FDOT CONTRACT: # BDV33-945-001

SITE ANALYSIS AND JUSTIFICATION

HENDRY COUNTY

REPORT

Prepared for

The Florida Department of Transportation

FDOT Contract #BDV33-945-001

Safety Project: Implementing a Transportation Safety Center (TSC) through Florida Local Technical Assistance Program (LTAP)

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1. INTRODUCTION

1.1 BACKGROUND

The Florida Department of Transportation has recognized that there is a need to assist small communities in Florida to improve highway safety. Federal funds are available for safety improvements on all public roads, but federal guidance requires the programming of safety funds to be data driven. In many cases the smaller communities do not have sufficient technical resources to conduct the required analysis.

Under the direction of the Florida Department of Transportation Office of Safety, the Transportation Safety Center (TSC) at LTAP has been developed to provide such assistance. This report documents a safety study led by TSC for selected road segments in Hendry County.

1.2 COUNTY SELECTION

Data in Table 1 show that Hendry County has the highest number of fatalities of the small counties (<50,000 population) in District 1. Hendry County was selected as the first county in District 1 to receive this assistance.

Table 1 Crashes in small counties in District 1 (2006-2013)

	Hendry		Desoto		Hardee		Glades		Okeechobee	
Total	**943**		**1071**		**1006**		**336**		**797**	
Fatal	48	5%	24	2%	27	3%	10	3%	17	2%
Injury	504	53%	546	51%	421	42%	152	45%	410	51%
Bike	16	2%	25	2%	6	1%	3	1%	21	3%
Pedestrian	36	4%	27	3%	19	2%	7	2%	39	5%

Source: Signal Four Analytics

Much of Hendry County is agricultural with a significant sugar cane operation in the eastern portion of the county. Rural roads mostly follow a grid system and are often located adjacent to major canals.

Roads are well maintained and the County has been steadily upgrading roads as funding allows. Some of the roads with a history of serious crashes have been recently upgraded or are scheduled for improvement during the next five years. However, the need cannot be fully met with current funding levels available in the County's road budget.

Hendry County has a small technical staff including a County Engineer, an Engineer Intern, and a Superintendent with extensive experience in road construction and maintenance. The Public Works Department has GIS capability. Information about road assets such as culverts is available from the County's GIS files. Hendry County is LAP Certified and has had success with this program.

1.3 STUDY METHODOLOGY

The analysis was conducted generally following the principles of the FHWA Road Safety Audit Guidelines. The format for the analysis and report followed the *Local Agency Guide for Developing Highway Safety Projects* prepared by the Transportation Safety Center at LTAP.

➢ Study team

The study team included various members of UF's research team and representatives of Hendry County who participated in the field reviews and provided supplemental information. Field studies were conducted during both daylight and nighttime conditions.

➢ Data sources and approach to data collection

Crash analysis was conducted for the period from 2006 through 2013 using Signal Four Analytics (http://s4.geoplan.ufl.edu/). The crash sites were identified and plotted on maps prior to the field study and helped guide the team in investigating the problem areas.

To the extent practical, the team used data obtained from public sources. Culvert information was provided by Hendry County in the form of a GIS shape file. Although much of the photography contained in this report was obtained from Google's Street View, conditions were verified by field observation.

Estimates and approximate feature locations like signs, guardrails, and culverts were considered adequate for estimating costs, but more detailed survey work will be required to obtain the information necessary to develop construction plans and quantities.

➢ Benefit-cost (B/C) analysis summary

Benefit/cost analysis was performed in accordance with the specifications described by the Florida Department of Transportation in State Safety Office Bulletin 10-01, regarding "Benefit/Cost Analysis, Roadside Safety Analysis Program, and Discount (Interest) Rate." Crash costs and the interest rate used in analysis also come from this document (http://www.dot.state.fl.us/rddesign/Bulletin/RDB10-09.pdf).

Crash modification factors used in analysis primarily originate from the FHWA Crash Modification Factor Clearinghouse (http://www.cmfclearinghouse.org/).

Countermeasure costs are based on statewide averages of unit costs (http://www.dot.state.fl.us/specificationsoffice/estimates/historicalcostinformation/AnnualSWAve/AnnualStatewideAverage11.xls).

Quantities used in estimating countermeasure costs are shown in **Appendix B – Basis of cost estimates**.

2. SELECTION OF STUDY SITES

In selecting sites for the study, the TSC study team looked for roads with a history of serious crashes, where no major improvements have been made recently, and where it appears that crashes can be effectively mitigated with short term improvements. The team examined crash information from the FDOT Safety Portal and Signal Four Analytics. The team also discussed the crash problems with Hendry County, and visited several locations before selecting the test sites.

2.1 OVERVIEW OF CRASHES IN HENDRY COUNTY

Figure 1 shows the distribution of local road crashes in Hendry County for the period from January 1, 2006 through December 31, 2013. Crashes in the rural areas are mostly along the major county roads, CR 832, 833, 835, and 846.

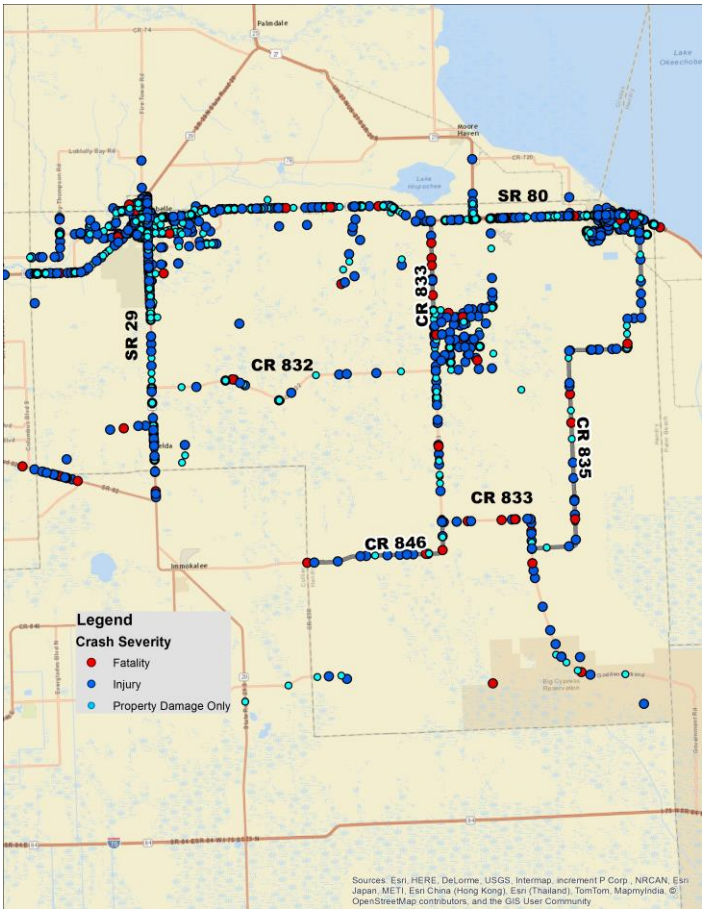


Figure 1 Crashes on local roads in Hendry County (2006- 2013)

In recent years, Hendry County has made significant improvements to some of these roads, including portions of CR 832 and southern sections of CR 833. Approximately 13 miles were reconstructed using funds available under American Recovery and Reinvestment Act (ARRA).

In addition, FDOT has assisted with a recent project to upgrade the signage on curves on CR 835.

Figure 2 shows the trend in fatal crashes for Hendry and other small counties in District 1 over the past eight years. No adjustment has been made to account for the reduced travel during the economic slump, but the road improvements made by Hendry County during this period have undoubtedly contributed to this reduction in crashes.

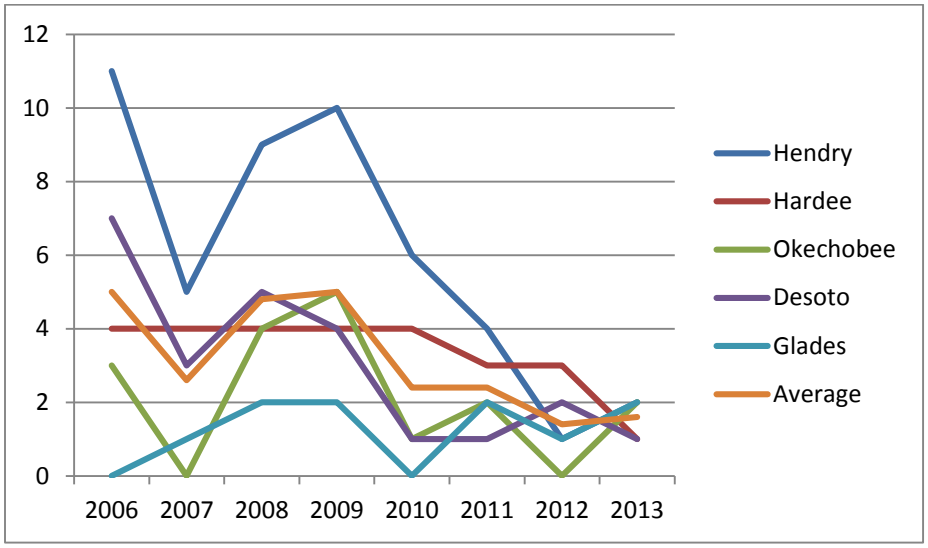


Figure 2 Trend in fatal crashes on local roads in small counties of District 1

Three major road segments were selected as sites for this safety study and are identified in Table 2 and Figure 3. In these segments, recent road improvements consisting of resurfacing and some signing upgrades have been made. Hendry County plans to reconstruct the intersection of CR 833 and CR 846, so this intersection is not included in this review.

For the period from 2006 through 2013, these three road segments represent nearly15% of the local road miles in Hendry County, yet account for approximately 25% of the fatal crashes on the local road system.

Table 2 Study segments and fatal crashes (2006-20013)

#	Approximate Road Miles	% of Miles	Fatal Crashes	% of Fatal Crashes
County Total	349		48	
CR 833	10	2.9%	5	10%
CR 846	11	3.2%	1	2%
CR 835	30	8.6%	6	13%
Study Totals	51	14.6%	12	25%

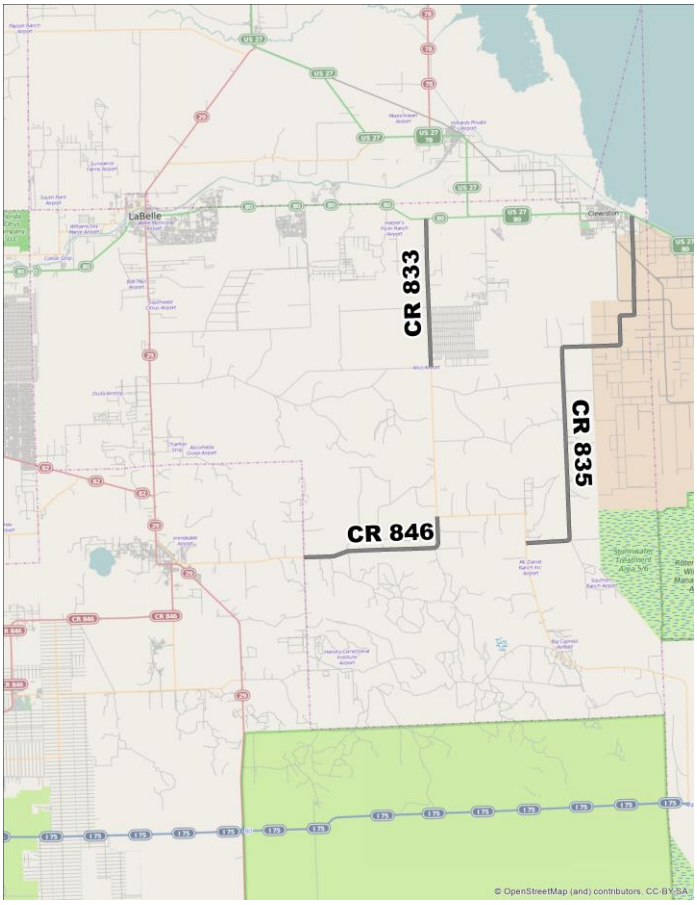


Figure 3 Study segments

2.2 HIGH CRASH LOCATIONS IN ALL CRASH ANALYSIS

FDOT's High Crash location listing on the Safety Portal for Hendry County is summarized in Table 3.

- Three of these sites (#2, # 4, and #5 on CR 835) are within the road segments selected for this study.
- One of the sites, (#3 on CR 832), was recently reconstructed. This improvement will likely address problems indicated by the historic data, so it was excluded from this study.
- Site #1, Sonora Avenue, is a candidate for major construction in the near future. No fatalities were reported in this section, and it was not selected for this study.
- Site #6, Bald Cypress Avenue, runs through a sparsely developed residential area. No fatalities were reported in this section, and it was not selected for this study.

Table 3 All Crash Analysis listing of High Crash Locations in Hendry County (2010)

Site #		BMP	EMP	Road Name	No. of Crashes	AADT	Fatalities	Injuries	PDO
1	Segments	0.000	0.700	Sonora Ave	9	2477	0	16	3
2	**Intersection**	**22.887**	**County Road 835**	**Unnamed Street**	**8**	**1669**	**1**	**6**	**4**
3	HRRR[1]	4.800	6.300	County Hwy 832	5	223	2	6	0
4	**HRRR**	**2.300**	**20.100**	**County Road 835**	**8**	**82**	**3**	**9**	**0**
5	**HRRR**	**22.600**	**23.100**	**County Road 835**	**4**	**1669**	**1**	**6**	**0**
6	HRRR	0.000	3.491	Bald Cypress Ave	4	44	0	8	0

Source: FDOT All Crash Analysis

2.3 EMPHASIS AREAS OF STRATEGIC HIGHWAY SAFETY PLAN

The Strategic Highway Safety Plan emphasizes bicycle / pedestrian, intersection, and lane departures crashes as priorities.

- **Bicycle/ Pedestrian crashes countywide**

  In Hendry County, most of the bicycle / pedestrian crashes occurred in the urban areas of Labelle and Clewiston. Sidewalks have been recently constructed in these areas, so historical data may not accurately reflect the extent to which this problem has been addressed by these projects.

- **Intersection crashes countywide**

  Intersection crashes are mostly within the urban area and account for approximately thirteen percent of the serious crashes in Hendry County. This is consistent with the percentage of serious intersection crashes in the other five small counties in District 1.

- **Lane Departure crashes countywide**

  Lane departures account for the most crashes in Hendry County. During the period 2006 through 2013, 308 (34%) of all crashes in Hendry County were classified as either "off-road" or "rollover". This compares to 23% for all five small counties in District 1.

[1] HRRR – (High Risk Rural Roads) "The Department uses methodology for HRRR that identifies hazardous locations, prioritizes the locations by severity, and selects the most severe location for project development. Analyses are based on fatal and serious injury crash rates for rural major collector, minor collector, and local road segments. Segments selected are those with average crash rates that are higher than the district's average crash rate for the same roadway type and on which there are a statistically significant number of fatal and serious injury crashes…..".

Figure 4 shows the distribution of the fatal off-road and rollover crashes. There were 56 off-road or rollover crashes involving fatalities in all five small counties. Of these, 23 (41%) were in Hendry County.

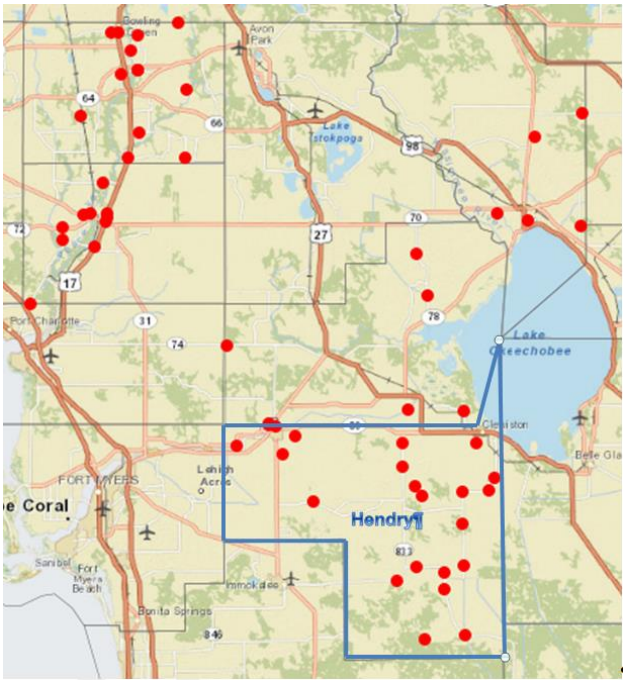


Figure 4 Off-road and rollover crashes involving fatalities for five small counties in District 1 (2006-2013)

2.4 CRASHES IN STUDY AREA

The crash analysis for the study sites was based on long form crash records for the period from January 1, 2006 to December 31, 2013. This eight-year period provides a more complete picture of the crash experience than the three or five-year periods commonly used. During this period, there were few significant changes in the characteristics of the study sections.

Maps showing the location of the crashes are included for all study segments in **- Crash** maps.

Table 4 Summary of crashes for study sites (2006 – 2013)

Crash Type	Total	Fatal	Injury	PDO	In Canal	Daylight	Non Daylight
ped/bike	3	2	1	0	0	0	3
Animal	11	0	6	5	0	4	7
Intersect/driveway	15	0	8	7	0	13	2
Lane depart- on road	18	1	14	3	1	12	6
Lane depart - off-road	49	10	25	14	29	21	28
debris	0	0	0	0	0	0	0
other	1	0	1	0	0	1	0
Totals	97	13	55	29	30	51	46

Crash types were summarized from the crash records as follows:
Intersect/driveway: Crash type: Rt turn, Lt turn, Rear end, Angle
Lane departure – on road: --Crash type: Head-on, Sideswipe
Lane departure – off-road: --Crash type: Off-road, Rollover
To determine whether a vehicle entered a canal, the narrative and diagrams for each crash record were reviewed.

➢ Bicycle / Pedestrian crashes in study area

Within the study area, one bicycle and one pedestrian crash were identified. Both of these involved persons walking or riding in the travel way of a rural road in non-daylight hours. Another crash, categorized as pedestrian, was apparently a homicide in which the victim was found on the roadway.

➢ Intersection crashes in study area

Within the study area, intersections are sparse. Sixteen percent of crashes in these areas involve maneuvers typical of driveway or intersections. Countywide intersection related crashes account for 29% of the total crashes.

➢ Lane Departure crashes in study area

Over half of the crashes in the study involved vehicles that left the roadway. These accounted for ten of the thirteen fatalities. **The dominant concern within the study area is with the lane departure crashes, particularly where the vehicle left the roadway.**

The crash summary in Table 4 shows that of the off-road/rollover crashes, 29 of 49 crashes involved vehicles entering a canal. Seven of thirteen fatalities in the study area involved vehicles entering a canal. Figure 5 shows these crash locations.

Figure 5 Crashes where vehicle entered a canal

3. SUMMARY OF RECOMMENDED COUNTERMEASURES

Table 5 provides a summary of potential countermeasures which are described in detail in a subsequent section: **4. Description and analysis of countermeasures.** Detailed cost and benefit calculations are shown in **Appendix C - Calculation of benefit/cost ratios**.

For the purpose of calculating benefits, similar countermeasures at several locations are organized in combinations that represent logical groups. Since budget limitations may make it difficult to fully fund improvements at all locations identified for each "countermeasure group", cost estimates and suggested priorities are shown for individual locations within these "groups".

Countermeasure groups: Curves

Level 1 refers to upgrade of signs. (Some of this work has already been completed by FDOT.) (see **4.1.1 Curve signing and warning).**

Level 2 includes both the Level 1 improvements and the additional work associated with paving shoulders in the curves. (see **4.1.2 Pavement marking and shoulder paving).**

Level 3 includes the Level 1 and 2 work as well as further enhancements at three of the curves. (see **4.1.3 Additional treatments at selected curves).**

Countermeasure groups: Tangents

For the Tangent groups, Level 1 refers to upgrade of pavement markings at all sections within the study site. (see **4.2 Pavement markings -** tangent sections**)**.

Level 2 countermeasures for the tangent areas include Level 1 improvements with the addition of guardrail along canals. (see **4.3 Canals and culverts - tangent sections.)**

> *The improvement identified as "CR 835 – Various Locations" will require a more detailed analysis before specific projects can be developed for implementation. The costs and benefit analysis for this improvement were based on a review of aerial photography and limited "windshield survey" of the area. While this information provided an "order of magnitude" estimate of costs and potential benefits, a more detailed survey that was beyond the scope of this study will be needed.*

Table 5 Summary of potential countermeasures

Curve Sections			Countermeasure Group							
			Level 1		Level 2				Level 3	
			Signs	Priority	Pavement Markings	Priority	Paved Shoulders	Priority	Guardrail	Priority
CR 835	At Rogers Road		9,898	1	10,591	2	204,545	2	33,840	2
CR 835	At Blumberg Road		11,895	1	12,136	2	939,351	2	47,955	2
CR 835	Between Rogers and Blumberg		11,447	1	11,461	2	257,576	3		
CR 835	Between Deer Fence and Blumberg		13,444	1	13,821	2	310,606	3		
CR 835	At Deer Fence		15,889	1	16,518	2	371,212	3	17,953	3
CR 846			17,438	1	20,057	2	450,758	3		
		Cost	80,010				*80,010*			
		NPV	274,501							
		B/C	***18.98***							
		Cost	Includes Levels 1 and 2 cost				2,698,643			
		NPV					339,232			
		B/C					***2.75***			
		Cost	Includes Levels 1 and 2 cost						2,798,390	
		NPV							387,670	
		B/C							***2.93***	

Tangent Sections			Countermeasure Group						
			Level 1		Level 2				
			Pavement Markings	Priority	Guardrail CR 833	Priority	Guardrail L-1 Canal	Priority	Guardrail CR 835	Priority
CR 833			256,805	2	606,644	3				
CR 835	L-1 Canal Crossing						47,738	3		
CR 835	Various Locations		731,669	2					2,116,617	4
CR 846			275,366	2						
		Cost	1,263,840							
		NPV	680,499							
		B/C	***3.82***							
		Cost			606,644					
Priority	Estimated Cost	NPV			125,095					
		B/C			***4.2***					
1	$ 80,010	Cost					47,738			
2	$ 2,574,115	NPV **					3,285	**		
3	$ 2,062,486	B/C **					***1.98***	**		
4	$ 2,116,617	Cost							2,116,617	
		NPV							134,369	
		B/C							***1.98***	

** The traditional "spot" analysis of the benefits for this short improvement does not adequately reflect the value of adding guardrail at this location since there were no recorded crashes during the analysis period that would be mitigated by the improvement. Throughout the corridor, several such crashes did occur at locations where the risk factors appeared to be less severe than at the L-1 canal crossing. The corridor-wide B/C ratio is used as the estimate of the benefit for adding guardrail at this short section within the corridor.

4. DESCRIPTION AND ANALYSIS OF COUNTERMEASURES

For the study area, the primary focus is on lane departure crashes and measures to mitigate the seriousness of these crashes. Opportunities for cost effective mitigation are:

1. Enhance warnings and recovery areas at six major curves
2. Upgrade pavement markings, including “rumble stripes”
3. Pave shoulders
4. Install guardrail or other barriers along canals

4.1 ENHANCE SIGNING, MARKINGS, AND RECOVERY AREAS AT MAJOR CURVES

The road segments on CR 846 and CR 835 have a total of six – 90 degree curves separated by long tangents (excluding the curve at the intersection of CR 846 and CR 833). The locations of these curves are identified in Figure 6.

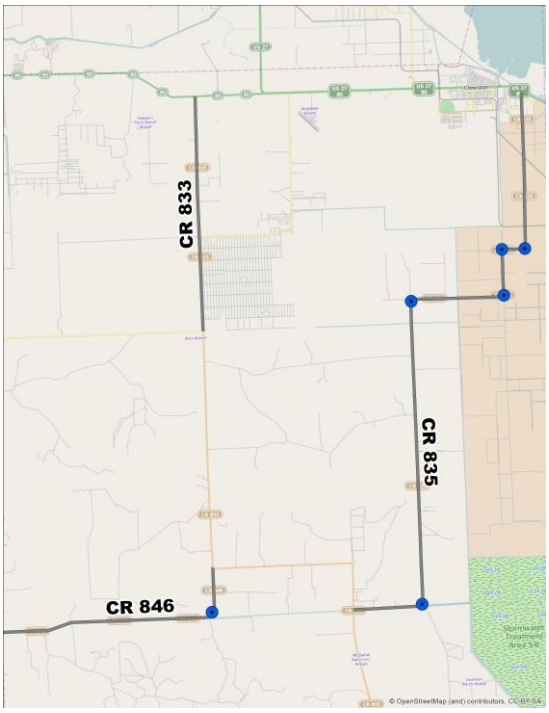


Figure 6 Major curves on CR 835 and CR 846

The grade throughout the area is flat. Lack of geographic features such as trees, buildings or other features to define the edge of right of way requires the driver to rely almost completely on his/her view of the roadway surface and guide signs to understand that there is a change in road alignment.

While the road is relatively easy to see in the daylight hours, at night the road surface is visible to the driver only a short distance ahead of the vehicle. Without other defining features to alert the driver to a change in alignment, it is easy for a driver to miss the cue when it is time to turn. This problem is exacerbated by the fact that the approaches are generally long tangents, where

a driver's attention is likely to be somewhat relaxed. The problem is especially serious in the instances where a canal is located adjacent to the road, and loss of control may result in a vehicle entering the canal.

Fourteen crashes occurred at curves in the study area. These were concentrated at two locations, but many of the risk factors exist at all six curves. Only two of these occurred during daylight hours, indicating that nighttime visibility is a major contributor to the problem. Eleven of the fourteen crashes involved vehicles entering a canal, and one resulted in a fatality.

The following countermeasures apply to all six curves within the study area. Additional countermeasures are suggested to address unique conditions at three of the curves.

4.1.1 Curve signing and warning

The combination of environmental conditions and the severity of crashes involving road departures at these curves warrant additional treatments in accordance with MUTCD guidance for enhanced conspicuity. In addition to the signs shown in Figure 7, "bright sticks" should be installed on all sign posts, including chevrons, and flashing beacons should be added at Rogers Road.

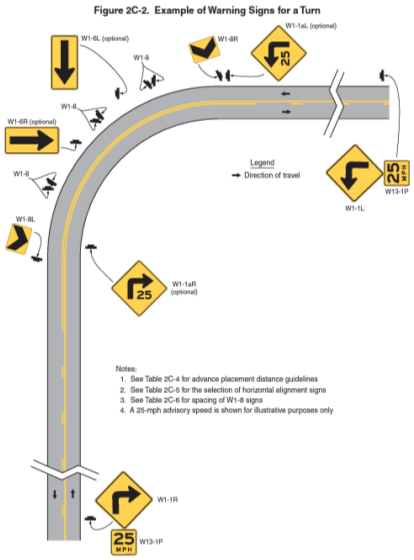


Figure 7 MUTCD guidance for warning signs at curves

4.1.2 Pavement marking and shoulder paving

➢ Pavement marking

Nighttime delineation of the lanes through the curves is critical, but truck traffic associated with the agricultural operations in the area presents a special problem for maintaining the pavement markings. The following recommended treatments for lane delineation through the curves are intended to maintain high quality delineation of the pavement while minimizing the deterioration caused by turning vehicles.

- "Rumble stripes" for centerline delineation (Figure 8). Ground in place rumble stripes should help guide vehicles through the curves and provide a surface for the pavement marking that is more durable than conventional striping and RPMs.

- “Rumble stripes” for outside lane delineation through the curves. In addition to providing critical alerts to drivers who may drift out of the lane, “rumble strips” along the outside lane line should discourage traffic from driving on RPMs on the shoulders.

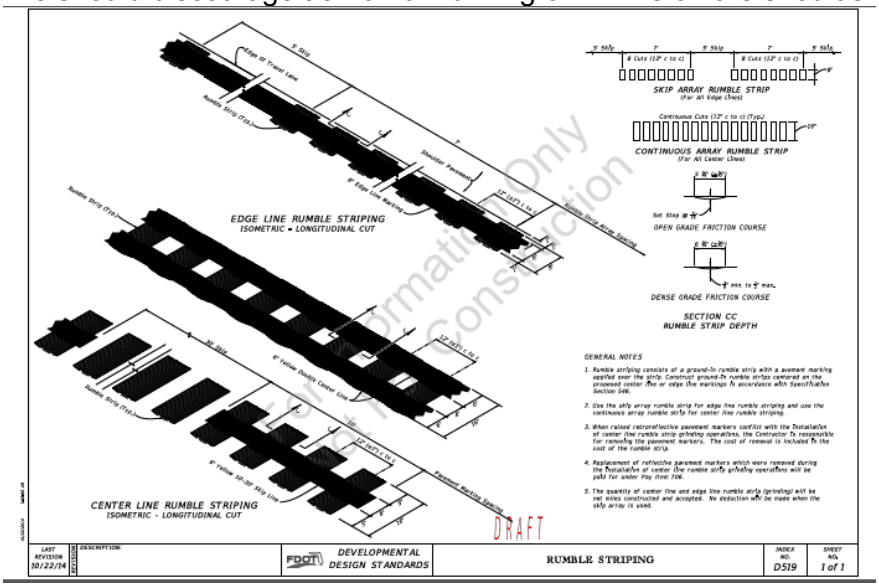


Figure 8 Rumble Striping

- Supplemental RPMs and chevron stripes on shoulders through curves and approaches. This treatment, especially on the outside of the curve, can be especially effective in providing nighttime delineation of the pavement and alerting the driver to the change in alignment. Placement of the ground in place rumble stripe at the lane line should help reduce the traffic over the RPMs.

This photograph illustrates how pavement markings, including raised pavement markers can be used to enhance the nighttime visibility of a curve.

Figure 9 Enhancement of nighttime visibility of a curve using raised pavement markers on shoulders

➢ Shoulder paving

At several of the curves the inside shoulder has been paved. This has generally addressed the problem of pavement edge drop-offs along the inside edge of, but additional shoulder paving along the outside edge would provide enhance the recovery area and allow for placement of the supplemental pavement markings.

The following treatment for shoulder paving and pavement marking is recommended for each of the six major curves:

- Add paved shoulder throughout curve and approaches as shown in Figure 10. In some cases, right of way or presence of ditches may limit the widening. At a minimum, the pavement should be 22 feet plus three feet for shoulders. Extend this cross section 500 feet in each direction from the PC and PT of the curve. (For most of the curves, the inside shoulder has been paved, but for the purposes of cost estimates it, is assumed the shoulder will be repaved throughout the entire length of the curve.)
- Use safety edge for all shoulder paving. (Figure 11)
- For pavement markings on the shoulder, use diagonal markings similar to the markings now in place on the inside paved shoulders at curves. Space these markings at 20 feet, and extend the pattern for the full length of the paved shoulder. Supplement the diagonal stripes with RPMs.

Figure 10 Recommended shoulder paving at curves

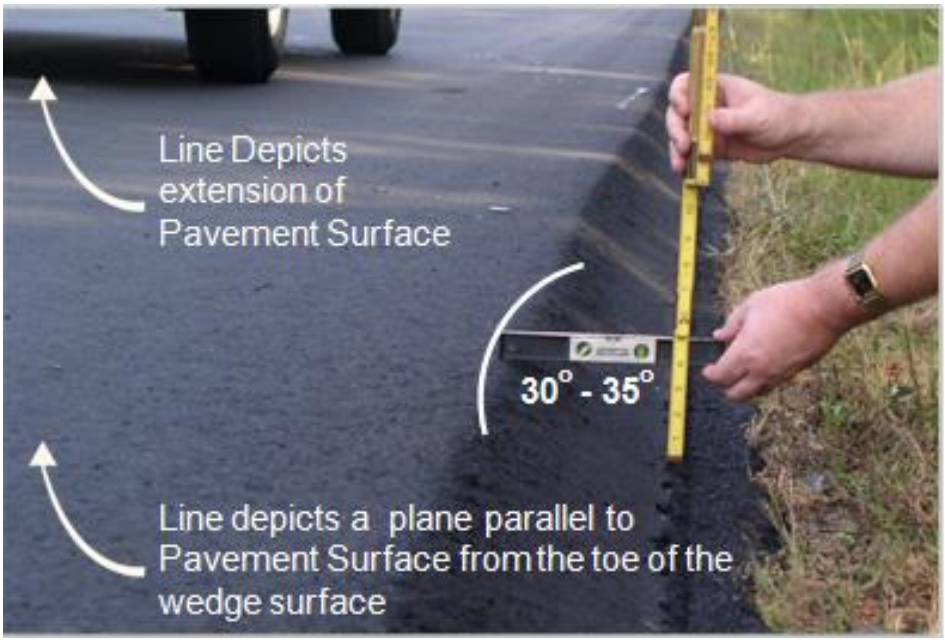


Figure 11 Safety edge – to be included in shoulder paving

4.1.3 Additional treatments at selected curves

In addition to the area-wide issues discussed in the previous section, the following discussions address site specific issues at several locations and include additional countermeasures to address these concerns.

- **CR 835 at Rogers Road**

Figure 12 CR 835 at Rogers Road

This curve has the most serious crash record of all locations reviewed. It has a posted advisory speed of 25 mph. Concerns at this location include:

- A large canal is located along the southern limits of the curve/intersection.
- The southbound approach is a long tangent through agricultural lands with a uniform appearance. There are few visual cues that the alignment changes abruptly, especially at night.
- Poles for a major power line along the south edge of the CR 835 right of way represent fixed obstacles. While they are outside the clear zone these have been struck by vehicles that failed to negotiate the turn. There is a short section of guardrail parallel to the canal, but it provides little opportunity to redirect a southbound vehicle.

Figure 13 Aerial view of CR 835 at Rogers Road

Twelve crashes were reported at this location. Ten of these involved vehicles that entered the canal, most from the southbound direction. One of these was fatal. Ten of the twelve crashes were in non-daylight conditions.

Table 6 Crashes on CR 835 at Rogers Road

Crash Type	Total	Fatal	Injury	PDO	In Canal	Day	Non day
ped/bike	0						
Animal	0						
Intersect/driveway	0						
Lane depart- on road	0						
Lane depart - off-road	12	1	4	7	10	2	10
Total	12	1	4	7	10	2	10

At the southbound approach to Rogers Road, the temporary construction warning sign with a flasher highlighted the intersection ahead, but the sign was removed at the completion of the construction (west of the curve).

New pavement markings have been applied through the curve in conjunction with recent resurfacing of the western approach to the curve.

Figure 14 Nighttime view at southbound approach to curve at Rogers Road intersection (during resurfacing of west approach to curve)

In this daytime photograph of the Rogers Road approach, the curve is more discernible, but the absence of other visual cues could make it difficult for an inattentive driver to slow adequately to negotiate the curve at a safe speed.

Figure 15 Daytime view at southbound approach to curve at Rogers Road intersection (from Google Street View)

Countermeasures:

- Upgrade signs and pavement markings; pave shoulders (included in recommendations for all major curves).
- Install advanced warning beacons on southbound and eastbound approaches to the curve.
- Install luminaires. Illumination of the area around a curve will alert the driver well in advance that there is a change in the features of the road and will provide positive assistance in helping identify the changes in the configuration. This is a critical feature for this location since most of the crashes occur at night. (Electrical service appears to be available at this location.).

If luminaires cannot be added to existing poles, consider placing any additional poles along the inside of the curve.

- Install guardrail, cable, or other positive barrier to redirect southbound vehicles that fail to negotiate the curve to prevent them from entering the canal.

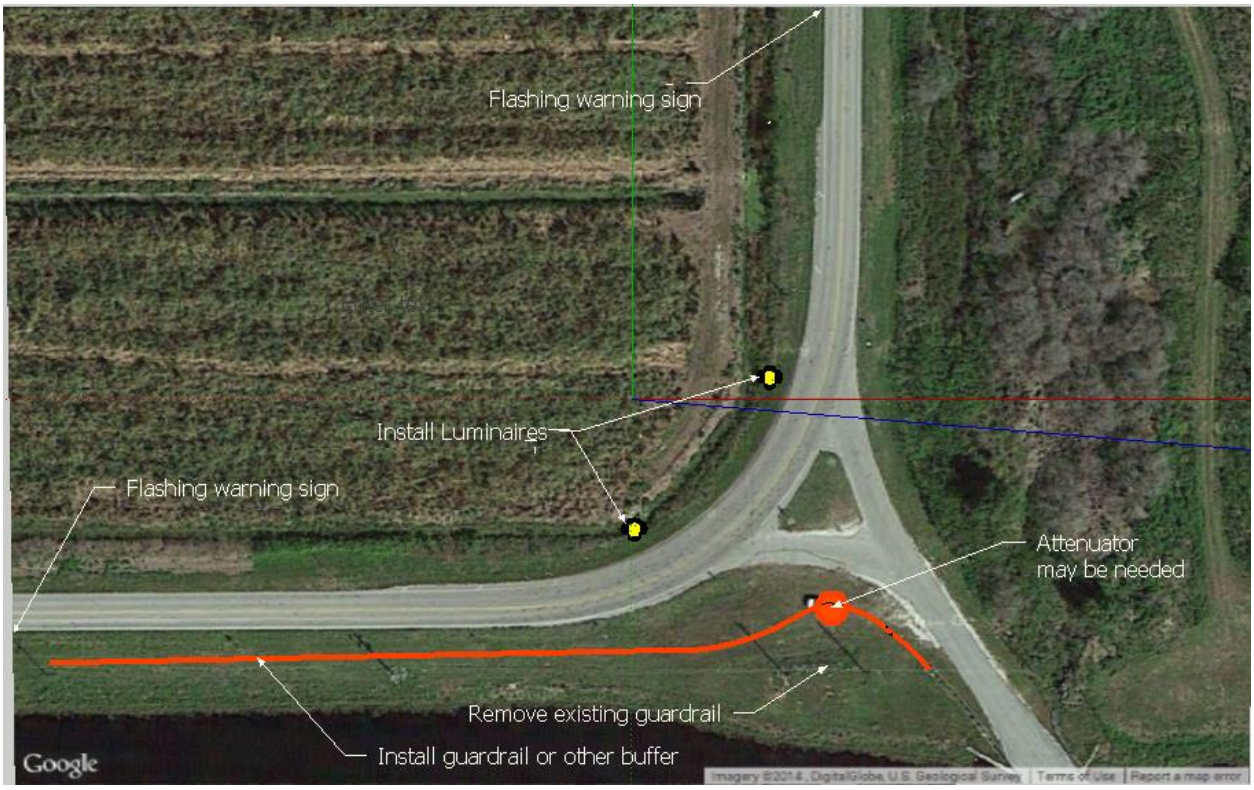


Figure 16 Approximate guardrail configuration at Rogers Road

➢ CR 835 at Blumberg Road

Figure 17 CR 835 at Blumberg Road

Blumberg Road intersects CR 835 near the midpoint of a curve. A substantial canal runs along the outside radius of the curve (Figure 18). Only the inside shoulder is paved. Some pavement edge drop-offs were noted on the outside pavement edge, and the outside shoulder slopes sharply toward the canal

The cross slope (superelevation rate) of the pavement varies through the curve. For the east-northbound traffic, such variations may make it difficult for the driver to follow the alignment of the road through the curve.

Figure 18 Curve at Blumberg Road

Signs have been recently upgraded, but pavement markings are worn. The primary concern at this location is that vehicles exiting to the outside of the curve have little opportunity to recover, and are likely to enter the canal.

This photograph, looking southeasterly from Blumberg Road, shows the shoulder sloping downward toward the canal. A vehicle that leaves the road in this area would have difficulty staying out of the canal.

Figure 19 Canal along outside of curve at Blumberg Road

Table 7 shows crashes for both approaches and the curve at Blumberg Road. Two crashes were recorded within the limits of the curve. In both instances, eastbound vehicles left the pavement to the right and were unable to regain control. One of these vehicles entered the canal. Both of these crashes occurred during non-daylight hours.

Table 7 Crashes on CR 835 west and north of intersection with Blumberg Road

Crash Type	Total	Fatal	Injury	PDO	In Canal	Day	Non day
ped/bike	1		1				1
Animal	1			1		1	
Intersect/driveway	0						
Lane depart- on road	4		3	1		4	
Lane depart - off-road	3		1	2	2	1	2
Total	**9**	**0**	**5**	**4**	**2**	**6**	**3**

Countermeasures:

- Upgrade signs and pavement markings; pave shoulders (included in recommendations for all major curves).

  Widening CR 835 to the outside would involve some fill in the canal. The recommended alternative is to widen the pavement to the inside of the curve, and shift the travel lanes further away from the canal.

- Restore appropriate superelevation rate throughout the length of the curve.
- Install guardrail along the outside edge of the curve. This would include extending the guardrail onto Blumberg Road.

  This would require extension and possible replacement of one or more culverts on Blumberg Road. Hendry County has indicated they would replace this culvert.

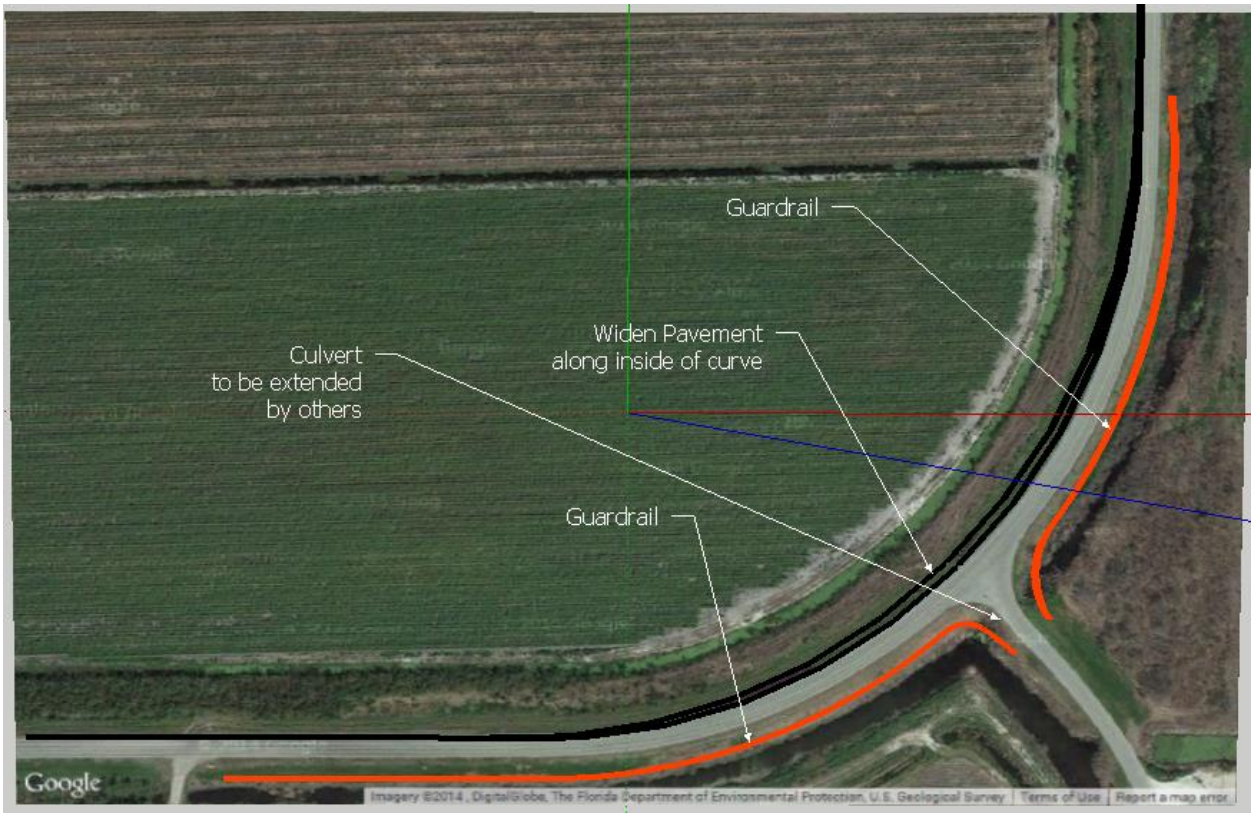


Figure 20 CR 835 at Blumberg Road

➢ CR 835 at Deer Fence Road

Figure 21 CR 835 at Deer Fence Road

CR 835 intersects an unpaved road, designated as Deer Fence Road, at a 90 degree curve. A SFWMD canal is located along the inside radius of the curve. There is a bridge over a canal at approximately the midpoint of the curve. The bridge has guardrail on the approaches, but this guardrail is short and leaves an unprotected area Shoulders on both sides of the road are unpaved and show signs of erosion and pavement edge drop-offs. (See Figure 23)

Figure 22 Curve at intersection of Deer Fence Road with CR 835

Figure 23 Southbound approach to curve at Deer Fence Road

During the study period, no crashes were reported within the limits of the curve; however, there were crashes to the north and west of the curve. The canal crossing with a narrow bridge, the intersection, and the change in alignment all add risk factors that make conditions at the curve even more severe.

Table 8 shows the crash history on the tangent sections to the west and north of Deer Fence Road. Of the sixteen crashes in this section, twelve were classified as either "off-road" or "rollover". In eight crashes, vehicles entered a canal. Three of these crashes where vehicles entered the canals were fatal. In this area, approximately half of the lane departure crashes occurred during the daylight hours.

Table 8 Crashes on CR 835 west and north of intersection with Deer Fence Road

Crash Type	Total	Fatal	Injury	PDO	In Canal	Day	Non day
ped/bike	1	1					1
Animal	2		1	1		1	1
Intersect/driveway	0						
Lane depart- on road	2		2		1	1	1
Lane depart off-road	12	4	5	3	7	7	5
Total	**17**	**5**	**8**	**4**	**8**	**9**	**8**

Countermeasures:

- Upgrade signs and pavement markings; pave shoulders (included in recommendations for all major curves).
- Upgrade and extend guardrail at bridge.

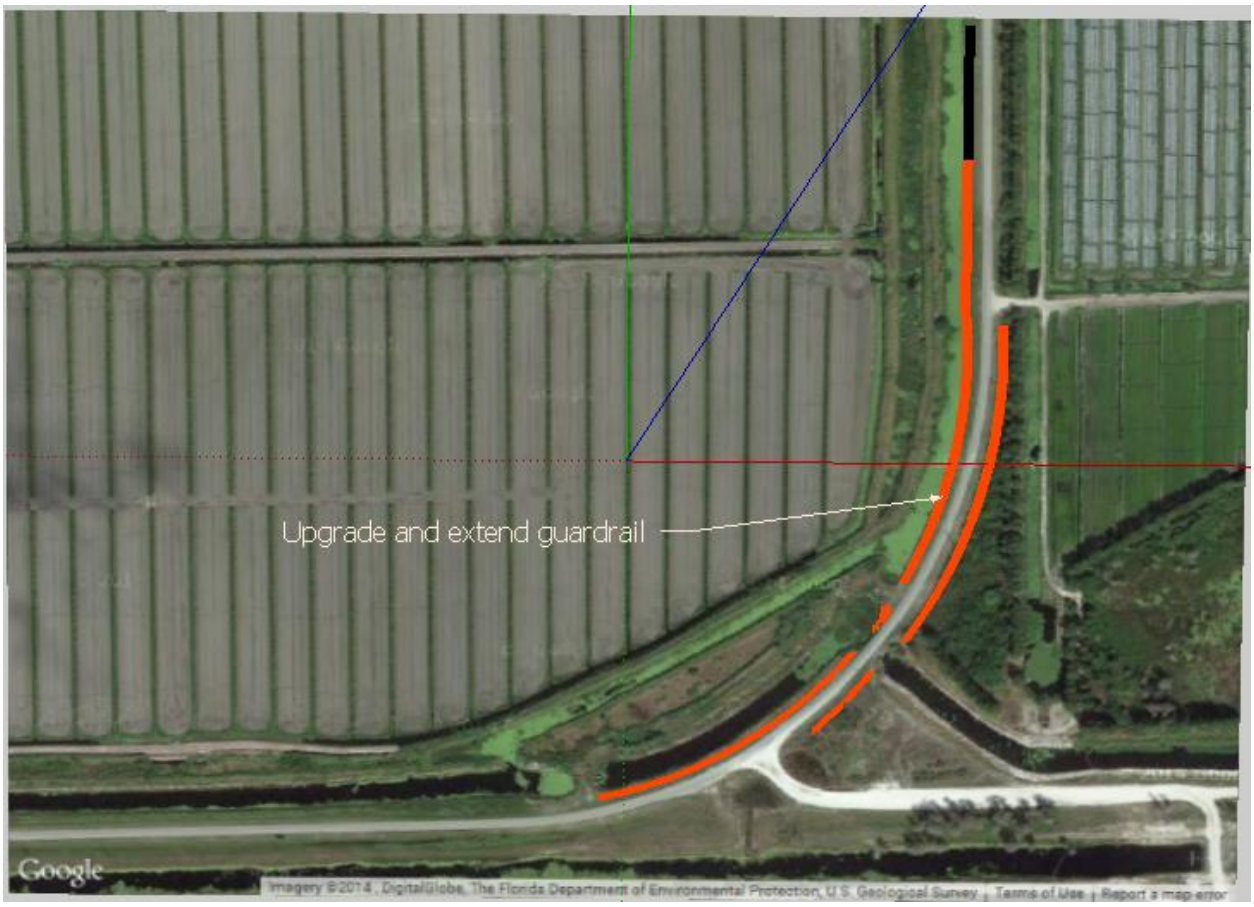


Figure 24 Recommended Guardrail improvements at Deer Fence Curve/ Intersection

Table 9 B/C for countermeasures at major curves

Level	*Countermeasure*	*Estimated Cost*	*Benefit/Cost*	*NPV*
1.	Upgrade warning signs at all curves	$ 80,010	18.98	$274,501
2.	Construct paved shoulders, upgrade markings to include audible centerline and edge line marking and shoulder pavement markings (all curves)	$2,698,643	2.75	$339,232
3	Additional countermeasures at three curves	$2,798,390	2.93	$387,670
	Rogers Road			
	• Install luminaires • Flashers for advanced warnings (both approaches) • Upgrade guardrail			
	Blumberg Road			
	• Add guardrail along northbound lane and on Blumberg Road approaches • Level pavement to restore consistent superelevation throughout the length of the curve.			
	Deer Fence Road			
	• Upgrade and extend guardrail			

Factors affecting implementation

Right of way	**It appears that improvements can be made within existing right of way. For the pavement widening at Blumberg road, some survey information may be required.**
Environmental impacts	**Shoulder and culvert work at Blumberg might involve fill in existing canal; Shifting the alignment to add the widening on the inside radius of the curve will eliminate the need to fill on the south/east side of the curve and will significantly reduce potential for environmental impact. Widening may require coordination with permitting agencies.**
Utilities	**Installation of luminaire at Rogers Road will require power connection. Transmission lines are on site, and power may be available.** **Unless flashing beacons are solar powered, power source will be required.** **Shoulder paving will require coordination with utilities.**
Community impacts	**None anticipated.**

4.2 PAVEMENT MARKINGS - TANGENT SECTIONS

The frequency of lane departure crashes in the study area, especially at night, suggests that upgraded lane marking are needed. All three roads in the study area are marked with centerline and edge markings, but in most areas the markings are worn and need to be refreshed. Raised pavement markers were original installed along the centerline and along the edge markings of the curves, but many are now missing or damaged.

Countermeasures:

- Restripe centerline, including replacement of RPMs, for all tangent sections within the study area.
- Install ground in place "rumble stripe" (Figure 8) along edge line of all roads except CR 835 from Joshua Boulevard to SR 80.
- Restripe edge line without rumble feature for CR 835 from Joshua Boulevard to SR 80. This area runs through a developed urban area where speeds are lower, lane departure crashes have been less severe, and noise from "rumble stripes" is likely to be objectionable (approximately 1.25 miles).

The map in Figure 25 shows the locations of the segments for marking upgrades.

Hendry County has recently resurfaced short sections of CR 835. In these areas, the pavement markings have been refreshed with thermoplastic centerline and edge markings and RPMs along the centerline. None of these have included audible/vibratory edge markings. Cost estimates are based on restriping and marking these sections in their entirety. Detailed survey of the existing conditions should be conducted before final plans are prepared and certain sections may be eliminated where the current markings still meet the intent of the countermeasure or resurfacing will be scheduled in the near future.

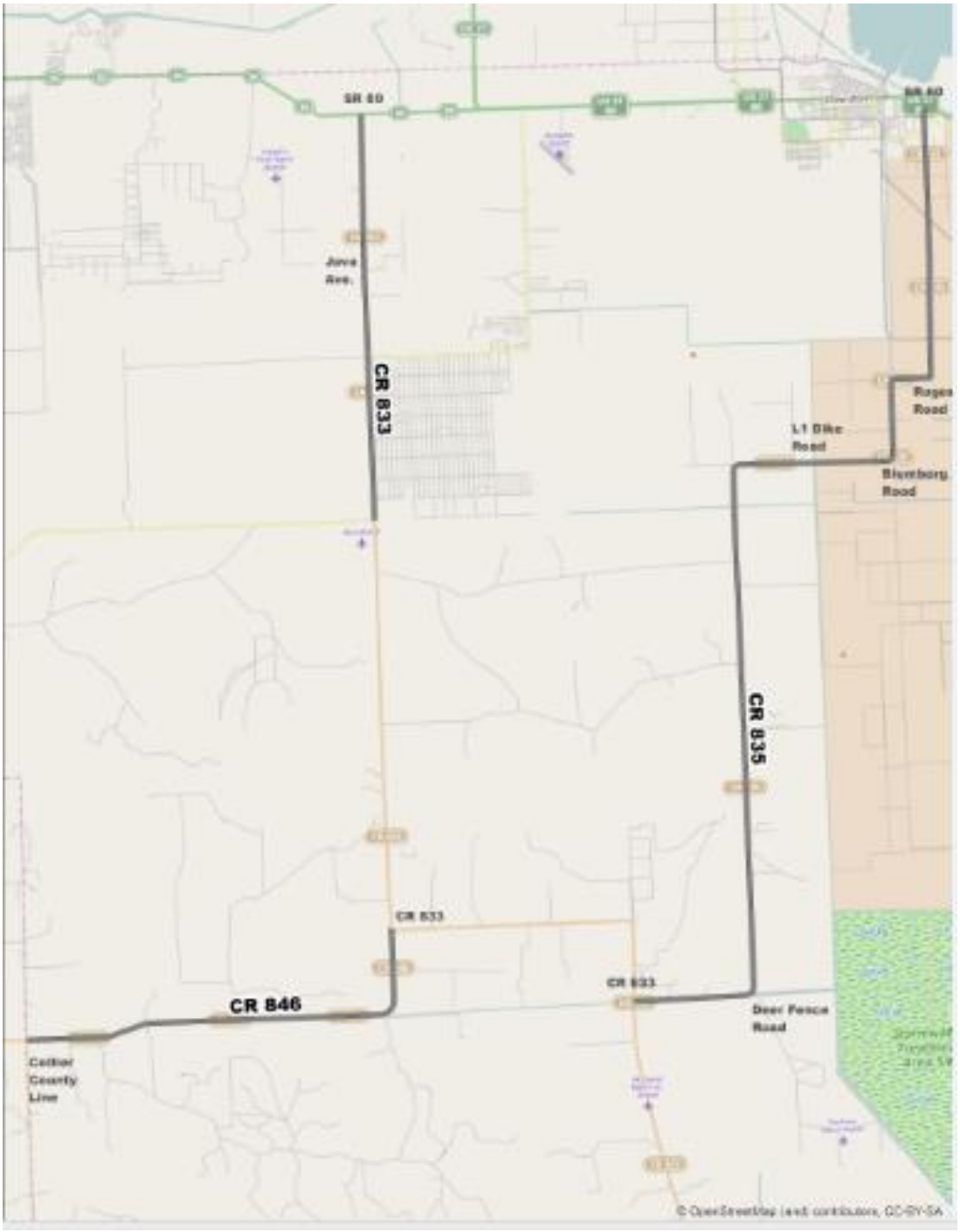


Figure 25 Road segments for pavement marking upgrades

Table 10 B/C – Upgrade signs and pavement markings for tangent sections[2]

Road	**Countermeasure**	**Miles**	**Estimated Cost**	**B/C**	**NPV**
CR 833	• Refresh and upgrade pavement markings on centerline and edge. Including rumble strips	**10.1**			
CR 835	• Refresh and upgrade pavement markings on centerline and edge. Including rumble strips	**10.83**			
CR 846	• Refresh and upgrade pavement markings on centerline and edge. Including rumble strips	**28.78**			
All sections		**49.71**	**$1,263,840**	**3.82**	**$680,499**

Factors affecting implementation

Right of way	All improvements can be implemented within existing right of way.
Environmental impacts	No significant environmental impacts are expected.
Utilities	No conflicts are anticipated.

[2] Cost of markings through curves is included in the discussion of Major Curves.

4.3 CANALS AND CULVERTS - TANGENT SECTIONS

Canals or deep ditches are common along the rights of way throughout the study area. These canals provide for drainage and irrigation for the agricultural operations. Some are managed by the South Florida Water Management District; others by private owners. The canals vary in width and depth.

Most canals are located outside of, but adjacent to the road rights of way. The canal banks are steep and errant vehicles that get beyond the edge of the right of way may have little chance of recovering. **Over half of the fatalities in the study area involved vehicles that entered a canal.**

In addition to canals parallel to the roadway, numerous canals and drainage ditches cross the road through culverts or small bridges. Figure 27 depicts one of the more severe conditions. Most major crossings have guardrail protection, but some of the smaller ditches and canals do not have this protection. Figure 28 shows the lengths of crossing culverts on all three roads within the study area.

In this recent crash, the driver reportedly fell asleep and crossed the road, striking the end of the guardrail. The vehicle overturned into the canal. Driver and passenger were able to escape by breaking out a window and sustained only minor cuts from the broken glass.

Figure 26 Crash site where vehicle entered canal

This photograph shows an unprotected crossing on CR 835. Pavement is approximately 20 feet wide. Distance between end walls is approximately 30 feet.

Figure 27 Canal crossing without guardrail on CR 835

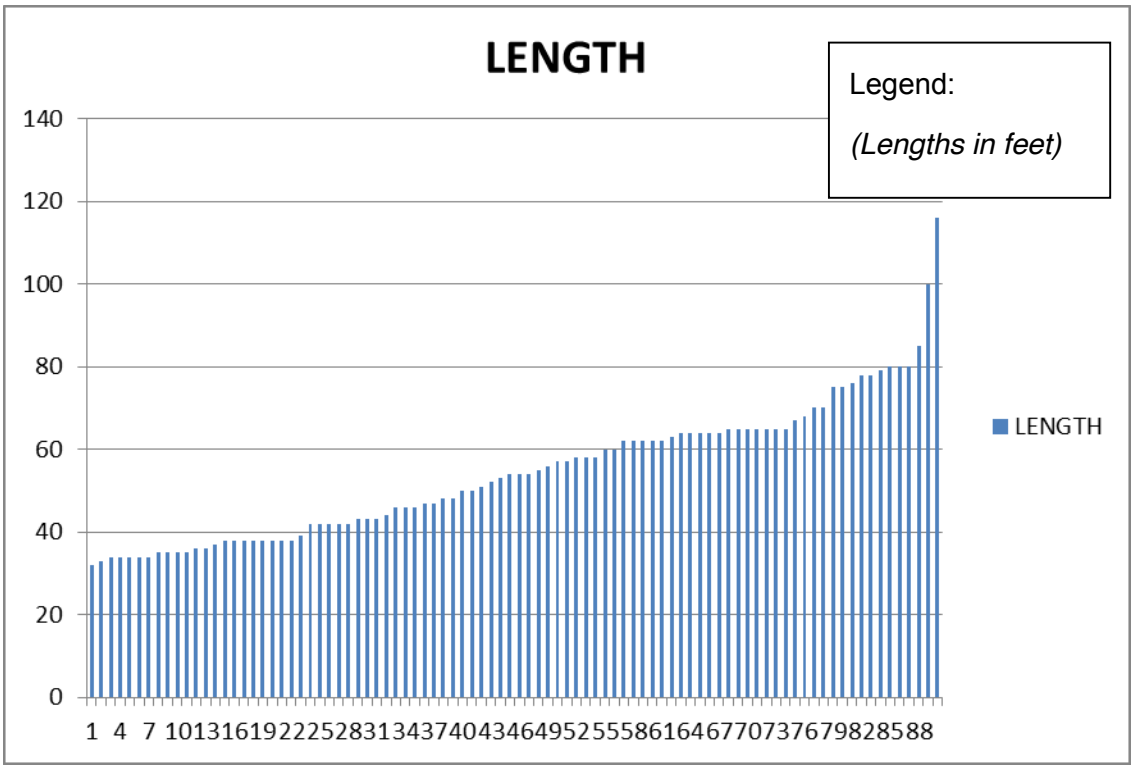


Figure 28 Culverts within the study area sorted by length (lengths shown in feet)

Source Hendry County GIS

In addition to upgrading the pavement markings to include audible/vibratory edge lines, two other alternatives were considered to reduce severe off-road crashes in the tangent sections: These were:

Shoulder paving

Addition of paved shoulders in the tangent sections has a relatively low benefit/ cost ratio. The cost of adding paved shoulders for the entire study area was estimated at nearly $20 Million with a B/C of less than 1.0. Except at curves, construction of paved shoulders on tangent sections does not appear to meet the threshold for HSIP funding at this time.

Guardrail (or cable barrier) along the canals, including culvert crossings.

Canals along the road are generally outside the road right of way, but a barrier would reduce the severity of off-road crashes. In many locations, a cable barrier may be a preferred alternate, but for the purpose of this report, cost estimates are based on use of guardrail. Selection of cable or guardrail should be made based on detail review of each site and consultation with Hendry County.

For some culvert crossings, extending the culvert or replacing headwalls with mitered end sections may be more appropriate.

- **CR 833 from Java Avenue to SR 80**

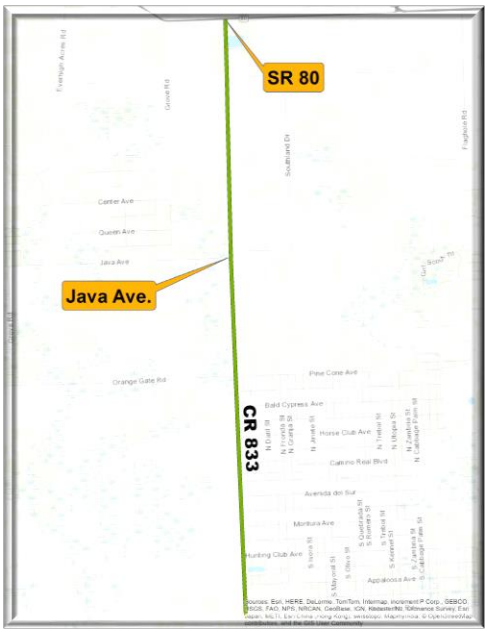


Figure 29 CR 833 from Java Avenue to SR 80

CR 833 from Java Avenue to SR 80 (4 miles) is bounded on the west side by a continuous canal under the jurisdiction of the South Florida Water Management District (SFWMD). The distance between the canal and the roadway varies from less than 20 feet near the intersection with SR 80 to more than 30 feet. Guardrail installations are present at intersections/driveways that cross the canal, but these generally extend only a short distance along CR 833.

Figure 30 Canal along west boundary of CR 833 south of SR 80

Table 11 shows the crash data for this section.

- Six crashes were designated as off-road or rollover. Four others involved vehicles entering the canal.
- There were three total fatalities – two involving vehicles in the canal.

Table 11 Crash summary – CR 833 from Java Avenue to SR 80

Crash Type	Total	Fatal	Injury	PDO	In Canal	Day	Non day
Bike/Ped							
Animal							
Intersect/driveway	6		3	3		6	
Lane depart- on road	2	1	1			1	1
Lane depart - off-road	6	2	4		4	2	4
Total	**14**	**3**	**8**	**3**	**4**	**9**	**5**

For the section of CR 833 South of Java Avenue, there are a limited number of canal crossings. None of these are shorter than 40 feet. None of the crashes in this section were associated with the culvert crossings.

Table 12 B/C – Guardrail at CR 833

Level	**Countermeasure**	**Cost**	**B/C**	**NPV**
1	Upgrade pavement markings (This is included in **4.2 Pavement markings - tangent** sections)			
2	Install guardrail along the west side of CR 833 between Java Avenue and SR 80	**$606,644**	**4.2**	**$125,095**

Note: Benefit and cost calculations for guardrail reflect the incremental benefits and costs after pavement markings are installed.

Factors affecting implementation

Right of way	Right of way in this corridor appears to be adequate. Verification of exact right of way limits is needed.
Environmental impacts	No significant environmental impacts are expected from guardrail north of Java Avenue.
Utilities	No significant conflicts are apparent, but will require standard utility coordination.
Community impacts	No community impacts are anticipated.

➢ L-1 Dike / Road intersection

Figure 31 CR 835 at L-1 Canal/Dike crossing

An unpaved road intersects CR 835 at the L-1 Canal/Dike of SFWMD. This intersection is at the top of the dike making it difficult for drivers approaching the intersection from either direction to see the road surface. Signs designate a school bus stop in the area, but there are no intersection warning signs.

The bridge crossing the canal is narrow and does not have guardrail on the approaches. Traffic on CR 835 is exposed to both the canal crossing the road and canals on each side of the embankment.

Figure 32 Eastbound approach to bridge over L-1 Canal

A small recreation area with a boat ramp is located just west of the L-1 Canal.

Although no crashes were reported at this intersection, the skid marks on the CR 835 approaches indicate that advanced warning for the intersection is needed. One reported crash was attributed to a vehicle with a wide load striking the bridge rail.

No crashes involving vehicles entering the canal at this specific location were reported during the analysis period; however, a recent crash was reported in which a vehicle entered the canal in the area of the boat ramp just west of the canal. The steep slopes on the approaches and the narrow bridge with exposed abutments are risk factors not present at most other locations in the corridor where vehicles did enter a canal.

.

Figure 33 Intersection of L1 Dike Road

Figure 34 Westbound approach to intersection at L-1 Dike Road

Countermeasures:

- Advanced warning signs alerting drivers to the intersection and narrow bridge.
- Guardrail at the bridge (Figure 35). Guardrail should be extended across the bridge.

Figure 35 Recommended guardrail at L-1 Canal / Intersection

Table 13 Guardrail at L-1 Canal / Intersection

Level	*Countermeasure*	**Cost**	**B/C**	**NPV**
1	Upgrade pavement markings (This is included in **4.2 Pavement markings - tangent** sections)			
2	Upgrade signs to include: • Advanced warnings for intersection • Narrow bridge Add guardrail at bridge approaches	$47,738	1.98	$3,285

Note: Benefit and cost calculations for guardrail reflect the incremental benefits and costs after pavement markings are installed.

No crashes involving the canal were reported within the limits of the proposed guardrail project at L-1 Canal Crossing, although the risk factors appear to be greater than at other sections of CR 835 where such crashes occurred. For this analysis it is assumed that the B/C for the entire corridor would apply to this short segment within the corridor.

Factors affecting implementation

Right of way	**No apparent additional right of way required.**
Environmental impacts	**None anticipated.**
Utilities	**Guardrail installation will require coordination with utilities.**
Community impacts	**None anticipated.**

- **CR 835 from CR 833 to SR 80**

Figure 36 CR 835

The northern end of this corridor (approximately 1.5 miles) lies within the developed area of Clewiston. The rest of the corridor passes through a large agricultural area. Throughout much of the corridor, large canals are located along at least one side of the road.

For this study, the extent of the canals that need protection was estimated from aerial photography. More detailed measurements and surveys will be required to develop an exact scope for a safety improvement project. However, in the tangent sections it is estimated that there are approximately twelve miles of roadway with canals adjacent to one or both sides.

There are also a significant number of culverts crossing the road. Nearly 30% of the culverts are less than 40 feet long (see Figure 38).

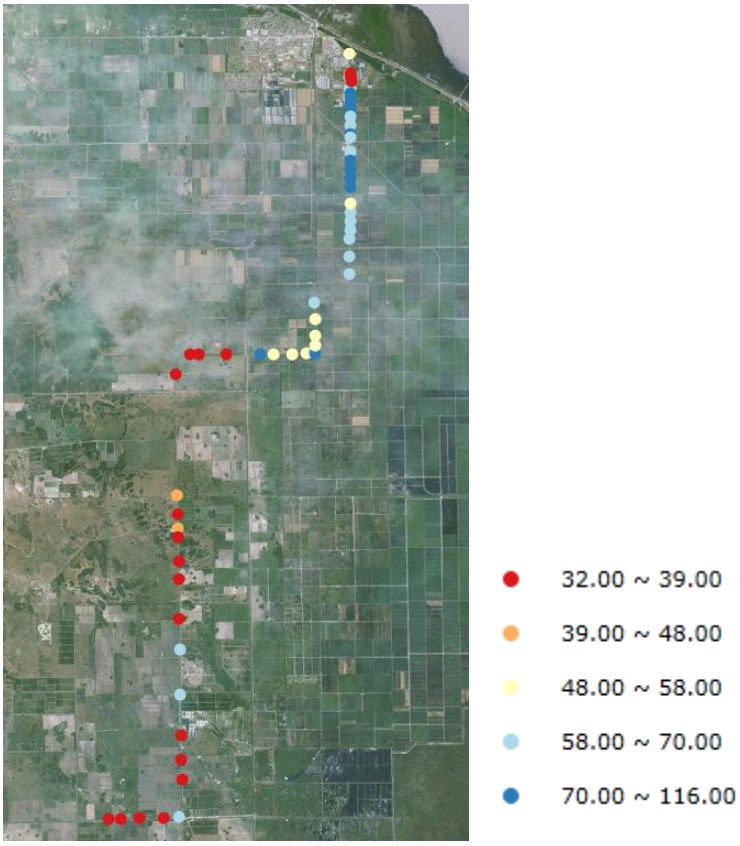


Figure 37 Culvert crossings on CR 835

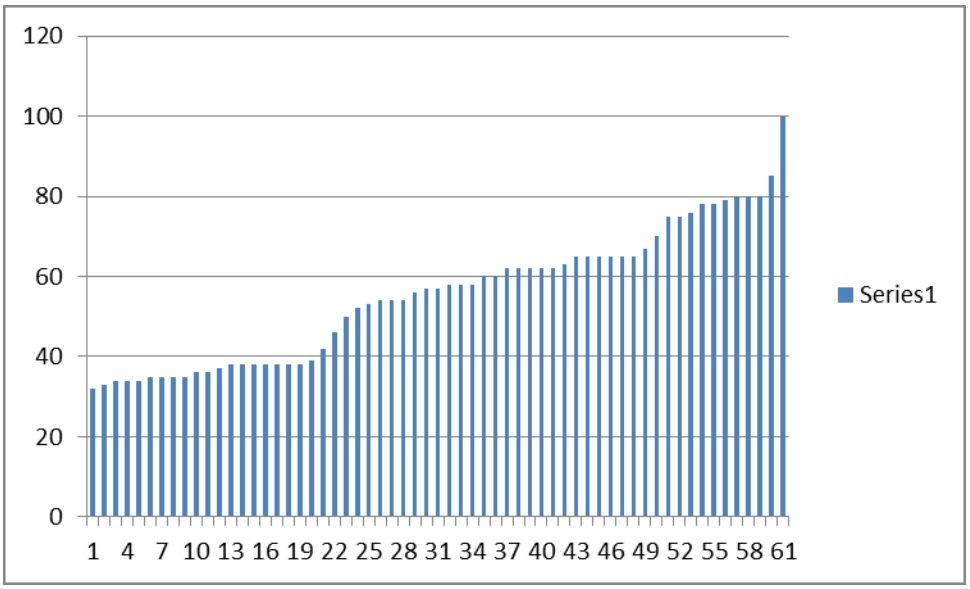


Figure 38 Lengths of culvert crossings on CR 835

In nearly half (23) of the crashes in this corridor, a vehicle entered a canal. Eleven of these canal related crashes occurred in the curves. Twelve of these were in the tangent sections.

Culvert crossings were not identified as a contributor to any of these crashes but the conditions at these crossings make them a particular concern.

Table 14 Crashes on CR 835

Crash Type	Total	Fatal	Injury	PDO	In Canal	Day	Non day
Ped/bike	2	1	1	0	0	0	2
Animal	4	0	2	2	0	3	1
Intersect/driveway	6	0	3	3	0	6	0
Lane depart- on road	10	0	8	2	1	8	2
Lane depart - off-road	33	6	14	13	22	12	21
Debris	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0
Total	**55**	**7**	**28**	**20**	**23**	**29**	**26**

Countermeasures:

- Install guardrail along the canals at various locations throughout the corridor.

  The numbers used here to estimate the guardrail needed for CR 835 represent a rough estimate based on a "windshield survey" and examination of aerial photography. More detailed data collection and analysis will be required to develop specific improvement projects in this corridor. The purpose of this analysis is to provide a general review of the problem and potential feasibility for safety improvements.

- Extend culverts and add appropriate end treatments or install guardrail where culverts cannot be extended to meet clear zone criteria. (In some cases, culverts do not appear to be functional and may be eliminated.)

  Many of the shorter culvert crossings are within areas where parallel guardrail is also needed. For the purpose of the benefit cost analysis, these crossings are included in the cost estimates for the linear guardrail.

  An "order of magnitude estimate" of costs associated with culvert extensions was based on the following assumptions.

  - *All pipes less than 40 feet in length will require an extension to be able to accommodate guardrail.*
  - *The number of culverts that require guardrail is approximately the same as the number of culverts less than 40 feet.*
  - *Some of the culverts may require complete replacement. It is assumed that the County will replace culverts as needed.*

- *Most culverts are in areas where continuous guardrail is needed on at least one side of the road. This estimate is based on the assumption that, on the average, a short guardrail section is needed on only one side of the road.*

Table 15 Potential countermeasures for CR 835

Countermeasure	*Distance (miles)*	*Cost*	*B/C*	*NPV*
Upgrade pavement markings to include edge line rumble stripes. – (covered under **4.2 Pavement** markings - tangent sections)--				
Construct guardrail along canals, including guardrail at culvert crossings or extension of culverts.- various locations	11.9	$2,116,617	1.98	$134,369

Note: Benefit and cost calculations for guardrail reflect the incremental benefits and costs after pavement markings are installed.

Mileage is estimated from aerial photography for the purpose of the benefit analysis. More detailed data collection and analysis will be required to develop specific improvement projects.

Factors affecting implementation

Right of way	**No apparent additional right of way required; confirm with detailed examination of right of way maps where widening is needed.**
Environmental impacts	**Other pavement widening, shoulder work may involve additional fill in canals which will require environmental permits.** **Replacement or extension of cross culverts will require coordination with regulatory agencies and may require permits.**
Utilities	**Shoulder paving will require coordination with all utilities; coordination with railroad is also required at two locations for any pavement or shoulder work.**
Community impacts	**None expected.**

➢ CR 846 from Collier County Line to CR 833

Figure 39 CR 846

Land use along this entire corridor is agricultural. The road segment includes one 90 degree curve at the intersection of Roberts Ranch Road, and two other minor curves. A major canal lies along the north edge of the road through most of the east- west segment (six miles) with smaller ditches along the south side.

Guardrails are in place at most critical canal or ditch crossings.

Ten crashes were reported during the analysis period, two involved animals. All others were lane departures with six involving overturning or off-road vehicles. Three vehicles entered a canal. One of these involved a fatality. Of the total eight lane departures, only two occurred during non-daylight hours. Overall, the frequency of crashes on this road is consistent with the average crash frequency for other roads in Hendry County.

Table 16 Crashes on CR 846

Crash Type	Total	Fatal	Injury	PDO	In Canal	Day	Non day
Ped/bike	0						
Animal	2		2				2
Intersect/driveway	0						
Lane depart- on road	2		2			1	1
Lane depart - off-road	6	1	4	1	3	5	1
Totals	**10**	**1**	**8**	**1**	**3**	**6**	**4**

Figure 40 Guardrail protection at major canal crossing

Figure 41 "Unprotected" culvert crossing on CR 846

Addition of guardrail along CR 846 appears to be less urgent than on CR 835.
In view of the limited budget available for funding these improvements, further guardrail upgrades in this corridor are not identified as candidates for HSIP funding at this time.

Countermeasure:

- Upgrade pavement marking (addressed in area-wide project).

Table 17 Potential countermeasures for CR 846

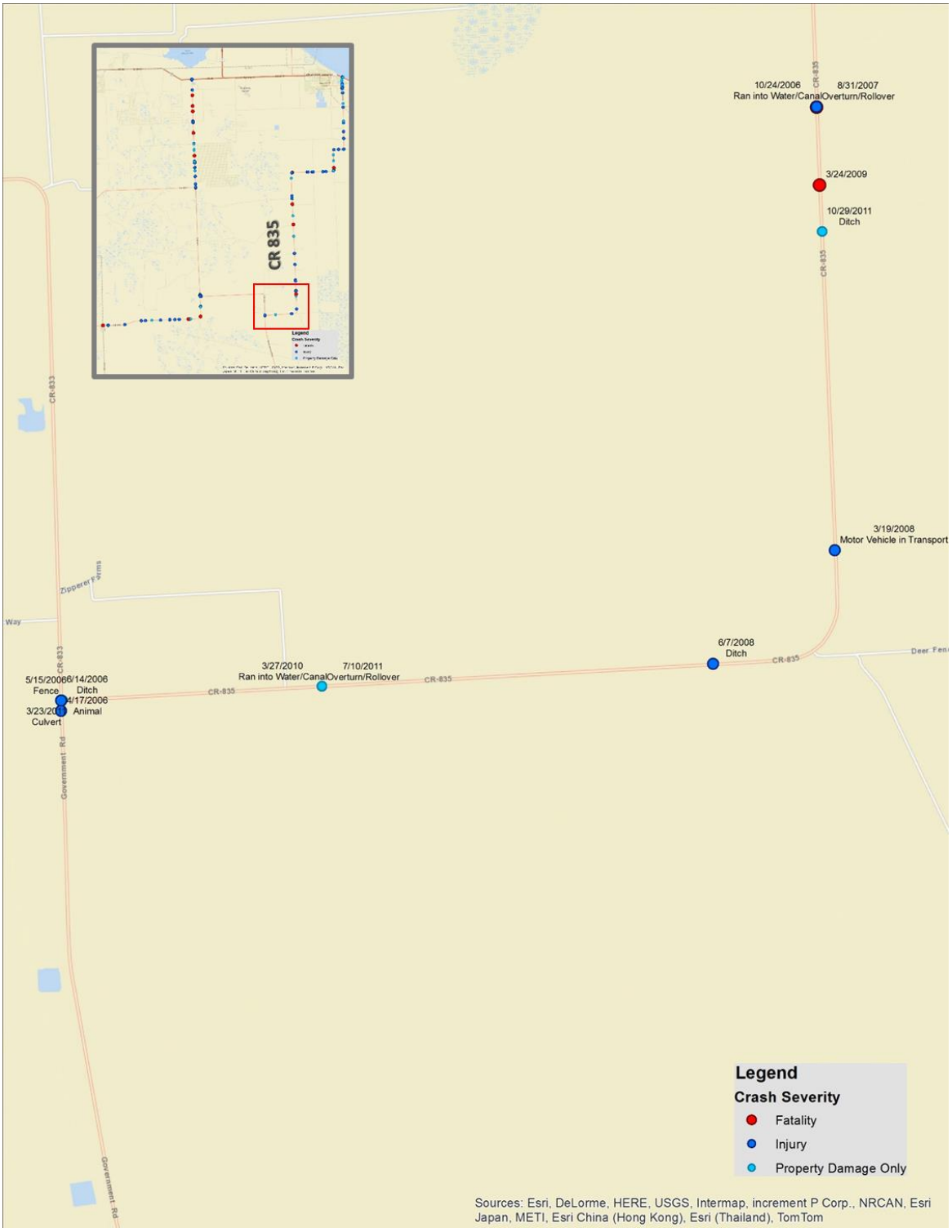
Countermeasure	*Distance (miles)*	*Cost*	*B/C*	*NPV*
Upgrade pavement markings to include edge line rumble stripes – (covered under **4.2 Pavement markings - tangent** sections)--				

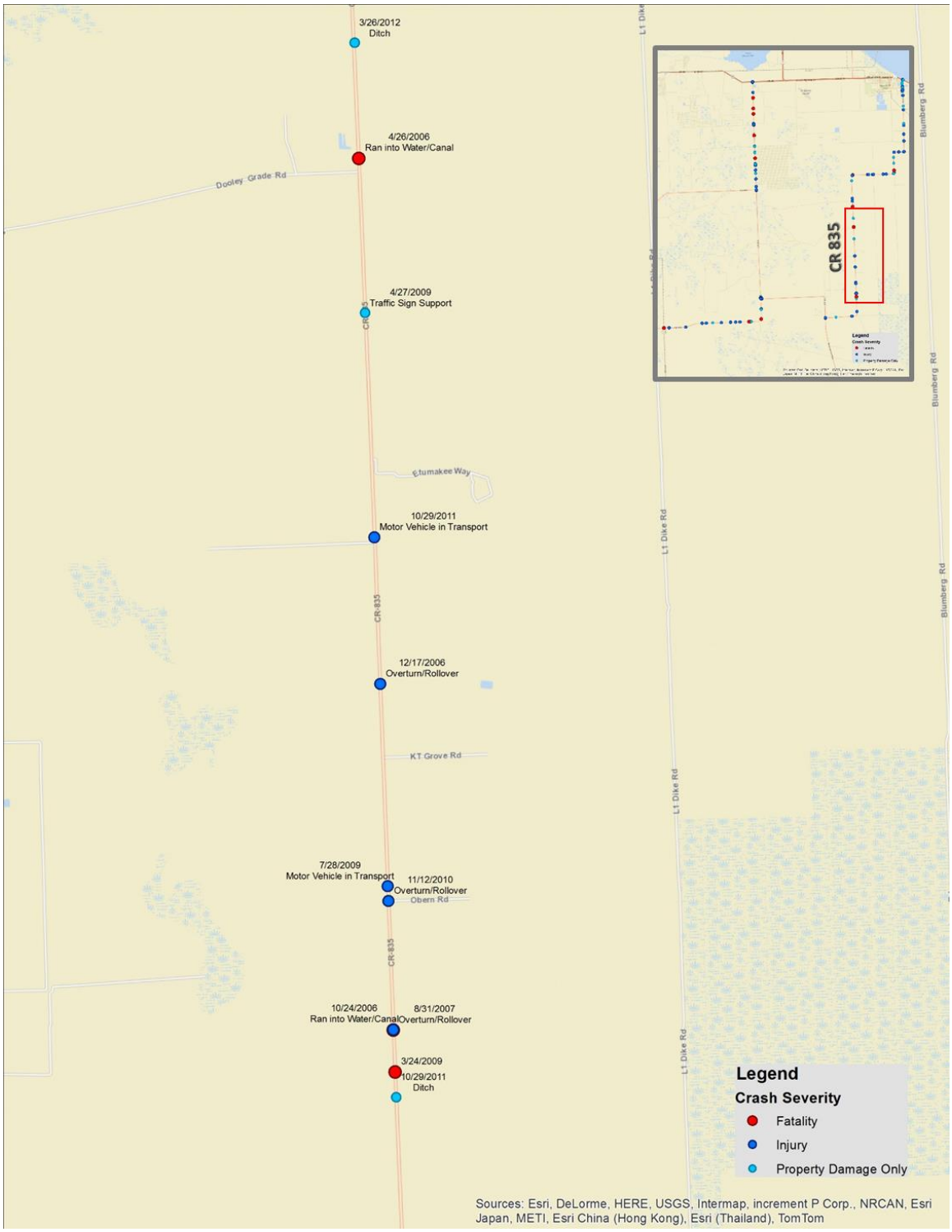
APPENDIX A - CRASH MAPS

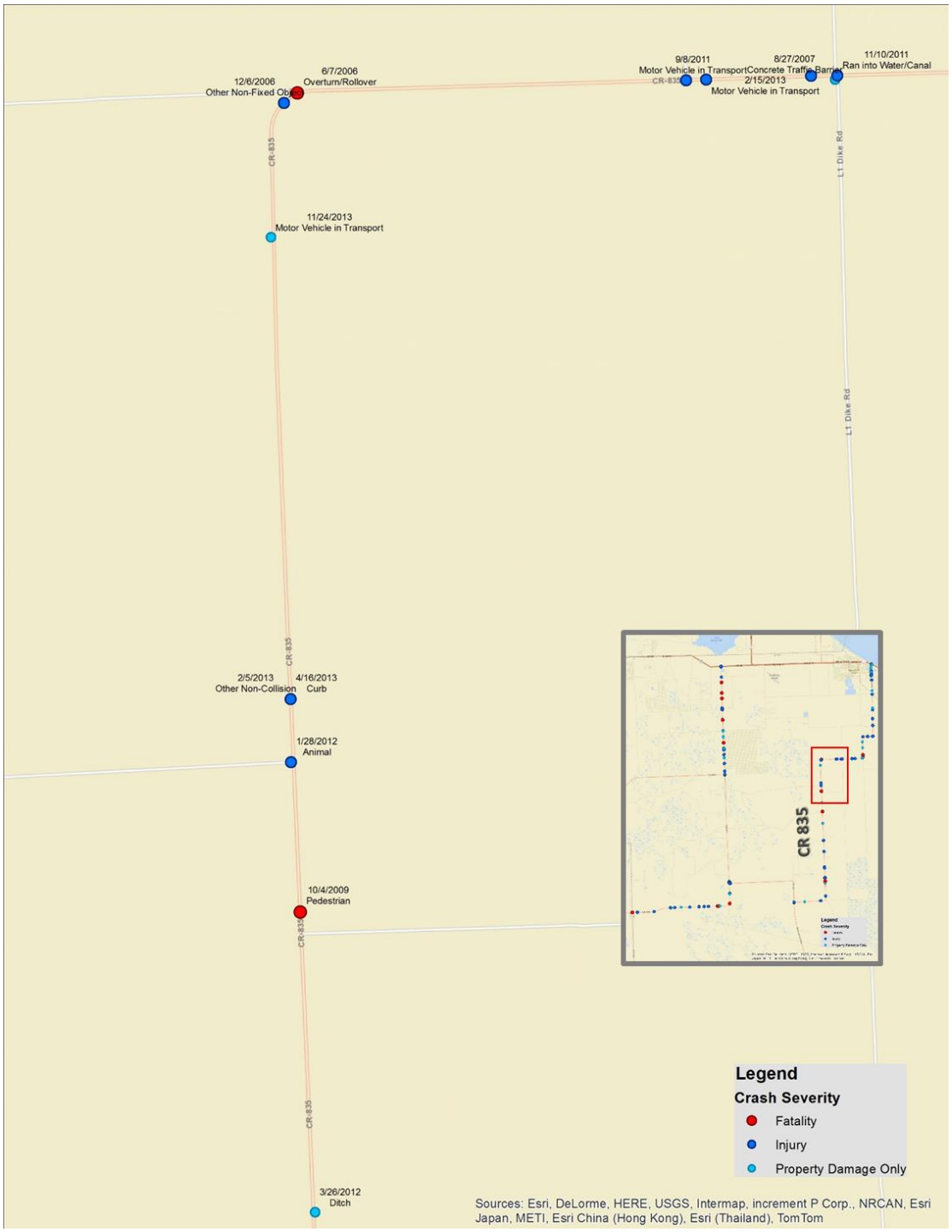
CR 833


3/27/2007
Animal
9/8/2008
Animal
4/10/2011
Overturn/Rollover
1/27/2009
Motor Vehicle in Transport
8/24/2012
Traffic Sign Support
4/19/2009
Animal
Orange Gate Rd
Pine Cone Ave
12/2/2006
Motor Vehicle in Transport
1/8/2006
Animal
Bald Cypress Ave
4/22/2007
Pedalcycle
Horse Club Ave
Avenida del Centro
Camino Real Blvd
5/26/2012
Traffic Sign Support
9/28/2008
Overturn/Rollover
Avenida del Clb
3/11/2013
Motor Vehicle in Transport
1/8/2012
Ditch
E Marimba Cir
Avenida del Sur
6/13/2010
Tree (standing)
11/24/2006
Fence
Montura Ave
6/10/2009
Motor Vehicle in Transport
Hunting Club Ave
Appaloosa Ave
2/14/2007
Motor Vehicle in Transport
2/10/2007
Other Non-Fixed Object
4/16/2007
Tree (standing)
2/27/2007
Motor Vehicle in Transport
2/10/2013
Fell/Jumped From Motor Vehicle
12/29/2007
Motor Vehicle in Transport
Perimeter Rd
Legend
Crash Severity
Fatality
Injury
Property Damage Only
Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom

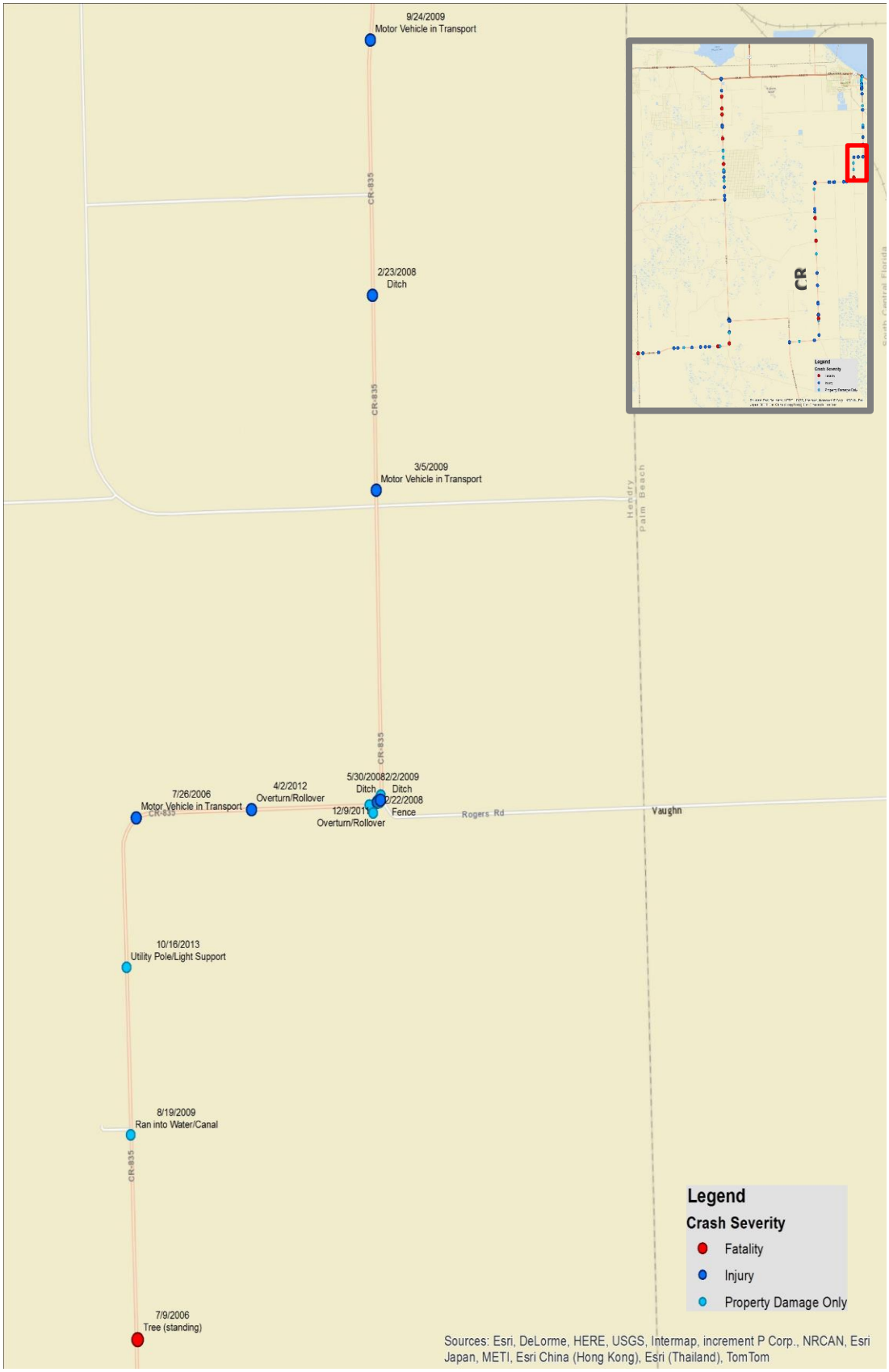
CR 835


CR 835
10/24/2006
Ran into Water/Canal
8/31/2007
Overturn/Rollover
3/24/2009
10/29/2011
Ditch
3/19/2008
Motor Vehicle in Transport
6/7/2008
Ditch
3/27/2010
Ran into Water/Canal
7/10/2011
Overturn/Rollover
5/15/2006
Fence
6/14/2006
Ditch
4/17/2006
Animal
3/23/20
Culvert
CR-835
CR-833
Government Rd
Zipperer Farms
Way
Deer Fen
Legend
Crash Severity
Fatality
Injury
Property Damage Only
Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom


3/26/2012
Ditch
4/26/2006
Ran into Water/Canal
Dooley Grade Rd
4/27/2009
Traffic Sign Support
CR-835
Etumakee Way
10/29/2011
Motor Vehicle in Transport
CR-835
12/17/2006
Overturn/Rollover
KT Grove Rd
7/28/2009
Motor Vehicle in Transport
11/12/2010
Overturn/Rollover
Obern Rd
CR-835
10/24/2006
Ran into Water/Canal
8/31/2007
Overturn/Rollover
3/24/2009
10/29/2011
Ditch
L1 Dike Rd
Blumberg Rd
CR 835
Legend
Crash Severity
Fatality
Injury
Property Damage Only
Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom

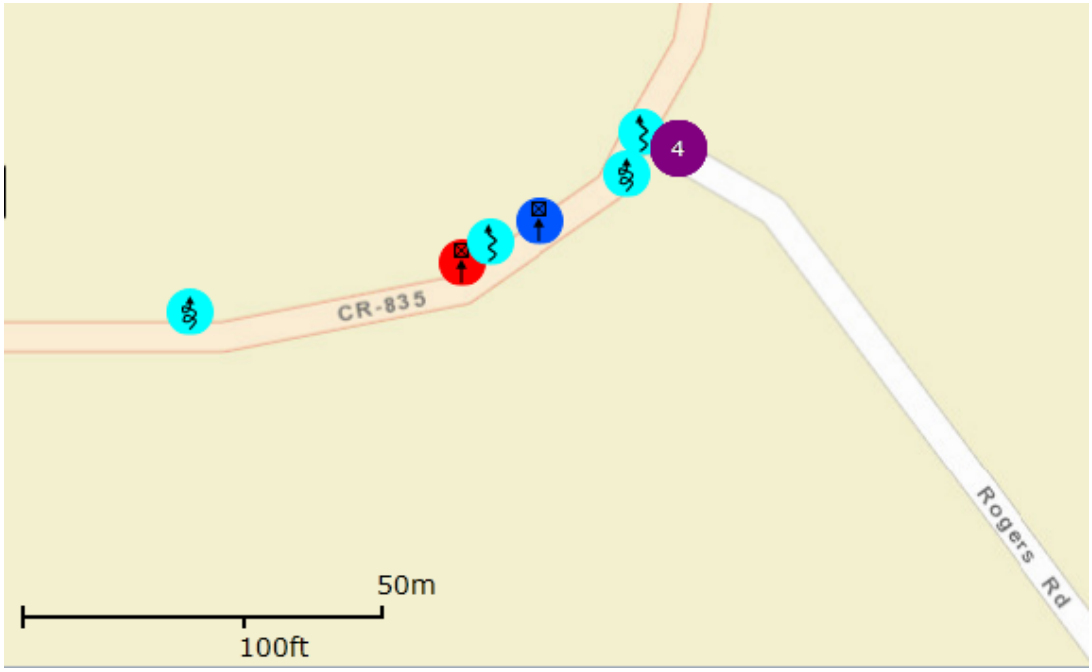

6/7/2006
Overturn/Rollover
12/6/2006
Other Non-Fixed Obj
9/8/2011
Motor Vehicle in Transport
8/27/2007
Concrete Traffic Barrier
2/15/2013
Motor Vehicle in Transport
11/10/2011
Ran into Water/Canal
CR-833
Lt Dike Rd
11/24/2013
Motor Vehicle in Transport
CR-835
2/5/2013
Other Non-Collision
4/16/2013
Curb
1/28/2012
Animal
10/4/2009
Pedestrian
CR-834
CR-835
3/26/2012
Ditch
CR 835
Legend
Crash Severity
Fatality
Injury
Property Damage Only
Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom


7/26/2006
Motor Vehicle in Transport
4/2/2012
Overturn/Rollover
10/16/2013
Utility Pole/Light Support
8/19/2009
Ran into Water/Canal
7/9/2006
Tree (standing)
7/31/2006
Motor Vehicle in Transport
2/19/2012
Overturn/Rollover
9/19/2008
Ditch
10/19/2013
Motor Vehicle in Transport
1/25/2006
Pedestrian
6/4/2006
Animal
11/10/2011
Ran into Water/Canal
8/27/2007
Concrete Traffic Barrier
9/8/2011
Motor Vehicle in Transport
2/15/2013
Motor Vehicle in Transport
CR-835
Lt Dike Rd
Blumberg Rd
Legend
Crash Severity
Fatality
Injury
Property Damage Only
Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom

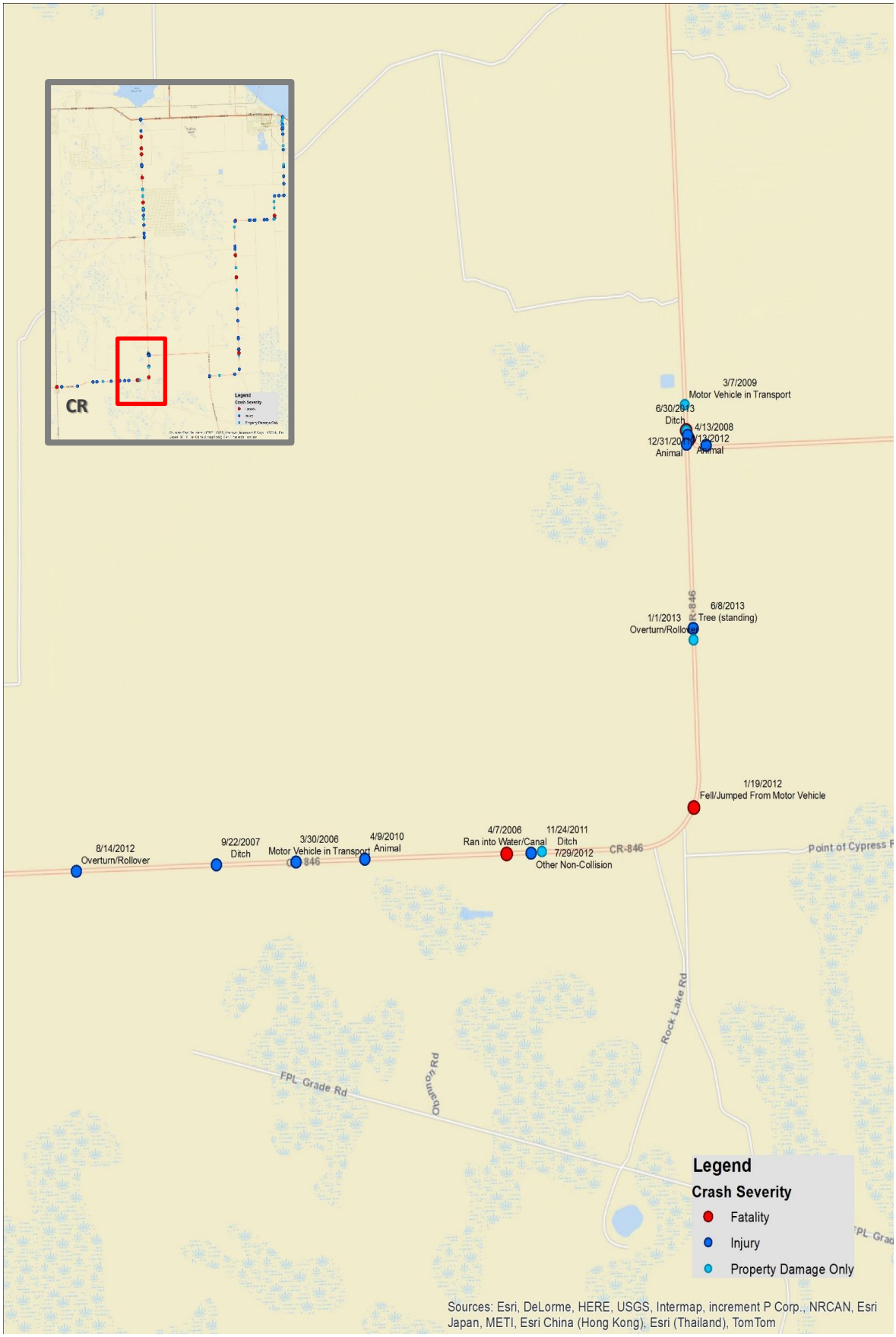

9/24/2009
Motor Vehicle in Transport
CR-835
2/23/2008
Ditch
CR-835
3/5/2009
Motor Vehicle in Transport
Hendry
Palm Beach
CR-835
7/26/2006
Motor Vehicle in Transport
CR-835
4/2/2012
Overturn/Rollover
5/30/2008
Ditch
12/9/2011
Overturn/Rollover
2/2/2009
Ditch
2/22/2008
Fence
Rogers Rd
Vaughn
10/16/2013
Utility Pole/Light Support
8/19/2009
Ran into Water/Canal
CR-835
7/9/2006
Tree (standing)
Legend
Crash Severity
Fatality
Injury
Property Damage Only
Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom


5/15/2007
Guardrail Face
5/27/2008
3/4/2011
Overturn/Rollover
7/12/2013
Overturn/Rollover
2/21/2010
Motor Vehicle in Transport
4/12/2008
Parked Motor Vehicle
1/14/2012
Traffic Sign Support
2/4/2010
Motor Vehicle in Transport
6/6/2007
Motor Vehicle in Transport
5/13/2009
Ditch
5/16/2012
Motor Vehicle in Transport
1/10/2010
Motor Vehicle in Transport
3/7/2006
Motor Vehicle in Transport
1/23/2010
7/21/2006
Fence
7/20/2006
Animal
6/6/2009
Other Non-Fixed Object
6/7/2006
Motor Vehicle in Transport
12/25/2012
Motor Vehicle in Transport
11/12/2010
Ran into Water/Canal
10/18/2006
Ran into Water/Canal
7/15/2013
Ran into Water/Canal
9/24/2009
Motor Vehicle in Transport
Hooker Point
Keela
Lake Okeechobee
Old US 27 Hwy
Hookers Point Rd
Davidson Rd
Ridgdill Rd
Sherwood Ave
Richmond Ave
Sassy Rd
Circle Ave
Corkscrew Blvd
Mathew
CR-835
South Central Florida
CR 835
Legend
Crash Severity
Fatality
Injury
Property Damage Only
Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom

CR 835 at Rogers Road



CR 846 from Collier County Line to CR 833


CR
3/7/2009
Motor Vehicle in Transport
6/30/2013
Ditch
4/13/2008
12/31/2012
Animal
Animal
6/8/2013
Tree (standing)
1/1/2013
Overturn/Rollover
1/19/2012
Fell/Jumped From Motor Vehicle
8/14/2012
Overturn/Rollover
9/22/2007
Ditch
3/30/2006
Motor Vehicle in Transport
4/9/2010
Animal
4/7/2006
Ran into Water/Canal
11/24/2011
Ditch
7/29/2012
Other Non-Collision
CR-846
Point of Cypress
Rock Lake Rd
FPL Grade Rd
Legend
Crash Severity
Fatality
Injury
Property Damage Only
Sources: Esri, DeLorme, HERE, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom

APPENDIX B - BASIS OF COST ESTIMATES

Crash Costs				
Two-lane rural road crash costs	$ 402,003			
Countermeasure / Activity	**Cost**	**Units**	**Lifespan**	**Item Number (from FDOT Average Unit Cost)**
Advanced Warning sign	$ 252.02	each	6	0700 20 11
Chevron	$ 252.02	each	6	0700 20 11
Stop sign	$ 252.02	each	6	0700 20 11
Curve warning sign with advisory speed plat	$ 336.20	each	6	based on 0700 20 11
Remove single post sign	$ 15.18	each	6	0700 20 60
Object marker sign	$ 126.78	each	6	0705 10 3
Audible Edgelines	$ 0.60	feet	6	0701 16111
Edgelines for rumble striping	$ 0.66	feet	6	0711 11151
Ground in place stripes	$ 1,024.41	mile	6	0546 72 51
Centerlines	$ 0.58	feet	6	0711 15211
RPMs	$ 3.01	each	6	0706 3
Transverse rumble strips	$ 3.23	feet	6	713102111
Stop bar (12" preformed tape)	$ 1.88	feet	6	71111123
Retroreflective strip for sign post	$ 60.00	each	6	N/A
Guardrail	$ 17.07	feet	25	0536 1 1
Guardrail removal	$ 1.29	feet	25	0536 73
Guardrail anchorage assembly	$ 1,818.39	each	25	0536 85 22
Culvert with mitered end sections	$ 11,691.32	each	25	430174130 and 430982129
Culvert extension	$ 99.07	feet	25	430174130
Flashing Beacon	$ 5,624.39	each	25	0700 90 11
Luminaires on signal poles	$ 418.44	each	6	0715 11111
Widen and pave shoulder (basic)	$ 350,000.00	mile	25	see group section below
Widen and pave shoulder (with added work)	$ 500,000.00	mile	25	see group section below
Mobilization	10%	LS		0101 1
Maintenance of Traffic	10%	LS		0102 1
Contingency and engineering	25%			
CEI	15%			
Interest rate	4.0%			
Pavement widening cost				
Basis of estimate:	Cost estimate is based on total project cost per mile for similar projects on county roads in District 2.			
	Data obtained from Work Program and projects selected based on descriptions in program.			
	Projects sampled were in Baker, Bradford, Columbia, and Dixie Counties.			
Assumptions:	Completed cross section will have a minimum 2-11' travel lanes with 2' paved shoulder with safety edge.			
	Work will include all other items necessary to meet standards (or design exception if appropriate), such as:			
		Guardrail upgrade, adjustment or addition if needed		
		cross culvert extensions and end sections		
		mitered end sections for roadside culverts		
		replace all signs to conform to MUTCD - including side road signing at intersections		
		All recommended pavement markings including thermo striping and RPMs		

APPENDIX C - CALCULATION OF BENEFIT/COST RATIOS

Curve Sections

Site: 5 curves on CR 835 and 1 curve on CR 846		
Length:	Rogers Curve	1350 feet
	CR 835 Curve #2	1700 feet
	Blumberg Curve	1800 feet
	CR 835 Curve #4	2050 feet
	Deer Fence Canal Curve	2450 feet
	CR 846 Curve	2975 feet

○ SIGNING UPGRADES AT SIX CURVES - LEVEL 1

Level 1 Countermeasures						
Countermeasure	Unit	Cost/Unit	Number	Cost	Annuity Factor	Annual Cost
Curve Signs (MUTCD 2C-2)						
Rogers Curve on CR 835						
Advanced warning signs	ea	$ 252.02	2	$ 504	5.24	$ 96
Curve warnings signs with advisory speed plates	ea	$ 336.20	2	$ 672	5.24	$ 128
Chevrons	ea	$ 252.02	12	$ 3,024	5.24	$ 577
Turn arrow	ea	$ 252.02	2	$ 504	5.24	$ 96
Sign removal	ea	$ 15.18	8	$ 121	5.24	$ 23
Reflective strip for sign posts	ea	$ 60.00	18	$ 1,080	5.24	$ 206
Second Curve on CR 835 (North to South)						
Advanced warning signs	ea	$ 252.02	2	$ 504	5.24	$ 96
Curve warnings signs with advisory speed plates	ea	$ 336.20	2	$ 672	5.24	$ 128
Chevrons	ea	$ 252.02	16	$ 4,032	5.24	$ 769
Turn arrow	ea	$ 252.02	2	$ 504	5.24	$ 96
Sign removal	ea	$ 15.18	8	$ 121	5.24	$ 23
Reflective strip for sign posts	ea	$ 60.00	22	$ 1,320	5.24	$ 252
Blumberg Curve on CR 835						
Advanced warning signs	ea	$ 252.02	2	$ 504	5.24	$ 96
Curve warnings signs with advisory speed plates	ea	$ 336.20	2	$ 672	5.24	$ 128
Chevrons	ea	$ 252.02	16	$ 4,032	5.24	$ 769
Turn arrow	ea	$ 252.02	2	$ 504	5.24	$ 96
Sign removal	ea	$ 15.18	8	$ 121	5.24	$ 23
Reflective strip for sign posts	ea	$ 60.00	22	$ 1,320	5.24	$ 252
Fourth Curve on CR 835 (North to South)						
Advanced warning signs	ea	$ 252.02	2	$ 504	5.24	$ 96
Curve warnings signs with advisory speed plates	ea	$ 336.20	2	$ 672	5.24	$ 128
Chevrons	ea	$ 252.02	20	$ 5,040	5.24	$ 962
Turn arrow	ea	$ 252.02	2	$ 504	5.24	$ 96
Sign removal	ea	$ 15.18	8	$ 121	5.24	$ 23
Reflective strip for sign posts	ea	$ 60.00	26	$ 1,560	5.24	$ 298
Deer Fence Canal Rd Curve						
Advanced warning signs	ea	$ 252.02	2	$ 504	5.24	$ 96
Curve warnings signs with advisory speed plates	ea	$ 336.20	2	$ 672	5.24	$ 128
Chevrons	ea	$ 252.02	24	$ 6,048	5.24	$ 1,154
Turn arrow	ea	$ 252.02	2	$ 504	5.24	$ 96
Sign removal	ea	$ 15.18	8	$ 121	5.24	$ 23
Reflective strip for sign posts	ea	$ 60.00	30	$ 1,800	5.24	$ 343
CR 846 Curve						
Advanced warning signs	ea	$ 252.02	2	$ 504	5.24	$ 96
Curve warnings signs with advisory speed plates	ea	$ 336.20	2	$ 672	5.24	$ 128
Chevrons	ea	$ 252.02	28	$ 7,057	5.24	$ 1,346
Turn arrow	ea	$ 252.02	2	$ 504	5.24	$ 96
Sign removal	ea	$ 15.18	8	$ 121	5.24	$ 23
Reflective strip for sign posts	ea	$ 60.00	34	$ 2,040	5.24	$ 389
Other Signs and Markings						
Stop Sign	ea	$ 252.02	3	$ 756	5.24	$ 144
Stop Bar	ea	$ 1.88	45	$ 85	5.24	$ 16
Subtotal				$ 50,007		$ 9,539
Mobilization		10%		$ 5,001		$ 954
MOT		10%		$ 5,001		$ 954
CEI		15%		$ 7,501		$ 1,431
Engineering and contingencies		25%		$ 12,502		$ 2,385
Total Cost				$ 80,010		$ 15,263

○ SHOULDERS AND PAVEMENT MARKINGS AT SIX CURVES - LEVEL 2

Level 2 Countermeasures						
Countermeasure	Unit	Cost/Unit	Number	Cost	Annuity Factor	Annual Cost
All countermeasures from Level 1	total			$ 50,007		$ 9,539
Pavement Markings						
Rogers Curve on CR 835						
Centerline	lf	$ 0.58	2,700	$ 1,554	5.24	$ 296
Edgeline	lf	$ 0.66	2,700	$ 1,782	5.24	$ 340
Ground in place rumble	mile	$ 1,024.41	0.511	$ 524	5.24	$ 100
RPMs	ea	$ 3.01	608	$ 1,829	5.24	$ 349
Rumble Strips	lf	$ 3.23	288	$ 931	5.24	$ 178
Second Curve on CR 835 (North to South)						
Centerline	lf	$ 0.58	3,400	$ 1,957	5.24	$ 373
Edgeline	lf	$ 0.66	3,400	$ 2,244	5.24	$ 428
Ground in place rumble	mile	$ 1,024.41	0.644	$ 660	5.24	$ 126
RPMs	ea	$ 3.01	765	$ 2,303	5.24	$ 439
Blumberg Curve on CR 835						
Centerline	lf	$ 0.58	3,600	$ 2,072	5.24	$ 395
Edgeline	lf	$ 0.66	3,600	$ 2,376	5.24	$ 453
Ground in place rumble	mile	$ 1,024.41	0.682	$ 698	5.24	$ 133
RPMs	ea	$ 3.01	810	$ 2,438	5.24	$ 465
Fourth Curve on CR 835 (North to South)						
Centerline	lf	$ 0.58	4,100	$ 2,360	5.24	$ 450
Edgeline	lf	$ 0.66	4,100	$ 2,706	5.24	$ 516
Ground in place rumble	mile	$ 1,024.41	0.777	$ 795	5.24	$ 152
RPMs	ea	$ 3.01	923	$ 2,777	5.24	$ 530
Deer Fence Canal Rd Curve						
Centerline	lf	$ 0.58	4,900	$ 2,820	5.24	$ 538
Edgeline	lf	$ 0.66	4,900	$ 3,234	5.24	$ 617
Ground in place rumble	mile	$ 1,024.41	0.928	$ 951	5.24	$ 181
RPMs	ea	$ 3.01	1,103	$ 3,319	5.24	$ 633
CR 846 Curve						
Centerline	lf	$ 0.58	5,950	$ 3,425	5.24	$ 653
Edgeline	lf	$ 0.66	5,950	$ 3,927	5.24	$ 749
Ground in place rumble	mile	$ 1,024.41	1.127	$ 1,154	5.24	$ 220
RPMs	ea	$ 3.01	1,339	$ 4,030	5.24	$ 769
All Curves						
Widen and Resurface	mile	$ 500,000	2.33	$ 1,167,140	15.62	$ 74,711
Milling at Blumberg	sy	2.3	4,800	$ 11,040	15.62	$ 707
Levelling/paving at Blumberg	sy	84.5	4,800	$ 405,600	15.62	$ 25,963
Subtotal				$ 1,686,652		$ 121,005
Mobilization		10%		$ 168,665		$ 12,100
MOT		10%		$ 168,665		$ 12,100
CEI		15%		$ 252,998		$ 18,151
Engineering and contingencies		25%		$ 421,663		$ 30,251
Total Cost				$ 2,698,644		$ 193,607

○ GUARDRAIL AND OTHER AT THREE CURVES - LEVEL 3

Level 3 Countermeasures						
Countermeasure	Unit	Cost/Unit	Number	Cost	Annuity Factor	Annual Cost
All countermeasures from Level 2 (includes Level 1)	total			$ 1,686,652		$ 121,005
Rogers Curve on CR 835						
Flashing warning beacon	ea	$ 5,624.39	1	$ 5,624	15.62	$ 360
Luminaire	ea	$ 418.44	2	$ 837	5.24	$ 160
Guardrail removal	lf	$ 1.29	60	$ 77	15.62	$ 5
Guardrail	lf	$ 17.07	415	$ 7,084	15.62	$ 453
Guardrail end	ea	$ 1,818.39	4	$ 7,274	15.62	$ 466
Object marker sign	ea	$ 126.78	2	$ 254	5.24	$ 48
Blumberg Curve on CR 835						
Guardrail	lf	$ 17.07	1,300	$ 22,191	15.62	$ 1,420
Guardrail end	ea	$ 1,818.39	4	$ 7,274	15.62	$ 466
Object marker sign	ea	$ 126.78	4	$ 507	5.24	$ 97
Deer Fence Canal Rd Curve						
Guardrail removal	lf	$ 1.29	20	$ 26	15.62	$ 2
Guardrail	lf	$ 17.07	200	$ 3,414	15.62	$ 219
Guardrail end	ea	$ 1,818.39	4	$ 7,274	15.62	$ 466
Object marker sign	ea	$ 126.78	4	$ 507	5.24	$ 97
Subtotal				$ 1,748,994		$ 125,262
Mobilization			10%	$ 174,899		$ 12,526
MOT			10%	$ 174,899		$ 12,526
CEI			15%	$ 262,349		$ 18,789
Engineering and contingencies			25%	$ 437,249		$ 31,315
Total Cost				$ 2,798,391		$ 200,419

CURVE BENEFIT CALCULATIONS

Curve Benefit Calculations

All Related Crashes	
Severity	Number of Crashes
K	1
A	1
B	3
C	3
O	8
Total	16

Crashes for Level 3 (Rogers, Blumberg, and Deer Fence)	
Severity	Number of Crashes
K	1
A	1
B	2
C	3
O	8
Total	15

Curve Warning Signs CMF	
Fatal	0.82
Injury	0.82
PDO	0.82

Curve Chevrons CMF	
Fatal	0.78
Injury	0.78
PDO	0.78

Level 1 Combined CMF	
Fatal	0.6396
Injury	0.6396
PDO	0.6396

Curve Audible Edgelines CMF	
Fatal	0.873
Injury	0.873
PDO	0.873

Widen Lane and Widen Shoulder CMF	
Fatal	0.8722
Injury	0.8722
PDO	0.8722

Advance Curve RPMs CMF	
Fatal	0.94
Injury	0.94
PDO	0.94

Centerline Curve RPMs CMF	
Fatal	0.76
Injury	0.76
PDO	0.76

Level 2 Combined CMF	
Fatal	0.3373
Injury	0.3373
PDO	0.3373

Guardrail CMF	
Fatal	0.56
Injury	0.53
PDO	1.00

Level 3 Combined CMF	
Fatal	0.1889
Injury	0.1788
PDO	0.3373

Benefit/Cost Ratio

	Level 1	Level 2	Level 3
Crashes Reduced	5.77	10.60	11.70
Benefit	$ 2,318,110	$ 4,262,711	$4,704,713
Annual Benefit	$ 289,764	$ 532,839	$ 588,089
Annual Cost	$ 15,263	$ 193,607	$ 200,419
B/C Ratio	18.98	2.75	2.93
Net Present Value	$ 274,501	$ 339,232	$ 387,670

Tangent Sections

PAVEMENT MARKINGS - LEVEL 1

Tangent Sections for Pavement Markings

Site: CR 833, CR 835, and CR 846

Length:	CR 833	10.10	Miles	SR 80 to CR 832 (SR 80 to Java Rd for Guardrail)
	CR 846	10.83	Miles	CR 833 to CL
	CR 835	28.78	Miles	SR 80 to CR 833

Pavement Marking Countermeasures

Countermeasure	Unit	Cost/Unit	Number	Cost	Annuity Factor	Annual Cost
Pavement Markings						
Centerline	lf	$ 0.58	524,897	$ 302,131	5.24	$ 57,635
Edge line	lf	$ 0.66	524,897	$ 346,432	5.24	$ 66,086
Ground in place	mile	$ 1,024.41	99.41	$ 101,839	5.24	$ 19,427
RPMs	ea	$ 3.01	13,122	$ 39,498	5.24	$ 7,535
Subtotal				$ 789,900		$ 150,683
Mobilization		10%		$ 78,990		$ 15,068
MOT		10%		$ 78,990		$ 15,068
CEI		15%		$ 118,485		$ 22,602
Engineering and contingencies		25%		$ 197,475		$37,670.70
Total Cost				$ 1,263,840		$ 241,092

Benefits

All Related Crashes

Severity	Number of Crashes
K	11
A	4
B	18
C	15
O	11
Total	59

Crashes Impacted by Marking Improvements

Severity	Number of
K	11
A	4
B	14
C	12
O	9
Total	50

Audible Edgeline CMF		RPM CMF		Combined CMF for Markings	
Fatal	0.89	Fatal	0.76	Fatal	0.6764
Injury	0.89	Injury	0.76	Injury	0.6764
PDO	0.89	PDO	0.76	PDO	0.6764

Edgeline and RPM crashes reduced:	16.18
RPM only crashes reduced:	2.16

Benefit/Cost Calculations

Crashes Reduced	18.34
Benefit	$ 7,372,735
Annual Benefit	$ 921,592
Annual Cost	$ 241,092
B/C Ratio	3.82
Net Present Value	$ 680,499

○ GUARDRAIL AT CR 833 - LEVEL 2

Site: CR 833

Length: CR 833 4.03 miles Java Rd to SR 80 for Guardrail

Guardrail Countermeasures

Countermeasure		Unit	Cost/Unit	Number	Cost	Annuity Factor	Annual Cost
Guardrail							
CR 833	Install new guardrail	lf	$ 17.07	21,300	$ 363,591	15.62	$ 23,274
	Anchorage assembly	ea	$ 1,818.39	8	$ 14,547	15.62	$ 931
	Object Marker	ea	$ 126.78	8	$ 1,014	5.24	$ 193
Subtotal					$ 379,152		$ 24,399
CEI			10%		$ 37,915		$ 2,440
MOT			10%		$ 37,915		$ 2,440
CEI			15%		$ 56,873		$ 3,660
Engineering and contingencies			25%		$ 94,788		$ 6,100
Total Cost					$ 606,644		$ 39,038

Benefit Calculations

All Related Crashes

Severity	Number of Crashes
K	3
A	0
B	3
C	2
O	0
Total	8

Guardrail CMF		Pavement Markings CMF		Combined CMF	
Fatal	0.56	Fatal	0.89	Fatal	0.4984
Injury	0.53	Injury	0.89	Injury	0.4717
PDO	1	PDO	0.89	PDO	0.89

Pavement markings crash reduction:	0.88
Pavement markings and guardrails crash reduction:	4.1463
Crash reduction from guardrails with pavement markings previously implemented:	3.2663

Benefit/Cost Calculations

Crashes Reduced		3.27
Benefit	$	1,313,062
Annual Benefit	$	164,133
Annual Cost	$	39,038
B/C Ratio		4.20
Net Present Value	$	125,095

○ GUARDRAIL AT CR 835 AT L-1 CANAL - LEVEL 2

Site: L1 Canal Crossing

Length: CR 835 0.06 miles L1 Canal Crossing

Guardrail Countermeasures

Countermeasure	Unit	Cost/Unit	Number	Cost	Annuity Factor	Annual Cost
L1 Canal Crossing						
Guardrail - Roadway	lf	$ 17.07	550	$ 9,389	15.62	$ 601
Guardrail - bridge	lf	$ 38.86	250	$ 9,715	15.62	$ 622
Shop bent sections	lf	$ 19.44	100	$ 1,944	15.62	$ 124
Anchorage assembly	ea	$ 1,818.39	4	$ 7,274	15.62	$ 466
Object Marker	ea	$ 126.78	4	$ 507	5.24	$ 97
Narrow bridge warning signs	ea	$ 252.02	2	$ 504	5.24	$ 96
intersection ahead signs	ea	$ 252.02	2	$ 504	5.24	$ 96
Subtotal				$ 29,836		$ 2,102
Mobilization			10%	$ 2,984		$ 210
MOT			10%	$ 2,984		$ 210
CEI			15%	$ 4,475		$ 315
Engineering and contingencies			25%	$ 7,459		$ 525
Total Cost				$ 47,738		$ 3,363

Benefit Calculations

All Related Crashes

Severity	Number of Crashes
K	0
A	0
B	0
C	0
O	1
Total	1

Guardrail CMF		Pavement Markings		Combined CMF	
Fatal	0.56	Fatal	0.89	Fatal	0.4984
Injury	0.53	Injury	0.89	Injury	0.4717
PDO	1	PDO	0.89	PDO	0.89

Pavement markings crash reduction:	0.11
Pavement markings and guardrails crash reduction:	0.11
Crash reduction from guardrails with pavement markings previously implemented:	0

Benefit/Cost Calculations

Crashes Reduced	0.00	
Benefit	$ -	
Annual Benefit	$ 6,649	**
Annual Cost	$ 3,363	
B/C Ratio	1.98	**
Net Present Value	$ 3,285	**

** The traditional "spot" analysis of the benefits for this short improvement does not adequately reflect the value of adding guardrail at this location since there were no recorded crashes during the analysis period that would be mitigated by the improvement. Throughout the corridor, several such crashes did occur at locations where the risk factors appeared to be less severe than at the L-1 canal crossing. The corridor-wide B/C ratio is used as the estimate of the benefit for adding guardrail at this short section within the corridor.

o GUARDRAIL AT CR 835 VARIOUS LOCATIONS FROM CR 833 TO SR 80 - LEVEL 2

Site: CR 835								
Length:	CR 835	11.94	miles	Davidson to Old SR 80, 2.5 miles North of Rogers Rd to				
Guardrail Countermeasures								
Countermeasure			Unit	Cost/Unit	Number	Cost	Annuity Factor	Annual Cost
CR 835 - Davidson to old SR 80								
	Install new guardrail		lf	$ 17.07	2,640	$ 45,065	15.62	$ 2,885
	Anchorage assembly		ea	$ 1,818.39	2	$ 3,637	15.62	$ 233
	Object Marker		ea	$ 126.78	2	$ 254	5.24	$ 48
CR 835 -2.5 miles north of Rogers to Joshua								
	Install new guardrail		lf	$ 17.07	7,920	$ 135,194	15.62	$ 8,654
	Anchorage assembly		ea	$ 1,818.39	16	$ 29,094	15.62	$ 1,862
	Object Marker		ea	$ 126.78	16	$ 2,028	5.24	$ 387
CR 835 - CR 833 to 1 mile south of Dooley Grade								
	Install new guardrail		lf	$ 17.07	52,500	$ 896,175	15.62	$ 57,366
	Anchorage assembly		ea	$ 1,818.39	22	$ 40,005	15.62	$ 2,561
	Object Marker		ea	$ 126.78	22	$ 2,789	5.24	$ 532
Culvert Extensions			lf	$ 99.07	400	$ 39,628	15.62	$ 2,537
Culvert Guardrail								
	Install new guardrail		lf	$ 17.07	3,000	$ 51,210	15.62	$ 3,278
	Anchorage assembly		ea	$ 1,818.39	40	$ 72,736	15.62	$ 4,656
	Object Marker		ea	$ 126.78	40	$ 5,071	5.24	$ 967
Subtotal						$ 1,322,886		$ 85,966
CEI				10%		$ 132,289		$ 8,597
MOT				10%		$ 132,289		$ 8,597
CEI				15%		$ 198,433		$ 12,895
Engineering and contingencies				25%		$ 330,721		$ 21,492
Total Cost						$ 2,116,617		$ 137,546

Benefit Calculations

All Related Crashes	
Severity	Number of Crashes
K	1
A	2
B	4
C	6
O	5
Total	18

Guardrail CMF		Pavement Markings		Combined CMF	
Fatal	0.56	Fatal	0.89	Fatal	0.4984
Injury	0.53	Injury	0.89	Injury	0.4717
PDO	1	PDO	0.89	PDO	0.89

Pavement markings crash reduction:	1.98
Pavement markings and guardrails crash reduction:	7.3912
Crash reduction from guardrails with pavement markings previously implemented:	5.4112

Benefit/Cost Calculations	
Crashes Reduced	5.41
Benefit	$ 2,175,319
Annual Benefit	$ 271,915
Annual Cost	$ 137,546
B/C Ratio	1.98
Net Present Value	$ 134,369