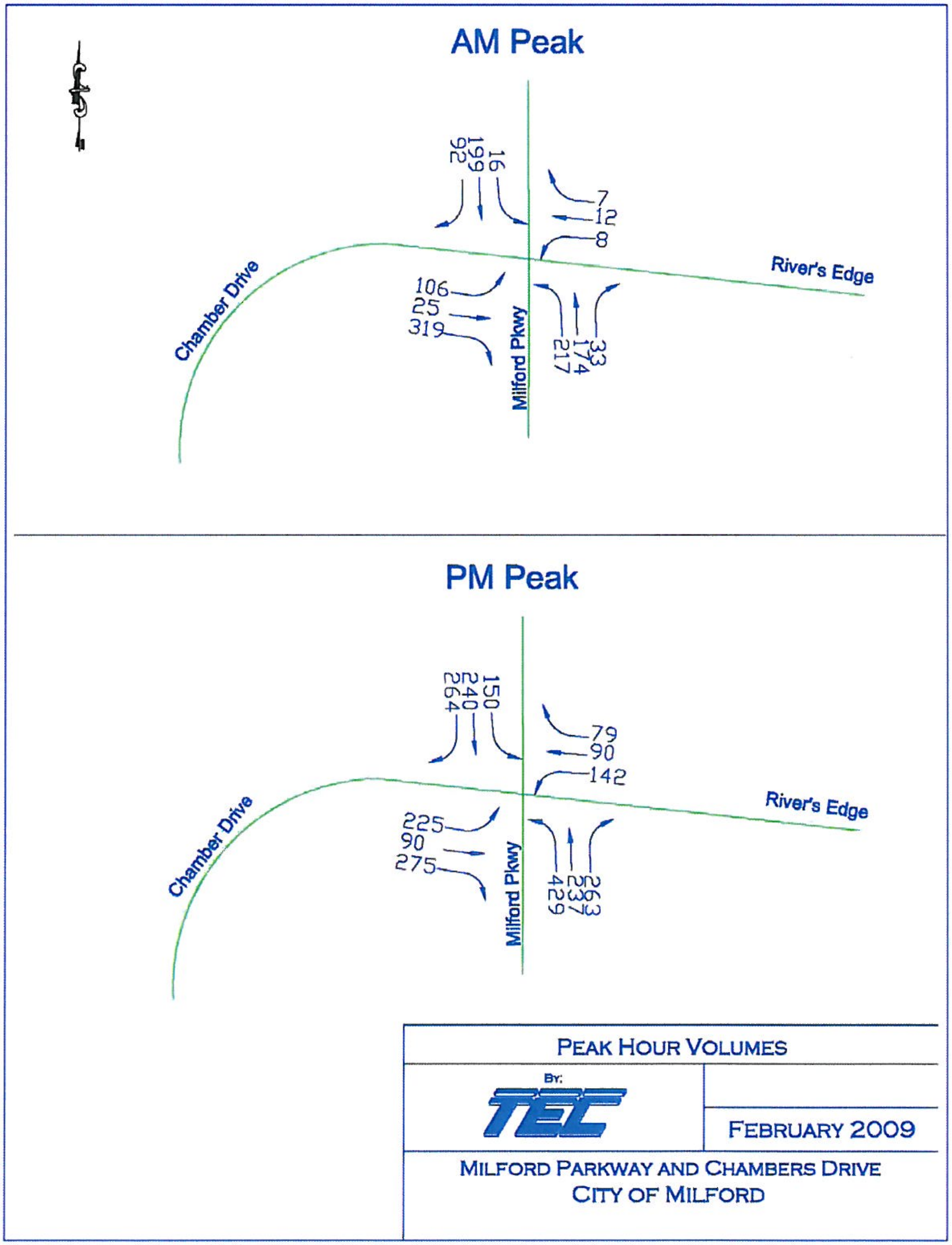


Figure 3: Peak Hour Volumes



III. CRASH DATA

A. Crash Report Summary

Crash data are the most important element of a safety study. The data can reveal crash patterns, which in turn can indicate safety problems. Without complete and accurate crash data, all analyses and recommendations are limited in value. Crash reports were obtained from the City of Milford.

The crash reports were grouped using several different criteria, including crash type, severity and environmental conditions among others. Collision diagrams were created to provide a visual depiction of the accidents. The crash summaries are provided in ***Figure 4*** and the collision diagrams are shown in ***Figure 5***. More comprehensive crash data is presented in ***Appendix C***.

B. Crash Data

ODOT has established a Highway Safety Program (HSP) that emphasizes safety in all phases of highway development. The HSP establishes procedures for project evaluation and statewide prioritization. The criteria used for scoring projects and determining prioritization are based on a point system corresponding to assigned value ranges. These statistics are generated from data collected over the most recent consecutive three year period. Data for the roadway section studied is listed below in ***Table 1***.

Table 1: Crash Statistics for Intersection from 2005-2007

Intersection	Crash Frequency	Crash Rate	RSI	EPDO Rate	Truck Percentage
Milford Parkway & Chamber Dr.	62	2.35	26050	3.03	2

The *crash frequency* is simply the total number of crashes for a given intersection or roadway segment during the three year study period.

The *crash rate* takes into consideration traffic counts to recognize the exposure of each location. For an intersection, the crash rate is the number of crashes at that intersection per one million entering vehicles. The crash rate for a roadway segment is the number of crashes along that segment per one million vehicle miles traveled.

The *Relative Severity Index (RSI)* represents the relative cost to society of a specific crash type. The RSI is the sum of the relative costs per crash divided by the total number of crashes. The costs associated with specific crash types were determined by ODOT and can be seen in the rate of return worksheets (***Figures 6A-E***).

The *Equivalent Property Damage Only (EPDO) Rate* weights crashes by property damage only, injury and fatality. The crashes are weighted as follows:

> *EPDO Rate = (# of PDO crashes * 1) + (# of injury crashes * 5.50) + (# of fatal crashes * 90.14)*

The EPDO Rate is then calculated by taking the EPDO value per one million entering vehicles for intersections or the EPDO value per one million vehicle miles for roadway segments.

Figure 4: Crash Summaries

CRASH SUMMARY

Crash Data					
Three Year Total	62	PDO	58	Truck %	2%
Annual Average	20.67	Injury	4	Fatal	
ADT (vpd)	24078	RSI	26050	EPDO Rate	3.03
Crash Rate (acc/MEV)	2.35	Seg Length (m)		ΔChange	1.10

	Freeway
√	Non-Freeway
√	Urban
	Rural
√	Spot Location
	Roadway Segment

Crash Type													
Description				1			2			Total			
	Total	Injury	Fatal	Total	Injury	Fatal	Total	Injury	Fatal	Total	%	Injury	Fatal
Not Stated													
Head On	1			1			1			3	5%		
Rear End	6			13	1		6			25	40%	1	
Backing				1			2			3	5%		
Sideswipe Meeting / Left-Turn													
Sideswipe Passing	3			4			5			12	19%		
Angle	5			2	1		7	1		14	23%	2	
Parked Vehicle													
Pedestrian													
Animal							1			1	2%		
Train													
Pedacycles													
Other Non Vehicle													
Fixed Object	1			1			1			3	5%		
Other Object													
NA													
Overturning													
Other Non Collision				1	1					1	2%	1	
Grand Total	16			23	3		23	1		62	100%	4	

Red Text-Crash Types Not Shown in table "Crash Analysis" spreadsheet

Light Conditions													
Description				1			2			Total			
	Total	Injury	Fatal	Total	Injury	Fatal	Total	Injury	Fatal	Total	%	Injury	Fatal
1 Daylight	8			20	2		14			42	68%	2	
2 Dawn													
3 Dusk	1									1	2%		
4-6 Dark	6			3	1		9	1		18	29%	2	
7 Glare													
8 Other													
9 Unknown	1									1	2%		
Grand Total	16			23	3		23	1		62	100%	4	

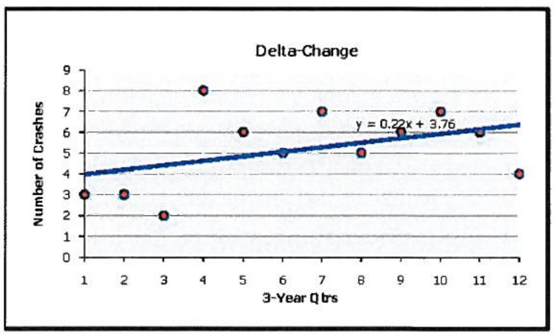
Road Conditions													
Description				1			2			Total			
	Total	Injury	Fatal	Total	Injury	Fatal	Total	Injury	Fatal	Total	%	Injury	Fatal
01 Dry	12			19	2		21	1		52	84%	3	
02 Wet	4			2			2			8	13%		
03 Snow													
04 Ice				1						1	2%		
05 Sand, Mud, Etc.				1	1					1	2%	1	
06 Water													
07 Slush													
08 Debris													
09 Rut, Holes, Etc.													
10 Other													
11 Unknown													
Grand Total	16			23	3		23	1		62	100%	4	

Weather													
Description				1			2			Total			
	Total	Injury	Fatal	Total	Injury	Fatal	Total	Injury	Fatal	Total	%	Injury	Fatal
01 Clear	8			20	3		21	1		49	79%	4	
02 Cloudy	4			1						5	8%		
03 Fog, Smog, Smoke													
04 Rain	2			2			2			6	10%		
05 Sleet, Hail													
06 Snow	1									1	2%		
07 Severe Crosswinds													
08 Blowing Soil, Sand, Dirt													
09 Other													
10 Unknown	1									1	2%		
Grand Total	16			23	3		23	1		62	100%	4	

CRASH SUMMARY

Direction (At Fault)													
Description				1			2			Total			
	From	To	I/F (From)	From	To	I/F (From)	From	To	I/F (From)	From	To	% From	I/F (From)
1 North	6	7		4	10		7	7	1	17	24	33%	1
2 South	4	7		11	6	2	6	6		21	19	32%	2
3 East	1	2			5		6	6		7	13	16%	
4 West	5			8	2	1	4	4		17	6	19%	1
5 Northeast													
6 Northwest													
7 Southeast													
8 Southwest													
9 Unknown													
Grand Total	16	16		23	23	3	23	23	1	62	62	100%	4

Direction (Not At Fault)													
Description				1			2			Total			
	From	To	I/F (From)	From	To	I/F (From)	From	To	I/F (From)	From	To	% From	I/F (From)
1 North	2	4		5	7		4	5		11	16	22%	
2 South	4	5		8	6	1	5	4	1	17	15	26%	2
3 East	4	3		1	6		5	6		10	15	20%	
4 West	4	2		7	2	1	7	6		18	10	23%	1
5 Northeast													
6 Northwest													
7 Southeast													
8 Southwest													
9 Unknown	1	1								1	1	2%	
Grand Total	15	15		21	21	2	21	21	1	57	57	100%	3



Delta Change			
	1	2	Quarter
3	6	6	1
3	5	7	2
2	7	6	3
8	5	4	4
1.400	-0.100	-0.700	ΔYear
	1.100		ΔChange

CRASH SUMMARY

Contributing Factor (At-Fault)								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
01 None (Motorist)	2	13%			1	4%	3	5%
02 Failure to Yield	5	31%	4	17%	5	22%	14	23%
03 Ran Red Light, or Stop Sign	1	6%			2	9%	3	5%
04 Exceeded Speed Limit								
05 Unsafe Speed								
06 Improper Turn			3	13%			3	5%
07 Left of Center								
08 Followed Too Closely	6	38%	11	48%	5	22%	22	35%
09 Improper Lane Change/Passing/Off Road			2	9%	1	4%	3	5%
10 Improper Backing			1	4%	2	9%	3	5%
11 Improper Start from Parked Position								
12 Stopped or Parked Illegally								
13 Erratic/Negligent Driving								
14 Swerving to Avoid			1	4%			1	2%
15 Failure to Control	1	6%			1	4%	2	3%
16 Vision Obstruction								
17 Driver Inattentiveness			1	4%	1	4%	2	3%
18 Fatigue/Asleep								
19 Operating Defective Equipment								
20 Load Shifting/Falling/Spilling								
21 Other Improper Action					1	4%	1	2%
22 Unknown (M)	1	6%			4	17%	5	8%
23 None (N-M)								
24 Improper Crossing (N-M)								
25 Darting (N-M)								
26 Lying and/or Illegally in Roadway (N-M)								
27 Failure to Yield Right of Way (N-M)								
28 Not Visible (N-M)								
29 Inattentive (N-M)								
30 Failure to Obey Signs, Signals, Etc. (N-M)								
31 Wrong Side of the Road (N-M)								
32 Other (N-M)								
33 Unknown (N-M)								
Totals	16	26%	23	37%	23	37%	62	

Pre-Crash Actions (At-Fault)								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
01 Straight Ahead	7	44%	13	57%	9	39%	29	47%
02 Backing			1	4%	2	9%	3	5%
03 Changing Lanes	1	6%	2	9%	1	4%	4	6%
04 Passing								
05 Turning Right	1	6%	3	13%	4	17%	8	13%
06 Turning Left	7	44%	3	13%	5	22%	15	24%
07 Making U-Turn								
08 Entering Lane			1	4%	1	4%	2	3%
09 Leaving Lane								
10 Parked								
11 Slowing/Stopped					1	4%	1	2%
12 Driverless								
13 Other								
14 Unknown								
15 Enter/Cross (N-M)								
16 Walking, Running (N-M)								
17 Working (N-M)								
18 Pushing Vehicle (N-M)								
19 App/Leave Veh (N-M)								
20 Play/Work On Veh (N-M)								
21 Standing (N-M)								
22 Other (N-M)								
23 Unknown (N-M)								
Totals	16	26%	23	37%	23	37%	62	

CRASH SUMMARY

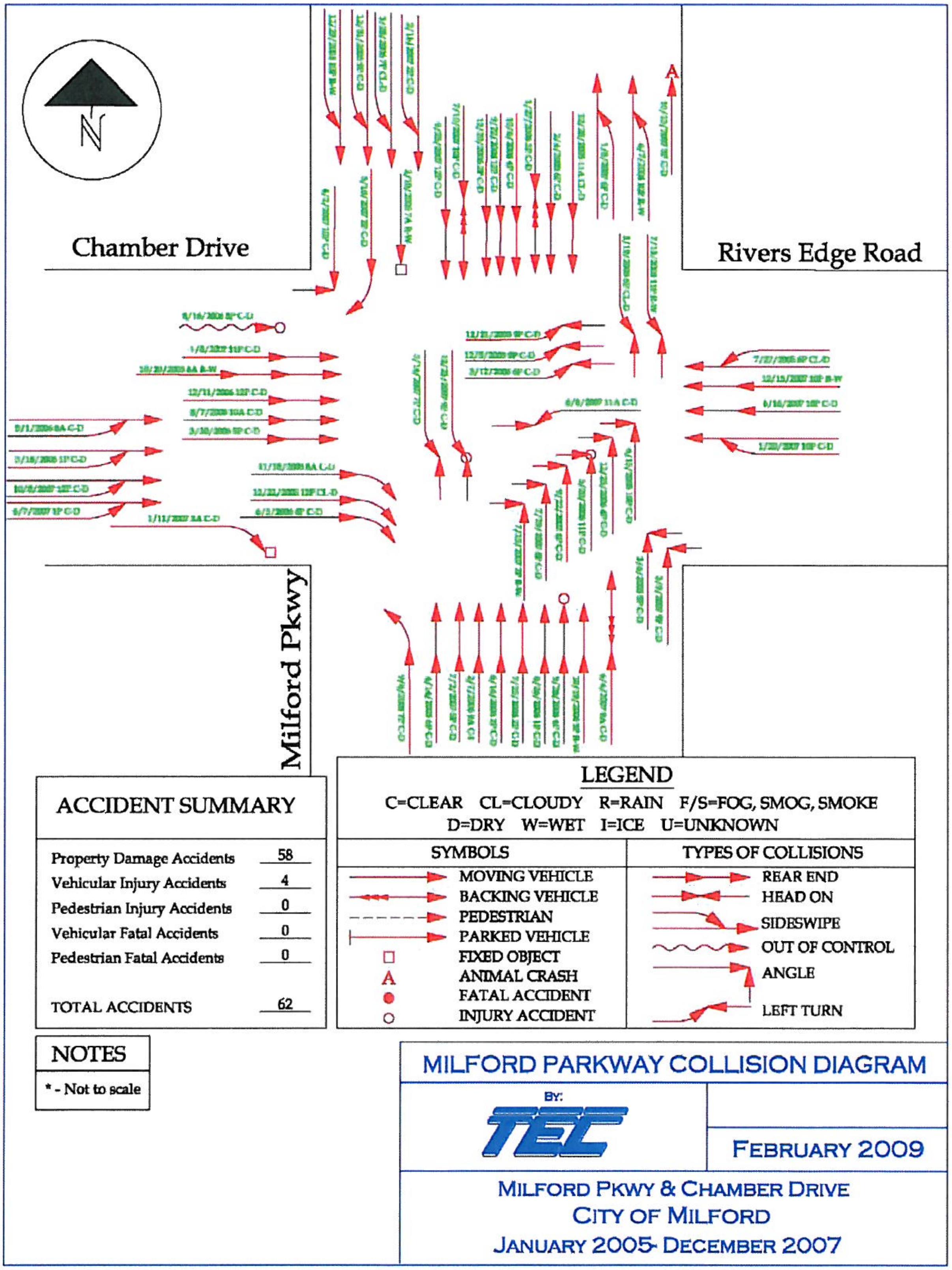
Vehicle Types								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
Trucks			2	5%	3	7%	5	4%
Other	33	100%	42	95%	41	93%	116	96%
Totals	33	27%	44	36%	44	36%	121	

Alcohol/Drug Suspected								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
1 None	14	21%	23	27%	22	26%	59	25%
2-5 Yes								
6 Unknown	2	3%			1	1%	3	1%
Totals	16	26%	23	37%	23	37%	62	

Driver Age								
Description			1		2		Total	
	#	%	#	%	#	%	#	%
<20			4	9%	11	25%	15	13%
20-24	5	16%	2	5%	3	7%	10	8%
25-65	23	74%	38	86%	25	57%	86	72%
>65	1	3%			3	7%	4	3%
NA	2	6%			2	5%	4	3%
Totals	31	26%	44	37%	44	37%	119	

Relative Severity Index (RSI)					
Description	Total	RSI-Urban	Sum of Products	Freeway	Non-Freeway
Not Stated		14798			
Head On	3	41327	123981		
Rear End	25	22568	564200		
Backing	3	31039	93117		
Sideswipe Meeting / Left-Turn		27145			√
Sideswipe Passing	12	29480	353760	Urban	Rural
Angle	14	25684	359576		
Parked Vehicle		24586			
Pedestrian		67346			
Animal	1	16606	16606		
Train		76658			
Pedacycles		40457		√	
Other Non Vehicle		45378		Spot Location	Roadway Segment
Fixed Object	3	26320	78960		
Other Object		26016			
NA					
Overturning		40709			
Other Non Collision	1	24882	24882		
Grand Total	62	26050	1615082	√	

Figure 5: Collision Diagrams



IV. CRASH ANALYSIS

A. Overview

The raw crash data for the years 2005 through 2007 were analyzed to identify patterns and possible safety deficiencies at the intersection. During this period, a total of 62 crashes occurred at this intersection, with 4 of these crashes resulting in injuries.

The predominant crash type along this section during the study years was rear end. Forty percent (40%) of the accidents were rear end accidents. The other accident types included Angle (23%), Sideswipe/passing (19%), Fixed Object (5%), Head-on (5%), Backing (5%), Animal (2%) and Other/Non-collision (2%).

Most frequently the contributing circumstance resulting in crashes at the intersection was following too closely, but failure to yield was also a contributing circumstance that resulted in a number of the crashes.

B. Possible Causes

The most prevalent crash type at this intersection is rear end crashes. Possible causes for rear end crashes include driver inattentiveness and signal timing problems and excess speed. Poor visibility, especially around the curve on Chamber Drive can also be a factor in these crashes.

The second highest crash type is angle or left turn accidents. These accidents are often caused by drivers running red lights. This can be attributed to insufficient clearance intervals and/or excess speeds.

There is also a high number of sideswipe/passing accidents. These accidents can occur when there is inadequate lane use signage. Drivers switch lanes suddenly when they realize they need to be in a different lane. Sideswipe/passing accidents can also be attributed to inadequate storage lanes. With inadequate storage space drivers can stack in the thru lane which forces thru vehicles to go around them.

C. Capacity Analysis

The software program *Synchro* was used to analyze capacity at the intersection. *Synchro* uses the methods prescribed in the *Highway Capacity Manual (HCM)* to determine the level of service (LOS). LOS is defined in terms of delay and is a measure of driver discomfort and intersection performance with respect to vehicular capacity and quality of service provided to road users. Delay refers to total average stopped delay experienced by motorists at the referenced intersection. For both signalized intersections the level of service has six classifications ranging from A to F. These classifications are shown in ***Table 2.***

Table 2: LOS at Signalized Intersections

Level of Service	Description	Delay (seconds per vehicle)
A	Very low delay	<10
B	Good progression	10-20
C	Limit of acceptable delay	20-35
D	Start of traffic breakdown	35-55
E	High delay	55-80
F	Congested conditions, unacceptable delay	>80

A capacity analysis was performed for both the AM and PM peak hours to compare the LOS for existing conditions against the LOS with proposed countermeasures along the corridor. Volumes were obtained from peak hour turning movement counts conducted by TEC Engineering. The proposed countermeasures are discussed in detail in *Section V, Recommended Countermeasures and Costs*. A summary of the results of the capacity analysis is shown in ***Table 3*** below. The complete *Synchro* output is presented in ***Appendix D***.

Table 3: Peak Hour LOS and Delay

Intersection	Scenario	Peak Hour	Approach LOS/Delay				Intersection LOS/Delay
			NB	SB	EB	WB	
Milford Parkway & Chamber Drive/River's Edge Road	Existing	AM	B/16.8 s	B/11.9 s	C/21.3 s	C/26.5 s	B/17.5 s
		PM	C/25.3 s	C/19.5 s	C/23.3 s	C/29.3 s	C/28.3 s
	With Out lots developed	AM	B/19.8 s	B/13.6 s	C/23.2 s	C/29.2 s	B/19.8 s
		PM	C/32.5 s	C/23.3 s	C/24.8 s	C/33.8 s	C/28.2 s

Capacity does not seem to be a problem at this intersection. The Levels of Service are acceptable for all approaches during the AM and PM Peak hours.

D. Turn Lane Analysis

There are existing turn lanes on all approaches at this intersection, therefore Turn Lane Warrants were not completed. Several of the existing turn lanes do not meet the design standards set forth in the Ohio Department of Transportation Location and Design Manual, Volume 1. These standards are based on the volume of turning vehicles, the speed and the cycle length at the intersection. ***Table 4*** shows the existing storage lengths along side the recommended storage lengths. The eastbound left turn lane and westbound right turn lane are inadequate. However, due to the geometric restrictions on the eastbound approach, only the westbound right turn lane will be considered for lengthening.

Table 4: Storage Lane Requirements

Approach	Lane	Existing	Required (existing volumes)	Recommended in previous study	Meets Standard
Northbound	Right Turn Lane	400	375	-	yes
	Left Turn Lane	800	500	891	yes
Southbound	Right Turn Lane	500	375	445	yes
	Left Turn Lane	400	250	-	yes
Eastbound	Right Turn Lane	800	375	537	yes
	Left Turn Lane	250	325	-	NO
Westbound	Right Turn Lane	200	300	-	NO
	Left Turn Lane	400	200	-	yes

*Existing storage lanes are the storage lengths measured at the time of this study.

V. RECOMMENDED COUNTERMEASURES AND COSTS

Several countermeasures are recommended at the intersection as a result of this study.

Short Term

The first short term recommendation is to review clearance intervals. Revising the clearance intervals to accommodate the actual speeds of the vehicles will reduce the rear end accidents and will also decrease the red light running which could reduce the occurrence of angle and left turn accidents. The recommended clearance intervals are based on the 85th percentile speed. The cost for this improvement is approximately $500.

Table 5: Recommended Clearance Intervals

Recommended Clearance Intervals				
	Existing		Recommended	
	Yellow	All Red	Yellow	All Red
NB	3.6	2.4	4.3	1.7
SB	3.6	2.4	4.3	1.7
EB	3.0	2.0	3.6	2.4
WB	3.0	2.0	3.6	2.4

The second short term recommendation is to install additional lane use signs. Additional signs should be installed on EB Chamber Drive and Southbound Milford Parkway. The signs will better advise drivers of which lane to be in before they get to the intersection. This will decrease the number of sideswipe/passing accidents which often occur when drivers change lanes abruptly. The cost for this improvement is approximately $300.

The third short term recommendation is to install a "Prepare to stop when flashing" sign for EB Chamber Drive. Due to the curvature of the road, the signal is not visible upon approaching. A flashing sign would make the drivers more aware of the signal ahead. The cost for this improvement is approximately $8000.

The fourth short term recommendation is to revise the location of the stop bars. An analysis was completed which determined that the left turn radii are not adequate for some approaches. The northbound left most turn lane should be moved back 20 feet. The southbound left turn lane should be moved back 10 feet. The westbound left turn lane should be moved back 20 feet. The cost for this improvement also includes the replacement of the loop detectors. The cost is approximately $8800.

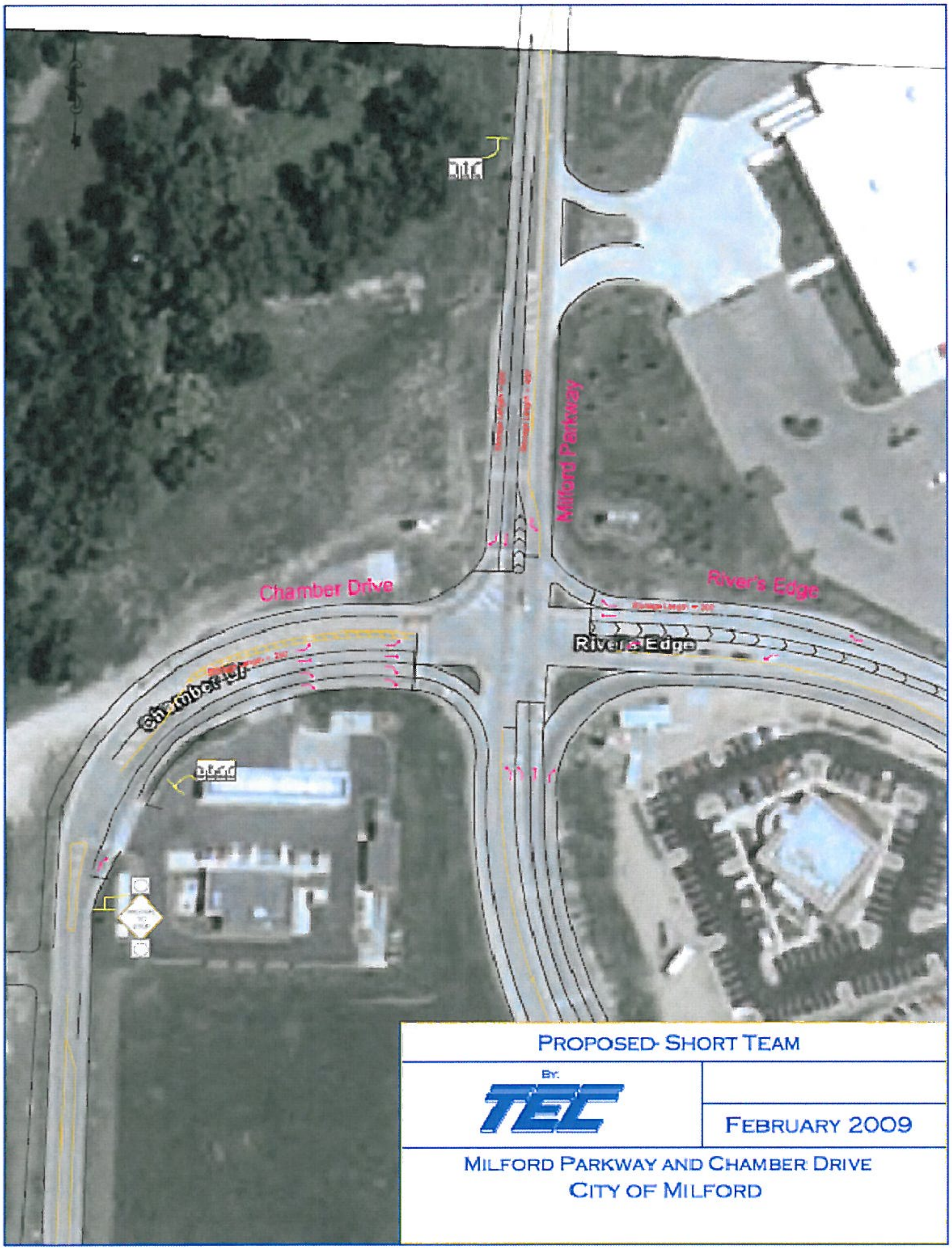
The final short term recommendation is to increase the storage lanes to the lengths recommended in *Section 4D*. Two of the storage lanes are not built to the recommended standard. The westbound right turn lane and the eastbound left turn lane. The eastbound left turn lane cannot be lengthened due to the westbound left turn lane into the UDF parking lot. The westbound storage lane should be lengthened from 200' to the recommended length of 300'. The approach will accommodate the longer turn lane with just minor pavement marking changes. There is a 12 foot section of pavement that was previously a left turn lane and is now a striped island. The thru lane can be shifted over slightly into this striped area to accommodated a longer right turn lane. The total cost for this improvement is $2,600.

The total cost for the short term improvements, including a 20% contingency is $23,780. A more detailed cost estimate is shown as *Table 6.*

Table 6: Short Term Cost Estimate

Cost Estimate-Short Term Improvements					
630	Sign, Flat Sheet	15	SQ FT	$10.00	$150.00
630	Sign Post	20	FT	$10.00	$200.00
631	Sign Flasher Assembly	1	EA	$1,400.00	$1,400.00
625	Conduit	500	FT	$5.00	$2,500.00
625	Trench	500	FT	$6.00	$3,000.00
632	Wiring	550	FT	$2.00	$1,100.00
632	Loop Lead In Cable	1200	FT	$2.00	$2,400.00
632	Detector Loops	3	EA	$2,000.00	$6,000.00
632	Signalization Misc. Review Clearance Intervals	1	LS	$500.00	$500.00
642	Stop line	40	FT	$10.00	$400.00
642	Channelizing Line	300	FT	$1.00	$300.00
642	Transverse line	150	FT	$2.00	$300.00
644	Removal of Pavement Marking	400	FT	$5.00	$2,000.00
SPEC	Contingency (20%):	1	LS	3,530.00	$3,530.00
Total					**$23,780.00**

Figure 6: Short Term Schematics



VI. RATE OF RETURN

The rate of return is a value used to quantify the benefits expected due to the implementation of improvements. Essentially, this value measures the expected yield or effective return of safety countermeasures. The effective return is an estimated interest rate that will make the net present value of the countermeasure minus the net present value of the countermeasure cost equal to zero. In this case, the net present value of the countermeasure is the expected dollar value of safety benefits in terms of crashes prevented. ODOT calculates the cost of crashes based on severity and location, and these costs were used in the rate of return calculation. The "Countermeasure Reduction Factors" used in the worksheets were provided by ODOT and are shown in ***Appendix F.*** The rate of return was calculated using accidents only in the direction improved by the recommendation. For example, only eastbound crashes are reduced by the Signal Ahead flasher installation. ***Table 7*** and the rate of return worksheets can be seen in ***Figure 7***.

Table 7: Rate of Return Values

Recommendation	Cost	ROR
Short Term Recommendations	$23,780	365%

Figure 7: Rate of Return Worksheets

RATE OF RETURN - ECONOMIC ANALYSIS WORKSHEET

LPA: City of Milford
Crash Location: Milford Pkwy & Chamber
Prepared By: TEC Engineering, Inc.

Years: 2005 2005 2007
ADT: 24078 vpd
Segment Length (mi): 0

Project #: P08095-001
Date: 7/21/2008

Year	TIME OF DAY: Day		Dawn/Dusk		Dark		ROADWAY CONDITION: Dry		Wet		Snow/Ice		CRASH TYPE: Rear End		SSM/LT		Angle		Head On		SS Pass		Fixed Object		Ran Off Road		Pedestrian		Other		TOTAL	
	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F
2005	8	0	1	0	6	0	12	0	4	0	0	0	6	0	0	0	5	0	1	0	3	0	1	0	0	0	0	0	0	0	16	0
2006	18	2	0	0	2	1	17	2	2	0	1	0	12	1	0	0	1	1	1	0	4	0	1	0	0	1	0	0	1	0	20	3
2007	14	0	0	0	8	1	20	1	2	0	0	0	6	0	0	0	6	1	1	0	5	0	1	0	0	0	0	0	3	0	22	1
Total	40	2	1	0	16	2	49	3	8	0	1	0	24	1	0	0	12	2	3	0	12	0	3	0	0	1	0	0	4	0	58	4
Avg.	13.33	0.667	0.333	0	5.333	0.667	16.33	1	2.667	0	0.333	0	8	0.333	0	0	4	0.667	1	0	4	0	1	0	0	0.333	0	0	1.333	0	19.33	1.333

RECOMMENDED IMPROVEMENTS

1. 25 Revise signal timing
2. 6 Upgrade signs - general
3. 30 Install warning sign-mounted flasher
4. 40 Widen for right turn lane, including resurfacing

CRASH TYPES	PDO CRASHES: R1	R2	R3	R4	RT	AVG PDO	EST. RED.	INJ. - FAT. CRASHES: R1	R2	R3	R4	RT	AVG INJ-FAT	EST. RED.
All	0.10	0.05			0.15	19.33	2.80	0.10	0.05			0.15	1.33	0.19
Rear End-WB only				0.20	0.20	1.67	0.33				0.20	0.20	0.00	0.00
SSM/LT						0.00	0.00						0.00	0.00
Angle						4.00	0.00						0.67	0.00
Head On						1.00	0.00						0.00	0.00
SS Pass				0.20	0.20	4.00	0.80				0.20	0.20	0.00	0.00
Fixed Object						1.00	0.00						0.00	0.00
Ran Off Road						0.00	0.00						0.33	0.00
Pedestrian						0.00	0.00						0.00	0.00
Dark						5.33	0.00						0.67	0.00
Wet						2.67	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
All-EB only			0.30		0.30	4.66	1.40			0.30		0.30	0.33	0.10
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
						0.00	0.00						0.00	0.00
	ESTIMATED PDO CRASH REDUCTION						5.34	ESTIMATED INJ. - FAT. CRASH REDUCTION						0.29

ADT Factor

Project Service Life: 20 years
Present ADT (PADT): 24078
Future ADT (FADT): 31301.4 — Future ADT determined using straight-line method & 1.5% annual growth rate

Average ADT = (PADT + FADT)/2 = (24078 + 31301.4)/2 = 27689.7
ADT Factor = Average ADT/PADT = 27689.7 / 24078 = 1.15

Average Annual Benefits

Annual PDO Benefits = Estimated PDO Crash Reduction * Avg PDO Cost = 5.34 * $9,960 = $53,140
Annual INJ.-FAT. Benefits = Estimated INJ.-FAT. Crash Reduction * Avg INJ. FAT. Cost = 0.29 * $82,224 = $24,037
Total Benefits = $77,177
Average Annual Benefits = ADT Factor * Total Benefits = 1.15 * $77,177 = $88,753

Rate of Return

Project Cost: $23,780
Maintenance and Energy Costs: $2,000
Salvage Value: $0

Rate of Return: 365%

Cost of Crashes for Determining ROR (2006)

System	PDO	I/F
Rural State Highway	$9,960	$82,224
Counties and Unincorporated Villages	$7,430	$59,234
Cities and Incorporated Villages	$10,846	$70,073

WHEN USING MULTIPLE COUNTERMEASURES, THE TOTAL REDUCTION FACTOR IS:

R1 + (1-R1)R2 + (1-R1)(1-R2)R3 + (1-R1)(1-R2)(1-R3)R4 + ... = RT