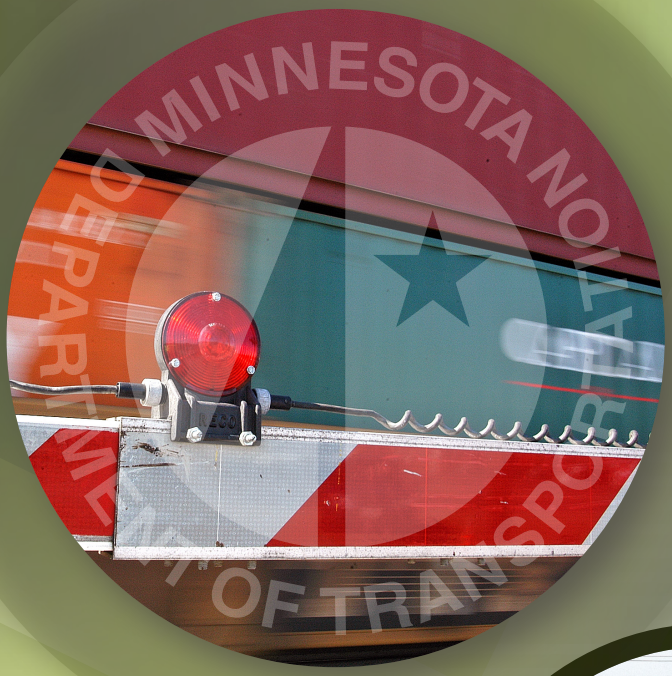
Rail Grade Crossing Safety Project Selection



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Prepared by:

CH2M HILL, Inc.

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16. Abstract (Limit: 250 words)

MnDOT's Rail Administration Section monitors the safety performance of more than 4,000 public rail grade crossings and develops the Department's Railroad-Highway Grade Crossing Safety Improvement Program. A total of 445 vehicle-train crashes occurred at the public crossings during the 10-year study period, extending from 2004 through 2013. Of these crashes, 52 involved fatalities and another 129 involved injuries. Analysis of the crash data reveals two key points; the density of fatal plus injury crashes is very low - 0.004 per grade crossing per year and almost 91 percent of the crossings had NO crashes of any kind during the study period. This data combined with the fact that Rail Administration staff used a pair of crash prediction models that included consideration of crash history (along with crossing geometry and train/vehicle exposure factors) to identify candidates for safety investment raised concern among MnDOT staff regarding whether or not the models placed too high a priority on prior crash history. This set of facts resulted in undertaking a study to determine how well the prediction models fit Minnesota's data and to attempt to identify a set of grade crossing risk factors that would support a statewide systemic evaluation. The study determined that both the FRA Accident Prediction Model and the Texas Hazard Index were poor fits with Minnesota's crash data. The study also identified a set of volume, speed, design and surrounding area features that were over-represented at crossings with crashes and that the crossings with multiples of these features present had the highest crash densities and could be considered high priority candidates for safety investment.

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FINAL REPORT 2016-25

Rail Grade Crossing Safety Report

Prepared for

Minnesota Department of Transportation

June 2016

Prepared by:

Howard Preston
Veronica Richfield
Maureen Jensen

CH2M HILL, INC.
1295 Northland Drive
Mendota Heights, MN 55120

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Acronyms and Abbreviations

AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
MnDOT	Minnesota Department of Transportation
mph	miles per hour
OFCVO	Office of Freight and Commercial Vehicles Operations, Rail Administration Section
PDO	property damage only
RGCIP	Rail Grade Crossing Improvement Program

SECTION 1

Introduction

The Minnesota Department of Transportation's (MnDOT) Office of Freight and Commercial Vehicles Operations (OFCVO), Rail Administration Section monitors the safety performance of more than 4,000 rail grade crossings along Minnesota's public road system and develops the Department's Railroad-Highway Grade Crossing Safety Improvement Program. A total of 445 vehicle-train crashes at the public rail grade crossings occurred within the 10-year period from 2004 through 2013. Of these crashes, 52 involved fatalities and another 129 involved injuries.

The crash numbers produce a density of fatal plus injury crashes (those involving a fatality or injuries) of 0.004 per grade crossing per year. This comparatively low density of fatal plus injury crashes combined with nearly 91 percent of grade crossings experienced NO crashes during the study period points to two key issues:

- Vehicle-train collisions are rare, representing less than 0.06 percent of all crashes and around 1 percent of fatalities, and widely scattered across the state system of roadways.
- The probability of occupants in any vehicle crash with a train being fatally injured is more than 20 times greater than other types of traffic-related crashes across Minnesota. Approximately 0.5 percent of all traffic crashes in Minnesota result in a fatality; whereas 12 percent of vehicle-train collisions result in a fatality.

To identify priority candidates for safety investment, Rail Administration staff currently use a pair of crash prediction models. These models consider crash history and a variety of crossing geometry, train and vehicle exposure factors to identify priority candidates for safety investments. However, Minnesota's crash data raised concern among staff regarding whether or not the models place too high a priority on prior crash history. In addition, the most common type of safety strategy implemented at priority grade crossings is to install an active control device, which is defined by CH2M HILL, Inc. as gates and/or signals, or install a STOP sign at low-volume crossings (passive control). An overview of crashes at rail grade crossings indicates that almost one-third of crashes involving an injury or fatality occur at crossings with active devices and more than one-half of fatal plus injury crashes at crossings with passive control occurred at locations with STOP signs.

These concerns have generated a desire among Rail Administration staff to gain a better understanding of rail grade crossing safety in Minnesota. A better understanding includes investigating a potential new approach to developing rail grade crossing safety projects by identifying candidate crossings for safety investment and selecting effective safety strategies. Key topics of this assessment include better documentation of crash details (contributing factors and driver behaviors) and crossing characteristics correlated with sites that have a history of crashes (road system and rail system).

There is a low density of crashes, widely scattered locations, and an extraordinarily few number of locations with multiple fatal plus injury crashes. MnDOT's Highway Safety Improvement Program managers developed a new analytical technique for evaluating systems with low-crash densities and a widely distributed pattern of fatal plus injury crashes. This technique has been successfully applied to roadway segments and intersections on state and county highway systems in Minnesota. The success of this technique is defined by the ability to generate prioritized lists of facilities based on the risk of fatal plus injury crashes and develop safety projects at high-priority candidate locations.

Given the similarity between fatal plus injury crashes at rail grade crossings and those at intersections across the state and the concerns about safety project development, key tasks to be accomplished with this study include:

- Conduct an analysis of Minnesota's public rail grade crossings to identify potential risk factors (roadway, rail, and traffic characteristics) that appear over-represented at the grade crossings with fatal plus injury crashes.
- Conduct a systemic analysis of grade crossings using identified risk factors.
- Produce a prioritized list of active- and passive-controlled crossings and compare the list to results from the crash prediction models currently in use.
- Evaluate the current approach to safety project development and the focus on installing signals and gates at high-volume locations and upgrading to STOP signs at low-volume locations and consider ways to increase the effectiveness of the rail safety program.

Sections of this report include:

- Section 1 – Literature Review
- Section 2 – Grade Crossing Assessment, an assessment of Minnesota's 4,000 plus public rail grade crossings (crashes analysis)
- Section 3 – Grade Crossing Characteristics
- Section 4 – Suggested Risk Factors, characteristics that appear to be over-represented at the few crossings with fatal plus injury crashes
- Section 5 – Results, results of the application of the suggested risk factors to the public rail grade crossings
- Section 6 – Conclusion
- Section 7 – Next Steps
- Section 8 – References

1.1 Literature Review

Six previously published research reports dealing with rail grade crossing safety were reviewed with a focus on highway and rail characteristics used in models attempting to predict grade crossing safety performance. Characteristics used to determine crash risk in each report is listed in Table 1-1 and summaries of each report are provided in Appendix A.

Prior to 2015, MnDOT's Rail Administration used the Federal Railroad Administration (FRA) Accident Prediction Model to prioritize and identify candidate crossings for safety investment. This model's results are heavily influenced by past crashes, but only a few crossings in Minnesota had multiple crashes. MnDOT staff searched for an alternative to the FRA Accident Prediction Model and selected the Texas Hazard Index for developing the 2017 safety project list. However, while the Texas index considers crash history, it places greater emphasis on the number and speed of trains and the type of in-place warning device (active or passive) being used. Also, the index does not effectively differentiate the risk levels at crossings with passive warning devices, which account for over 60 percent of Minnesota's public rail grade crossings. These deficits create a potential need for a better predictive model to assist the Rail Administration staff with identifying candidate crossings for safety investment.

Table 1-1. Highway and Grade Crossing Characteristics used in Predictive Models

	Research Report						
Characteristics	**Texas (1)**	**Iowa**	**California**	**Texas (2)**	**Texas (3)**	**FHWA**	**Minnesota**
Highway ADT		X	X	X	X	X	X
Heavy Vehicles	X	X	X	X			
School Busses		X	X	X			
EMS Route		X					
Nearby Intersections	X	X	X	X		X	X
Nearest At-Grade Crossing							X
Spillback	X			X			
Functional Class		X		X			
Rural versus Urban			X		X	X	
Paved Roads			X		X	X	
Number of Lanes			X		X	X	
Highway Alignment			X				
Vehicle Speeds			X	X			X
Type of Device	X		X				
Train Volume			X	X	X	X	X
Time Table Speed			X	X	X	X	X
Number of Tracks			X	X	X	X	X
Type of Train			X				
Hazmat			X	X			
Skew			X	X			X
Sight Distance			X	X	X		X
Crash History			X	X			

Notes:

All reports from Table 1-1 are included in Appendix A.

Sources: Cooper et. al., 2012; Federal Highway Administration, 2007; Hans et. al., 2015; Texas Department of Transportation, 2011; Weissmann et. al., 2013; Woolridge et. al., 2000.

SECTION 2

Grade Crossing Assessment

The Minnesota public rail grade crossings assessment used two databases; the 10-year train-vehicle grade crossing crash records from the FRA and the inventory of public grade crossings from MnDOT Rail Grade Crossing Improvement Program (RGCIP).

2.1 Crash Analysis

FRA records for crashes at rail grade crossings in Minnesota that occurred in the 10-year period (between 2004 and 2013) were provided by MnDOT in a database that contained 548 total crashes, of which 70 involved a fatality. Consistent with prior MnDOT practice, the crashes involving pedestrians, wheelchairs, and confirmed suicides were removed from the analysis and crashes involving bicyclists, tractors, and snowmobiles were retained. In addition, crashes at private crossings were retained in the database but not included in the analysis because of the lack of corresponding grade crossing data. The remaining 445 total crashes (including 52 fatal) that occurred at the public rail grade crossings were included in the analysis.

In an attempt to generate a larger and more credible data set to compensate for the relatively small number of annual vehicle-train crashes, a 10-year period was chosen for the crash analysis instead of the typical 3- or 5-year period that has been used in traditional highway safety studies. In addition, to be consistent with current FHWA safety planning guidance and the goals established in Minnesota's Strategic Highway Safety Plan, it was initially decided to use fatal plus injury crashes as the safety performance measure for this analysis. This approach is based on observations that indicate characteristics and contributing factors (that is, fatal plus injury crashes are over-represented on rural, high–speed, two-lane highway segments, whereas property damage only (PDO) crashes are over-represented at signalized intersections along multi-lane suburban arterials) are not common across all severities of crashes. Also, support for the national Toward Zero Deaths initiative requires states to focus safety planning efforts on fatal plus injury crashes. However, the FRA crash data do not disaggregate injuries by the A (incapacitating), B (moderate), and C (minor) designations used in other MnDOT safety analyses. Therefore, this study used the total number of injury crashes (fatal plus injury) because attempting to generate A, B, and C injury numbers is beyond the scope of this effort.

The FRA database documents 445 total crashes at public rail grade crossings in Minnesota during the 10-year study period, including 52 that resulted in fatalities (Figure 2-1). These data support the notion that rail grade crossing crashes are rare. The statewide average is 0.01 total crashes per crossing per year and 0.001 fatal crashes per crossing per year. The crash data were also disaggregated by active versus passive warning device (Figure 2-1), roadway jurisdiction (Figure 2-2), and rural versus urban (defined as within the boundaries of incorporated municipalities) area (Figure 2-3). Key findings include:

- Approximately 38 percent of crossings have active warning devices and those crossings have about 37 percent of total crashes.
- Fatal plus injury crashes are slightly over-represented at grade crossings with passive control (70 percent of fatal plus injury crashes versus 62 percent of crossings).

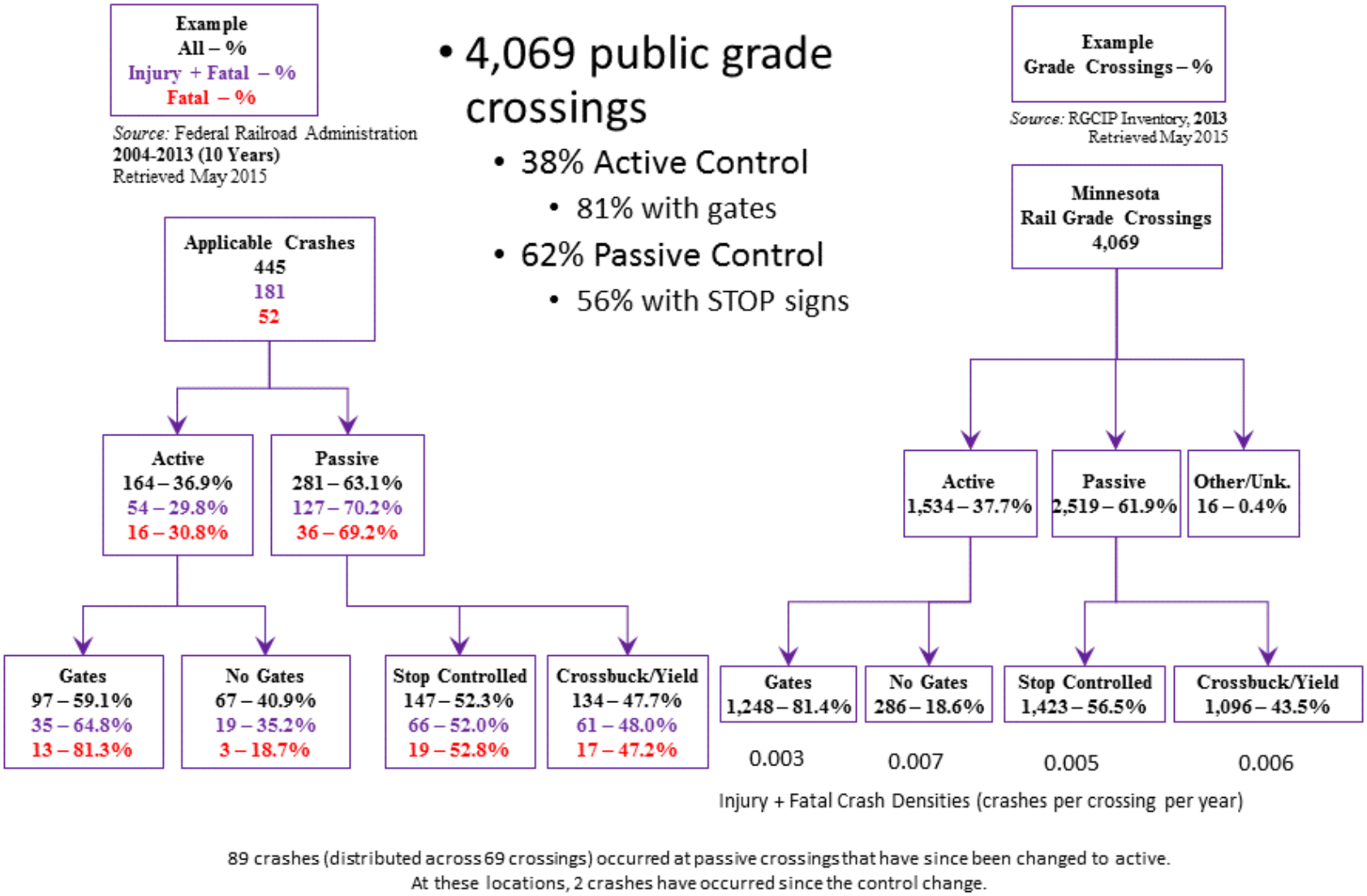


Figure 2-1. Crash and Crossing Overview

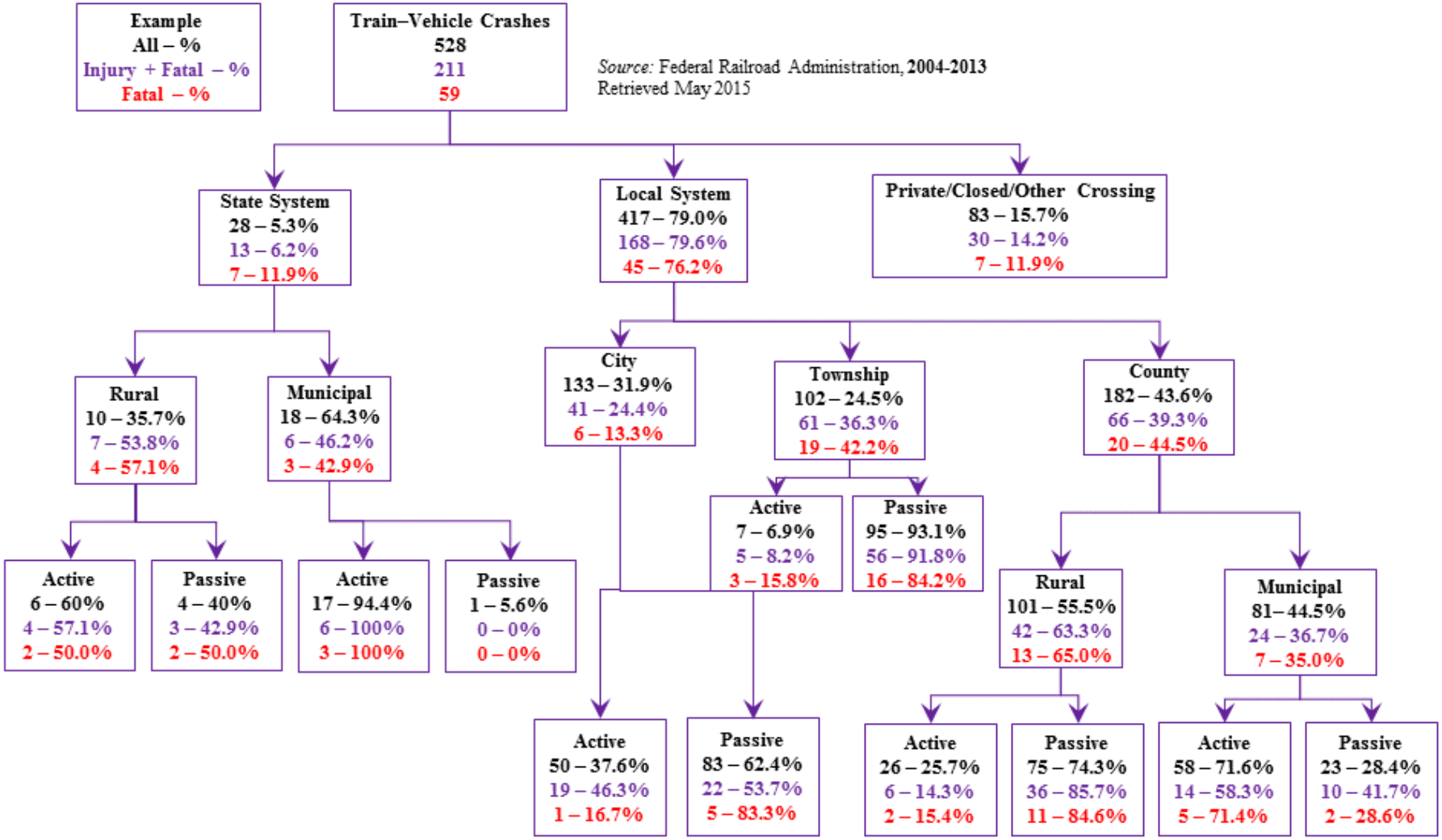
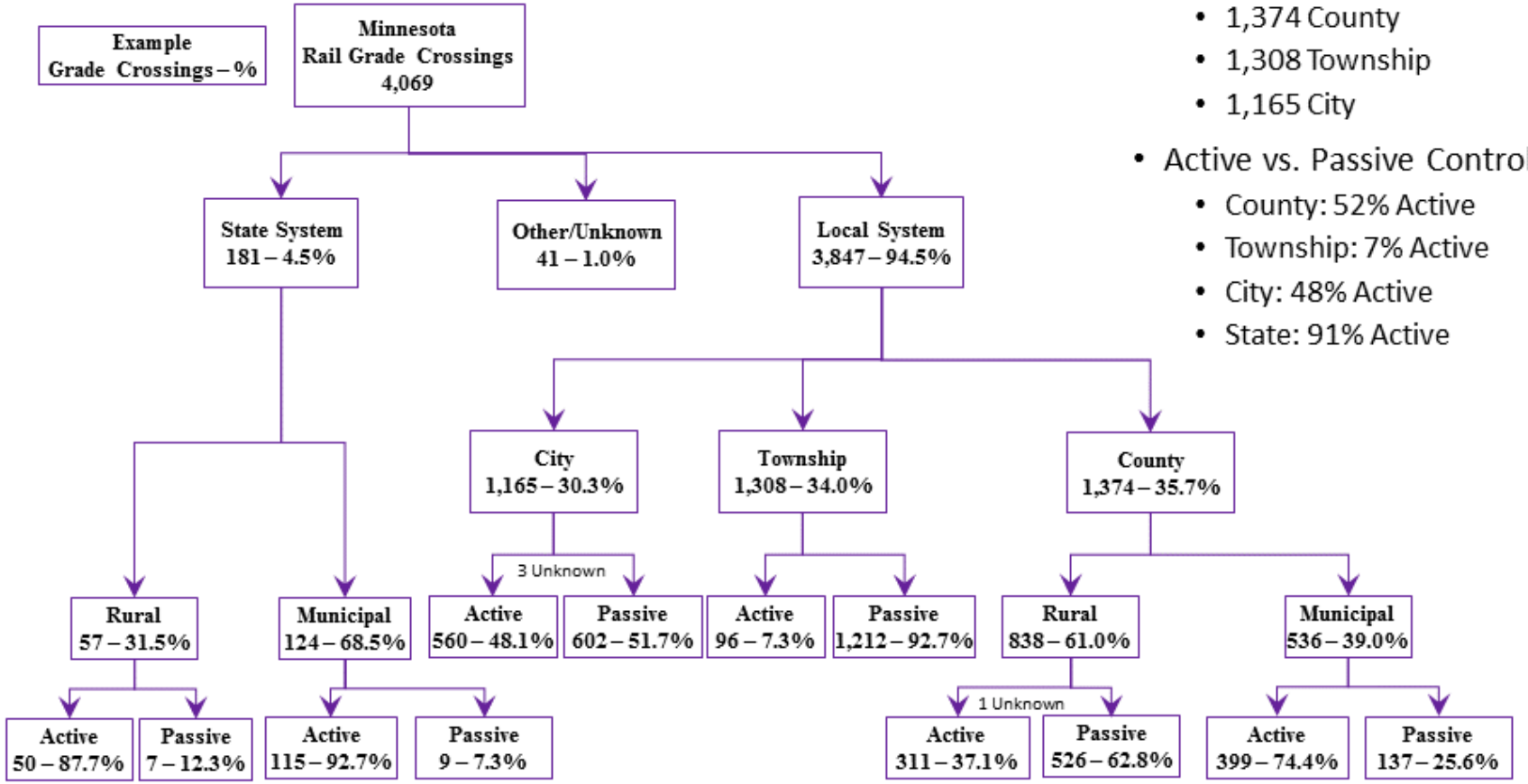


Figure 2-2. Crash Overview



- 3,847 (95%) Local System
  - 1,374 County
  - 1,308 Township
  - 1,165 City
- Active vs. Passive Control
  - County: 52% Active
  - Township: 7% Active
  - City: 48% Active
  - State: 91% Active

Source: RGCIP Inventory, **2013**
Retrieved May 2015

Crossing Type (Active vs. Passive) is defined as that present at the time of database retrieval (May 2015).

2

Figure 2-3. Crossing Overview

- Total and fatal crash densities are virtually identical for active and passive warning devices; 0.01 total crashes per crossing per year and 0.001 fatal crashes per crossing per year. The density of fatal plus injury crashes is slightly, but not significantly, higher at crossings with passive warning devices 0.005 versus 0.004 at crossings with active warning devices.
- Additional investigation of crash data regarding the type of active warning device revealed that gates reduce the density of total (0.008 versus 0.02) and fatal plus injury (0.003 versus 0.007) crashes for active crossings. The investigation also determined that the distribution of fatal crashes is proportional to the distribution of passive devices and the crash densities (0.001) are virtually identical.
- At crossings with passive warning devices, the distribution of crashes is basically proportional to the distribution of the devices. Approximately 52 percent of crashes occur at 56 percent of crossings with STOP signs. The densities of total, fatal plus injury crashes, and fatal crashes at crossings with STOP signs are slightly lower than the crossings without STOP signs (0.010 versus 0.012, 0.005 versus 0.006, and 0.0013 versus 0.0016, respectively). These crash densities would require converting all 1,096 crossings without STOP signs to crossings with STOP signs to eliminate one fatal plus injury crash per year.
- Approximately 5 percent of total crashes, 6 percent of fatal plus injury crashes, and 12 percent of fatal crashes occur at crossings on the state highway system, which results in approximately 80 percent of crashes occurring at crossings on local systems (the remaining crashes occurred at private/closed crossings).
- The distribution of total crashes is roughly proportional to the distribution of crossings on state and local systems. However, if only fatal crashes are considered, the data indicate these crashes are over-represented on roadways with higher speeds – rural state highways, township, and county roads.
- The greatest number of total crashes, fatal plus injury crashes, and fatal crashes occur at crossings on the county system (182, 66, and 20, respectively), followed by township and then municipal crossings. Grade crossings on the state system have the fewest number of all categories of crashes.

To provide insight about the distribution of crossings and crashes across Minnesota, two additional analyses were completed. The first analysis was a disaggregation of crossings by highway system (Figure 2-4) and the second was a disaggregation of crashes by county and severity (Tables 2-1, 2-2, and 2-3). The results of these analyses include:

- Of the 4,069 public rail grade crossings, approximately 5 percent (181) are on the state system and 95 percent on the local system (3,847), including 1,374 on county roads, 1,308 on township roads, and 1,165 on municipal streets.
- The distribution of active warning devices across the various systems is not equal or proportional to the distribution of crossings. Ninety-one percent of crossings on the state system, 52 percent of crossings on the county system, 48 percent of crossings on municipal systems, and 7 percent on township roads have active warning devices.
- Based on the total number of crashes at rail grade crossings, the top three counties are: Hennepin (55), Ramsey (33), and St. Louis (29). Based on fatal plus injury crashes, the top three counties are: St. Louis (14), Hennepin (9), and Ramsey (9). Based on fatal crashes, the top three counties are: St. Louis (4), Becker (4), and Stevens (4). The only counties to make the top 10 lists for every category of crash severity are St. Louis, Otter Tail, and Blue Earth.

Table 2-1. Top counties – Total Crashes

Top Counties - Total Crashes						
County	**All Severities**		**Fatal plus Injury**		**Fatal**	
Hennepin	**55**	**10%**	9	4%	0	0%
Ramsey	**33**	**6%**	9	4%	0	0%
St louis	**29**	**5%**	14	7%	4	7%
Winona	**18**	**3%**	4	2%	0	0%
Freeborn	**15**	**3%**	5	2%	0	0%
Otter Tail	**15**	**3%**	7	3%	3	5%
Blue Earth	**14**	**3%**	6	3%	2	3%
Steele	**14**	**3%**	6	3%	1	2%
Sherburne	**13**	**2%**	4	2%	3	5%
Dakota	**13**	**2%**	5	2%	1	2%

Table 2-2. Top Counties – Fatal plus Injury Crashes

Top Counties - Fatal plus Injury Crashes						
County	**All Severities**		**Fatal plus Injury**		**Fatal**	
St louis	29	5%	**14**	**7%**	4	7%
Hennepin	55	10%	**9**	**4%**	0	0%
Ramsey	33	6%	**9**	**4%**	0	0%
Brown	12	2%	**8**	**4%**	0	0%
Faribault	12	2%	**8**	**4%**	3	5%
Kandiyohi	12	2%	**8**	**4%**	2	3%
Otter Tail	15	3%	**7**	**3%**	3	5%
Becker	12	2%	**7**	**3%**	4	7%
Stevens	8	2%	**7**	**3%**	4	7%
Blue Earth	14	3%	**6**	**3%**	2	3%
Steele	14	3%	**6**	**3%**	1	2%

Table 2-3. Top Counties – Fatal Crashes

Top Counties - Multiple Fatalities						
County	**All Severities**		**Fatal plus Injury**		**Fatal**	
St louis	29	5%	14	7%	**4**	**7%**
Becker	12	2%	7	3%	**4**	**7%**
Stevens	8	2%	7	3%	**4**	**7%**
Faribault	12	2%	8	4%	**3**	**5%**
Otter Tail	15	3%	7	3%	**3**	**5%**
Sherburne	13	2%	4	2%	**3**	**5%**
Kandiyohi	12	2%	8	4%	**2**	**3%**
Blue Earth	14	3%	6	3%	**2**	**3%**
Polk	11	2%	5	2%	**2**	**3%**
Anoka	8	2%	4	2%	**2**	**3%**
Chippewa	6	1%	4	2%	**2**	**3%**
Scott	9	2%	2	1%	**2**	**3%**
Pennington	4	1%	2	1%	**2**	**3%**
Redwood	3	1%	2	1%	**2**	**3%**

The last items documented regarding crashes at rail grade crossings include driver action, age, and gender (Figures 2-5, 2-6, and 2-7). Data indicate that the most common action by drivers in all severities of crashes at grade crossings is simply not stopping (55 to 68 percent). This is followed by stopping on the crossing (10 to 21 percent) and then stopping prior to the crossing and proceeding (5 to 15 percent). The fraction of drivers reported either going around or through gates is approximately 10 percent. The data also indicate that young drivers (age 15 to 49) are over-represented in all severities of crashes and middle age (45 to 49) and older drivers (55 to 74) are over-represented in fatal crashes. The vast majority of drivers involved in crashes at-grade crossings are males (80 percent).

2.2 Results

This effort included documenting the history of crashes at each grade crossing, which revealed that (during the 10-year study period) 91 percent of crossings had no crashes, 96 percent had no crashes resulting in injuries, and 99 percent of the crossings had no crashes involving a fatality. It also was determined that only 1 crossing had 2 fatal crashes, 13 crossings had multiple injury crashes, and 56 crossings (less than 1 percent) had multiple crashes of any kind. No public rail grade crossing in Minnesota averaged a single grade-crossing-related crash per year. More than one-half of the grade crossings with a fatal plus injury crash had no prior crashes and approximately 5 percent of the crossings with multiple crashes had a PDO crash precede a fatal plus injury crash.. Therefore, it is determined that the presence of a prior crash is not a significant indicator that additional crashes are likely to follow.

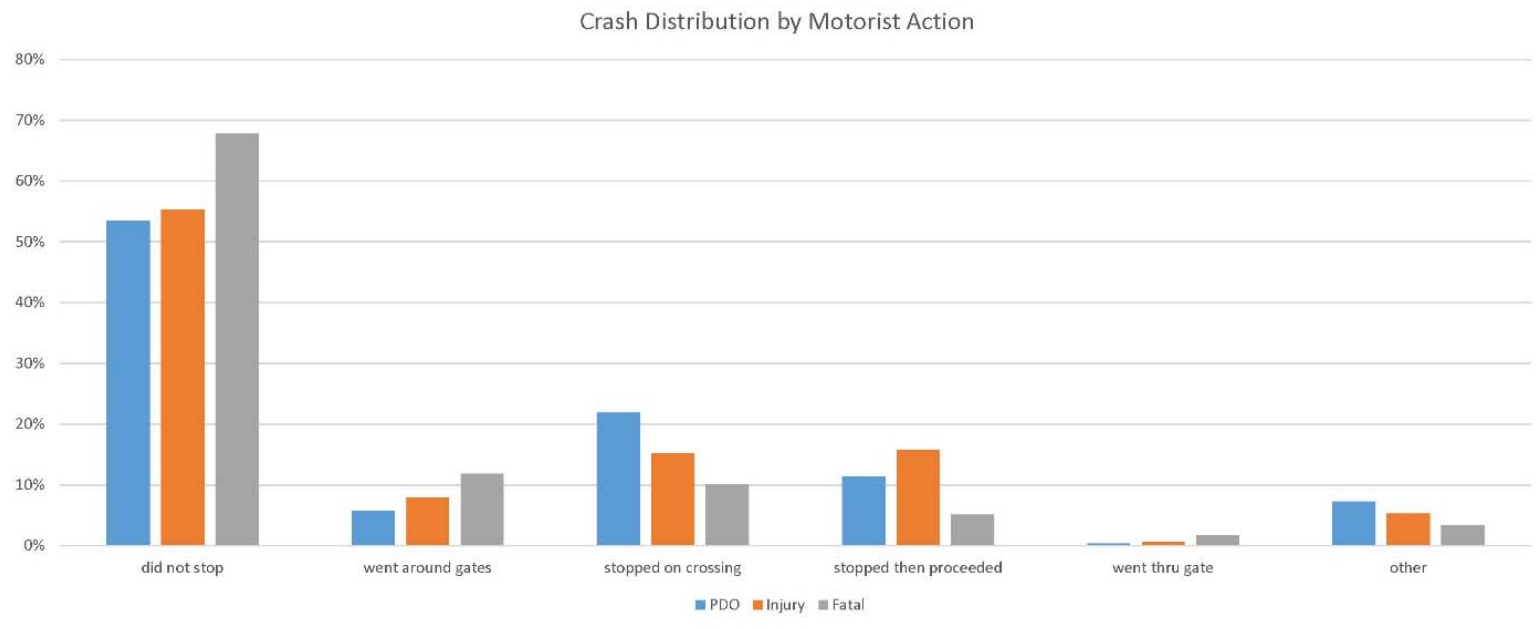


Figure 2-4. Motorist Action

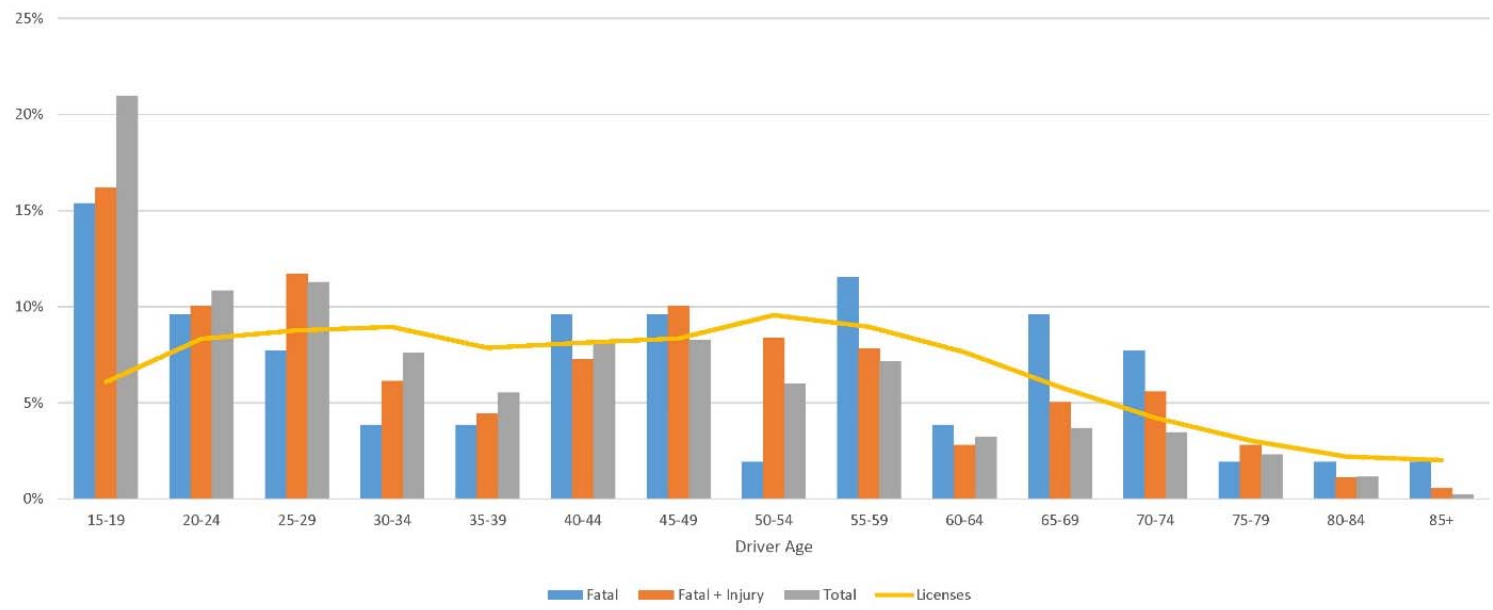


Figure 2-5. Demographics – Age

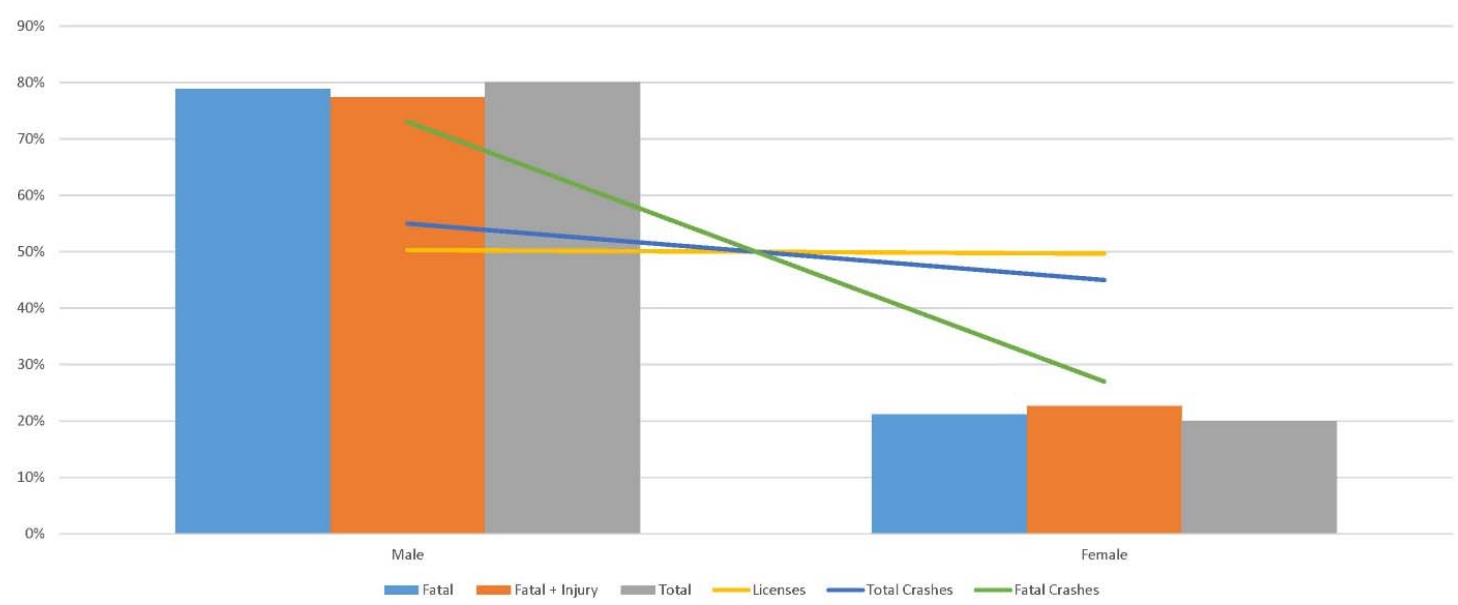


Figure 2-6. Demographics – Gender

SECTION 3

Grade Crossing Characteristics

A key aspect of this project involved identifying roadway, rail, and traffic characteristics at the small fraction of the crossings with crashes. These features were used in the systemic risk assessment of public rail grade crossings. The systemic analysis is a cross-sectional study that grouped crossings based on the type of warning device – active or passive. The analysis did not include a before versus after evaluation at crossings where the warning device was upgraded.

The initial step in this process involved identifying the rail and roadway features as documented in the RGCIP inventory and noting features that appear to be common at the crossings with crashes. The initial distribution of the crossings looked at the variety of grade crossing features including jurisdiction, in-place warning device, rural or urban area, and geometric features. Results of this effort include:

- A variety of geometric features were investigated and hump crossings and track curvatures do not effect crashes.
- Deficient-approaching and clearing-sight-distance grade crossing skew angles greater than 15 degrees, and proximity to nearby intersections and grade crossings do have an effect on crashes. Grade crossings within 0.25 to 1 mile from a nearby crossing are highly over-represented Fatal + Injury and Fatal crashes (Figure 3-1).
- Roadway volume and train traffic was documented at each crossing and indicates the majority of total crashes and especially fatal crashes occur at highway volumes under 500 vehicles per day and at train volumes greater than 4 vehicles per day. The cross product of vehicle-train volume (Figure 3-2) greater than 1,000 is over-represented for all severities of crashes. The reported roadway volume at a number of rural crossings along the county and township system are default values because actual traffic counts have not been collected.
- Rail corridor characteristics including the number of tracks and train (time table) speed were documented. Multiple mainline tracks and higher train speeds (over 30 miles per hour [mph]) are associated with higher fractions of total crashes and fatal crashes.
- A variety of highway characteristics were documented; including jurisdiction, road surface, number of lanes and speed limit. Based on the number of grade-crossing-related crashes, crossings along county and township (rural) systems are most at-risk. When crashes are compared to the number of crossings, the county system is over-represented for fatal crashes. From a roadway design perspective, paved, two-lane roads are over-represented for all severities. Roadways with high speed limits (40 mph and greater) are over-represented for fatal crashes and low-speed-limit roadways are over-represented for total crashes. The functional classification of the roadway and the presence of heavy vehicle deceleration/acceleration lanes appear to be unrelated to grade crossing crashes.

Nearest At-Grade Crossing

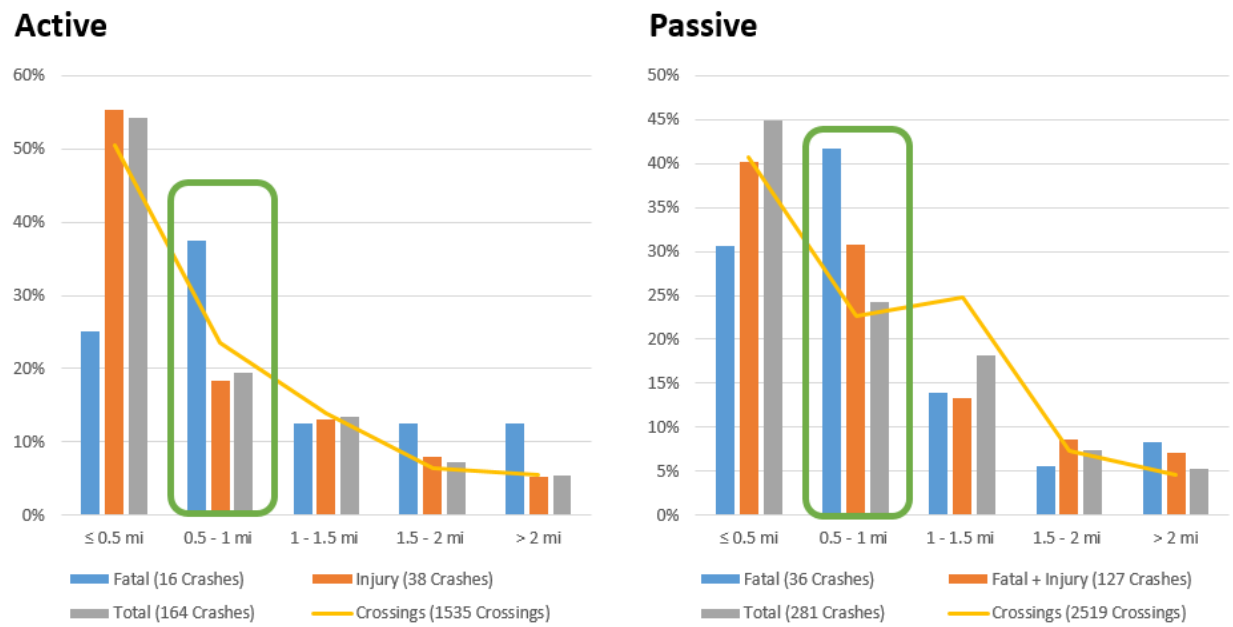


Figure 3-1. Distance to Nearest Grade Crossing

Volume Cross-Product

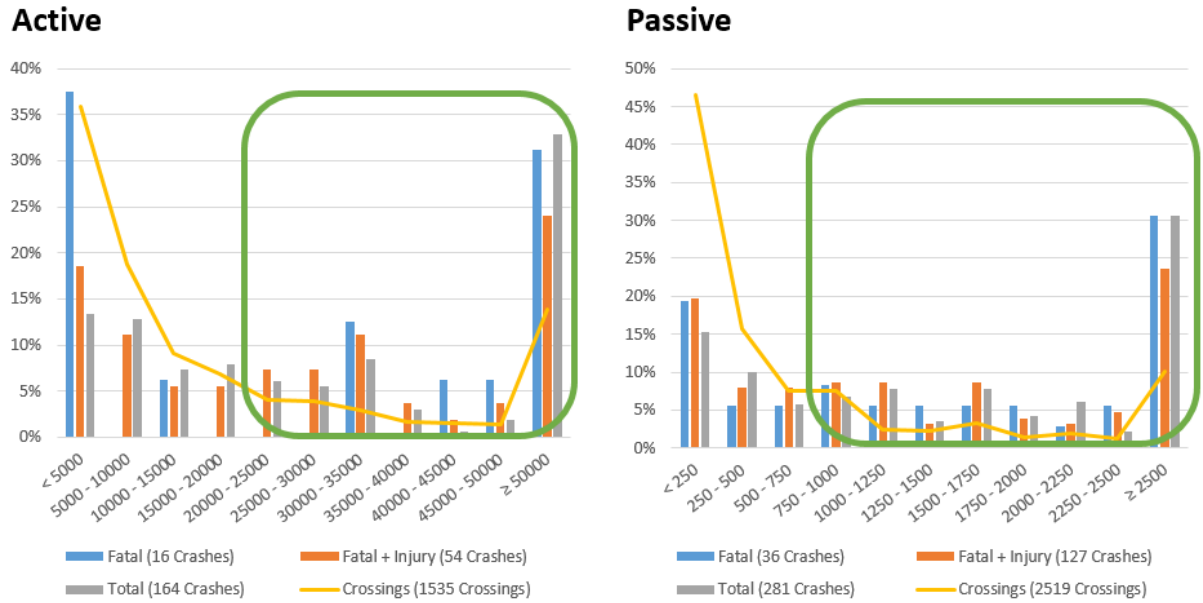


Figure 3-2. Train-Vehicle Cross Product

SECTION 4

Suggested Risk Factors

Review and analysis of available data for the 445 grade-crossing-related crashes at the 4,069 public rail grade crossings in Minnesota identified a set of rail and highway characteristics that appear to be over-represented at crossings with crashes. These results point to a set of physical and traffic characteristics that could be used to conduct a systemic risk assessment of grade crossings in Minnesota. The risk assessment could produce a prioritized list of crossings based on multiple risk factors to identify crossings considered high-priority candidates for safety investment. Minnesota's data does not support use of prior crashes as a good indicator of future risk. Only slightly more than 1 percent of grade crossings had 2 or more crashes during the 10-year study period. Also, of the 4 percent of the crossings with either a fatal or an injury crash, over one-half had no prior crashes.

The rail and highway characteristics that appear to be the most promising for use as risk factors to identify and prioritize grade crossings for future safety investment are described below and summarized in Table 4-1.

- Volumes: Data indicate risk for crashes at rail grade crossings increases with increasing volumes of roadway traffic, train traffic, and the volume cross product above certain minimum levels. For crossings with active warning devices, the minimum volume threshold is 2,500 vehicles per day and 10 trains per day. For crossings with passive warning devices, the minimum threshold is 150 vehicles per day and 4 trains per day. The minimum thresholds for the volume cross product are 20,000 at active crossings and 750 for passive crossings. Analysis demonstrates that at active crossings, 14 percent of crossings have a volume cross product greater than 20,000 and those crossings account for 74 percent of fatal crashes. Analysis of the passive crossings produces similar results. Twenty-seven percent of crossings have a volume cross product greater than 750 and account for 66 percent of fatal crashes. Existing traffic volume data at low-use crossings are in most cases assumed values and, therefore, not accurate.
- Speeds: Similar to traffic volumes, the data indicate that the risk for crashes increases with higher roadway speed limits and maximum (train) timetable speeds above certain minimum levels, with one exception. The exception is roadway speed limit at crossings with passive devices. For crossings with active warning devices, the minimum threshold is a roadway speed limit of 45 mph and a maximum (train) timetable speed of 31 mph. For crossings with passive warning devices, there is no minimum roadway speed limit and the threshold for (train) timetable speed is 36 mph. The data indicate there is no observable difference in risk associated with roadway speed limit for passive crossings. This may be explained by the approximate 70 percent of passive crossings that occur on rural local roads with a statutory speed limit of 55 mph. Using the maximum (train) timetable speed concept to prioritize crossings, the analysis demonstrates that 60 percent of crossings have maximum timetable speeds greater than 31 mph and account for 90 percent of fatal crashes at active crossings. At passive crossings, 50 percent have maximum timetable speeds greater than 35 mph and account for 90 percent of fatal crashes (Figure 4-1).
- Design: Two characteristics associated with the design of the rail grade crossings effected the risk; multiple mainline tracks and skew angles greater than 15 degrees. No observable difference in risk was found for passive crossings with multiple mainline tracks.. The majority of passive crossings occur on rural local roads where there is only a single mainline track.
- Surroundings: Four characteristics had an effect on risk: distance to nearby intersections, distance to the nearest crossing, clearing sight distance, and approaching sight distance. For active crossings, having an intersection immediately adjacent to the crossing up to a separation of 99 feet increased risk. For passive crossings, the at-risk separation increased to between 40 and 99 feet. For active and

passive crossings, having another grade crossing that is between 0.5 and 1 mile away, increases the risk. Failing sight distance in any quadrant is associated with increased risk, especially for fatal crashes at active crossings and injury crashes at passive crossings. A possible explanation for this is that more than 70 percent of active crossings are within municipal boundaries, where speeds are lower, road alignments straighter, and vertical alignments are relatively flat. These factors minimize the effect of approaching sight distance. As proof of concept for using surrounding characteristics to prioritize crossings, two examples are provided. First, for active and passive crossings having another at-grade crossing between 0.5 and 1 mile away occurred at around 24 percent of crossings, which accounted for approximately 40 percent of fatal crashes (Figure 4-2). In the case of clearing sight distance, 100 percent of fatal crashes at active devices and almost 60 percent of fatal crashes at passive devices had sight distance fail in at least one quadrant (Figure 4-3).

Table 4-1. Suggested Risk Factors

Risk Factors	Active		Passive	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Volumes				
Roadway AADT	2,500	Unlimited	150	Unlimited
Total Trains per Day	10	Unlimited	4	Unlimited
Volume Cross Product	20,000	Unlimited	750	Unlimited
Speeds				
Roadway Speed Limit	45	Unlimited		
Maximum Timetable Speed	31	Unlimited	36	Unlimited
Design				
Number of Mainline Tracks	2	Unlimited		
Skew	≥15°		≥15°	
Surroundings				
Distance to Nearby Intersection	1 foot	99 feet	40 feet	160 feet
Distance to Nearest Crossing	0.5 mile	1 mile	0.5 mile	1 mile
Clearing Sight Distance	Any Quadrant Fails		Any Quadrant Fails	
Approaching Sight Distance			Any Quadrant Fails	

Note:
Version 02 - 2016-4-4
AADT = annual average daily traffic

Maximum Timetable Speed

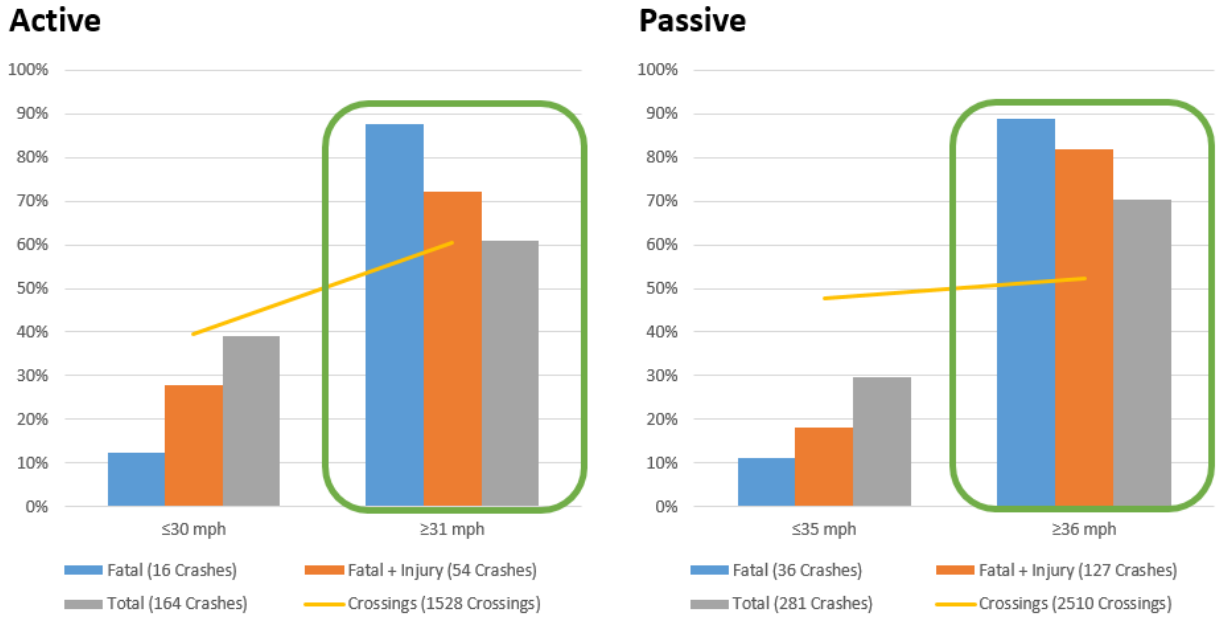


Figure 4-1. Risk Factors: Proof of Concept – Maximum time Table Speed

Nearest At-Grade Crossing

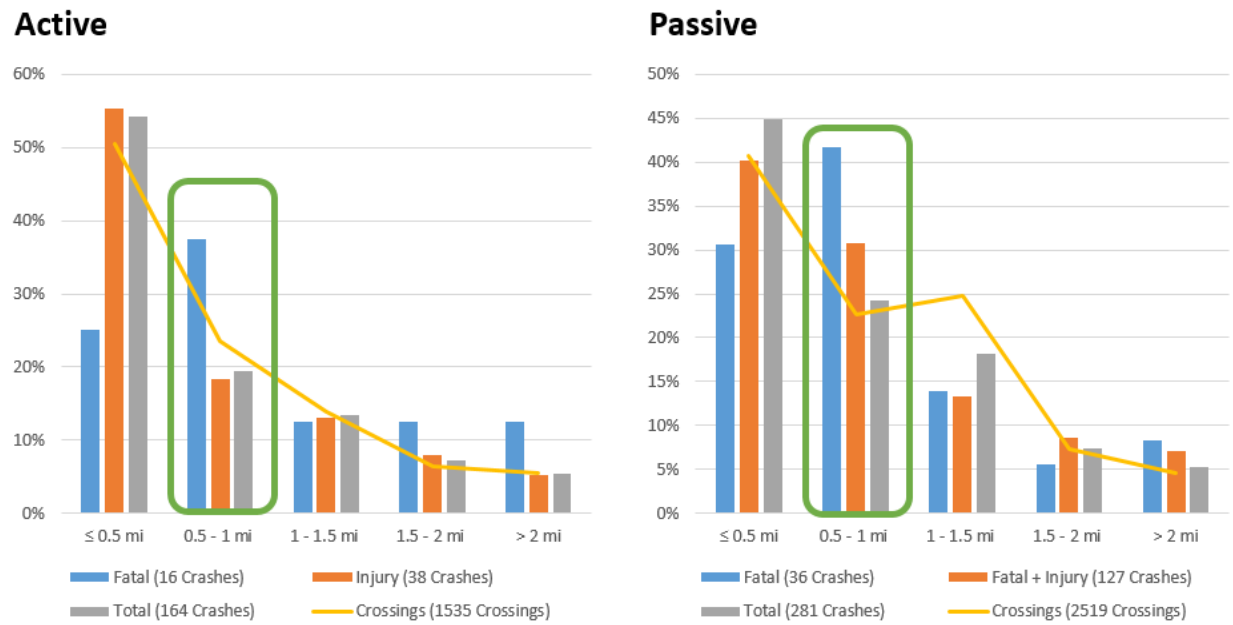


Figure 4-2. Risk Factors: Proof of Concept – Nearest At-Grade Crossing

Clearing Sight Distance

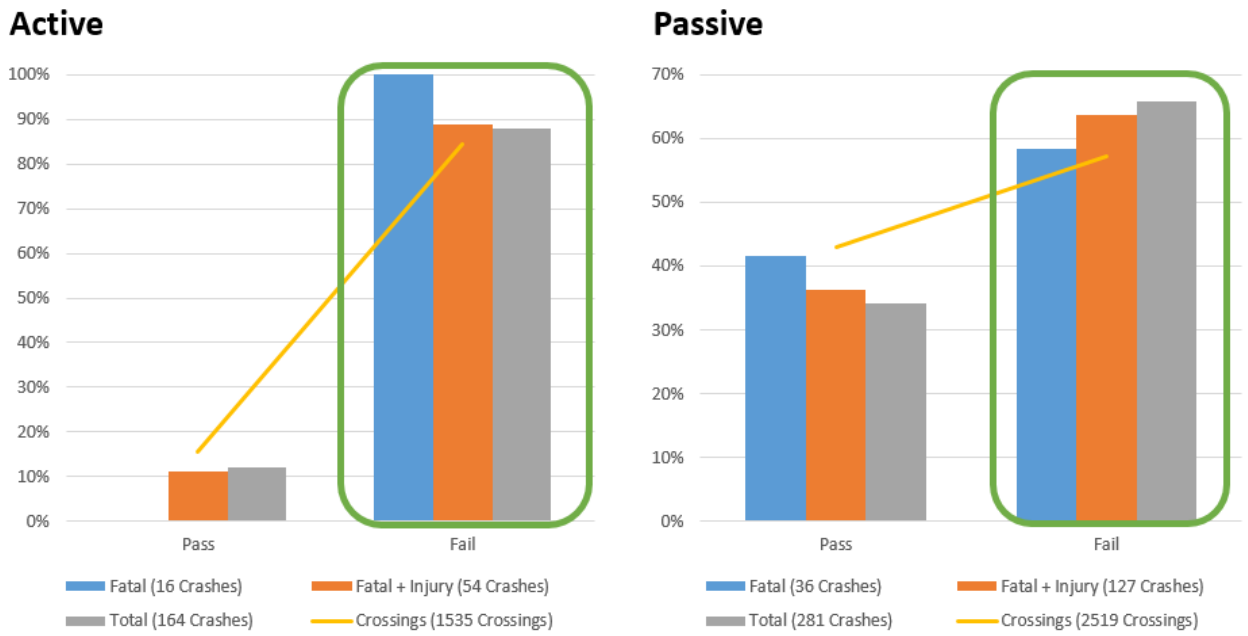


Figure 4-3. Risk Factors: Proof of Concept – Clearing Sight Distance

SECTION 5

Results of the Application of the Suggested Risk Factors

The adopted risk factors (10 for active and 9 for passive crossings) were applied to the public rail grade crossings using RGCIP data and a review of aerial photographs (Google Earth) of each crossing. The results of the assessment were tabulated on spreadsheets for active (Table 5-1) and passive (Table 5-2) crossings and included: identification of the crossing, the rail operator, location information, the type of control, and documented risk factors for each crossing.

Table 5-1. Sample Risk Assessment Output – Prioritized Listing of Active Crossings

Risk Rating	Active		Passive	
0	24	2%	11	0%
1	93	6%	73	3%
2	206	13%	291	12%
3	307	20%	457	18%
4	310	20%	591	23%
5	289	19%	527	21%
6	190	12%	389	15%
7	76	5%	137	5%
8	38	2%	43	2%
9	2	0%	0	0%

Table 5-2. Sample Risk Assessment Output – Prioritized Listing of Passive Crossings

U.S. DOT Number	City	County	Crossing Location	Jurisdiction	Control Type Gates	Passive - Roadway AADT	Passive - Total Trains per Day	Passive - Volume Cross Product	Passive - Maximum Timetable Speed	Passive - Skew	Passive - Distance to Nearby Intersection	Passive - Distance to Nearest Crossing	Passive - Clearing Sight Distance	Passive - Approaching Sight Distance	Passive - Risk Rating (of 9)	Crash Prediction	Texas Priority Index
911204C	Springfield	Brown County	County Road 5	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.090296	216.8
195412B		Faribault County	430 Avenue	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.069307	58.88
193300V		Dodge County	635 Street	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.044066	91.36
067718E		Kandiyohi County	45 Avenue SW	Township	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.03785	116.571
067868M	Howard Lake	Wright County	13 Avenue	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.026109	424.32
193616F	Springfield	Brown County	O Connell Avenue	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.021884	271.04
695539V	Alexandria	Douglas County	Birch Avenue	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.021746	245.52
067445M	Tintah	Traverse County	Oak Street	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.021005	199.68
689126M	Medina	Hennepin County	Tamarack Drive	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.019961	908.64
689328K	Brooten	Stearns county		Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.019959	599.04
067912X	Benson	Swift County	20 Avenue SE	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.019313	130.56
695614E	Henning	Otter Tail County	Marshall Avenue	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.018854	149.76
075622K	Appleton	Swift County	N Hering Street	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.018291	149.76
185338W	Shakopee	Scott County	W 3rd Avenue	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.018027	165.13
193356P		Blue Earth County	631 Avenue	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.016544	108.96

Table 5-2. Sample Risk Assessment Output – Prioritized Listing of Passive Crossings

U.S. DOT Number	City	County	Crossing Location	Jurisdiction	Control Type Gates	Passive - Roadway AADT	Passive - Total Trains per Day	Passive - Volume Cross Product	Passive - Maximum Timetable Speed	Passive - Skew	Passive - Distance to Nearby Intersection	Passive - Distance to Nearest Crossing	Passive - Clearing Sight Distance	Passive - Approaching Sight Distance	Passive - Risk Rating (of 9)	Crash Prediction	Texas Priority Index
695921D		Marshall County	230 Street NE	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.015984	83.52
689308Y		Stearns County	School Street	Township	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.015871	277.92
195447C	Fairmont	Martin County	Pioneer Drive	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.015571	120
195446V	Fairmont	Martin County	Fairlakes Avenue	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.015539	119.2
067545S	Morris	Stevens County	Northridge Drive	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.015497	360
193423G		Blue Earth County	589 Avenue	County	Passive - None	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.015434	428.48
695929H		Marshall County	290 Street NW	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.015228	71.28
061256V	Hibbing	Saint Louis County	Labarce Road	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.015165	370.7
076408J	Hinckley	Pine County	7 Street NE	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.014771	291.2
076433S	Kerrick	Pine County	Klein Radd	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.014771	291.2
695522S	Forada	Douglas County	4 Street SE	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.014727	66.24
695947F		Marshall County	390 Street NW	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.014626	62.64
193600J	Springfield	Brown County	Burns Avenue S	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.014284	66.56
193613K	Springfield	Brown County	Washington Avenue N	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.014284	66.56
193577S		Brown County	CSAH 10	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.014076	61.92

Table 5-2. Sample Risk Assessment Output – Prioritized Listing of Passive Crossings

U.S. DOT Number	City	County	Crossing Location	Jurisdiction	Control Type Gates	Passive - Roadway AADT	Passive - Total Trains per Day	Passive - Volume Cross Product	Passive - Maximum Timetable Speed	Passive - Skew	Passive - Distance to Nearby Intersection	Passive - Distance to Nearest Crossing	Passive - Clearing Sight Distance	Passive - Approaching Sight Distance	Passive - Risk Rating (of 9)	Crash Prediction	Texas Priority Index
067321U	Ruthton	Pipestone County	Aetna Street	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.014021	264.992
260080L		Carlton County	E Harney Road	Township	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.014019	219.079
695973V	Halma	Kittson County	Cleveland Avenue	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.013815	54
312212R	Roosevelt	Roseau County	690 Avenue	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.013735	199.92
195396U		Faribault County	70 Street	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.013673	78.88
251912C		Saint Louis County	Maple Grove Radd	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.013374	168.96
067853X		Wright County	55 Street SW	Township	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.013022	178.5
067560U	Donnelly	Stevens County	140 Street	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.012885	199.68
185407C		Blue Earth County	549 Avenue	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.012297	48.755
695950N	Strandquist	Marshall County	Lincoln Street	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.012197	183.04
193377H		Steele County	Havana Road	County	Passive - None	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.011893	51.04
695671T	Vergas	Otter Tail County	S Town Line Road	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.011433	149.76
695952C	Strandquist	Marshall County	Marshall Street	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.011433	149.76
695984H	Lake Bronson	Kittson County	HILL Street	Municipal	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.011433	149.76
061094V		Kandiyohi County	45 Street NW	Township	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.011374	118.4

Table 5-2. Sample Risk Assessment Output – Prioritized Listing of Passive Crossings

U.S. DOT Number	City	County	Crossing Location	Jurisdiction	Control Type Gates	Passive - Roadway AADT	Passive - Total Trains per Day	Passive - Volume Cross Product	Passive - Maximum Timetable Speed	Passive - Skew	Passive - Distance to Nearby Intersection	Passive - Distance to Nearest Crossing	Passive - Clearing Sight Distance	Passive - Approaching Sight Distance	Passive - Risk Rating (of 9)	Crash Prediction	Texas Priority Index
075336E	Danvers	Swift County	Front Street	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.011057	149.76
075634E	Holloway	Swift County	150 Avenue SW	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.011057	149.76
067723B		Kandiyohi County	75th Avenue SW	Township	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.010096	95.55
193430S		Blue Earth County	Lime Valley Road N	Township	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.009121	83.52
695793X		Polk County	350 Street SE	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.009043	73.08
695847B		Pennington County	130 Street NE	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.008815	66.96
081721W		Polk County	350 Avenue SE	County	Passive - None	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.007755	59.339
193745V	Balaton	Lyon County	220 Avenue	Municipal	Passive - None	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.007306	59.04
251852V		Saint Louis County	Stark Road	County	Passive - Stop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.007238	57.44
193427J		Blue Earth County	583 Avenue	Township	Passive - None	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.007182	41.12
185464R		Blue Earth County	194 Street	Township	Passive - Stop	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8	0.007075	45.57
193312P		Steele County	SE 34 Avenue	Township	Passive - None	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.006287	38.08

The expected results of this effort were to find a minority of crossings with large numbers of risk factors. Also, these few crossings would need crash densities higher than the subset of crossings with fewer risk factors. The results of the application of risk factors at active and passive crossings (Table 5-3) indicate that this first expectation was met. Approximately 8 percent of crossings had 7 or more risk factors. Crash density computation for each subset of crossings by the number of risk factors indicates the high-priority crossings (those with seven or more risk factors) have total (Figure 5-1), fatal plus injury (Figure 5-2), and fatal (Figure 5-3) crash densities between three and six times greater than the average for the crossings with fewer risk factors. This information suggests the application of adopted risk factors to Minnesota's system of public rail grade crossings was successful. The approach identified a minority of crossings being high risk. Likewise, the high-priority crossings had crash densities substantially above the average for crossings with fewer risk factors.

Table 5-3. Risk Factors at Active and Passive Crossings

U.S. DOT Number	City	County	Crossing Location	Jurisdiction	Control Type Gates	Active - Roadway AADT	Active - Total Trains Per Day	Active - Volume Cross Product	Active - Roadway Speed Limit	Active - Max Timetable Speed	Active - Number of Mainline Tracks	Active - Skew	Active - Distance to Nearby Intersection	Active - Distance to Nearest Crossing	Active - Clearing Sight Distance	Active - Risk Rating (of 10)	Crash Prediction	Texas Priority Index
082932W	Ramsey	Anoka County	Armstrong Boulevard NW	County	Gates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	9	0.041337	3589.199
082946E	Elk River	Sherburne County	Proctor Avenue	County	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	8	0.164841	6995.453
082944R	Elk River	Sherburne County	Jackson Street NW	Municipal	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8	0.091947	3257.303
081018G	Detroit Lakes	Becker County	Washington Avenue	County	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8	0.091217	2435.565
689355G		Pope County	MNTH 29	State	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	8	0.088705	324.432
082517B		Sherburne County	165 Avenue SE	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	8	0.08144	3569.58
067246K	Saint Cloud	Sherburne County	7 Street SE	Municipal	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8	0.073125	1314.18
067244W	Saint Cloud	Sherburne County	Minnesota Boulevard	State	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8	0.067682	1054.935
689217T		Wright County	CSAH 3	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	8	0.054521	431.856
082928G	Ramsey	Anoka County	Sunfish Lake Boulevard NW	County	Gates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	8	0.050042	5037.443
082926T	Anoka	Anoka County	Ferry Street N	State	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	8	0.048896	10329.97
082930H	Ramsey	Anoka County	Ramsey Boulevard NW	County	Gates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	8	0.048269	5664.529
082806C	Coon Rapids	Anoka County	85 Avenue NW	County	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	8	0.046609	4947.873
082807J	Coon Rapids	Anoka County	Foley Boulevard NW	County	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	8	0.044245	3229.623
097638T	Royalton	Morrison County	W Center Street	County	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8	0.040459	898.8462
082953P		Sherburne County	CSAH 15	County	Gates	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	8	0.035375	2322.765
082804N	Fridley	Anoka County	77 Avenue NE	Municipal	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	8	0.035291	2246.096
391216H	Red Wing	Goodhue County	Sturgeon Lake Rd	Municipal	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	8	0.034669	2781.369
067251G	Sauk Rapids	Benton County	2 Avenue S	Municipal	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8	0.031819	1191.582
391253K	Cottage Grove	Washington County	Innovation Road	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	8	0.029599	343.854
082936Y	Elk River	Sherburne County	Jarvis Street	Municipal	Gates	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.029024	871.6386
384044K	Rosemount	Dakota County	150 Street W	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	8	0.028605	554.356
082938M	Elk River	Sherburne County	165 Avenue NW	Municipal	Gates	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	8	0.027546	674.7627
062898M		Clay County	230 Street S	County	Gates	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	8	0.024786	501.12
876416K	Rosemount	Dakota County	Rich Valley Boulevard	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	8	0.02407	211.695
689182U		Wright County	Meridian Avenue NE	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	8	0.023517	561.456

Table 5-3. Risk Factors at Active and Passive Crossings

U.S. DOT Number	City	County	Crossing Location	Jurisdiction	Control Type Gates	Active - Roadway AADT	Active - Total Trains Per Day	Active - Volume Cross Product	Active - Roadway Speed Limit	Active - Max Timetable Speed	Active - Number of Mainline Tracks	Active - Skew	Active - Distance to Nearby Intersection	Active - Distance to Nearest Crossing	Active - Clearing Sight Distance	Active - Risk Rating (of 10)	Crash Prediction	Texas Priority Index
067711G		Kandiyohi County	30 Street SW	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	8	0.022045	311.1108
689150N	Greenfield	Hennepin County	Dogwood Street	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	8	0.021849	619.056
380424D	Rosemount	Dakota County	145 Street W	Municipal	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8	0.020675	376.935
061570E	Coon Rapids	Anoka County	Egret Boulevard NW	Municipal	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	8	0.020545	559.93
061580K	Andover	Anoka County	Crosstown Boulevard NW	Municipal	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	8	0.020366	538.93
689172N		Wright County	Division Street SE	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	8	0.019885	423.648
380414X		Dakota County	170 Street W	Township	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	8	0.015392	145.156
082803G	Fridley	Anoka County	Osborne Road NE	County	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	7	0.100822	4123.113
689118V	Plymouth	Hennepin County	Vicksburg La	Municipal	Gates	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	7	0.095745	1216.656
082914Y	Coon Rapids	Anoka County	Crooked Lake Boulevard NW	County	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	7	0.085956	2928.218
097674N		Morrison County	165 Street	County	Gates	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	7	0.059966	742.77
075717T	Randall	Morrison County	MNTH 115	State	Gates	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	7	0.05387	357.21
082811Y	Coon Rapids	Anoka County	Hanson Boulevard NW	County	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	7	0.052585	6655.718
260123C		Saint Louis County	MNTH 37	State	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	7	0.051503	287.7182
917432K	Elk River	Sherburne County	Tyler Avenue NW	Municipal	Gates	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	7	0.050447	3374.935
061057T	Independence	Hennepin County	CSAH 92	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	7	0.049412	290.598
688952K	Crystal	Hennepin County	Broadway Avenue	County	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.048183	1132.272
097908P	Pipestone	Pipestone County	8 Avenue NE	State	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.046069	152.0415
067285B	Marshall	Lyon County	240 Avenue	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	7	0.045835	168.2317
062872K		Becker County	180 Avenue	Township	Gates	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	7	0.04013	25.201
082923X	Anoka	Anoka County	4 Avenue	County	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	7	0.038284	2022.968
067230N	Clear Lake	Sherburne County	Main Avenue	State	Gates	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	7	0.035071	3263.106
924664S		Sherburne County	200 Street	County	Gates	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	7	0.034364	1231.965
085928S	Coon Rapids	Anoka County	119 Avenue NW	Municipal	Gates	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	7	0.033826	1703.468
067245D	Saint Cloud	Sherburne County	15 Avenue SE	County	Gates	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	7	0.03346	2716.56
062847C	Frazee	Becker County	Lake Street N	State	Gates	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	7	0.031448	1409.052

Table 5-3. Risk Factors at Active and Passive Crossings

U.S. DOT Number	City	County	Crossing Location	Jurisdiction	Control Type Gates	Active - Roadway AADT	Active - Total Trains Per Day	Active - Volume Cross Product	Active - Roadway Speed Limit	Active - Max Timetable Speed	Active - Number of Mainline Tracks	Active - Skew	Active - Distance to Nearby Intersection	Active - Distance to Nearest Crossing	Active - Clearing Sight Distance	Active - Risk Rating (of 10)	Crash Prediction	Texas Priority Index
062867N	Audubon	Becker County	4 Street	County	Gates	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	7	0.028752	1190.862
696288G	Buffalo	Wright County	5 Street NE	Municipal	Gates	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	7	0.028622	935.856
097629U	Rice	Benton County	Main Street W	County	Gates	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	7	0.027915	1128.784
691417C	Vadnais Heights	Ramsey County	CSAH 96	County	Gates	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	7	0.026991	465.192
061089Y	Willmar	Kandiyohi County	30 Street NW	County	Gates	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	7	0.026566	491.264
380416L		Dakota County	160 Street W	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	7	0.026566	595.54
689206F		Wright County	CSAH 6	County	Gates	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	7	0.024911	187.056
689177X	Buffalo	Wright County	2 Street S	Municipal	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.02438	791.856
062791K		Otter Tail County	MNTH 106	State	Gates	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	7	0.023874	425.43
082978K	Minneapolis	Hennepin County	Talmadge Avenue SE	Municipal	Gates	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	7	0.023767	242.73
061577C	Andover	Anoka County	Bunker Lake Boulevard NW	County	Gates	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	7	0.023474	1042.93
876265X	Albert Lea	Freeborn County	Margaretha Avenue	County	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.022997	188.812
260081T		Carlton County	N Cloquet Road E	County	Gates	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	7	0.022921	192.0898
061625P	Cambridge	Isanti County	11 Avenue SE	Municipal	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.022796	356.93
075713R	Elk River	Sherburne County	Ogden Street NW	Municipal	Gates	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	7	0.022485	399.375
260126X	Mountain Iron	Saint Louis County	Fayal Road	County	Gates	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	7	0.021786	126.3015
696395W		Wright County	Dague Avenue SE	County	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.021765	388.656
067831X	Willmar	Kandiyohi County	Lakeland Drive SE	Municipal	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	7	0.021158	280.64
062911Y	Glyndon	Clay County	100 Street S	County	Gates	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	7	0.020967	235.335
062834B		Otter Tail County	CSAH 60	County	Gates	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	7	0.020678	220.98
082515M		Sherburne County	CR-50	County	Gates	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	7	0.020387	426.195
876270U	Albert Lea	Freeborn County	S Newton Avenue	Municipal	Gates	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	7	0.020292	199.144
061591X	Oak Grove	Anoka County	Viking Boulevard NW	County	Gates	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	7	0.019858	482.93
876356D	Owatonna	Steele County	NW 26 Street	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	7	0.019851	528.495
062801N	New York Mills	Otter Tail County	S Boardman Avenue	Municipal	Gates	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	7	0.019741	180.96
062795M		Otter Tail County		County	Gates	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	7	0.019664	177.48

Table 5-3. Risk Factors at Active and Passive Crossings

U.S. DOT Number	City	County	Crossing Location	Jurisdiction	Control Type Gates	Active - Roadway AADT	Active - Total Trains Per Day	Active - Volume Cross Product	Active - Roadway Speed Limit	Active - Max Timetable Speed	Active - Number of Mainline Tracks	Active - Skew	Active - Distance to Nearby Intersection	Active - Distance to Nearest Crossing	Active - Clearing Sight Distance	Active - Risk Rating (of 10)	Crash Prediction	Texas Priority Index
097618G		Todd County	Dower Lake Road	Township	Gates	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	7	0.01915	158.775
067834T	Willmar	Kandiyohi County	7 Street SW	County	Gates	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	7	0.019147	181.824
067265P		Benton County	Frost Road	Township	Gates	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	7	0.018256	165.5682
260149E	Mountain Iron	Saint Louis County	Mineral Avenue	County	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	7	0.018065	287.298
876273P	Albert Lea	Freeborn County	Garfield Avenue	Municipal	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.017717	257.856
067234R		Sherburne County	CSAH 16	County	Gates	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	7	0.017445	131.04
876352B	Owatonna	Steele County	North Street	Municipal	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.017417	302.72
076411S	Sandstone	Pine County	MNTH 123	State	Gates	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	7	0.017297	258.93
260171S	Cook	Saint Louis County	Vermilion Boulevard	County	Gates	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	7	0.017262	252.637
067811L		Meeker County	CSAH 1	County	Gates	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	7	0.017229	122.094
075112G	Cloquet	Carlton County	Old Carlton Road	County	Gates	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	7	0.016954	182.912
061578J	Andover	Anoka County	Andover Boulevard NW	County	Gates	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	7	0.016744	234.43
067710A	Willmar	Kandiyohi County	Willmar Avenue SW	County	Gates	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	7	0.016594	242.2511
097910R	Pipestone	Pipestone County	E Main Street	County	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.016372	216.5163
067239A		Sherburne County	42 Street	County	Gates	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	7	0.016317	99.225
251850G		Saint Louis County	Midway Road	County	Gates	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	7	0.015799	115.296
061491T		Isanti County	367 Avenue NE	County	Gates	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	7	0.01578	118.93
252070K	Mountain Iron	Saint Louis County	CSAH 7	County	No Gates	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	7	0.015767	122.7765
067284U	Marshall	Lyon County	W College Drive	State	Gates	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	7	0.015664	191.0363
097644W		Morrison County	83 Street	County	Gates	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	7	0.01555	86.268
876276K	Albert Lea	Freeborn County	Hammer Road	Municipal	Gates	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	7	0.015107	166.87
695637L		Otter Tail County	MNTH 78	State	Gates	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	7	0.014775	137.988
075710V	Bemidji	Beltrami County	Division Street NW	Municipal	Gates	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	7	0.014635	215.404
061510V		Kanabec County	MNTH 70	State	Gates	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	7	0.014288	132.93
380362H	Dundas	Rice County	Hester Street	County	Gates	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	7	0.014155	114.356
097837V		Sherburne County	115th Avenue SE	County	Gates	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	7	0.014116	55.125

Table 5-3. Risk Factors at Active and Passive Crossings

U.S. DOT Number	City	County	Crossing Location	Jurisdiction	Control Type Gates	Active - Roadway AADT	Active - Total Trains Per Day	Active - Volume Cross Product	Active - Roadway Speed Limit	Active - Max Timetable Speed	Active - Number of Mainline Tracks	Active - Skew	Active - Distance to Nearby Intersection	Active - Distance to Nearest Crossing	Active - Clearing Sight Distance	Active - Risk Rating (of 10)	Crash Prediction	Texas Priority Index
061054X	Independence	Hennepin County	CSAH 90	County	Gates	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	7	0.013615	129.438
067238T		Sherburne County	45 Avenue	Township	Gates	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	7	0.012957	38.745
097610C		Todd County	470 Street	Township	Gates	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	7	0.010871	20.5716
097640U		Morrison County	58 Street	Township	Gates	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	7	0.009819	13.9356
097642H		Morrison County	68 Street	Township	Gates	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	7	0.009819	13.9356
097649F		Morrison County	113 Street	Township	Gates	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	7	0.007837	5.9724

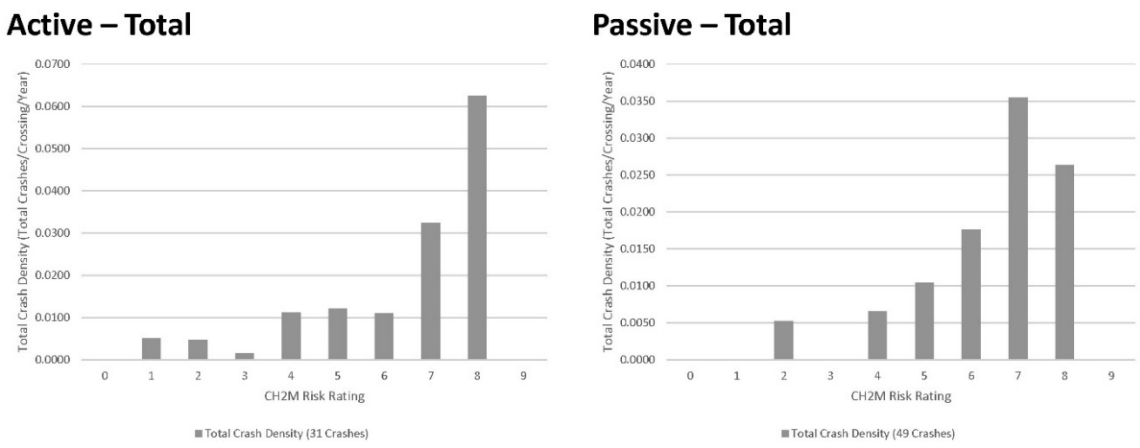


Figure 5-1. Active versus Passive Totals

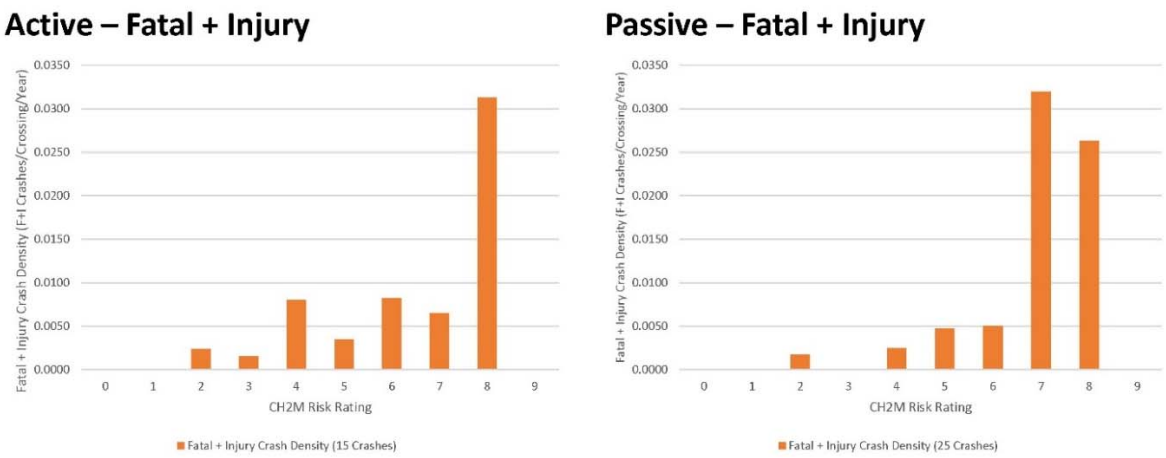


Figure 5-2. Active versus Passive Fatal plus Injury

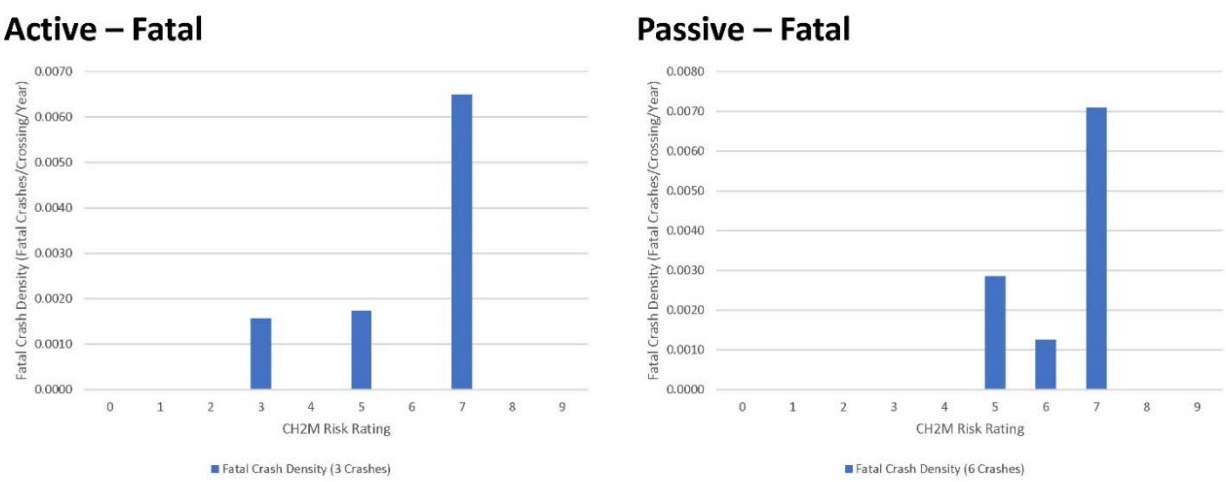


Figure 5-3. Active versus Passive Fatal

The final analytical effort involves comparing results of the systemic risk assessment to outputs from the FRA Accident Prediction Model and the Texas Priority Index. The outcome from this effort provides insight about how results from the three approaches compare to each other and whether or not the systemic risk analysis based on Minnesota data is a better fit than the other models.

The FRA Accident Prediction Model provides a good fit for crashes in the 10-year study period. However, given the majority of crossings that experienced a fatal or injury crash had no recent history of crashes of any severity, the emphasis of prediction model on prior crash history may detract from long-term trends.

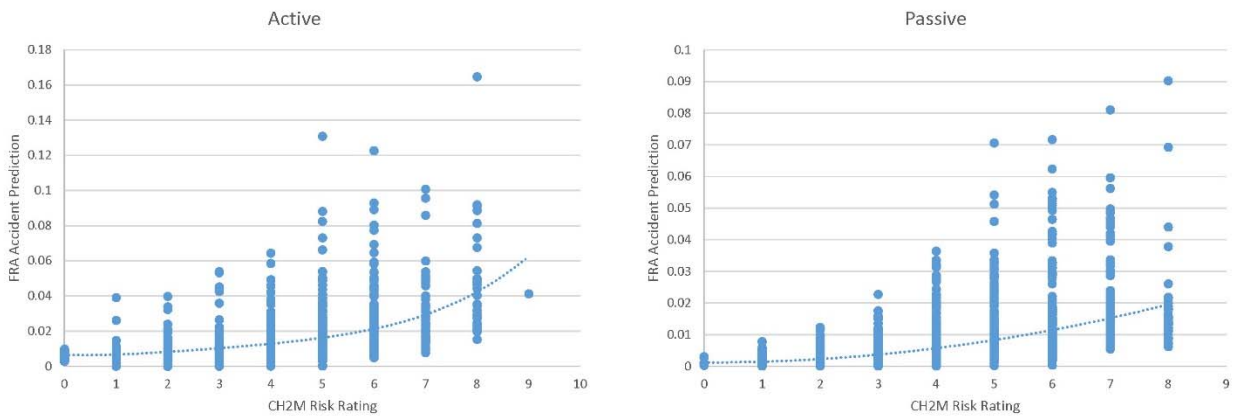


Figure 5-4. Active versus Passive Risk Rating

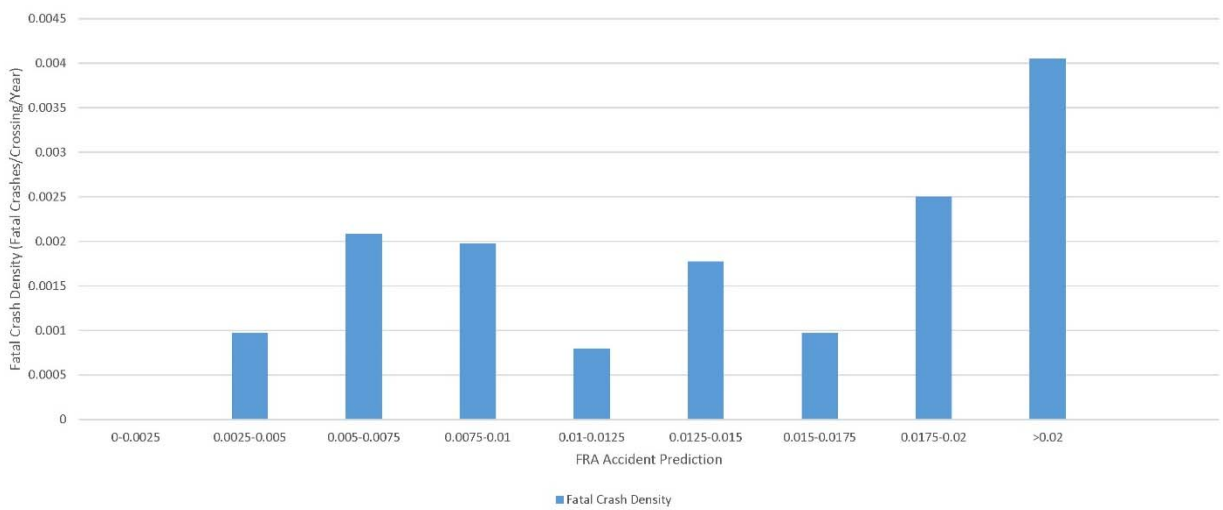


Figure 5-5. FRA Accident Prediction Model

The Texas Priority Index produces a comparatively poor fit for Minnesota's rail grade crossing crashes in the 10-year study period. According to this model, the crash distribution provides little to no correlation with the prioritization of crossings and crossings considered at-risk are generally considered at-risk in the systemic risk rating. Comparing the Texas Priority Index to the systemic model (Figure 5-8), the systemic model represents an overall higher density of fatal crashes among the crossings it deems to be of higher risk.

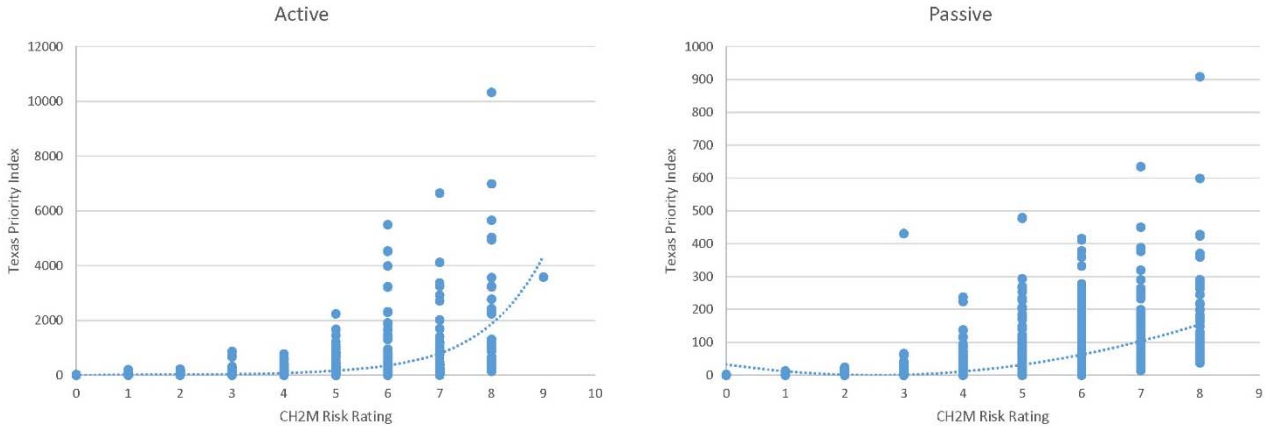


Figure 5-6. Active versus Passive Risk Rating

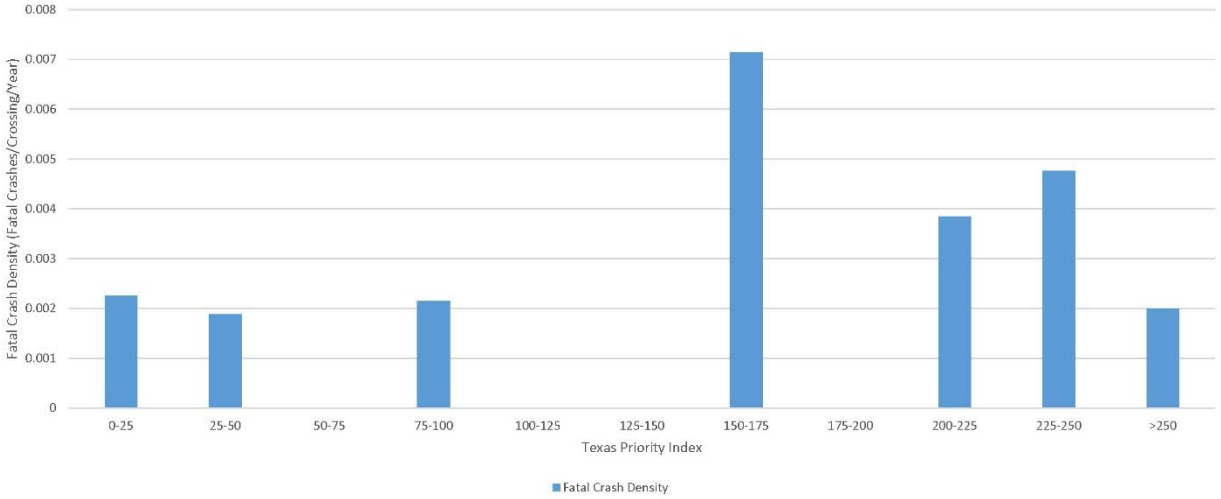


Figure 5-7. Texas Priority Index for Fatal Crash Density

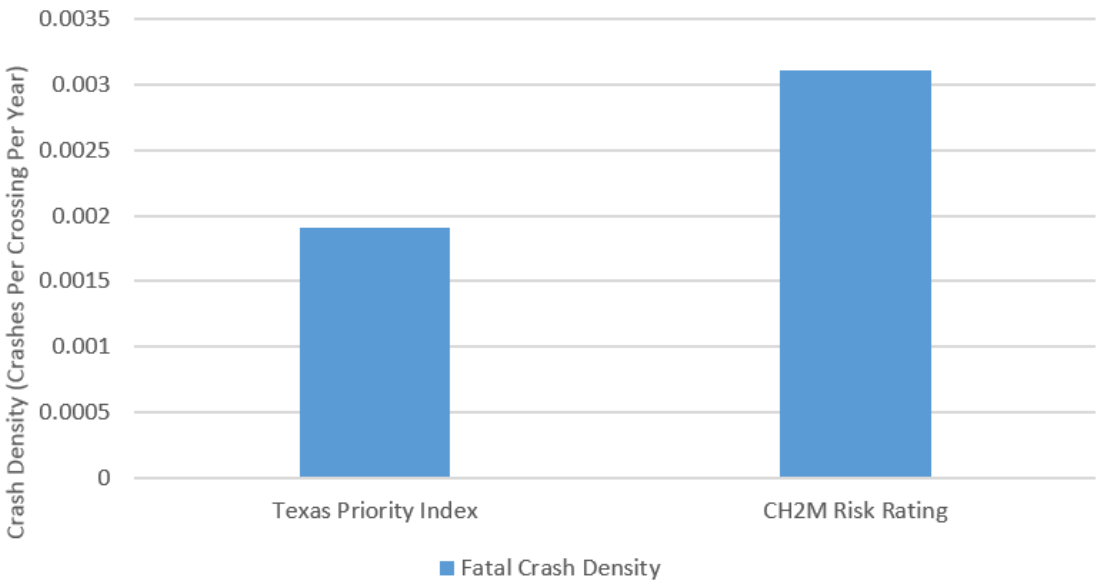


Figure 5-8. Comparison of Systemic Model to Texas Priority Index for Fatal Crash Density

SECTION 6

Conclusion

- Vehicle train collisions at rail grade crossings are rare. Over the 10-year study period, more than 4,000 public rail grade crossings in Minnesota have averaged approximately 45 crashes and 5 fatal crashes per year. During this time, 91 percent of the grade crossings had no crashes, 96 percent had no crashes resulting in injuries, and 99 percent had no fatal crashes.
- MnDOT Rail Administration staff's concerns about the current use of existing crash prediction models to identify candidates for safety investment appear justified by the analysis of Minnesota's data. The crash prediction models' theory that the occurrence of a prior crash at a grade crossing is a good predictor of a future crash at that same location is not consistent with the data for Minnesota. More than 50 percent of crossings with an injury crash had no prior crashes.
- FRA Accident Prediction Model is highly influenced by the occurrence of prior crashes and the most recent application in 2014 was only able to identify 21 crossings (0.8 percent) as a priority and most were ultimately determined to be poor candidates for safety investment.
- The Texas Hazard Index uses the number and speed of trains, roadway traffic volume, and prior crashes. This index was used to develop the Fiscal Year 2017 safety program. It was determined that this model was a poor fit with Minnesota's crash data based on documentation of relatively low crash density at the identified priority crossings.
- The crash data analysis documented a number of important facts that should be considered in the future when rail safety projects are being developed.
  - For passive warning devices, the average crash densities are very similar for crossings with STOP signs (0.0013 fatal crashes per crossing per year and 0.005 fatal plus injury crashes per crossing per year) and crossings without STOP signs (0.0016 and 0.006).
  - At crossings with passive warning, the most common factor contributing to fatal crashes are motorists NOT stopping (83 percent).
  - At crossings with active warning devices, the addition of gates as compared to flashing lights only results in lower densities of total and fatal plus injury crashes. Relative to fatal crashes, densities at crossings with and without gates are identical. At crossings with gates, 50 percent of fatal crashes involved motorist bad driving behavior, either driving around or through the gates.
- After review and analysis of rail grade crossing crash and design characteristics databases, a set of volume, speed, design, and surrounding area features were identified as over-represented at crossings with crashes. Additional analysis demonstrated that the minority of crossings with majority of these features had the highest crash densities. Following review by this project's Technical Advisory Panel, these characteristics were adopted as the risk factors to be used in the systemic risk analysis of public rail grade crossings.
- The adopted risk factors were applied to the public rail grade crossings and a review of key results indicates that the systemic approach successfully produced a prioritized list of crossings with active and passive warning devices. Success was measured by the most at-risk crossings (with 7 or more risk factors out of a possible maximum of 10 at active and 9 at passive crossings) accounted for approximately 8 percent of the system. These top-ranked crossings had crash densities three to six times greater than the subset of crossings with fewer risk factors.
- During the course of this study, Rail Administration staff have shared that their gold standard safety project involves installing an active warning device consisting of a four-quadrant gate system with

cantilever flashers at the identified high-priority crossings with passive devices. Based on a typical installation cost of approximately $500,000 per crossing, the more than 2,500 crossings with passive control and MnDOT's current level of rail safety funding ($5 million per year), it would take on the order of 250 years to achieve a high level of safety at all public rail grade crossings in Minnesota. MnDOT staff also shared that a recent review of the more than 1,500 current active systems determined that many were approaching the end of their useful lives and the annual cost for replacements would use the entire rail safety budget. This situation results in enormous challenges for addressing future safety deficiencies at crossings with passive warning devices.

- MnDOT has already closed approximately 500 crossings, however, financial and system management challenges associated with 4,000 grade crossings and documented marginal safety effectiveness of key strategies (addition of STOP signs and converting passive crossings to flashers and gates) that comprise the rail safety program backbone point to the need to close additional crossings. A closed crossing reduces inventory, reduces maintenance costs for warning devices, and eliminates the possibility of vehicle-train collisions.

SECTION 7

Next Steps

The following steps should be considered in the future.

- Consider adopting fatal plus injury crashes as the primary performance measure for the safety program managed by the Rail Administration instead of fatal and total crashes (historic approach). Fatal plus injury crashes have been adopted by FHWA as the primary performance measure for developing each state's Strategic Highway Safety Plan. Fatal plus injury crashes also have been adopted by MnDOT as the performance measure used in developing Minnesota's Highway Safety Improvement Program. This move has been, in large part, due to FHWA and AASHTO's support for the national Toward Zero Deaths initiative and due to the recognition that characteristics of and solutions to fatal plus injury car crashes are different than PDO crashes. If the Rail Administration's goal is to address safety at the crossings determined to be most at risk for crashes involving injuries and fatalities, the analytical process has to reflect that goal by using fatal plus injury crashes as the performance measure.
- Consider supplementing predictive models with the systemic risk assessment results. The comparison of results for both applications indicates that the systemic risk assessment provides a better fit with Minnesota's crash data and produces a broader list of potential candidates for safety investment.
- Consider placing a high priority on closing crossings by adjusting current project development practices to reward local agencies that participate in safety projects that include closing crossings. Over the years, MnDOT has changed the practice of requiring local agencies to pay the local share of rail grade crossing improvement projects due to concerns about missing opportunities to improve safety at priority crossings if local agencies declined to come up with their matched cost amount for projects at high-priority candidate crossings. Encouraging local agencies to give greater thought to closing crossings could involve bringing back local match requirements for improvements and making the match equal to the reward for closing two nearby crossings. The idea of requiring a local match for grade crossing improvements concerns staff in MnDOT's Rail Administration Section. Staff members worry that MnDOT may not be able to undertake an improvement at a grade crossing documented in a priority listing due to a local government's decision to not provide the local matching funds. Other states have expressed the same concerns and have taken a proactive approach to address the liability issue by stamping documents regarding the safety enhancement of crossings using Federal-aid highway funds with a note citing 23 U.S. Code 409. This Federal law (an overview along with a summary of a supporting U.S. Supreme Court case is included in Appendix B) establishes that any data, analyses, lists, or reports dealing with the safety enhancement of intersections, roadway segments, or railway-highway crossings using Federal-aid highway funds are not discoverable and cannot be used in any Federal or State court proceeding. This Federal law directly addresses the concern expressed by MnDOT's Rail Administration Section staff, but it would be best to confer with MnDOT's attorneys for specific legal advice.
- MnDOT staff have indicated that they have regularly tried to close crossings and, in most cases, have met considerable resistance from local agencies where 95 percent of the rail grade crossings are located. Two thoughts are provided for consideration. First, more crossings are located along the county road system, which has the highest number of total, fatal plus injury, and fatal crashes. Therefore, a pilot project that involves partnering with a number of counties (Blue Earth, Otter Tail, and St. Louis are the only counties on the top ten list for total, fatal plus injury, and fatal crashes) should be considered. This program could include conducting a study that results in identifying a small number of high-risk candidates for upgrades to active warning devices and the closure of a

larger number of nearby low-risk crossings. The second approach involves seeking changes to state statutes that appear to prevent the closure of some crossings. MS8830.2720 indicates that a rural crossing may be vacated if there is another crossing within 1 mile and if the crossing has fewer than 150 vehicles per day. MnDOT staff have indicated that these values are outdated and, "have caused them to walk away from excellent closure candidates over mere tenths of a mile."

- As is the case with highway-related crashes, bad motorist behavior appears to be a contributing factor in a majority (almost 85 percent) of fatalities at rail grade crossings. To address this issue, the Rail Administration should consider investigating ways of partnering with law enforcement to increase efforts to address the high level of motorist involvement contributing to fatal crashes, especially disregarding STOP signs and driving through or around gates. State law prevents electronic enforcement and requires the presence of law enforcement officers to observe violations. However, the technology to document violations electronically exists.
- Consider replacing STOP signs with YIELD signs as part of periodic sign maintenance activities along low-volume roads in rural areas. This strategy is based on: documented poor safety effectiveness associated with STOP signs at rail grade crossings, 86 percent of fatal crashes at crossings with STOP signs involved motorists not stopping, county engineers' concern about minimizing the severity for STOP signs in locations that indicate a need to stop, and notice that the new Manual on Uniform Traffic Control Devices will be adding verbiage discouraging the use of STOP signs at low-volume roadway intersections.
- If it is determined that STOP signs will continued to be used, consider developing new guidelines for their application based on a combination of minimum roadway and train volumes and available sight distance.
- At crossings with active control, consider continuing recent practice to use gates at all crossings with active devices and include strategies as part of the safety projects that make it increasingly difficult for motorists to drive around the gates, such as adding narrow median islands on the approaches to rail grade crossings. When possible, MnDOT has been adding gates but there are exceptions (for example, when gates are not feasible).
- Consider returning to using a corridor approach in developing a rail grade crossing safety plan. Over time, the use of various crash prediction models has resulted in a scatter shot approach. Identification of rail corridors based on the owner's desire to participate, combined with a partnership with the counties, could result in the preparation of comprehensive safety plans, including maps of corridors with in-place active devices, high-priority candidates for improvement, and candidates for closure noted. With this type of information available, if a crisis would occur as a result of a fatal crash, an initial solution would be available that has already been determined to fit into a broader plan.

SECTION 8

References

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Appendix A
Research Reports

California Experience: Applying Safety Treatments to Rail-Highway At-Grade Crossings

Title Applying Safety Treatments To Rail-Highway At-Grade Crossings
Year May 2012
URL http://safetrec.berkeley.edu/sites/default/files/Applying%20Safety%20Treatments%20To%20Rail-Highway%20At-Grade%20Crossings.pdf

Summarize Information in Railroad-grade Crossing Areas

Overview/Problem Statement

Highway-railway grade crossing collisions tend to spread over a vast number of sites. Predicting the risk at highway-rail grade crossings using crash prediction models is an approach where historical crash database serves the strong basis for understanding the problems and proposing effective countermeasures.

1) Does the document present a model for assessing the risk or safety performance of an at-grade railroad crossing? If yes, what inputs are used by the model?

This document reviews other at-grade railroad and highway prediction models by a number of studies (Fitzpatrick et al., 1996; Qureshi et al., 2003 and Qureshi et al., 2005) and the variables used in these models by other studies Federal Railroad Administration (FRA). The comprehensive list of predictors in the models are summarized in Table 1.

TABLE 1
List of Predictors

Vehicular Traffic	Rail Traffic	Crossing Specifications	Additional variable
AADT*	Number of fast trains	Number of main tracks*	Crossing angle
School buses*	Number of slow trains	Land development*	Proximity to highway intersections
Trucks*	Number of passenger trains*	Crash experience*	Crossing delay
Hazmat	Number of freight trains*	Highway paved*	
Speed of highway traffic*	Total number of trains*	Number of highway lanes*	
	Maximum timetable speed*	Type of warning device*	
	Switching movements*	Sight distance	
		Highway alignment	
		Clearance time	

* Field is included in the FRA inventory database.

2) Does the document present how the inputs were identified and verified as predictors for safety performance?

There are no specific details on the background of selecting the predictors.

3) Does the document summarize grade crossing countermeasures and their effectiveness? If yes, please describe.

There are three physical improvements to the at-grade crossings, proposed in this document, which are briefly shown here:

- Channelization devices effectiveness: when added to two-quad gate crossings, violations are cut by 75 percent to 80 percent (Ko et al., 2007; Transpo Group, 2000; Khattak and McKnight, 2008; Khattak et al., 2007; Caird et al., 2002).
- Long-arm gates effectiveness: before-after study in three test scenarios indicated that 67 percent reductions of violations and 84 percent reductions after 1 year. These gates discourage the driver to drive around the gates.
- Improvement of intersection and interchange safety for roadway users of at-grade railroad-highway crossings effectiveness: Strategic Highway Safety Plan (SHSP) will be a good avenue to determine the effectiveness over the time when considering at-grade crossing crashes are rare and random events if expressed by crash frequency per year per crossing, a systematic way of identifying those crossing and applying countermeasures in terms of possible improvements that brings potential reduction of fatal and serious injury crashes significantly.

4) Is guidance provided on the conditions to use discussed countermeasures? If yes, please describe.

- Channelization devices particularly the delineators (commercially known as Qwick Kurb) could be potentially damaged by the heavy vehicles. Some studies indicated that amount of damage was a function of traffic volume, percentage of trucks, and whether sharp turns were involved (Khattak et al. 2007; Ko et al., 2007). Also, channelization devices could pose a maintenance problem if the lane width is less than 3.4 meters (11 feet). In addition, the practical length of the traffic separator system should be based on the maximum queue lengths of the approach to discourage vehicles stopped at the back of the queue from entering the crossing from the wrong side of the road.
- Long-arm gates should not be used when the corridor has high percentage of heavy vehicle movements. The problem with heavy vehicle movement, particularly tractor-trailers, is that they could potentially go through the gate and could break off the movement, which can make the crossing unguarded. The authorities should be very conscientious about not installing long-arm gates on routes with significant (more than 1 or 2 percent) truck traffic.
- Conditions for the third countermeasure, which justify the implementation of the countermeasures include:
    - Where should limited safety funds be allocated? Which crossings have the largest potential of risks where safety intervention is justified?
    - Which countermeasures should be considered to enhance safety at hotspots (i.e., crossings with unacceptable risks) in a cost effective and practicable manner? (Saccomanno et al., 2006)

Also, under SHSP improvement plan, contributing factors should be identified to apply for countermeasures. The most influential safety factors responsible for the 41 percent reduction in incidents at highway-rail grade crossings between 1994 and 2003 (Horton et al., 2006). Table 2 shows the success factors of significant reduction and Caltrans interest of factors by Caltrans as per policies and procedures:

TABLE 2
Success Factors of Significant Reduction and Caltrans Interest of Factors by Caltrans

Success factors for significant reductions (Horton et al., 2006)	Factors of interest by Caltrans
Commercial driver safety	Sight Lines Clearance
Locomotive conspicuity	Grade Crossing Maintenance Rule
Grade crossing maintenance	Crossing Closure and Grade Separation
More reliable motor vehicles	Warning Device Upgrades
Sight lines clearance	The Section 130 Program
Freight car reflectorization	
Pedestrian safety	

5) Does the document describe the approach or provide an overview of a state's rail grade crossing safety programs? If yes, please describe.
No safety program is addressed.

Additional Notes

The researcher noted that public crossings have some type of warning device present [assuming it hasn't been knocked down or vandalized] and that crashes are a result of the driver violating the signs/signals/gates or incorrectly estimating a train's arrival by not judging the approaching train's distance and speed.

The authors cited a prior report that had observed that two thirds of drivers who "approached a rural rail grade crossing in the presence of activated warning flashers crossed the tracks despite the warnings and the approaching train." The authors supported a prior established viewpoint that drivers use active warning devices as a cue that they will need to make a decision on whether or not to cross. The risk drivers assumed when crossing after a warning device was activated was equated to the risk a pedestrian takes when crossing a busy roadway.

The report states that a "common driver error is misjudgment of the time remaining until the train arrives at the crossing (i.e., train speed and distance)." A driver's ability to gauge the speed of an approaching object has multiple influencing factors. These factors include "driving experience, visual cues available, light conditions, the presence of visual information in the background, and adaptation to previously encountered train speed levels." The authors noted that prior research indicated people have more difficulty judging speed when looking at an object head on [speed is inferred from the rate of change in the object's size] and that larger objects appear slower than a small object traveling at the same speed. Both human limitations can lead to conflicts and crashes at rail grade crossings.

Based on past research, the authors noted that drivers crossing around barrier gates tended to stop or slow on approach significantly less than those crossing with flashers only. One possible explanation is that drivers violating the gate made a hurried decision out of a sense of urgency to beat the gate.

Texas Experience: Design Guidelines for At-Grade Intersections near Highway-Railroad Grade Crossings

Title Design Guidelines for At-Grade Intersections near Highway-Railroad Grade Crossings
Year November 2000
URL http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/1845-3.pdf

Summarize Information in Railroad-grade Crossing Areas

Overview/Problem Statement

This document discusses the challenge of at-grade highway-railroad crossing and some design guidelines that provide helpful information in the following s areas: traffic control devices, signal interconnection, channelization, high-profile or hump crossings, and illumination.

1) Does the document present a model for assessing the risk or safety performance of an at-grade railroad crossing? If yes, what inputs are used by the model?

No, this document does not present any model on safety performance on the at-grade railroad crossing.

2) Does the document present how the inputs were identified and verified as predictors for safety performance?

This document presents the design guidelines for traffic control devices, signal interconnection, channelization, high-profile crossings, and illuminations. These factors also could be considered to identify inputs for safety performance under this topic. The factors considered for these types of design guidelines that help improve the safety of at-grade railroad crossing are presented in Table 1.

TABLE 1
Factors for Preventive Design Features

Design Features	Factors to consider
Traffic control devices	Type of highway, volume and speed of railroad and vehicular traffic, volume of pedestrian traffic, accident history, sight distance, geometrics, number of tracks at the crossing, and volume of school buses or vehicles transporting hazardous materials
Interconnection	Motor vehicle traffic volumes, approach speeds, queue lengths
Channelization	Type of design vehicle, the cross sections of the roadways, traffic volumes (vehicle and train), vehicle speed, train speed, type and location of traffic control devices, right-of-way, and terrain
High profile crossing	Types of vehicle and low-ground clearance vehicle
Illumination	Nighttime train operations, history of nighttime accidents that appear related to visibility of the train; accident history of nighttime side-of-the-train accidents, long or slow trains, reliable sources of power, restricted sight distance of the crossing

3) Does the document summarize grade crossing countermeasures and their effectiveness? If yes, please describe.

No, this document does not discuss on the effectiveness of the countermeasures.

4) Is guidance provided on the conditions to use discussed countermeasures? If yes, please describe.

This document highlights some of the engineering design features and guidelines that could be utilized for possible countermeasures of the safety concerns.

A. Guidelines for Traffic Control Devices

Active highway-railroad grade crossings within 200 feet of highway signalized intersections are required to have interconnections or preemption between the highway traffic signal controllers and the grade crossing controllers. Also, the signs, marking, signals, and gates should follow the guidelines from the *Manual of Uniform Traffic Control Devices* (MUTCD) (FHWA, 2009).

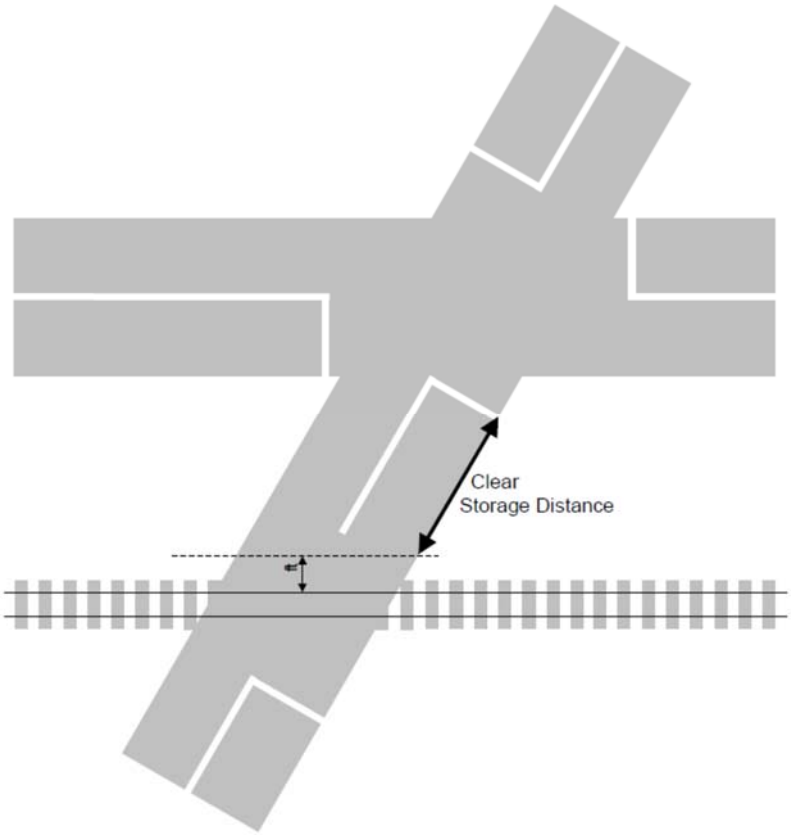
Reference guidelines:

- MUTCD
- Preemption of Traffic Signals At or Near Railroad Grade Crossings with Active Warning Devices
- A Policy on Geometric Design of Highways and Streets

B. Guidelines for Interconnection

Clear Storage Distance is the distance available for vehicle storage measured with 6 feet from the rail nearest to the intersection STOP BAR on the highway. At skewed crossings and intersections, shown in the figure below, the clear storage distance is measured with the 6 feet distance to be measured perpendicular to the nearest rail, either along the centerline, or right edge line of the highway, as appropriate, to the usual stopping point of vehicles on the highway to obtain the shorter distance.

FIGURE 1
Clear Storage Distance in Skewed Intersection



The 95th percentile queue length analysis needs to be performed based on the design traffic volume on the approach crossing the tracks. If computed queue length exceeds the Clear Storage Distance in more than 5 percent of signal cycles during the design hour, the intersection should be considered and designed for interconnection.

Reference guidelines:

- Manual on Uniform Traffic Control Devices

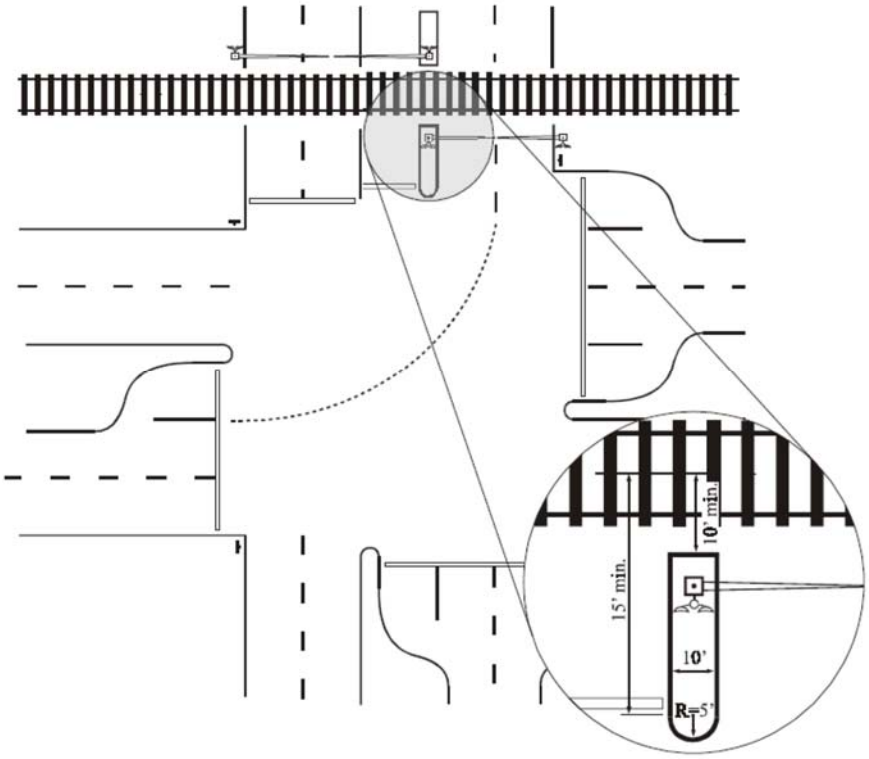
- Preemption of Traffic Signals At or Near Railroad Grade Crossings with Active Warning Devices
- The Implementation Report of the USDOT Grade Crossing Safety Task Force

C. Guidelines for Channelization

If any observation study at concerned locations indicates that significant numbers of motorists are attempting to drive around crossing gates at a railroad grade crossing, an engineering analysis should be performed to determine whether a channelization can be a possible and effective measure to reduce the problem.

Islands can provide some support for the crossing gate to limit the length of crossing arms at the grade crossing. Even sometime longer length crossing arms are available, common practice is to limit the arm length to roughly 40 feet. Under the circumstances, a median island provides opportunity to lower arms from both sides of the lanes by reducing the length required (in reality, by 40 feet).

FIGURE 2
Channelization for Turning Vehicles



Reference guidelines:

- A Policy on Geometric Design of Highways and Streets
- NCHRP Intersection Channelization Design Guide
- Railroad-Highway Grade Crossing Handbook
- Manual on Uniform Traffic Control Devices
- Geometric Design Criteria for Highway-Rail Intersections (Grade Crossings)

D. Guidelines for High-profile Crossings

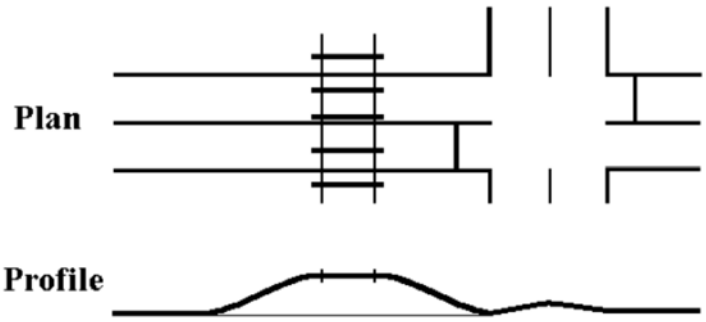
As per *Green Book* (City of New York, 2014) crossing surface should be at the same plane as the top of the rails for a distance of 2 feet outside the rails. The surface of the highway should not be more than 3 inches higher or lower than the top of the nearest rail at a point of 30 feet from the rail unless track

superelevation dictates otherwise. Vertical curves should be used to traverse from the highway grade to the level plane of the rails.

To assess the issue of low ground clearance, a design vehicle needs to be considered for specific locations. The selection of a specific design vehicle depends on local conditions and design vehicle that has been suggested has a wheelbase of 36 feet, a clearance of 5 inches, and 0 feet overhang front and rear (Eck and Kang, 1993).

In case of low-clearance vehicle, Low Ground Clearance (W10-5) warning symbol sign should be installed in advance of the crossing. Per MUTCD, new warning symbol signs such as this, which potentially may not be readily recognizable by the public, should be accompanied by an educational plaque for at least 3 years after initial installation. Also, supplemental message such as Ahead, Next Crossing, or Use Next Crossing (with appropriate arrows) should be placed at the nearest intersecting road where a vehicle can detour or at a point on the roadway wide enough to permit a U-turn.

FIGURE 3
Plan and Profile of At-grade Intersection



Reference guidelines:

- HANGUP software, TxDOT Design Division, Railroad Coordinator
- Manual on Uniform Traffic Control Devices

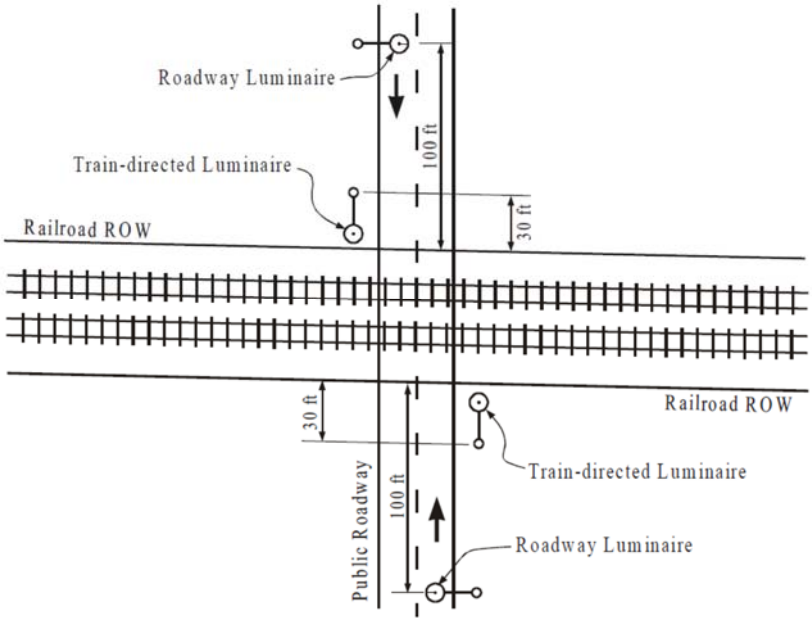
E. Guidelines for Illumination

The circumstances that potentially indicate the need of illumination at a grade crossing include:

- Nighttime train operations
- Accident history of nighttime accidents that appear related to visibility of the train
- Accident history of nighttime, side-of-the-train accidents
- Low ambient light levels
- Vertical or horizontal roadway alignments that prevent vehicle headlights from illuminating the crossing such that stopping sight distances are not achieved
- High-profile crossings where the vehicle headlights may not illuminate the train or oncoming vehicle headlights pass under the train
- Long or slow trains
- Reliable sources of power (although solar-powered lights activated by the train may be considered)
- Restricted sight distance of the crossing

Issue of Transient Visual Adaptation can be trickled by utilizing the design value for the roadway as the calculation base. This starting point indicates the use of design speed of the roadway, and the reduced lighting-level sectors should be illuminated for a 5-second continuous exposure to the sector illumination level of 0.50 the preceding higher-lighted sector, but the average illumination in the terminal sector should not be less than 0.25 foot-candle (2.7 lux) or more than 0.5 foot-candle (5.5 lux).

FIGURE 4
Illumination at the At-grade Rail Crossing



Reference guidelines:

- Roadway Lighting Handbook
- Geometric Design Criteria for Highway-Rail Intersections (Grade Crossings)
- American National Standard for Roadway Lighting

5) Does the document describe the approach or provide an overview of a state's rail grade crossing safety programs? If yes, please describe.

No, this document does not discuss or highlight safety programs.

Iowa Experience: Development of Railroad Highway Grade Crossing Consolidation Rating Formula

Title	Development of Railroad Highway Grade Crossing Consolidation Rating Formula
Year	February 2015
URL	http://www.intrans.iastate.edu/research/documents/research-reports/RR_%20hwy_grade_xing_closure_rating_formula_w_cvr.pdf

Summarize Information in Railroad-grade Crossing Areas

Overview/Problem Statement

The stated objective of the project was to develop a quantitative method to asses a crossing's eligibility for consolidation. However, the objective stated that the focus was "predominantly on factors beyond safety and risk."

The potential risk factors identified by stakeholders as critical for at-grade highway and railroad crossings are traffic volume, heavy-truck traffic volume, proximity to emergency medical services (EMS), proximity to schools, road system, and out-of-distance travel. Since there is limited information in the literature on the systematic way of evaluating the risks, this research highlights formula-based or systematic approach to evaluate the crossings for consolidation.

1) Does the document present a model for assessing the risk or safety performance of an at-grade railroad crossing? If yes, what inputs are used by the model?

This document highlights the Excel spreadsheet based weight-index matrix, which helps to set up for highway-rail grade crossing consolidation prioritization.

- Demand factors
  - Traffic volume – Annual average daily traffic (AADT)
  - Truck traffic volume – Heavy-truck AADT
  - Proximity to EMS
  - Proximity to primary and secondary schools
  - Roadway System – Areas of interest include farm-to-market and primary routes
- Alternate route factors
  - Out-of-distance travel
  - General highway safety
- Other railroad and roadway-related factors
  - Distance from the nearby highway intersections to the at grade railroad crossing

2) Does the document present how inputs were identified and verified as predictors for safety performance?

The logic of selecting the factors (i.e., predictors) for this evaluation process is listed below:

- Traffic volume: Crossings with lower traffic volume should be considered less essential because an inverse relationship exists between traffic volume and crossing necessity.
- Truck traffic volume: Crossings with lower heavy-truck volume should be considered less essential because inverse relationship exists between truck traffic volume and crossing necessity.

- Proximity to EMS: The more EMS within the specified vicinity of a crossing area (6 miles of a rural crossing or 3 miles of an urban crossing), the higher the need of a crossing.
- Proximity to primary and secondary schools: The more schools within the specified vicinity of a crossing, the more need of the crossing should be considered.
- Roadway system: The combined farm-to-market and primary road factor is considered for the highway-rail grade crossing consolidation to represent the importance of these roadways.
- Out-of-Distance travel: The greater the out-of-distance travel value, the more need a highway-rail grade crossing should be considered.
- Alternate route crash rate: alternate routes with no crashes, or a crash rate of 0 crashes per hundred million vehicle miles of travel (HVMT), should be considered since they would have less of a safety-related impact on motorists.

3) Does the document summarize grade crossing countermeasures and their effectiveness? If yes, please describe.
No, this document explains the process of weight- index matrix for prioritization tool, not specifics on countermeasures.

4) Is guidance provided on the conditions to use the discussed countermeasure? If yes, please describe.
This document briefly discussed the guidance criteria/conditions on the closure of railroad crossings or usage of the prioritization tool.

FHWA recommendation on the crossing closure- The FHWA criteria for closing crossings on mainlines with a section of track with more than 5 crossings in a 1-mile segment should be evaluated for closure. The criteria for crossing closure consideration on *branch lines* are as follows:

- Less than 2,000 average daily traffic (ADT)
- More than two trains per day
- An alternate crossing within 0.25 mile that has less than 5,000 ADT for two lanes
- Less than 15,000 ADT for four lanes

The criteria for crossing closure consideration on *spur tracks* are as follows:

- Less than 2,000 ADT
- More than 15 trains per day
- An alternate crossing within 0.25 mile that has less than 5,000 ADT if two lanes or
- Less than 15,000 ADT if four lanes

Highway-rail grade crossing consolidation prioritization is a data-intensive approach. Data updates and data management is critical in the process. Factors related to the attributes change with the updated data and the variation may not be noticeable. With the updated data, the normalized factors, factor ranks, and final composite rank will be automatically recalculated for each crossing.

5) Does the document describe the approach or provide an overview of a state's rail grade crossing safety programs? If yes, please describe.
There are no details on the safety program.

Additional Notes

General observations on prioritization tool under the research project include:

- Wide variation does not exist within the road system factor, school frequency factor, and EMS frequency factor.
- Once appropriate attributes are updated as necessary, the normalized factors, factor ranks, and final composite rank will be recalculated for each crossing.
- Fairly large rank differences may exist within a given factor.
- Ranks of individual factors are not necessarily in the same order as the final, which indicates the influence of factor weights on the final results.
- If relative ranking among all factors is generally consistent or whether marked rank differences existed among factors, a limited additional travel would be required with closure of the crossing. However, based on statewide assessment, a fairly high number of schools are located near the crossing and may be impacted.
- Some of the crash rate values are relatively large because of low vehicle miles traveled values (from short and/or low AADT alternate routes) serving as the denominator of the crash rate equation.

To modify the factor's rank by its importance, the Pugh method was used to develop a weight schema. A key factor of developing the schema was the Texas Administrative Code determining if a factor was more important, equally important, or less important to the other factors when determining a location's eligibility for closure.

Texas Experience: Texas Highway-Rail Grade Crossing Safety Action Plan

Title	Texas Highway-Rail Grade Crossing Safety Action Plan
Year	August 2011
URL	http://ftp.dot.state.tx.us/pub/txdot-info/rail/crossings/action_plan.pdf

Summarize Information in Railroad-grade Crossing Areas

Overview/Problem Statement

Texas has more public-grade crossings with any other state and second highest number of fatalities at public-grade crossings (second to California).

Texas is one of the top states for highway-rail grade crossing collisions from 2006 to 2008 and is required to develop a highway-rail grade crossing safety action plan as directed by 49 Code of Federal Regulation 234. The Highway-Rail Grade Crossing Safety Action Plan has three objectives:

1) Identify specific solutions for improving safety at crossings, including highway-rail grade crossing closures or grade separations

2) Focus on crossings that have experienced multiple accidents or are at high risk for such accidents

3) Cover a 5-year time period.

1) Does the document present a model for assessing the risk or safety performance of an at-grade railroad crossing? If yes, what inputs are used by the model?

No, this document does not highlight any model development. However, it focuses on the historical crash analysis comparing any site with a crash to sites with a single crash and to sites with multiple crashes.

2) Does the document present how inputs were identified and verified as predictors for safety performance?

The contributing or risk factors have been identified from a 5-year historical crash analysis (2003 to 2007).

The following factors were identified as relevant factors at locations that experienced multiple-collisions. These factors became the basis for the action plan and recommended countermeasures.

- Active device
- Distance from the adjacent intersection (within 75 feet)
- Warning device interconnected with a nearby highway signal (within 75 feet)
- Adequacy of preemption at the crossings
- Class 4 track [maximum possible running speed of 60 mph for a freight train and 80 mph for a passenger train]
- Involvement of truck-trailer and trucks

- Traffic is queuing from the adjacent intersections and drivers fail to keep a safe distance from the hazard zone at a crossing

3) Does the document summarize grade crossing countermeasures and their effectiveness? If yes, please describe.

There are no specific countermeasures proposed. Rather, a set of action plan and guidelines were proposed from the stakeholder meeting. A diverse group of local traffic engineers, railroad partners, Texas Operation Lifesaver, Federal Highway Administration (FHWA) and Federal Railroad Administration (FRA) staff, as well as Texas Department of Transportation (TxDOT) staff, participated in a stakeholder's brainstorming meeting. This meeting recommended a list of action plans under four program areas for grade crossing safety improvements:

A. Evaluation

- Perform additional analysis to study multiple-collision locations
- Utilize analysis of collision data at highway-rail grade crossings
- Update the Section 130 program priority index used by TxDOT

B. Engineering

- Consolidation
- Pre-emption
- Continue to make passive-to-active upgrades
- Low cost engineering improvements for multiple-collision locations, with a focus on STOP and YIELD sign updates

C. Education

- Texas operation lifesaver
- Driver education
- Public safety education materials
- Improve communication of grade crossing safety information

D. Enforcement

- Promote grade crossing enforcement initiatives
- Promote new enforcement technology

4) Is guidance provided on the conditions to use discussed countermeasures? If yes, please describe.

No guidance is provided on the condition to use discussed countermeasures.

5) Does the document describe the approach or provide an overview of a state's rail grade crossing safety programs? If yes, please describe.

Texas Grade Crossing Inventory and Crossing Safety Program: Being identified as one of the six states by the US Department of Transportation's office of Inspector General (OIG), TxDOT is requested to work cooperatively by FRA on a highway-rail grade crossing safety action plan.

- Section 130 Program/Crossing Closure and Consolidation Program: Identify and close redundant and unnecessary highway-rail grade crossings

- Railroad Grade Separation Program: Address the construction of new grade separation structures at existing at-grade highway-rail crossings and the rehabilitation or replacement of deficient highway. underpasses of railroads on the state highway system
- Grade Crossing Hazard Elimination in High-Speed Rail Corridors: Under Section 1103(f) of SAFETEA-LU allows federal funds to be used for hazard elimination along designated high-speed rail corridors.

Texas Experience: Integrated Prioritization Method for Active and Passive Highway-Rail Crossings

Title	Integrated Prioritization Method for Active and Passive Highway-Rail Crossings
Year	January 2013
URL	http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6642-1.pdf

Summarize Information in Railroad-grade Crossing Areas

Overview/Problem Statement

The motivation of Highway-Rail Grade Crossing Safety Program is to lower the severity and frequency of train-vehicle crashes to effectively utilize the federal funds to improve safety at public at-grade crossings. With that objective, this research effort attempts to identify the low-volume and passive crossings with risk factors, and broaden the priority index threshold to remain valid with varying data and prioritization methodology in favor of passive and low-volume crossing.

1) Does the document present a model for assessing the risk or safety performance of an at-grade railroad crossing? If yes, what inputs are used by the model?

The final crash prediction model that combines the potential variables identified by the expert panel from the past studies and the Department of Transportation (DOT) risk indices include:

$$\begin{aligned}\hat{\mu} = \exp\big[&-6.9240 + P_f_indicator_T \\ &+ 0.2587 \times HwyPaved - 0.3722 \times UrbanRural + 0.0706 \times TrafLane \\ &+ 0.0656 \times TotalTrack + 0.0022 \times ActualSD1 + 0.0143 \times MaxSpeed \\ &+ 0.0126 \times MinSpeed + 1.0024 \times Log_{10}(TotalTrn + 0.5) \\ &+ 0.4653 \times Log_{10}(AADT) - 0.2160 \times NearbyInt + 0.0092 \times Higher_SPD_Lmt\big]\end{aligned}$$

where

$\hat{\mu}$ =predicted number of crashes per year at a crossing.

$$P_f_indicator_T = \begin{cases} 0.5061 & if \quad P_f = F \\ -0.2006 & if \quad P_f = G \\ 0 & if \quad P_f = X \end{cases}$$

HwyPaved=1 if paved; 2 if not

UrbanRural=1 if Urban; 2 if Rural

TrafLane=Number of roadway lanes

TotalTrack=Number of Main Tracks+Number of Other Tracks

ActualSD1=Actual stopping distance, approach 1

MaxSpeed=Maximum typical train speeds

MinSpeed=Minimum typical speeds for switching

TotalTrn=Total daily trains

AADTF==PAADT (when it exists) or AADT (when PAADT does not exist)

NearbyInt=1 if nearby intersection is present in either approach; 2 if not

Higher_SPD_Lmt=Higher roadway speed limit between approach 1 and approach 2

2) Does the document present how inputs were identified and verified as predictors for safety performance?

In developing the crash prediction models for Texas, the researchers used negative binomial regression models.

A wide range of literature on potential risk variables were analyzed from past research studies on the relevant area of interest representing through variables. The variables were identified from the research and field measurements, which are found to be statistically significant in the model to identify and quantify the relative risk. In addition, an expert panel is formed to assess the crash prediction equation/process and identify the representative variables based on the following criteria:

- Accuracy of the model
- Number of difficult variables (to collect)
- Explainability
- Number of key variables
- Inclusion of crossing control type
- Number of variables for which data are not available
- Number of total variables
- Inclusion of weighting factors

Many state agencies (i.e., DOTs) use a mix of variables based on measured variable values in the field and incorporate factors expressed in the variables based on lookup tables developed for quantifying at-grade crossing risk. State DOTs examined the variables and develop their priority/hazard indices based on Table 1, which shows the importance of selecting and using the variables of greatest importance in evaluating the risk level.

TABLE 1
State DOT Use of Variables in Priority Index Formulae

Priority Index Variable	Number of State DOTs Using Variable
Trains per day	43
Existing protection	37
Accident records	23
Number of tracks	22
Highway vehicular speed	22
Condition or type of crossing	20
Number of traffic lanes	15
Sight distance	14
Daily distribution of vehicular or train volumes	14
Condition of approaches	6
Approach gradient	6
Type of train	5
Angle of crossing	5
School buses and/or HAZMAT carriers	5
Pedestrian hazard	1
Time crossing is blocked	1
Darkness	1

See Table 2-3 (page 26 of *Integrated Prioritization Method for Active and Passive Highway-Rail Crossings*) for the effects of selected variables on the objective function of the risk quantification**.**

3) Does the document summarize grade crossing countermeasures and their effectiveness? If yes, please describe.
No specific details regarding the countermeasure and effectives is proposed in this document.

4) Is guidance provided on the conditions to use discussed countermeasures? If yes, please describe.
No specific details regarding the guidance on the countermeasures mentioned in this document.

5) Does the document describe the approach or provide an overview of a state's rail grade crossing safety programs? If yes, please describe.
No specific details on safety program is mentioned in this document.

Additional Notes

Chapter 1 included a reflection on a limitation of the prior Texas ranking method. The suggestion that active and passive crossings are independently evaluated also was included.

"A brief analysis of the original TPI underscores a limitation common to all priority indices found in the literature (see Chapter 2); it is mathematically impossible for the same index to emphasize the crossing exposure (product of vehicular and train volumes) while simultaneously assigning high priorities to low-volume crossings with safety concerns. As a result, many agencies, including TxDOT, analyze active and passive crossings separately."

Page 4-15 includes a discussion and evaluation of a methodology to compare a prior and revised ranking method.

FHWA: Assessment of Crossing Safety and Operation

Title	Assessment of Crossing Safety and Operation: Chapter 3
Year	August 2007
URL	http://safety.fhwa.dot.gov/xings/com_roaduser/07010/sec03.htm

Summarize Information in Railroad-grade Crossing Areas

Overview/Problem Statement

This document particularly focuses on Federal Highway Administration (FHWA) requirements and technical aspects of evaluating safety and proposes system-wide approach. The objective of the Highway Safety Improvement Program (HSIP) is to reduce "the number and severity of accidents" and decrease "the potential for accidents on all highways." Federal-Aid Policy Guide (FAPG) 924 requires the planning component to consist of:

- A process for collecting and maintaining a record of collision, traffic, and highway data including, for highway-rail grade crossings and the characteristics of highway and train traffic.
- A process for analyzing available data to identify highway locations, sections, and elements determined to be hazardous on the basis of collision experience or collision potential.
- A process for conducting engineering studies of hazardous locations, sections, and elements to develop highway safety improvement projects.
- A process for establishing priorities for implementing highway safety improvement projects.

1) Does the document present a model for assessing the risk or safety performance of an at-grade railroad crossing? If yes, what inputs are used by the model?

FHWA prediction model is developed to predict the likelihood of a collision occurring over a given period of time given conditions at the crossing in real number (frequency) with a series of factors multiplied together. This crash prediction model is intended to be used to rank crossings or identify potential high-crash locations for further review.

$$a = K * EI * MT * DT * HP * MS * HT * HL$$

where:

a = initial collision prediction, collisions per year at the crossing

K = formula constant

EI = factor for exposure index based on product of highway and train traffic

MT = factor for number of main tracks

DT = factor for number of through trains per day during daylight

HP = factor for highway paved (yes = 1.0 or no = 2.0)

MS = factor for maximum timetable speed

HT = factor for highway type

HL = factor for number of highway lanes

Final collision formula –

$$B = \frac{T_0}{T_0 + T}\,(a) + \frac{T}{T_0 + T}\left(\frac{N}{T}\right)$$

where:

B = second collision prediction, collisions per year at the crossing

a = initial collision prediction from basic formula, collisions per year at the crossing

N/T = collision history prediction, collisions per year, where N = number of observed collisions in T years at the crossing

$$T_0 = \frac{1.0}{(0.05 + a)}$$

Values for the second collision prediction, B; for different values of the initial prediction, a; and different prior collision rates, N/T, are tabularized.

Fatal crash likelihood formula:

$$P(FA|A) = \frac{1}{(1 + CF\ X\ MS\ X\ TT\ X\ TS\ X\ UR)}$$

where:

CF = Formula Constant = 695

MS = Maximum Timetable Train Speed Factor = $ms^{-1.074}$

TT = Thru Trains per Day = $(tt + 1)^{-0.1025}$

TS = Switch Train per day Factor = $(ts + 1)^{0.1025}$

[ts = Number of switch train per day]

UR = Urban-Rural Crossing Factor = UR = $e^{0.1880ur}$

[Urban Crossing = 1; Rural Crossing = 0]

Injury crash likelihood formula:

$$P(IA|A) = \frac{1 - P(FA|A)}{(1 + CI\ X\ MS\ X\ TK\ X\ UR)}$$

where:

CI = Formula Constant = 4.280

MS = Maximum Timetable Train Speed Factor = $ms^{-0.2334}$

[ms = maximum timetable train speed (mph)]

TK = Switch Train per day Factor = $e^{0.1176tk}$

[tk = total number of tracks at crossings]

UR = Urban-Rural Crossing Factor = UR = $e^{0.1844ur}$

[Urban Crossing = 1; Rural Crossing = 0]

2) Does the document present how inputs were identified and verified as predictors for safety performance?

Each factor in the prediction formula represents a characteristic of the crossing described in the national inventory. Based on the crossing categories, the parameters vary as shown in Table 1 and needs to be applied in the initial crash prediction formula. However, no research was presented in Chapter 3 on why the characteristics are used in the crash prediction model.

TABLE 1

Crossing Category Parameters

Crossing Category	Formula Constant K	Exposure Index Factor EI	Main Tracks Factor MT	Day Thru Trains Factor DT	Highway Paved Factor HP	Maximum Speed Factor MS	Highway Type Factor HT	Highway Lanes Factor HL
Passive	0.002268	$\frac{c\,x\,t + 0.2}{0.2}^{0.3334}$	$e^{0.2094mt}$	$\frac{d + 0.2}{0.2}^{0.1336}$	$e^{-0.6160(hp-1)}$	$e^{0.0077ms}$	$e^{-0.1000(ht-1)}$	1.0
Flashing Lights	0.003646	$\frac{c\,x\,t + 0.2}{0.2}^{0.2953}$	$e^{0.1088mt}$	$\frac{d + 0.2}{0.2}^{0.0470}$	1.0	1.0	1.0	$e^{0.1380(hl-1)}$
Gates	0.001088	$\frac{c\,x\,t + 0.2}{0.2}^{0.3116}$	$e^{0.2912mt}$	1.0	1.0	1.0	1.0	$e^{0.1036(hl-1)}$

FRA (Federal Railroad Administration) collision prediction formula combines three independent calculation process to produce a collision prediction value.

First, the basic formula provides an initial hazard ranking based on a crossing's characteristics, similar to the Peabody-Dimmick formula and the New Hampshire Index.

The second calculation utilizes the actual collision history at a crossing over a determined number of years to produce a collision prediction value. This procedure is highly dependent on the assumption that future collisions per year at a crossing will be the same as the average historical collision rate over the time period used in the calculation.

The third equation adds a normalizing constant, which is adjusted periodically to keep the procedure matched with current collision trends.

3) Does the document summarize grade crossing countermeasures and their effectiveness? If yes, please describe.

Chapter 3 does not provide a specific countermeasure but rather proposes a system-wide improvement approach, which covers a wide range of improvements as described below.

The concept of using the systems approach to highway-rail grade crossing improvements is focused for the federal-aid system for all public crossings where the systems approach provides a comprehensive method for addressing safety and operations at crossings. The objective of the systems approach for crossings is to improve both safety and operations of the total system or segments of the system.

The systems approach can be applied to a segment of the rail component of the system to improve operating efficiency and safety over a specified segment of a rail line, all crossings would be considered in the evaluation. As such, the systems approach is often called the corridor approach.

The systems approach can be applied to an urban area, city, or community. In this case, all public crossings within the jurisdiction of a public agency are evaluated and programmed for improvements. The desired outcome is a combination of engineering improvements and closures such that both safety and operations are highly improved.

An example demonstrated project in Illinois, where FHWA sponsored system approach for crossing improvements, includes the following:

- Removal of vegetation
- Pavement widening
- Reconstruction of approaches
- Installation of 12-inch lenses in crossing signals
- Relocation of train loading areas
- Closure of crossings
- Removal of switch track
- Installation of traffic control signs pertinent to crossing geometries

4) Is guidance provided on the conditions to use discussed countermeasures? If yes, please describe.

Specific countermeasures are not addressed in Chapter 3. However, an engineering study, proposed here, provides the process to conduct the assessment, identify deficiencies, and propose countermeasures accordingly:

1. Diagnostic Team Study Method
2. Traffic Conflict Technique
3. Collison Study
4. Traffic Study
5. Near-Hit Report
6. Enforcement Study

5) Does the document describe the approach or provide an overview of a state's rail grade crossing safety programs? If yes, please describe.

There are no specific details provided in Chapter 3.

FHWA: Assessment of Crossing Safety and Operation

Title Assessment of Crossing Safety and Operation: Chapter 5
Year August 2007
URL http://safety.fhwa.dot.gov/xings/com_roaduser/07010/sec05.htm

Summarize Information in Railroad-grade Crossing Areas

Overview/Problem Statement

This document focuses on Federal Highway Administration (FHWA) requirements and technical aspects of evaluating safety and proposes system-wide approach. The objective of Highway Safety Improvement Program (HSIP) is to reduce "the number and severity of accidents" and decrease "the potential for accidents on all highways." Federal-Aid Policy Guide (FAPG) 924 requires the planning component to consist of:

- A process for collecting and maintaining a record of collision, traffic, and highway data, including, for highway-rail grade crossings and the characteristics of highway and train traffic.
- A process for analyzing available data to identify highway locations, sections, and elements determined to be hazardous on the basis of collision experience or collision potential.
- A process for conducting engineering studies of hazardous locations, sections, and elements to develop highway safety improvement projects.
- A process for establishing priorities for implementing highway safety improvement projects.

1) Does the document present a model for assessing the risk or safety performance of an at-grade railroad crossing? If yes, what inputs are used by the model?

The methodology for the crash prediction model is presented in Chapter 3 (Summary section).

2) Does the document present how inputs were identified and verified as predictors for safety performance?

The methodology for the crash prediction model is presented in Chapter 3 (Summary section).

3) Does the document summarize grade crossing countermeasures and their effectiveness? If yes, please describe.

Table 1 summarizes Canadian research on the effectiveness of various treatments at rail grade crossings.

TABLE 1
Countermeasure Type, Effectiveness, and Cost

Countermeasure	Effectiveness	Cost
STOP signs at passive crossings	Unknown	$1,200 to $2,000
Intersection lighting	52-percent reduction in nighttime collisions over no lighting	Unknown
Flashing lights	64-percent reduction in collisions over crossbucks alone 84-percent reduction in injuries over crossbucks 83-percent reduction in deaths over crossbucks	$20,000 to $30,000 in 1988
Lights and gates (two) with flashing lights	88-percent reduction in collisions over crossbucks alone	$150,000

	93-percent reduction in injuries over crossbucks 100-percent reduction in deaths over crossbucks 44-percent reduction in collisions over flashing lights alone	
Median barriers	80-percent reduction in violations over two-gate system	$10,000
Long arm gates (three-quarters of roadway covered)	67 to 84–percent reduction in violations over two-gate system	Unknown
Four-quadrant gate system	82-percent reduction in violations over two-gate system	$125,000 from standard gates $250,000 from passive crossing
Four-quadrant gate system with median barriers	92-percent reduction in violations over two-gate system	$135,000
Crossing closure	100-percent reduction in violations, collisions, injuries, deaths	$15,000
Photo/video enforcement	34 to 94–percent reduction in violations	$40,000 to $70,000 per installation
In-vehicle crossing safety advisory warning systems	Unknown	$5,000 to $10,000 per crossing plus $50 to $250 for a receiver

4) Is guidance provided on the conditions to use discussed countermeasures? If yes, please describe.

Chapter 5 presents guidance developed by a Technical Working Group (TWG). "The TWG document is intended to provide guidance to assist engineers in the selection of traffic control devices or other measures at highway-rail grade crossings. It is not to be interpreted as policy or standards and is not mandatory." The guidance provides an overview of required and best practices when selecting passive or active warning devices. Additional detail is provided for considering closing or grade separating crossings.

5) Does the document describe the approach or provide an overview of a state's rail grade crossing safety programs? If yes, please describe.

No state specific details are provided in Chapter 5. The FAPG, however, presents models for identifying countermeasures for at-grade crossings. This includes:

- Economic analysis methods that are contained in the *Highway Safety Improvement Program User's Manual*.
- U.S. DOT developed a resource allocation procedure for highway-rail grade crossing improvements. This procedure was developed to assist states and railroads in determining the effective allocation of federal funds for crossing traffic control improvements. The model is designed to provide an initial list of crossing traffic control improvements that would result in the greatest collision reduction benefits on the basis of cost-effectiveness considerations for a given budget. The procedure considers only the traffic control improvement alternatives: (1) for passive crossings, single track, two upgrade options exist: flashing lights or gates; (2) for passive, multiple-track crossings, the model allows only gates as an improvement option; and (3) for flashing light crossings, the only improvement option is gates. Other improvement alternatives, such as removal of site obstructions, crossing surface

improvements, illumination, and train detection circuitry improvements, are not considered in the resource allocation procedure. The input data required for the procedure consist of the number of predicted collisions, the safety effectiveness of flashing lights and automatic gates, improvement costs, and the amount of available funding.

- A FRA highway-rail grade crossing investment analysis tool, GradeDec. The program computes benefit-cost metrics for a rail corridor, a region, or an individual grade crossing. Model output allows a comparative analysis of grade crossing alternatives designed to mitigate highway-rail grade crossing collision risk and other components of user costs, including highway delay and queuing, air quality, and vehicle operating costs. GradeDec is intended to assist state and local transportation planners in identifying the most efficient grade crossing investment strategies. GradeDec implements the corridor approach to reducing collision risk that was developed as part of the Transportation Equity Act for the 21st Century's Next-Generation High-Speed Rail Program.

Additional Notes

The FAPG notes that the recent trend towards reducing crash potential (opposed to addressing sustained high crash locations) indicates that benefit-cost studies may have the greatest relevance for major investments.

Appendix B
U.S. Supreme Court Validation of 23 U.S.C. § 409

23 U.S.C. § 409 : US Code - Section 409: Discovery and admission as evidence of certain reports and surveys

Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 148 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data

Pierce County, Washington v. Guillen

Supreme Court of the United States, 2003
123 U.S. 720

Brief Fact Summary

The Court addressed whether 23 U.S.C. section 409, which protects information "compiled or collected" in connection with certain federal highway safety programs from being discovered or admitted in certain federal or state trials, is a valid exercise of Congress's authority under the Constitution.

Rule of Law and Holding

This Court lacks jurisdiction to hear the tort portion of the case but has jurisdiction to hear the Public Disclosure Act portion. Certain state-court judgments can be treated as final for jurisdictional purposes even though further proceedings are to take place in the state courts.

Edited Opinion

Note: The following opinion was edited by CVN Law School staff. © 2008 Courtroom Connect, Inc.

JUSTICE THOMAS delivered the opinion of the Court.

We address in this case whether 23 U. S. C. § 409, which protects information "compiled or collected" in connection with certain federal highway safety programs from being discovered or admitted in certain federal or state trials, is a valid exercise of Congress' authority under the Constitution.

Beginning with the Highway Safety Act of 1966, Congress has endeavored to improve the safety of our Nation's highways by encouraging closer federal and state cooperation with respect to road improvement projects. To that end, Congress has adopted several programs to assist the States in identifying highways in need of improvements and in funding those improvements. Of relevance to this case is the Hazard Elimination Program (Program) which provides state and local governments with funding to improve the most dangerous sections of their roads. To be eligible for funds under the Program, a state or local government must undertake a thorough evaluation of its public roads. Specifically, § 152(a)(1) requires them to "conduct and systematically maintain an engineering survey of all public roads to identify hazardous locations, sections, and elements, including roadside obstacles and unmarked or poorly marked roads, which may constitute a danger to motorists, bicyclists, and pedestrians, assign priorities for the correction of such

locations, sections, and elements, and establish and implement a schedule of projects for their improvement."

Not long after the adoption of the Program, the Secretary of Transportation reported to Congress that the States objected to the absence of any confidentiality with respect to their compliance measures. According to the Secretary's report, the States feared that diligent efforts to identify roads eligible for aid under the Program would increase the risk of liability for accidents that took place at hazardous locations before improvements could be made. In 1983, concerned that the States' reluctance to be forthcoming and thorough in their data collection efforts undermined the Program's effectiveness, the United States Department of Transportation (DOT) recommended the adoption of legislation prohibiting the disclosure of information compiled in connection with the Program.

To address the concerns expressed by the States and the DOT, in 1987, Congress adopted 23 U. S. C. § 409, which provided:"Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled for the purpose of identifying[,] evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 152 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be admitted into evidence in Federal or State court or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data."

The proper scope of § 409 became the subject of some dispute among the lower courts. Some state courts, for example, concluded that § 409 addressed only the admissibility of relevant documents at trial and did not apply to pretrial discovery. According to these courts, although information compiled for § 152 purposes would be inadmissible at trial, it nevertheless remained subject to discovery. Other state courts reasoned that § 409 protected only materials actually generated by a governmental agency for § 152 purposes, and documents collected by that agency to prepare its § 152 funding application remained both admissible and discoverable.

As amended, § 409 now reads:

"Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 152 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data."

Ignacio Guillen's wife, Clementina Guillen-Alejandre, died on July 5, 1996, in an automobile accident at the intersection of 168th Street East and B Street East (168/B intersection), in Pierce County, Washington. Several months before the accident, petitioner had requested § 152 funding for this intersection, but the request had been denied. Petitioner renewed its application for funding on April 3, 1996, and the second request was approved on July 26, 1996, only three weeks after the accident occurred.

Beginning on August 16, 1996, counsel for respondents sought to obtain from petitioner information about accidents that had occurred at the 168/B intersection.1 Petitioner declined to provide any responsive information, asserting that any relevant documents were protected by § 409. After informal efforts failed to resolve this discovery dispute, respondents turned to the Washington courts.

While the appeal in the PDA action was pending, respondents filed a separate action, asserting that petitioner had been negligent in failing to install proper traffic controls at the 168/B intersection. In connection with the tort action, respondents served petitioner with interrogatories seeking information regarding accidents that had occurred at the 168/B intersection. Petitioner refused to comply with the discovery request, once again relying on § 409. Respondents successfully sought an order to compel, and petitioner moved for discretionary appellate review of the trial judge's interlocutory order.

Having determined that § 409 protects only information compiled or collected for § 152 purposes, and does not protect information compiled or collected for purposes unrelated to § 152, as held by the agencies that compiled or collected that information, we now consider whether § 409 is a proper exercise of Congress' authority under the Constitution. We conclude that it is.

It is well established that the Commerce Clause gives Congress authority to "regulate the use of the channels of interstate commerce." In addition, under the Commerce Clause, Congress "is empowered to regulate and protect the instrumentalities of interstate commerce, or persons or things in interstate commerce, even though the threat may come only from intrastate activities." As already discussed, Congress adopted § 152 to assist state and local governments in reducing hazardous conditions in the Nation's channels of commerce. That effort was impeded, however, by the States' reluctance to comply fully with the requirements of § 152, as such compliance would make state and local governments easier targets for negligence actions by providing would-be plaintiffs a centralized location from which they could obtain much of the evidence necessary for such actions. In view of these circumstances, Congress could reasonably believe that adopting a measure eliminating an unforeseen side effect of the information-gathering requirement of § 152 would result in more diligent efforts to collect the relevant information, more candid discussions of hazardous locations, better informed decisionmaking, and, ultimately, greater safety on our Nation's roads.

Consequently, both the original § 409 and the 1995 amendment can be viewed as legislation aimed at improving safety in the channels of commerce and increasing protection for the instrumentalities of interstate commerce. As such, they fall within Congress' Commerce Clause power. Accordingly, the judgment of the Washington Supreme Court is reversed, and the case is remanded for further proceedings not inconsistent with this opinion.

It is so ordered.

Prepared for:

Prepared by:
CH2M HILL, Inc.

TR0419161148MSP
Photos courtesy: MnDOT