

Speed Management Action Plan for Randolph County

Analysis, Problem Identification, Planning, Implementation



FHWA Safety Program



U.S. Department of Transportation
Federal Highway Administration



<http://safety.fhwa.dot.gov>

CONTENTS

Chapter 1. Overview of the Plan.....	1
Safety Goals of the Plan.....	1
Need for the Plan.....	2
Plan Approaches.....	5
Organization of this Document	6
Definitions of Terms	8
Action Plan Summary	11
Evaluation and Performance Measures	14
Sustaining and Updating the Plan	14
Chapter 2. Speeding-related Safety Issues	16
Data and Methods.....	16
Countywide Issues.....	17
Rural Areas Crash Characteristics.....	17
Speed Study Results	19
Rural Areas – Other Key Challenges and Issues	19
Urban Areas Crash Characteristics	20
Urban Areas – Other Key Challenges and Issues.....	21
Other Key Countywide Issues.....	22
Corridor Problems	22
Urban, Multi-lane Corridors (undivided).....	22
Urban, Two-lane Corridors	24
Rural, Two-Lane Routes.....	25
Chapter 3. Speed Management Actions, Strategies, and Countermeasures	27
Actions and Strategies to Address Countywide Issues.....	27
Actions, Strategies, and Countermeasures to Address High Crash Corridors.....	31
Countermeasures for Urban, Multi-Lane Corridors	33
Countermeasures for Urban Two-lane Roads.....	40
Countermeasures for Rural Two-Lane Roads.....	46
Systematic Speed Management Approach within Other Safety Programs	52
Roadway Departure and Curves.....	52
Pedestrian Plans, School Zones	53
Highway Safety Improvement Program (HSIP)	53
Chapter 4. Multi-year Implementation Plan.....	54
Detailed Proposed Implementation Actions	54
*Action Item 4 - Step 5. Selection and Ranking of Countermeasures	58
Implementation Steps following Project Approval	60

Evaluation Plan	62
Action Plan Update.....	63
Additional References.....	64
Appendix A.....	67
CMFs for Fatal and Injury Crashes due to Changes in Operating Speeds	67
Appendix B.....	68
Countywide Analysis Results	68
Corridor Screening Methods	73
Corridor Screening Results	75
Urban, Multi-lane Corridors	76
Urban, Two-lane Corridors	77
Other Area Types.....	81
Crash Issues Near Schools	81
Sections with Curve-related Crash Problems.....	81
Appendix C.....	88
Countywide Proactive Approach - Additional Considerations.....	88
Countywide Comprehensive Approaches - Additional Considerations	89
Systematic Approach - Additional Countermeasures Considerations	90
Appendix D.....	93
Economic Analysis Examples	93
Program Evaluation Measures	96

TABLES

Table 1. Action Items for Randolph Co. Speed Management Safety Action Plan and Timeline for Implementation.	12
Table 2. Next Steps for Action Plan Implementation. This Table may be updated to incorporate On-going Action Steps and Schedules.	14
Table 3. Characteristics associated with Speeding-related (SR) and Severe Crashes in Rural Areas of Randolph County, compared with Statewide averages, that might be Treated by Engineering, Enforcement, and Educational Countermeasures. (Crash Years, 2007-2011.)	18
Table 4. Characteristics highly associated with Speeding-related (SR) and Severe Crashes in Municipalities of Randolph County that might be treated by Engineering, Enforcement, and Educational Countermeasures. (Crash years, 2007-2011.)	21
Table 5. Proactive and Comprehensive Action Items and Strategies to Address Countywide Issues.....	28

Table 6. Systematic and Comprehensive Actions to Address Speeding and Related Crashes on High Crash Corridors.	32
Table 7. Countermeasures and Crash Effects (Crash Modification Factors or CMFs) for Urban, Multi-Lane Corridors.*	35
Table 8. Target Crash Reductions for Urban, Undivided, Multi-lane Roads.....	40
Table 9. Countermeasures and Crash Effects (CMFs) for Urban Two-lane Corridors.	42
Table 10. Target Crash Reductions for Treatment of 11 Urban Two-lane Roads.....	46
Table 11. Countermeasures and Crash Effects (CMFs) for Rural, Two-Lane Corridors.....	48
Table 12. Target Crash Reductions for a Priority List of Rural, Two-lane Roads.	52
Table 13. Action Item 1 - Speed Limit Setting.....	55
Table 14. Action Item 2 - Build Support through Communications and Publicity.....	56
Table 15. Action Item 3 - Develop Proactive Speed and Safety Review Process for New Roads.	57
Table 16. Action Item 4 - Develop Systematic Screening and Prioritization Process.	58
Table 17. Action Item 5 - Develop a Corridor-focused Targeted Enforcement Program.	61
Table 18. Action Item 6 - Implement Speed and Safety Review through Other Safety Plans and Programs.	62
Table 19. Randolph County Reportable Crashes by Road Classification and Numbers Located to Routes.	69
Table 20. Speeding-related (SR) Crash Characteristics in Randolph County, NC with Statewide comparisons.....	70
Table 21. Fatal (K-severity) and Disabling-Injury (A-severity) Crash Characteristics in Randolph County, with Statewide (NC) comparisons.	71
Table 22. Analysis Matrix and Roadway Miles for Screening for Speeding-related Crash Problems by Corridor.	74
Table 23. Prioritized List of Urban Multi-lane Routes for Speed and Safety Review.	76
Table 24. Prioritized List of Urban Two-lane Routes for Speed and Safety Review.	78
Table 25. Priority List of Rural Two-lane Routes for Speed Limit and Safety Review.	80
Table 26. School properties ranked by five-year number of Severe and Speeding-related crashes within One Mile of School Property.	82
Table 27. Road Segments with Three or more Severe crashes indicated to occur at a Curve.....	84
Table 28. Road Sections with Eight or More Any Severity Crashes at Curves.....	85
Table 29. Estimated Crash Reductions from Randomly Targeted, but Highly Visible Enforcement that covers 60% of network crashes or 70% of Fatal and A-type crashes.	93
Table 30. Cost-benefit analysis of Road Diet Implementations. (Assuming three corridors with AADT < 10,000 can be treated, with low range and high-range estimates of effect.).....	94
Table 31. Estimated Crash Reductions for Curve-related Crashes (assuming 12 curves with the highest frequencies of KAB crashes or 35 curves with the highest number of total crashes can be treated).	95

Table 32. Estimated Crash Reductions from Automated Speed Enforcement (ASE) Deployed within One mile of Schools.	96
Table 33. Example Program Evaluation Matrix	97
Table 34. Example Countermeasure or Program Safety Evaluation Matrix.....	98

FIGURES

Figure 1. Crash and Speeding-related Fatal and Injury Trends in Randolph County, NC, 2007-2011.	3
Figure 2. Randolph County Speeding-related Crashes, 2007-2011.....	4
Figure 3. Expected fatal crash reductions for small average speed reductions at lower and higher initial speeds. (Based on data in Table 3E-2 from Highway Safety Manual, 2010).....	67
Figure 4. Distributions of Speeding-related, and Injury Crashes by Rural and Urban Locations.	68
Figure 5. Rural Killed and Disabling Crashes by Crash Hour, 2007-2011.....	72
Figure 6. Scatter plot of 85th percentile (point) speeds by speed limit for a select group of roads.	72
Figure 7. Speeding-related or Pedestrian or Bicycle Crashes within One Mile of School Properties.....	83
Figure 8. Number of Crashes with Fatal (K), Disabling (A), or Evident (B) severity of injuries within one mile of school property.	83
Figure 9. Randolph County Growth Management Areas.	88

Chapter 1. Overview of the Plan

This Speed Management Action Plan characterizes Randolph County's speeding and safety problems and speed management issues, identifies appropriate countermeasures and strategies, and describes implementation actions the State, County, and other partners can take to reduce speeding and speeding-related fatal and injury crashes on the County's roads. This Plan will facilitate coordination and cooperation among State and local agencies including road planners, designers and managers, enforcement officials, public health practitioners, and policy-makers to identify and implement the most cost-effective and feasible strategies.

The remainder of this chapter outlines the safety goals of the Plan, the need for the Plan, broadly describes the speed management approaches, outlines the remaining Plan content, defines terms used, and provides an overview of the problems and action items for implementing specific strategies.

Safety Goals of the Plan

The safety goals of the Plan are to reduce speeding-related crashes and injuries.

The safety goals of this Action Plan are as follows:

- ❖ **Goal 1:** Reduce fatal and injury crashes, especially those attributed to speeding. Speeding includes operating a vehicle at speeds above limits and exceeding a safe speed for existing conditions.
 - **Short-term goal:** Reduce fatal and injury crashes related to speeding by 10 percent within five years. Analysis of the problem and identification of potential solutions and anticipated implementation led to this target.
 - **Longer-term goal:** Significantly reduce the number of fatal and injury crashes each year through enhanced enforcement and publicity measures, as well as improved roadway designs and operations.¹
- ❖ **Goal 2:** Improve compliance with speed limits.

This plan will help the County contribute to the State meeting its Strategic Highway Safety Plan (SHSP) safety goals. The most recent SHSP for North Carolina (2007) had an overall goal of reducing the fatality rate to 1.0 person per 100 million vehicle miles traveled by 2008, although that goal had not yet been met as of 2011. In 2011, the average three-year Statewide fatality

¹A potential long-term target for speed-related crash reductions is from 30-35 percent of fatal and injury crashes, or the proportion indicated to have speeding as a contributing factor.

rate was 1.18. Randolph County's most recent average three-year fatality rate was slightly higher at 1.23. Although speeding was identified as a concern, and speed management strategies were included, specific safety goals for speeding-related strategies were not defined in North Carolina's 2007 SHSP. However, the SHSP is due to be updated. This County Plan could potentially help the State implement targets for speed management actions in support of the overall SHSP safety goals as well as provide a model for other local communities.

Need for the Plan

Nearly 16,000 crashes were reported in Randolph County during the five-year period of 2007 to 2011. In total, 32 percent of 15,740 reportable crashes resulted in injuries or possible injuries. These crashes are estimated to have a dollars-equivalent average comprehensive cost to the community of ***more than \$160 million per year.***

Major characteristics of the speeding and injury crash problem include the following:

- An average of nearly 17 percent of the County's total crashes were considered speeding-related by officers who investigated the crashes, compared with an average of 10 percent for the State of North Carolina as a whole.
- Around 1,000 injury crashes, including fatalities, were reported each year (Figure 1).
- There were 101 fatal crashes in the County that resulted in 111 people killed, and an additional 152 crashes that resulted in disabling-type injuries. On average, 35 percent of the fatal and disabling-injury crashes were associated with speeding according to data from police crash reports (Figure 1).
- Speeding-related crashes, and fatal and injury crashes, are widely dispersed across urban areas, highway corridors and the extensive rural secondary road network (See Figure 2).

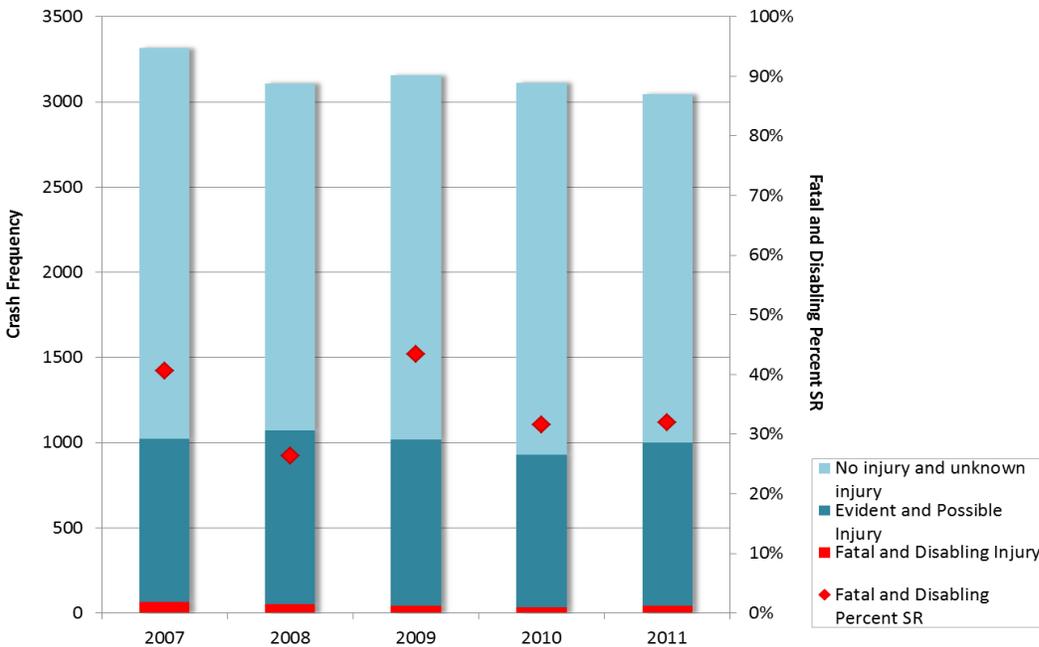


Figure 1. Crash and Speeding-related Fatal and Injury Trends in Randolph County, NC, 2007-2011.

Many of the speed management issues and challenges are not unique to Randolph County. Some of the issues identified include the following:

- **Speed Limit Setting:** The various ways that speed limits are set across rural and urban areas, changes in development and other factor have resulted in roads that send mixed messages to drivers about appropriate speeds. (Methods and practices include statutory maximums for a legacy road network that existed prior to current design standards, speed zoning through engineering studies, and different practices among city and State jurisdictions.) The message that speed limits are established for safety reasons has been contaminated.
- **Speeding Above Limits is Common:** Randolph County speed studies and NC survey data show that speeding five miles or more above limits is common, even on low speed roads.²

² North Carolina Governor’s Highway Safety Program (n.d.). FY 2012 Annual Report.

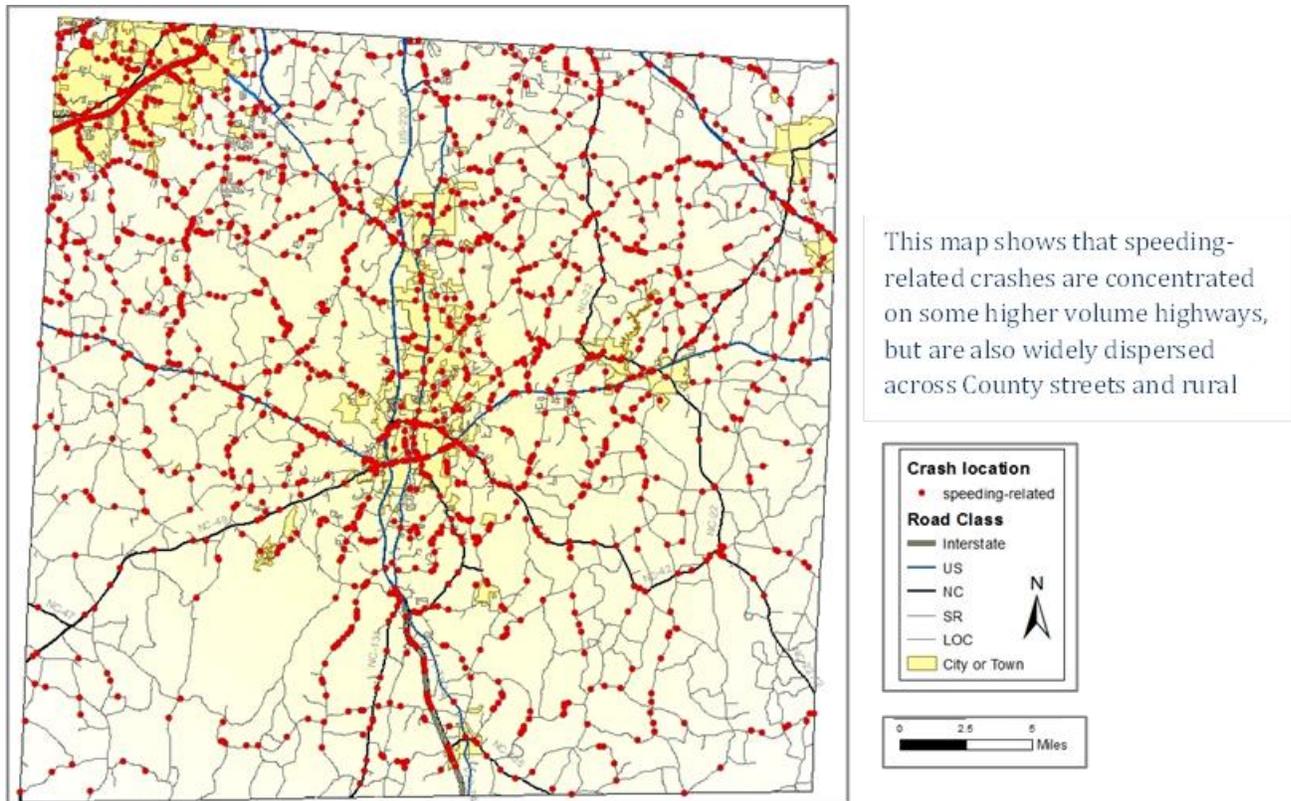


Figure 2. Randolph County Speeding-related Crashes, 2007-2011.

(Note: Only mileposted crashes that could be mapped to State roads are shown, approximately 74% of the total.)

- **Design:** Issues with high-to-low speed transition zones from rural to more developed areas, roadway designs that are often incompatible with area land uses and road purposes, a lack of self-enforcing roadway designs, and limited funds for making improvements each year create challenges.
- **Enforcement:** Current policy decisions by County and city agencies and elected leaders limit the presence of traffic law enforcement in the County. Low levels of enforcement, legal barriers to implementing automated speed enforcement, and challenges to enforcing on an extensive rural, two-lane road network may all contribute to the prevalence of speeding.
- **Adjudication:** The courts are clogged with violators who challenge their speeding citations. This situation results in frequent plea agreements due to the need to process many citations through the courts, and may further weaken enforcement efforts. The processes may also lead to inconsistent treatment of offenders, and potentially, allows repeat and flagrant violators to escape punishment, if such violators are not identified. In addition, research shows that punitive measures meted out through the courts (and through insurance penalties) may not be effective deterrents.
- **Public Information and Education, and Culture of Speeding:** A lack of educational or publicity support for enforcement or other speed management efforts encourages a

culture that seems to embrace driving fast and limits population-wide deterrence of speeding.

This Plan identifies engineering and road design measures to help better manage speeds and to target related safety issues that may contribute to excessive speed for conditions types of crashes. Since it is only possible for the State DOT to treat a small portion of the road network with engineering measures each year (most roads warranting treatment are managed by the State), the County also needs to seek ways to improve enforcement and adjudication to support established limits. Even if roads are well-designed to support reasonable and safe speed limits established, highly visible and committed enforcement is needed to support those limits. Chapter 2 describes the problems in more detail. Speed management is a complex endeavor that requires all parties to work together. This Plan includes much technical information useful to engineers and other professionals, but also includes information relevant for enforcement and injury prevention specialists, and policy-makers.

Some of the challenges of implementing effective measures can be met through Speed Plan activities that: 1) specifically address the barriers to a more systematic approach to implementing effective solutions; 2) prioritize strategies based on factual information and best practice knowledge; and 3) strengthen existing partnerships, communication, and work toward mutually-agreeable solutions through the safety goals of the community and State. For example, some engineering measures with proven safety benefits (e.g. roundabout intersection designs), are likely to improve mobility as well as safety. Road diets or conversions of traffic lanes may also help to reduce speeds and crashes while providing space for other uses such as bicycle lanes or parking for local businesses. Access management measures can also reduce the numbers of conflicts that may contribute to speeding-related crashes along complex corridors. The Plan action steps should foster inter-agency collaboration and implementation of effective strategies.

Challenging some of the existing beliefs about speed may also be important to maximize success. For example, widespread, low-level speeding may be as much of a safety problem as flagrant, but less frequent speeding by large amounts. The Highway Safety Manual estimates that a 2 mph reduction in average operating speed from 30 mph will yield a reduction in fatal crashes of 34 percent (AASHTO, 2010; and [Appendix A](#)).

This Speed Management Action Plan will help Randolph County stakeholders, including the North Carolina Department of Transportation (NCDOT), public safety agencies, injury prevention partners, and other stakeholders work together to identify optimal solutions to reduce the level of speeding and the resultant serious injuries and fatalities in a cost-effective manner.

Plan Approaches

The Plan incorporates the following types of approaches to help meet the safety goals:

- ❖ Develop proactive and coordinated approaches to roadway planning, roadway design, and other speed management measures to reduce the opportunities to speed and lower the risk of serious harm on improved or new roads.
- ❖ Use a systematic approach to identify and treat current severe crash problems resulting from speeding in excess of limits or exceeding a safe speed for existing conditions.
- ❖ Use comprehensive and coordinated enforcement, educational, and engineering strategies to improve motorist compliance with speed limits and with the basic speed rule. Seek the support of multiple stakeholders and the public for effective speed management and crash reduction strategies.

These approaches and associated strategies and countermeasures are described in greater detail in later sections.

Organization of this Document

The following descriptions of organization and content should aid users of this document:

Chapter 1 – Overview of the Plan – This chapter describes the Safety Goals of the Plan, Need for the Plan, the general Plan Approaches, a Summary of Action Items of the Plan, Evaluation and Update of the Plan, and Definitions of Terms used in the Plan.

Note that the short-term safety goal reflects analysis of the problem, the potential solutions available, and assessment of what portion of the problem might be targeted by countermeasures within a five-year implementation period. Plan implementers may adjust the crash reduction target to reflect the strategies selected and a more detailed determination of extent of planned implementation. Improving speed compliance serves as a short-term measure to assess enforcement and public education efforts, and of implemented design improvements. Plan implementers may wish to establish a specific speed compliance target as more data are gathered about the extent of speeding. They may also establish a long-term crash reduction target.

Chapter 2 – Speeding-related Safety Problems – Chapter 2 describes the Countywide crash and speed management issues identified, and speeding-related safety and severe crash problems identified for certain corridor types and other location types.

Note that the primary focus of this Plan is on corridors, predominantly State-owned routes, including intersections. However, Towns could implement a similar systematic approach to identify and treat problems on local streets. Problem identification does not have to rely only on crash data. Local knowledge of the problems, speed studies, and more formal community input that has already been incorporated into other safety or transportation plans are important sources of information.

Chapter 3 Speed Management Action Items, Strategies, and Countermeasures – Chapter 3 describes the solutions to problems described in Chapter 2.

Actions and Strategies to Address Countywide Problems. This section describes the types of proactive and comprehensive action steps and strategies needed to address the Countywide safety problems and speed management issues.

Actions, Strategies, and Countermeasures to Address High Crash Corridors. This section describes systematic and comprehensive actions and countermeasures to target existing speeding-related safety problems on high crash corridors. Local stakeholders could use similar measures to target other areas of concern such as local streets near schools.

Systematic Speed Management Approach within Other Safety Programs. This section describes how speed management plan activities may be coordinated with other safety programs.

Chapter 4 – Multi-year Implementation Plan – Chapter 4 outlines the Detailed Proposed Implementation Actions and specific strategies that may be implemented within each Action Item, Selection and Ranking of Countermeasures, additional Implementation steps Evaluation Plan, and plan renewal processes (Action Plan Update).

References – References include sources for additional information that were cited in the plan, and additional supplemental resources.

Appendix A – Supplemental information for Chapter 1. For the first time, with publication of the *Highway Safety Manual* in 2010, estimates of the effect of changes on injury and fatal crashes resulting from changes in average operating speeds are available.

Appendix B – This supplemental information for Chapter 2 provides detailed results of problem identification and *lists of priority corridors for further diagnosis and potential treatment*. These or similar lists refined by the stakeholders, may be used in implementing the systematic treatment of problem areas identified through network screening.

Appendix C – Additional information for Chapter 3 about strategies and countermeasures that may be implemented through the Plan.

Appendix D – Supplemental information for Chapter 4 provides examples of economic analyses of feasible countermeasures. There is also supplemental information on plan and countermeasures evaluation.

Separate document - *Randolph County Speed Management Plan – Field Visits: Summary and Speed Management Plan Recommendations* is available as a separate report to local stakeholders.

Speed Management Toolkit – Separate FHWA resource with additional countermeasures crash modification factors, tip sheets, and links to other resources useful for speed management plan implementation.

Definitions of Terms

The following are definitions for terms used in this document:

Basic Speed Rule – The Basic Speed Rule requires vehicle operators to drive at a speed that is reasonable and prudent. As a corollary to this rule, State laws usually provide that "every person shall drive at a safe and appropriate speed when approaching and crossing an intersection or railroad grade crossing, when approaching an going around and curve, when approaching a hill crest, when traveling upon any narrow or winding roadway, and when special hazards exist with respect to pedestrians or other traffic or by reason of weather or highway conditions." North Carolina's Basic Speed Rule states "No person shall drive a vehicle at a speed greater than is reasonable and prudent under the conditions then existing. NC ST § 20-141(a)." ³

Comprehensive approach – A comprehensive approach aims to make use of the full range of strategies to address speeding-related safety problems related to the road user, the streets and highways, the vehicle, the environment, and the management system. Comprehensive strategies in this Plan include engineering and design, enforcement and judicial measures, education and publicity, management strategies, policies, evaluation, and coordinating the strategies to achieve the bottom line safety targets.

Coordinated approach – The goal of a coordinated approach to any traffic safety area, including speed management "is to move away from independent activities of engineers, law enforcement, educators, judges, and other highway-safety specialists," including injury prevention and publicity experts, and to promote the formation of working groups and alliances that represent all of the elements of the safety system. In so doing, the team can draw upon their combined expertise and resources to reach the bottom-line goal of targeted reduction of crashes fatalities and injuries.

Countermeasure – Essentially, a treatment to reduce the frequency and severity of crashes.

Crash modification factor (CMF) – Multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure. Standard errors of the estimate give an idea of the quality of the estimate and potential variation of effect. If available, calibrated State estimates may provide a better estimate of effects for the State. ⁴

³ NHTSA (2011b). *Summary of State Speed Laws*. Eleventh Edition. Current as of February 1, 2010. DOT HS 811 457. U.S. DOT National Highway Traffic Safety Administration.

⁴ Crash Modification Factors Clearinghouse. U.S. Department of Transportation, Federal Highway Administration. <http://www.cmfclearinghouse.org/>

Crash reduction factor (CRF) – Estimate of the percentage reduction in crashes due to a particular countermeasure.⁵ The crash modification factor (CMF) estimates in tables in this document can be used to estimate expected crash reduction percentages $[(1 - \text{CMF}) * 100]$.

Highway Safety Improvement Program – The “Highway Safety Improvement Program (HSIP) [is] a core Federal-aid program. The goal of the program is to achieve a significant reduction in traffic fatalities and serious injuries on all public roads, including non-State-owned public roads and roads on tribal lands. The HSIP requires a data-driven, strategic approach to improving highway safety on all public roads that focuses on performance.” This program was continued by MAP-21, the federal transportation bill that went into effect October 21, 2012.⁶

Operating speed(s) – The speeds at which vehicles actually travel under free-flow (unconstrained or uncongested) conditions. The most often used measure of operating speed is the 85th percentile speed (see definition), but average or mean speed and other speed distributional measures may also be used.⁷

Proactive approach – A proactive approach, as described in this document, is a practice of planning and designing new roads or street improvements that considers intended operating speed and appropriate speed limits in the very earliest stages. A proactive approach aims to engage safety and mobility goals and various stakeholders in the planning, design, and operations of streets and highways to target speeds appropriate to the land uses and purposes of the road to minimize future problems. (See *self-enforcing road design*.)

Road Departure Plan – The North Carolina Roadway Departure (Safety) Implementation Plan (2009) was developed with support from FHWA. The Road Departure Plan describes strategies and implementation of countermeasures to reduce road and lane departure crashes and injuries.

⁵ *Ibid.*

⁶ See FHWA’s HSIP webpage for more information on eligibility and requirements: http://safety.fhwa.dot.gov/hsip/gen_info/resources_npr.cfm

⁷ Donnell, E.T., Hines, S.C., Mahoney, K.M., Porter, R.J., McGee, H. (2009). Speed Concepts: Informational Guide. Report No. FHWA-SA-10-001, Washington, D.C.: Office of Safety, Federal Highway Administration. Available at: http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa10001/

Roadway Safety Audit – RSAs offer a formalized way for an expert, multi-disciplinary team to make a qualitative assessment of safety conditions from the perspective of different road users, and to identify potential treatment alternatives.⁸

Rural/urban crash – A rural or urban crash indicates whether the crash was reported to occur inside municipal boundaries (urban) or outside any municipality (rural).

Rural/urban road section – Rural or urban was defined by whether or not a road section was within municipality boundaries (urban) or outside (rural).

Self-enforcing road design – A self-enforcing roadway design, which may be an objective of the proactive approach, is road design that reinforces established limits and reduces *opportunities* to speed.⁹ The goal of such designs is to increase consistency of design with limits, and to minimize the need for traffic law enforcement to enforce speed limits because the road itself induces drivers to adopt operating speeds that are within established limits.

Self-explaining road design – The development of a consistent design and appearance for each roadway purpose or function category.¹⁰ Self-explaining designs complement self-enforcing design by making the type of road, and associated speed limit(s), more readily evident to drivers.

Severe crash – Two definitions are used. For Countywide analyses, a severe crash is defined as a crash involving fatalities (K-type) or disabling-type injuries (A-type from the crash reporting system). For network screening, which depends on smaller subsets of the data, the definition includes crashes involving evident (B-type) injuries.

Speeding-related crash – The definition of speeding-related crash used is based on indications that any driver involved in the crash contributed to the crash by travelling “in excess of the posted limit” or “in excess of safe speed for conditions.” The latter definition flows from NC’s Basic Speed Rule statute. The public safety officers responding to and reporting on the crash make these assessments.

Systematic approach – In this document, the systematic approach is a process to identify and prioritize locations where speeding-related crashes are concentrated or greater than expected, and to apply systematic diagnosis and treatment of the problems. Diagnosis will

⁸ See FHWA Roadway Safety Audit Guidelines (2006) and other resources on FHWA’s RSA webpages (<http://safety.fhwa.dot.gov/rsa/>) for more information. Include speed limit review and assessment of speeding-related safety issues as part of the audit process.

⁹ Brewer, J. et al. (2001). Geometric Design Practices for European Roads. Report No. FHWA-PL-01-026, Washington, D.C.: FHWA. <http://contextsensitivesolutions.org/content/reading/geometric-design-practices/resources/geometric-design-practices/>

¹⁰ *Ibid.*

include checks for consistency between speed limits, road design and operations (such as signal timing), and operating speeds. The systematic approach then follows up with application of appropriate remedies, including potential changes to speed limits to rectify inconsistencies and improve safety. Remedies may include design and engineering changes as well as application of enforcement and educational measures.

85th percentile speed – The speed at or below which 85 percent of vehicles travel.

Action Plan Summary

As mentioned, there are three basic approaches to this Plan: Proactive, Comprehensive, and Systematic. A brief description of the approaches follows:

- ❖ A **Proactive approach** aims to foster creation of self-enforcing roadway designs appropriate to the land use, and user needs (functions of the road) to reduce future speeding and injury risk. The approach engages to develop collaborative and consistent policies, procedures and safety guidance in speed-limit setting and design for new projects and roadway improvements.
- ❖ The key focus of **Comprehensive strategies** is to seek community support for the program, to coordinate various stakeholders and engage the community in setting and enforcing appropriate limits, and to complement and enhance the effectiveness of design and engineering measures with locally-tailored communications and educational measures.
- ❖ A **Systematic approach** will be used to identify and treat existing speeding and safety problems with cost-effective countermeasures (engineering and enforcement-related measures), and to coordinate such a systematic approach with other Safety Plans and focus areas.

For implementing the Systematic approach, the Plan uses problem screening (based on prior crashes) and follow-up diagnosis to identify and prioritize areas with speeding-related problems to treat. The main road types to be treated through the Systematic approach within the current five-year period are:

- Multi-lane, but not physically-divided, urban routes.
- Two-lane urban corridors.
- Rural, two-lane roads.

The Systematic approach aims to make use of the following strategies:

- Reviewing speed limits; improving the relationship among speed limits, target operating speeds, and design.
- Setting appropriate limits considering area land use, and user needs for safety as well as mobility.
- Implementing appropriate safety improvements to the roadway.
- Seeking support from enforcement, the courts, public health professionals, and communications experts to support reasonable and safe limits, and speed compliance by drivers.

- Determining the need for more extensive improvements such as major redesign.

The Proactive approach also makes use of similar processes, with some changes, but implements these for new projects and upgrades.

Table 1 outlines the Speed Management Plan Action Items that were selected as most promising or needed by key stakeholders through meetings and further stakeholder discussion. Each Action Item involves processes, coordinated actions and policies to use to develop and implement the most appropriate types of countermeasures and to sustain an on-going and effective speed management program. Chapter 3 describes alternate countermeasures and strategies available to address identified problems. Table 1 also identifies agency roles and prospective timelines. The section on Detailed Proposed Implementation Actions in Chapter 4 describes strategies for implementation in more detail.

Table 1. Action Items for Randolph Co. Speed Management Safety Action Plan and Timeline for Implementation.

Table 1 Action Item	Stakeholder Roles	Approach Timeline
1) Develop a County Council or task force to engage on speed limit setting and safety, coordination of design and enforcement for existing roads, and to work toward a consistent limit setting process and outcomes throughout the County. (Proactive and Comprehensive approaches)	Lead: Regional Planning Organization, Transportation Advisory Commission (Piedmont Triad Regional Council [PTRC-TAC]) and Injury Prevention specialists (e.g. County Public Health department) Others: NCDOT, Municipal Staff, Elected Officials, Law Enforcement, Judicial Officials, Public and Private Partners Need support: Local elected and public officials	Proactive 3 – 5+
2) Frame the Speeding and Safety Problem through a Public Information and Education Program to build support for effective policies and comprehensive strategies, to seek funding, and to improve effectiveness of enforcement and engineering countermeasures. (Comprehensive approach)	Lead: Injury prevention (e.g. County Public Health Dept.) Others: NCDOT Communications Office, DA’s office, Law Enforcement, NCDOT Safety and Mobility Office (pos.), Emergency responders (pos.)	Comprehensive 2 – 4 years

Table 1 Action Item	Stakeholder Roles	Approach Timeline
3) Develop an inter-agency speed and safety review process to assess land use and transportation plans, designs, and implemented projects to ensure that new and improved roads meet sound speed management design and safety principles for the area land uses and intended purposes of the street or highway. (Proactive approach)	Lead: Regional Planning Organization (PTRC-TAC) Others: NCDOT: Transportation Planning Branch, Division, Roadway Design, Safety and Mobility, Bicycle and Pedestrian Division County and local planning staff; elected officials; law enforcement representatives, public health	Proactive 1 – 3 years
4) Review existing speed limits, conduct additional diagnosis, and develop treatment plans for prioritized lists of problem corridors. (Systematic approach)	Lead: NCDOT Safety and Mobility Others: Municipal Staff (city streets), County Staff (rural routes), Law Enforcement agencies, Judiciary, Health officials, Regional Planning Organization, Municipal Planning Organization Need support: Local elected officials if speed limits are changed	Systematic 3 – 5 years
5) Develop a corridor focused, high visibility enforcement and adjudication effort. (Comprehensive approach)	Lead: State Highway Patrol, local law enforcement agencies, and NCDOT Safety and Mobility Others: Courts officials, Injury Prevention Communications experts, Need support: Elected officials	Systematic and Comprehensive 3 – 5 years
6) Implement speed and safety reviews within the HSIP program, including Intersections and Sections, with the NCDOT Roadway Departure Plan and with any Pedestrian Safety Plans. (Systematic approach)	Lead: NCDOT Safety & Mobility Office Others: Law enforcement agencies, NCDOT Safety engineers, Division of Bicycle and Pedestrian Transportation (potentially), Local agency staff (in urban areas)	Systematic 3- 5 years

Table 2 describes Initial steps for Plan implementation. The speed management workgroup may continue to add to and update Table 2 to schedule and track action steps, decisions, and implementation progress.

Table 2. Next Steps for Action Plan Implementation. This Table may be updated to incorporate On-going Action Steps and Schedules.

Implementation steps	Timeline	Steps completed
DOT and local stakeholders review plan elements including problem types, potential countermeasures, and proposed action steps.	Two weeks from receipt of draft plan	Done
Schedule meeting to prioritize most promising Action Steps and strategies.	Two weeks from receipt of draft plan	Done
Verify lead agencies, staff leadership and other Owners to be involved in Action Step Planning and Implementation activities.	Three weeks from receipt of draft plan	Done
Schedule meetings of workgroups for individual or combined action steps.	Two months from receipt of plan	
Seek support of local elected officials and the public by conducting additional outreach.	As needed	

Evaluation and Performance Measures

The evaluation measures will include interim process measures and safety outcome measures consistent with the safety goals of the Plan. Since the goals of the plan are to reduce fatal and injury crashes and to improve speed compliance, the primary measures of program effectiveness are:

- Changes in crash frequency and severity.
- Changes in operating speed distributions.

Process measures and implementation measures will also be used to track and link program efforts to safety outcomes, and to improve and sustain the program. Specific countermeasures may be evaluated, as feasible, to determine treatment effects in the local context.

See Chapter 4, Evaluation Plan section, for more information.

Sustaining and Updating the Plan

As the stakeholders continue to meet and prioritize the Action Items and particular strategies, consider the following:

- The implementation timeline for this initial plan is five years, but can be changed as needed. Depending on the Action Items advanced, some strategies will likely require longer than five years to fully carry out and implement.
- The plan is a working document, and may be updated and revised as actions or strategies are refined and revised.
- As already mentioned, a Plan evaluation using relevant performance measures is part of the implementation. Plan implementation and safety progress should be monitored

with appropriate performance measures throughout the implementation period. The plan should be fully evaluated around the end of the implementation period as to how much of the plan was implemented and whether Safety Goals were met.

- To sustain and build the program, update the plan near the end of the initial plan period. The update will incorporate input from the Plan evaluation, an updated problem identification, and incorporation of new proven countermeasures.

Chapter 2. Speeding-related Safety Issues

This chapter provides a brief description of the problem identification processes. This chapter also describes the speeding-related safety problems and speed management problems identified through these methods. The safety problems are the targets for strategies and countermeasures outlined in Chapter 3. The general speed management issues and challenges are addressed through the Action Items and strategies outlined in the Plan as well as in some cases by specific countermeasures.

Data and Methods

Analysts conducted three types of data analyses using data for five years of reportable crashes (2007-2011) obtained from NCDOT's State crash files:

- **County-level analyses.** County-level frequency tables using crash data variables were used to identify Countywide trends and general crash factors associated with significant proportions of speeding-related or severe crashes. Speeding crash relationships were also compared to Statewide trends, but since conditions in Randolph County may be different than those for the State as a whole, those comparisons should be interpreted cautiously.
- **Network screening** at a corridor level was performed using crash data matched to roadway sections. (Roadway inventory data up to date as of 2011 were also obtained from NCDOT as GIS-based inventory files.) Only mileposted crashes and sections of roadway (a majority of State-owned roads; few local streets) could be included in these analyses. Network screening identified routes where severe and/or speeding-related crashes were over-represented compared with other similar routes. The characteristics used to categorize roads included rural or urban location, whether the road was physically divided or undivided, and number of lanes. Intersection crashes were included in the corridor-level screening.
- **Spatial analyses.** Spatial analyses in a GIS (ARCMAP10) platform were used to rank schools by severe and speeding-related crashes, and to rank road sections with crashes on/near curves. The results of these analyses are included in Appendix B as supplemental information Stakeholders opted to focus on corridors in the current Plan.

Other problem identification resulted from:

- **County Stakeholders meeting.** Input from Randolph County stakeholders through workshop held January 9, 2013. Follow-up prioritization meeting held April 19, 2013.
- **Field visits.** To gain insight into the nature of the problems, a team of road safety stakeholders and an FHWA representative conducted problem assessment field visits to 10(+) corridors identified through the preliminary network screening. A companion report has been provided to stakeholders (Randolph County Speed Management Plan – Field Visits: Summary and Speed Management Plan Recommendations, Conducted February 10 – 14, 2013). Complete, independent roadway safety audits (RSAs) would ideally be used to identify specific design and roadway problems, behavioral issues, and recommend appropriate treatments (in addition to other engineering studies).

- **Pre-existing speed data.** A limited number of speed study reports were obtained for routes preliminarily identified as having crash problems. These data were useful for noting general prior speeding trends and operating speed-speed limit relationships.
- **Expert speed management workshop.** Input from a Statewide stakeholders and expert speed management workshop held in October of 2011 in Raleigh, NC (independent of the present project).

Countywide Issues

There were nearly 16,000 reported crashes for Randolph County over the five-year analysis period. General Countywide trends include the following:

- 2,644, or 16.8 percent of the total crashes, were indicated to involve speeding, compared to a Statewide average of 10.1 percent.
- 253, or 1.6 percent of total crashes, involved fatal or disabling type injuries (slightly higher than the Statewide average).
- Approximately 59 percent of total crashes occurred in rural areas.
- 77 percent of speeding-related crashes occurred in rural areas.
- 72 percent of fatal and disabling injury crashes occurred in rural areas.

For further Countywide crash analyses, the data were subset by whether crashes occurred in rural or urban locations. Both issues and solutions may vary for towns and cities (urban) versus rural locations. Speed limit setting procedures may vary, and some of the stakeholders are different. A summary of key results is provided in the following sections.

Rural Areas Crash Characteristics

Table 3 shows characteristics of the speeding-related and severe crash problems in rural areas of the County. Note that there is significant overlap between crashes that are both speeding-related and more severe, as illustrated in Figure 1. The traits that are associated with high percentages of speeding-related or severe crashes could be targets for widespread engineering countermeasures at locations with similar problem types, and for treatments such as anti-speeding enforcement and publicity campaigns. Suitable countermeasures are described in Chapter 3. More discussion about some of the speeding crash issues follows:

- 61 percent of speeding-related crashes in rural areas were associated with curves. (This does not necessarily mean that the curve contributed to the crash.) Curves were also strongly associated with serious injury crashes (38 percent), although to a smaller degree.
- More speeding-related (42 percent) and severe crashes (48 percent) occur at night.
- A much larger portion (21 percent) of severe crashes occurred at intersections compared with the proportion of speeding-related crashes (7 percent).
- Alcohol was also a factor in a larger portion of severe crashes (30 percent) compared with speeding-related crashes (13 percent).
- Teen drivers were involved at a lower rate in severe crashes (13 percent) compared with speeding-related crashes (24 percent).

- Slippery surfaces (wet, icy, and snowy roads) were present in 18 percent of speeding-related crashes but in only 2 percent of severe crashes.

Curves, crashes at night, and intersections may be targets for widespread efforts due to the high percentages of speeding and severe crashes at these locations or conditions. (See Table 20 and Table 21 in Appendix B for more detailed results and comparisons.) In addition, measures targeting alcohol could also help to reduce more severe, speeding-related crashes.

The top three types of crashes in rural Randolph County were the following:

- Striking fixed objects (a type of road departure crash) (2899, 31 percent of rural crashes).
- Collisions with animals (2106, 23 percent of rural crashes).
- Rear-end collisions (1244, 13 percent of rural crashes).

Roadway departure and fixed object crash types are frequently associated with speeding. Rear-end collisions may also be related to operating speeds and sight-distance issues. The preponderance of animal collisions on rural roads is also a consideration for determining appropriate limits.

Speeding and more severe crashes also vary by hour of day. Evening hours have higher proportions of speeding, and account for larger numbers of severe crashes (Figure 5 in Appendix B). These hours may be key times for speed enforcement. The effects of engineering countermeasures during evening and hours of darkness should be considered when prioritizing countermeasures (Table 3).

Table 3. Characteristics associated with Speeding-related (SR) and Severe Crashes in Rural Areas of Randolph County, compared with Statewide averages, that might be Treated by Engineering, Enforcement, and Educational Countermeasures. (Crash Years, 2007-2011.)

Crash Characteristics	Number of Rural SR Crashes - County (2036)	Percent of All Rural SR Crashes - County	Average Percentage of Rural SR Crashes Statewide	Number of Rural Severe ¹ Crashes - County (182)	Percent of All Rural Severe ¹ Crashes - County	Average Percentage of Rural Severe Crashes Statewide
Two-lane road	1727	85%	75%	151	83%	79%
Nighttime (most unlighted roads)	857	42%	38%	87	48%	41%
On curve	1239	61%	54%	70	38%	41%
Alcohol involved	262	13%	10%	54	30%	27%
Intersection	150	7%	7%	38	21%	17%
Teen drivers (16 to 19)	497	24%	22%	23	13%	15%
Multi-lane, divided	231	11%	19%	17	9%	14%
Wet Roads (incl. standing water)	558	27%	36%	10	5%	11%
Icy/snowy roads	379	19%	18%	4	2%	1%

Speed Study Results

Analysts reviewed summary results for 89 different pre-existing speed studies conducted by NCDOT. Data were for routes that had been identified through preliminary screening as having potential speeding-related crash problems. The studies dated from 1998 to the present, and included multiple studies at a few locations. Key findings follow:

- The results showed that speeding above limits was widespread on the vast majority of the roads where speed studies were conducted. In 73 percent of the road locations studied, the 85th percentile speed was above limits.
- 85th percentile speeds were at least 5 mph over limits for more than 40 percent of routes.
- 85th percentile speeds of at least 10 mph above limits were observed on a significant percentage (12 percent) of the roads studied. (See Figure 6 and other information in Appendix B.)

Roads with high levels of speeding and severe crash problems should be priorities for speed limit review, enhanced enforcement and/or engineering treatments. Roads identified as having severe and speeding-related crash problems that do not have high levels of speeding above the limits may need lower limits as well as other safety measures.

Rural Areas – Other Key Challenges and Issues

Other issues in rural areas include the following:

- The maximum *statutory rural* (outside municipal boundaries) *speed limit* in the State and County is 55 mph. This limit applies to many miles of rural secondary routes, a legacy farm-to-market network that serves residences and other local access, unless a speed ordinance and posted limit are present. Most of the rural secondary corridors were not designed or built to modern standards for 55 mph highways, and there may be a number of geometric features (e.g. narrow roads, poor shoulders, sharp curves and steep grades, short sight distance) and other conditions (lack of lighting, number of driveways or junctions) that violate driver expectancy for a 55 mph road. Changes in development and traffic patterns over time have also affected many routes. These issues likely affect the widespread nature of crashes on the rural road network.
- Most requests for speed studies, currently, are for lower limits. Based on the foregoing issues, State safety engineers think that a lower statutory maximum speed limit might provide a safer baseline limit, with the burden on speed limit review to justify a higher limit (NC Speed Management Recommendations, report to NCDOT, 2012 draft).
- Most speed studies and safety treatments currently are initiated in a reactive approach to problems (speeding complaints or crashes).
- Policy decisions and other enforcement challenges result in a low level of enforcement on rural and some urban streets and highways.

Urban Areas Crash Characteristics

The following characteristics were observed for Randolph County urban areas crashes:

- About 41 percent of Randolph County total reported crashes occurred within various municipal limits in the County.
- About 28 percent of severe (KA-severity crashes) occurred within urban areas.
- About 23 percent of speeding-related crashes occurred within urban areas.

Table 4 summarizes characteristics that are associated with significant portions of the speeding-related and severe crashes within municipalities or the *urban* areas of the County. These factors may be targets for implementation of engineering countermeasures, and for treatments such as anti-speeding enforcement and publicity campaigns.

As with rural areas, there were differences in the degree to which traits were associated with speeding versus severe crashes. Two-lane, undivided urban roads were most highly represented in severe crashes (65 percent), even more so than for speeding-related crashes (49 percent). The proportion of severe crashes that occurred on two-lane roads was also much larger than for the State on average, but this may be in part due to the extent of mileage of different road types in the County. A larger percentage of urban severe crashes occurred at intersections compared with speeding-related crashes. Alcohol was also more involved in severe crashes, while wet roads and teen drivers seem to be less represented in more severe crashes than in speeding-related crashes in urban areas (Table 4).

Table 4. Characteristics highly associated with Speeding-related (SR) and Severe Crashes in Municipalities of Randolph County that might be treated by Engineering, Enforcement, and Educational Countermeasures. (Crash years, 2007-2011.)

Crash Characteristic	Number and Urban SR Crashes in County (n = 615)	Percent of Urban SR Crashes in County	Average Percentage of Urban SR Crashes Statewide	Number of Urban Severe Crashes in County (n = 71)	Percent of Urban Severe Crashes in County	Average Percentage of Urban Severe Crashes Statewide
Two-lane, undivided	302	49%	37%	46	65%	33%
Multi-lane, divided	199	32%	36%	9	13%	33%
Multi-lane, undivided	82	13%	15%	12	17%	26%
Crash at curve	184	30%	28%	17	24%	18%
Dark (lighted)	83	14%	24%	15	21%	27%
Dark (unlighted roadways)	134	22%	14%	12	17%	15%
Crash at Intersection	67	11%	15%	16	23%	30%
Alcohol-involved	59	10%	11%	15	21%	23%
Wet roads	314	51%	48%	12	17%	13%
Teen driver	138	22%	20%	11	16%	13%

Urban Areas – Other Key Challenges and Issues

Some of the other issues identified through Statewide and local stakeholder meetings include the following:

- The urban default statutory maximum is 35 mph. To change limits on State-owned roads passing through municipalities requires agreement through concurrent State and local ordinances, but such concurrence may be difficult to achieve.
- Many urban streets and highways still carry the statutory limits, but both lower limits and higher limits have been posted through speed zoning and ordinances. A diversity of practices among towns and history of ordinances, annexations, statutory limits, and designs has resulted in a variety of limits for similar and diverse types of roads.
- Some of the smaller communities in the County at present lack their own police departments, and/or traffic enforcement capabilities. The Trinity and Archdale area has several major highways, large amount of traffic, significant fatal crashes, and safety issues around high schools according to information provided at the stakeholder kick-off meeting. Trinity is one of the communities lacking local traffic enforcement.

Other Key Countywide Issues

The following issues were identified through stakeholders meetings and other sources:

- Drivers may not know what limits are, particularly statutory limits that are not posted.
- Traffic courts are overwhelmed with processing appearances by violators that opt to contest their tickets. Many plea arrangements and convictions for non-speeding offenses are the outcomes. Thus, drivers may perceive that convictions for speeding as charged are rare and that violators are treated inconsistently.
- Apart from Statewide initiatives such as No Need to Speed, which are twice-yearly enforcement blitzes, there have been no coordinated efforts to create sustained, randomly targeted, but high-visibility speed enforcement campaigns. Current enforcement focuses on a few top crash corridors. Drivers are very likely aware that there is little risk of being detected speeding on other roads.

Corridor Problems

The start of a systematic process is to identify zones, corridors, or areas that may have more than expected or a higher than average proportion of speeding-related crashes for that road type. These roads may be good candidates for further assessment and potential treatment. Network screening was used to identify locations, or more specifically corridors, where speeding may be contributing to crash and injury problems. The screening approach grouped similar road types (rural/urban, design configuration, and number of lanes) for analysis, and made use of the following measures:

- Proportion of crashes that were speeding-related.
- Proportion of crashes with more severe injuries.
- Rate of more severe injury crashes per mile of roadway length.

Neither traffic volume data nor actual operating speed data were available for all road sections, especially for the lower-volume rural roads that predominate in this County, and hence traffic volume data were not used in the screening methods. Traffic volume and actual speeds should be considered during field review and diagnosis. Results of the screening process focused attention on the following three types of routes for application of a systematic approach:

- Urban, multi-lane, but not physically-divided corridors.
- Urban, two-lane corridors.
- Rural, two-lane roads.

In addition, a spatial analysis demonstrated potential for identifying area-wide concerns such as neighborhoods or areas near schools that may have severe and speeding-related crash problems.

Urban, Multi-lane Corridors (undivided)

An average of about five percent of total crashes resulted in severe injuries and about four percent of crashes were speeding-related on urban, multi-lane, but not physically divided corridors.

Six corridors that accounted for most of the mileage and the crashes on these road types were identified for further diagnosis. See Table 23 in Appendix B

Appendix B information provides additional detailed analysis results, supplementing results in Chapter 2 for a list of these corridors. Focusing attention on these six corridors for treatment would target approximately:

- 6 percent of fatal crashes (6 fatal crashes).
- 6 percent of severe crashes (94 severe crashes).
- 3 percent of speeding-related crashes (70 speeding-related crashes).
- 12 percent of total crashes (1788 crashes).
- Less than 1 percent (0.7 percent) of the County's mileposted roadway miles.

As mentioned, several of the priority corridors were visited by the field review team for more in-depth assessment of the types of problems present.

Problem types observed (see companion document, Speed Management Recommendations from Roadway Safety Field Visits) on a few of these urban, multi-lane roads include the following:

- Transition areas from rural, high speed, multi-lane roads to lower speed urban, multi-lane corridors do not adequately convey to drivers the need to slow. Transitions in land use are often gradual and difficult to perceive, and the road designs do not change much, or at all.
- Limits may change abruptly from 55 to 45 to 35 (rural to urban transition).
- Some corridors have diverse adjacent land uses (residential, commercial, senior living, schools), many driveways and connections, and significant conflict areas associated with a five-lane (two lanes in each direction with a center, two-way left turn lane) design.
- The same type environments provide a complex background to drivers, and may obscure important safety information, especially if drivers are traveling at higher speeds. Traffic signals, school caution signs, other warning signs, and wayfinding information may be difficult to see amidst the utility poles, commercial signs, and driveway connections. Drivers from out-of-town may be most in need of cues about speed limits, directional information, and other safety information.
- Few pedestrian or bicycle amenities are present on some roads and therefore separation of different weight and speed (type) of users is often inadequate. (There are few and infrequent traffic signals, no pedestrians signals or crosswalks, lack of median/refuge islands or other crossing aids, lack of bike facilities, lack of sidewalks in some areas.)
- Law enforcement and judicial officials perceive the 35 mph limit on some sections of urban, multi-lane arterial-type corridors to lack credibility to drivers and they deem such sections challenging to enforce since many drivers exceed the 35 mph limit.
- Some multi-lane corridors are overbuilt, and do not need multiple lanes to carry only low traffic volumes of mostly local traffic.

- Skewed angle intersections and intersections with other geometric problems (sight distance issues due to grades and curves) are present on both arterial-type, higher volume, and local, lower volume corridors. Skewed angle intersections can lead to high turning speeds as well as sight distance / visibility issues at intersections.
- Significant angle and rear-end collision types were common on both higher volume (highway type) and lower-volume, local corridors.

Urban, Two-lane Corridors

On average, about 8 percent of all crashes on urban two-lane routes were severe, and 13 percent were indicated to be speeding-related.

A subset of 11 corridors was identified through the screening process for further review. See Table 24 in the Appendices for Chapter 2, for the list of urban two-lane corridors to consider for implementing the systematic approach.

This subset of 11 corridors accounted for approximately:

- 4 percent of severe crashes in the County (63 severe crashes).
- 2 percent of speeding-related crashes (54 speeding-related crashes).
- 3 percent of total crashes (485 total crashes).
- 1 percent of the County's mileposted roadway miles.

Problems observed that could potentially contribute to speeding and speeding-related crashes on some of these urban two-lane streets (that have similar characteristics) included:

- The street design and configuration does not change from rural to urban areas. The urban portions are striped and look like rural highways.
- Rural to urban high to low-speed transitions: Changes in land use and driveway density are often gradual and difficult to perceive from high (55 mph limits) to low-speed (generally 35 mph) urban areas. Speed transition area treatments from rural to incorporated areas are generally lacking.
- Typical of many rural two-lanes in the region: There may be no sidewalks, shoulders, or other space for bikes or for pedestrians to walk resulting in a lack of separation of different user types. Pedestrians were observed walking in the road or along the road edge. Since the statutory urban speed limit is 35, and travel speeds may be higher, separation seems inadequate.
- Ditches and numerous fixed objects (mailboxes, hard structures, trees, and signposts) are near the roadway; lanes tend to be narrow, and there is little recovery opportunity if vehicles run off edge of the road or encroach on the opposite lane.
- Large vehicles are also common on some corridors.
- Rear-end and angle type crashes were common for the route observed.
- Fixed object and road departure crash types were also represented – types often associated with too fast for conditions.
- Curves or grades may result in inadequate sight distance at intersections and numerous driveways in some sections, especially if vehicles are speeding.

- Acute angle intersections, some also associated with curves, may add to sight distance issues, especially problematic for sharp left turns and if approach speeds are high.
- There is little delineation or confusing alignment at some skewed junctions; drivers unfamiliar with the route may have difficulty perceiving which route they need to follow.
- Roadway drop-offs at intersecting roadways combined with curves on approaches (e.g. Hub Morris and Liberty) could result in vehicles losing control at intersections.

Rural, Two-Lane Routes

Rural, two-lane roads represent the majority of roadway inventory miles in the County, although the average annual daily traffic volumes are low. Many routes have less than 1000 vehicles per day. The vast majority are classified as State Secondary roads, although a few two-lane roads serve as U.S. or North Carolina highways. Unless a speed ordinance exists, rural roads have a maximum, statutory speed limit of 55 mph. Roads operating under the default maximum do not have to be posted with the limit. The assumption is that most of the rural two-lane roadway miles presently operate under the statutory limit.

A subset of 18 corridors was prioritized through the screening process for additional systematic diagnosis (Table 25 in Appendix B).

The prioritized group of 18 corridors accounted for the following:

- About 13 percent of the County's severe crashes, or 204 severe crashes.
- About 8 percent of the County's speeding-related crashes, 214 speeding-related crashes.
- About 9 percent of the County's total reported crashes, 1438 total crashes.
- About 4 percent of the County's mileposted roadway miles.

Problem types observed during field visits included:

- There is typically little to no paved shoulder; ditches and numerous fixed objects including trees and mailboxes are near the roadway.
- There are many curves and curves with grade and curve-related crashes; some routes seem to have few and short tangent sections between curves.
- Other corridors have longer tangent sections, which may allow drivers to attain high speeds between curves/grades or other features that may require slower travel.
- The curves and grades contribute to sight distance issues at intersections, driveways, and other areas. Rear-end collisions (13 percent of rural crashes) suggest potential sight distance problems that could relate to prevailing speeds. (Conduct further analyses to determine if rear-end collisions are over-represented at particular locations.)
- The 55 mph statutory limit, unless a speed zone exists, may not be appropriate for many sections (and as further described under the Countywide problem description).
- There is no space for bicyclists to travel or for pedestrians to walk along these roads except in the travel lane.
- There may be inconsistencies in the treatment of curves with similar geometries (advisory limits, warnings, etc.).

- Edge lines may not show up well in adverse weather or at night.
- Rumble strips and safety edge have not yet been widely implemented on state secondary routes.
- Many miles of these roads, largely low volume, with low level of enforcement.
- Emergency response time may be high due to distances to more remote areas.
- Fixed object (road departure) crashes are the most common type (35 percent of all rural crashes).
- Animal collisions are also common (23 percent).

Chapter 3 describes action items, strategies, and countermeasures for addressing many of the problem types and crash problems described in this chapter.

Chapter 3. Speed Management Actions, Strategies, and Countermeasures

This chapter describes actions that may be used to implement Countywide strategies and countermeasures and to systematically assess and treat the Problem Corridors identified through network screening. In addition, the chapter outlines alternate engineering and enforcement strategies to treat identified safety or speed management issues, along with expected effects on crashes.

Actions and Strategies to Address Countywide Issues

The focus of Countywide actions will be to foster creation of land-use-appropriate and self-enforcing roadway designs over time by engaging to develop more collaborative and consistent policies, procedures and guidance in speed-limit setting and design. The NC Complete Streets guidelines are resource that could be used as a starting framework to assess the network function and purpose of roads, and to develop appropriate speed limit-setting policies and designs for new projects or improvements. Under a Complete Streets approach, current and future land use and user safety as well as mobility needs should be key elements in speed limit setting and target travel speeds.

The key focus of comprehensive strategies is to engage law enforcement and the community in setting appropriate limits, and to build support among the public and law enforcement community to enforce close to established limits. Enforcement and publicity are especially needed to supplement design and engineering when road designs or limits cannot be changed, or design and engineering measures are insufficient to achieve the desired operating speeds. It may also be desirable to engage with other stakeholders Statewide to seek the legal authority to use proven tools such as automated enforcement to supplement traditional enforcement.

Table 5 describes three Action Items and related strategies that the State, County, and other partners may use to address the issues identified in Chapter 2. The Action Item describes the process and/or group needed to consider the strategies and issues characterized in the second and third columns, respectively. Most of the strategies outlined in Table 5 do not have proven crash reduction or safety effects, but flow from best practice principles or provide the framework for a sustainable speed management program.

Table 5. Proactive and Comprehensive Action Items and Strategies to Address Countywide Issues.

Table 5 Action Items	Strategies that may be included under these Action Items	Issues to be Addressed
<p>Develop a County Council/task force to engage on speed limit setting and safety, coordination of design and enforcement for existing roads, and to work toward a more consistent limit setting process and outcomes throughout the County. (Comprehensive and Proactive)</p>	<ul style="list-style-type: none"> ▪ Set appropriate speed limits for the roadway design, context, and users to improve safety for new and existing roads. ▪ Develop a collaborative speed limit setting process among NCDOT, local governments and law enforcement. Seek public input about safe and appropriate speeds. ▪ Consider using NCDOT’s Complete Streets guidelines (NCDOT, 2012) and collaborative processes to guide implementation (e.g. determine road types and target operating speeds/speed limits, and appropriate design). ▪ Consider using fewer different speed limits, for example 25, 35, and 45 mph in urban areas to help improve driver comprehension. 	<ul style="list-style-type: none"> ▪ Varied practices and outcomes in setting speed limits, especially in urban/suburban areas across the County. ▪ Lack of agreement between the State DOT and communities about appropriate speed limits on urban streets. ▪ Poor credibility and enforceability of speed limits on some roads; may lead to general lack of speed limit credibility. ▪ Many sections of urban streets that have incompatible design with speed limits and/or current land uses. ▪ Many rural two-lane routes that were not designed to current 55 mph limits. ▪ Drivers may not know the speed limits, particularly statutory limits that are not posted.

Table 5 Action Items	Strategies that may be included under these Action Items	Issues to be Addressed
<p>Frame Problem through a Public Information and Education Program - to help support effective limit setting policies and comprehensive strategies, to seek funding, and to provide support of enhanced enforcement and other effective countermeasures. (Comprehensive)</p>	<ul style="list-style-type: none"> ▪ Ensure that drivers know what all speed limits are, including statutory maximums. ▪ Improve communications about the safety reasons for effective policies and strategies to improve public and political support. ▪ Seek additional funding and political support to increase enforcement in rural and urban areas. ▪ Increase visibility/conspicuity of enforcement to enhance deterrent effects. ▪ Work toward gaining State legal authority to utilize automated (photo) speed enforcement as an enforcement tool. ▪ Use publicity and education to enhance speed-deterrent effects of enforcement programs and other programs. (See Countermeasures That Work and other resources for the types of programs that are likely to be effective, or seek technical assistance. See Keys to Communication Success tip sheets in the <i>Speed Management Toolkit</i>.) 	<ul style="list-style-type: none"> ▪ Poor credibility and enforceability of speed limits on some roads may lead to general lack of speed limit credibility. Difficulty in agreeing on appropriate limits. ▪ Drivers may not know what limits are, particularly when statutory limits are not posted, or are infrequently posted. ▪ Widespread speeding above limits. ▪ Insufficient enforcement resources, low enforcement presence in many areas. ▪ Political and administrative challenges to implement stricter adjudication of speeding violations. ▪ Legal barriers to implementing automated enforcement under current State law. ▪ Speeding-related (SR) crashes involve all ages of drivers. Teens accounted for about 25 percent of speeding-related and a lower proportion of severe crashes. ▪ A high percentage (77 percent) of speeding-related crashes are in rural areas. ▪ A high percentage of speeding-related crashes (35 percent) occur at night (most on unlighted roads). ▪ A high percentage of speeding-related crashes occur at curves (54 percent).

Table 5 Action Items	Strategies that may be included under these Action Items	Issues to be Addressed
<p>Develop an inter-agency speed and safety assessment process to review plans, designs, and implementation to ensure that new projects meet sound speed management design and operations principles for the area land uses and intended purposes of the road. (Proactive)</p>	<ul style="list-style-type: none"> ▪ Coordinate with transportation and land use plans in setting limits and designing roads. ▪ Set or revise speed limits early in the new project planning process to provide adequate safety for the land use, road type, and expected users. ▪ Consider using NCDOT’s Complete Streets guidelines (NCDOT, 2012) and collaborative approach to coordinate with land use, user needs, and guide implementation. ▪ Consider specific designs, signs, and markings to apply to similar road types throughout jurisdiction (self-explaining designs). ▪ Utilize tools such as the Interactive Highway Safety Design Model (IHSDM) to evaluate design consistency and estimate safety and operational performance of design alternatives. ▪ Conduct speed and safety reviews of designs, during construction and implementation of all new and pending projects, including maintenance and operations projects, to ensure that: <ul style="list-style-type: none"> ▪ Design is matched to elicit speeds close to the intended speed limit (self-enforcing). (Note that even if design speeds close to the limit are used, the <i>perceived</i> design speed may be higher, leading to higher driver speed selection.) ▪ Operations features are coordinated with target speeds. ▪ Facilities and operations separate different weight and speed of users on roads with moderate or high limits and target operating speeds. ▪ Speed-managing designs that will have long-lasting effects are prioritized. ▪ Review work zone procedures, signing, compliance, and monitoring to ensure that work zone speed zones are credible and appropriately implemented. ▪ Consider variable speed limits for new /improved freeways 	<ul style="list-style-type: none"> ▪ Lack of self-enforcing roadway designs and safety issues relating to inappropriate speed for area land uses and other conditions. ▪ Lack of credibility of speed limits due to frequent incompatibility with design or operations during certain times or at certain locations. ▪ Street and road designs and/or limits that are incompatible with each other or with current or future land uses or other transportation needs. ▪ Reactive approach to managing speed and providing safety treatments not as effective as initial good design. ▪ Difficulty in enforcing speed limits where inferred design speed or actual design speed is significantly higher than limit.

Specific opportunities to implement the proactive strategies include the following:

- **Opening of US 311 bypasses (under construction and review).** Conduct speed and safety review before opening the new highway.
- **US 64 bypass (pending)** including connections with local streets.
- “Big” urban/suburban roads such as US 311, Archdale, and US 64 in Asheboro and Ramseur have many design issues, conflicts, and crashes. When alternate/ bypass routes are opened, there is also an opportunity for purpose, speed and safety-oriented design review once some of the traffic functions are shifted from the current roads.
- **Zoo Parkway connector (planned).**
- **County Comprehensive Transportation Plan**, currently under development. Specific plans in the County’s Comprehensive Transportation Plan (CTP) that are under active consideration should be assessed with regard to their compatibility with current and future land uses, and designs for appropriate speed.
- **Other transportation plans** including The Central Region of NC Bicycle Plan and other multi-modal plans (pedestrian, bicycle, and transit plans).
- **Land use and development plans** including a County-level growth management plan adopted in 2009 to guide economic and residential development. See Appendix C for a map from that plan.
- Coordinate with **North Carolina DOT’s Complete Streets Policy** and implementation approach in all plans and pending projects.

Actions, Strategies, and Countermeasures to Address High Crash Corridors

As mentioned, the systematic approach is the process used to identify, prioritize, and treat existing safety and speed management issues by corridors or other areas. A pragmatic approach will find ways to implement speed and safety review and speed managing improvements within other safety programs, and through planned maintenance and operations improvements as is done in North Carolina’s Complete Streets implementation approach.

Table 6 describes three Action Items and Strategies to implement a systematic approach to treating corridors or other areas of concern, and to address some of the barriers and challenges in a local speed management program. As in Table 5, the Action Items provide the organizational set-up for selecting and developing a cost-effective treatment package of countermeasures. The systematic approach to diagnosing and treating speeding-related issues can be applied to the corridors identified through network screening for that purpose, or other areas systematically identified.

Table 7, Table 9, and Table 11 provide more details on alternate countermeasures or strategies that can be selected through the actions and systematic processes outlined in Table 6. Although individual diagnosis should be performed *for each corridor*, application of more uniform designs, markings, and other treatments for similar area and road types may be tried, especially for proven measures. Such treatment could improve consistency of message to drivers about safe speeds in similar land use and roadway contexts.

Table 6. Systematic and Comprehensive Actions to Address Speeding and Related Crashes on High Crash Corridors.

Table 6 Action Items	Strategies that may be Used	Issues to be Addressed
<p>Develop team and schedule to conduct speed and safety reviews and develop treatment recommendations for prioritized lists of three different corridor types. (Systematic approach)</p>	<ul style="list-style-type: none"> ▪ Conduct speed and engineering studies and additional diagnosis steps. ▪ Conduct Roadway Safety Audit as part of diagnosis. As part of the safety audit process: <ul style="list-style-type: none"> - Involve law enforcement and local elected officials. - Determine the area (land use) and roadway context (purposes and users of the road, what types of conflicts and severity of crashes may occur based on existing design). - If changing the limit is an option, determine appropriate limit based on the context described (above). - Assess credibility of the speed limit to drivers. - Determine what changes can be made to the roadway to improve safety and support proposed limit. - Determine timeline (short, long-term) for engineering, other improvements. - Determine what other safety improvements are needed – e.g., on higher speed roads, are safer pedestrian crossings needed? - Determine whether enforcement improvements are needed to improve compliance with limits (including any changed limits). ▪ Apply similar countermeasures to similar location / problem types. ▪ Take advantage of maintenance and operations opportunities to reconfigure or make other design or engineering improvements. 	<ul style="list-style-type: none"> ▪ This systematic approach should be used for each of the prioritized problem corridors identified through network screening – undivided, multi-lane, urban streets; undivided, two-lane urban streets; and undivided, rural, two-lane routes. ▪ Specific problem types and countermeasures for each road type are described in Table 7, Table 9, and Table 11

Table 6 Action Items	Strategies that may be Used	Issues to be Addressed
<p>Develop a corridor focused enforcement and adjudication plan to target corridors with severe crash problems and speeding. (Systematic and Comprehensive)</p>	<ul style="list-style-type: none"> ▪ Randomly target enforcement to select corridors with high frequencies of severe crashes and speeding. ▪ Tighten adjudication of citations for targeted corridors and publicize the effort. ▪ Coordinate with engineering and design to enforce roads where changes cannot be implemented right away. ▪ Enhance deterrent effects of any type of speed enforcement program with publicity. 	<ul style="list-style-type: none"> ▪ Widespread speeding above limits. ▪ Insufficient enforcement resources, low enforcement presence in many areas. ▪ Legal barriers to implementing automated enforcement under current State law. ▪ Widespread plea agreements and low conviction rate for many violators who contest charges in court.
<p>Implement speed and safety reviews within the HSIP program, within the NCDOT Roadway Departure (crash reduction) Plan and with any future Pedestrian Safety Plans. (Systematic)</p>	<ul style="list-style-type: none"> ▪ Incorporate routine diagnosis of speeding issues into other safety programs and plans. ▪ Assess whether corridor-level speed management issues are contributing to spot safety issues. ▪ Implement corridor or area-wide speed reviews and speed management countermeasures if needed to supplement spot safety improvements. ▪ Coordinate with law enforcement to supplement or provide enhanced enforcement before engineering measures can be implemented. 	<ul style="list-style-type: none"> ▪ Speeding at intersections, inappropriate speeds in pedestrian areas, speeding-related roadway departure crashes.

The next three sections describe effective countermeasures that might be selected through the Action Items to address issues on the three road types. Recall that the corridor screening approach included intersection crashes, and treatment of intersections is considered within each corridor type.

Countermeasures for Urban, Multi-Lane Corridors

Although urban multi-lane corridors (not access-controlled) accounted for lower overall proportions of more severe crashes and speeding-related crashes compared to total crashes, the crashes are spread over a relatively low number of miles of roadway, but which may have higher volumes of traffic. Speed management measures applied to these roadways would target a significant proportion of the problem, and may be cost-effective per mile of roadway treated, even if speeding crash rates (per vehicle miles) are lower than on other types of roads. The availability of speed-controlling and crash-reducing countermeasures for urban (even if small town, urban) situations also increases the feasibility of treating speeding-related crashes

on these roadways. Some of these streets also tend to serve a variety of important functions from serving through traffic to local access to homes, schools and businesses.

Screening highlighted six routes for further diagnosis (listed in Table 23 in Appendix B). Speeding-related engineering countermeasures for urban, multi-lane corridors include (but are not limited to):

- Speed studies, limit review, and potentially changes to limits or speed zones.
- Roundabout intersection design.
- Road diets (conversions of regular traffic lanes to other uses).
- Road / lane narrowing through markings or physical measures.
- Gateway treatments.
- Medians or median islands.
- Coordinated signal progression/ signal timing change.
- Other design elements (lighting, sidewalks, street trees) that highlight the urban nature of the corridor.

Table 7 lists alternate countermeasures to treat issues on undivided, multi-lane, urban corridors. The expected effects on crashes are shown in the “CMFs” column. CMFs (or crash modification factors) show the expected effects (with standard errors) of the different treatments. Factors less than 1 have a crash-reducing effect. (A CMF of 0.7 is expected to yield a crash rate of 0.7 times the prior crash rate, or a 30 percent crash reduction, controlling for traffic volume and other trends.) The types of crashes covered by the CMF estimates are shown below the estimate. In addition to addressing the types of issues shown in the “Problem Types Treated” column, speed-reducing or controlling countermeasures are expected to lower the frequency of fatal and severe injury crashes of all types. The estimates (or locally-calibrated estimates) may be used to help determine the benefits (and cost-effectiveness) of each treatment. However, each corridor must be assessed through further diagnosis steps to determine the most appropriate treatment or combination of treatments.

Further diagnosis will include intersections as well as corridor-wide issues. Other intersection improvements may be needed in addition to more direct speed-managing improvements shown in Table 7.

Enforcement and related communications will supplement or complement design and engineering improvements or target improved compliance when changes cannot be made to the street right away. Emphasis should be on corridors with higher proportions or rates of severe crashes related to speeding. Crash modification factor estimates for automated enforcement and earned media are shown in Table 7. Expected safety effects of other enforcement measures are described in the NCHRP Guide for Reducing Speeding-Related Crashes (NCHRP, 2009) and Countermeasures That Work (NHTSA, 2011). See also Effectiveness of Behavioral Highway Safety Countermeasures. NCHRP Report 622 and other resources listed in the supplemental references. Such measures might include reduced enforcement thresholds, enhanced publicity of enforcement, and improved adjudication of citations. Roads where limits are changed may also be in need of improved enforcement.

Table 7. Countermeasures and Crash Effects (Crash Modification Factors or CMFs) for Urban, Multi-Lane Corridors.*

Table 7 Countermeasure / Strategy	CMFs (with std. errors)¹¹	Issues Addressed	More Information
Conduct speed studies, limit review, and potentially implement changes to speed limits or length of zones	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Credibility and Enforceability of speed limit. ▪ Limits may change abruptly from 55 to 45 to 35; other transition issues. 	^{12, 13} Changes in speed limits may not affect crashes much without other supporting measures
Improve signing of speed zones with package of larger signs and new warning signs; repeat signs more frequently; use on both sides of multi-lane roads.	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Transition areas issues ▪ Limits may change abruptly from 55 to 45 to 35 ▪ Drivers on multi-lane roads may miss signs ▪ Credibility and Enforceability of speed limit. 	^{14, 15}

¹¹ Standard errors provide an indication of the precision and reliability of the CMF estimate. Small standard errors relative to the CMF indicate less variability in the expected outcome.

¹² Forbes, G.J. T. Gardner, H. McGee, R. Srinivasan. (2012) Methods and Practices for Setting Speed Limits: An Informational Report. Available at: http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa12004/

¹³ USLimits2 tool, Available at: <http://safety.fhwa.dot.gov/uslimits/>

¹⁴ Torbic, D.J. et al., (2012). *Design Guidance for High-Speed to Low-Speed Transition Zones for Rural Highways*. NCHRP Report No. 737, Washington, D.C.: Transportation Research Board. Available: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_737.pdf

¹⁵ Design guidance and Excel workbook also available at project webpage: NCHRP 15-40 [Final], Design Guidance for High-Speed to Low-Speed Transition Zones for Rural Highways, <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2721>

Table 7 Countermeasure / Strategy	CMFs (with std. errors) ¹¹	Issues Addressed	More Information
Road diet conversion from multiple, undivided lanes to fewer traffic lanes with bicycle or parking lanes.	0.53 (0.01 s.e.) All crash types; all severities 4000 – 14,000 AADT, small urban areas	<ul style="list-style-type: none"> Big road, multi-lanes, and carry only low traffic volumes of mostly local traffic, which can lead to speeding. 	¹⁶ May require changes in detection at signalized intersections, re-timing, or addition of turn lanes
Repl. Stop-controlled Intersection with Roundabout	0.22 (0.07 s.e.) Injury	Any of the roundabout measures: (Replace Stop-controlled, one-lane or two-lane; or Replace Signal-controlled, one-lane or two-lane) may treat these problem types: <ul style="list-style-type: none"> Intersection collisions - About 11 percent of severe crashes in urban areas occurred at intersections. 	^{17, 18} May also help to lower corridor section speeds
- One-lane (if number of lanes reduced)			
- Two lane Roundabout	0.28 (0.09 s.e.) injury	<ul style="list-style-type: none"> Speeding on corridor or on intersection approaches. 	
Repl. Signal-controlled intersection with Roundabout	0.451 (0.115 u.s.e) Injury and Fatal	<ul style="list-style-type: none"> Skewed angle intersections, sight distance issues. Other geometric issues (observed). Low-speed turns related to acute angle. High speed turns related to obtuse angle 	^{17, 18, 19,}
- One lane (if number of lanes reduced)			
- Two lane Roundabout	0.288 (0.065 u.s.e) Injury and Fatal		

¹⁶ Road Diet Roadway Configuration. FHWA Proven Safety Countermeasures Available at: http://safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_013.pdf

¹⁷ Isebrands, H., Hallmark, S., Fitzsimmons, E. and Stroda, J. (2008). *Toolbox to Evaluate the Impacts of Roundabouts on a Corridor or Roadway Network*, St. Paul, Minnesota: Minnesota Department of Transportation. Available: <http://www.lrrb.org/media/reports/200824.pdf>

¹⁸ NCHRP (2010). *Roundabouts: An informational guide, Second edition. NCHRP Report 672*, Transportation Research Board: Washington, D.C. Available: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdf

¹⁹ Woodmansey, A., and Spalding, K. (2012). Montana's Roundabout Corridor. *Public Roads* 75 (no.2), <http://www.fhwa.dot.gov/publications/publicroads/12janfeb/02.cfm>

Table 7 Countermeasure / Strategy	CMFs (with std. errors)¹¹	Issues Addressed	More Information
Realign skewed intersections	See more information link	<ul style="list-style-type: none"> ▪ Skewed angle intersections; visibility. ▪ High speed turns on obtuse angle. ▪ Low speed turns. ▪ Sight distance issues due to angle. 	20
Gateway treatment combination	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Transition areas from rural, high speed, multi-lane roads to lower speed urban, multi-lane corridors do not adequately convey to drivers the need to slow. ▪ Speeding on urban sections of these corridors 	14, 15
Median	0.78 (0.02 s.e.) Serious, Minor Injury	Median-problem types treated: <ul style="list-style-type: none"> ▪ Transition areas from rural, high speed, multi-lane roads to lower speed urban, multi-lane corridors do not adequately convey to drivers the need to slow. ▪ Lack of pedestrian/cyclist refuges when crossing wide roads. 	14, 15
Median	0.54 (0.48 a.s.e) Pedestrian-motor vehicle		14, 15
Center median island	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Drivers speeding – wider roads. ▪ Need for pedestrian refuge. 	21
Signal coordination/ traffic progression to encourage consistent speed between signals	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ High-volume corridors with speeding between intersections. ▪ Speeding between signals. ▪ Speed variance within a section. ▪ Speeding-related rear-end crashes. 	22, 23, 24,25 See Dixie Drive corridor study suggests issues with flows and intersections which could lead to frustration and excessive acceleration between signals.

²⁰ Realign Intersection Approaches to Reduce or Eliminate Intersection Skew (2008). UNSIGNALIZED INTERSECTION SAFETY STRATEGIES), U.S. DOT, Federal Highway Administration webpage:

http://safety.fhwa.dot.gov/intersection/resources/intsafestratbro/ub16_intersection_skew.pdf

²¹ FHWA Traffic Calming website: http://safety.fhwa.dot.gov/speedmgt/traffic_calm.cfm

Table 7 Countermeasure / Strategy	CMFs (with std. errors) ¹¹	Issues Addressed	More Information
Increase pavement friction	Varied estimates available for different intersection types and sections	<ul style="list-style-type: none"> About 45% of all urban area crashes and 17% of severe crashes were assoc. with wet surfaces; further analysis needed of which intersections may have issues. 	²⁶
Narrow travel lanes	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> Credibility and Enforceability of speed limit. 	^{27, 28}
Various optical/perceptual pavement markings	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> Transition areas from rural, high speed, multi-lane roads to lower speed. Curves. 	²⁹ Effects may be less long-term than design/physical measures

²² NCHRP (2003). *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan. NCHRP Report 500, Volume 5: A Guide for Addressing Unsignalized Intersection Collisions*. Washington, D.C.: Transportation Research Board. Available: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v5.pdf

²³ Signalized Intersection Safety Strategies (2008). Companion slides to *NCHRP Report 500, Volume 12: A Guide for Reducing Collisions at Signalized Intersections*. U.S. DOT, FHWA, Office of Safety. Available: http://safety.fhwa.dot.gov/intersection/signalized/presentations/nchrp500_v12/

²⁴ Koonce, P., et al. (2008). *Traffic Signal Timing Manual*, Chapter 6. Washington, D.C.: FHWA. Publication No. FHWA-HOP-08-024. Available: <http://ops.fhwa.dot.gov/publications/fhwahop08024/chapter6.htm#6.2>

²⁵ Kimley-Horn and Associates. (2011). *US 64 Corridor Study*. Raleigh, NC: North Carolina Department of Transportation.

²⁶ FHWA's Pavement Friction program website: http://safety.fhwa.dot.gov/roadway_dept/pavement/pavement_friction/

²⁷ Engineering Countermeasures for Reducing Speeds: a Desktop Reference of Potential Effectiveness (2009) (FHWA) website: http://safety.fhwa.dot.gov/speedmgt/ref_mats/eng_count/

²⁸ AASHTO (2010). *Highway Safety Manual*. 1st edition. Washington, D.C.: American Association of State Highway and Transportation Officials. Available: <http://www.highwaysafetymanual.org/Pages/default.aspx>

²⁹ Engineering Countermeasures for Reducing Speeds: a Desktop Reference of Potential Effectiveness (2009) (FHWA) website: http://safety.fhwa.dot.gov/speedmgt/ref_mats/eng_count/

Table 7 Countermeasure / Strategy	CMFs (with std. errors)¹¹	Issues Addressed	More Information
Randomly target high visibility enforcement to cover a large proportion of high crash corridors and improve adjudication	0.826 (no s.e.) Total crashes	<ul style="list-style-type: none"> ▪ -Widespread speeding and related crashes. 	30
Automated speed enforcement (mobile, conspicuous)	0.85 (0.11 s.e.) Fatal, Serious and Minor Injury – urban arterials	<ul style="list-style-type: none"> ▪ Speeding and related crashes. ▪ Need for supplemental enforcement & deterrence. 	31, 30
Automated speed enforcement (fixed, conspicuous)	0.52 (0.14 s.e.) Serious, Minor Injury – urban freeway	<ul style="list-style-type: none"> ▪ Speeding and related crashes. ▪ Need for supplemental enforcement & deterrence. 	31,30
Publicity related to enforcement (automated)	0.9 (0.12 s.e.) Fatal, Serious and Minor Injury - urban	<ul style="list-style-type: none"> ▪ Speeding and related crashes. ▪ Need for supplemental enforcement & deterrence. 	31,30
Enforce closer to limit (especially if limits are changed).	No CMFs available. (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ High enforcement and adjudication tolerances. ▪ Widespread speeding above limits. 	32

Table 8 shows the crash reduction target developed for urban-multi-lane corridors. This target assumes that the six priority corridors identified in Table 23 are treated with a package of measures that have an average of 20 percent expected reduction in total crashes and 30 percent reduction in severe crashes. The following crash savings are expected:

³⁰ See Chapter 3 in NHTSA (2011). *Countermeasures that Work*. Publication no. DOT HS 811 444, U.S. Department of Transportation, National Highway Traffic Safety Administration. Available: <http://www.ghsa.org/html/publications/countermeasures.html>

³¹ AASHTO (2010). *Highway Safety Manual*, 1st edition. Washington, D.C.: American Association of State Highway and Transportation Officials. Available: <http://www.highwaysafetymanual.org/Pages/default.aspx>

³² NCHRP. (2009). *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan. NCHRP Report 500, Volume 23: A Guide for Reducing Speeding-Related Crashes*. Washington, DC: Transportation Research Board. Available: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v23.pdf

- ❖ Target Crash Reductions for Urban, Undivided, Multi-lane Roads - An estimated 28 severe crashes and 363 total crashes could be prevented, with an estimated crash cost savings of from \$5.4 to about \$6 million dollars (Table 8). (The reason for the differing assumptions for severe and total crashes is that speed-reducing measures often reduce more severe crashes to a greater degree than total crashes.)³³

Table 8. Target Crash Reductions for Urban, Undivided, Multi-lane Roads.

Crash Types/severity	Crashes targeted	% Crash reduction target	Five-year Crash Savings	Avg. Monetary costs (urban)	Five-year Crash-cost savings*
Total crashes	1788	20%	363	\$15,000 avg.	±\$5.38 million
KAB-severity	94	30%	28	F = \$1,600,000 A = \$85,000 B = 32,000	\$5.96 million

*It may be reasonable to include more years of savings if the countermeasures will have a longer useful life.

Countermeasures for Urban Two-lane Roads

The 11 priority corridors identified have a higher than average severity (more than 10 percent severe crashes) compared to all urban two-lanes (8 percent), and accounted for 6 percent of all severe crashes in the County.

Problem types for some of these roads were described in Chapter 2. Issues include roads that were not designed for an urban environment and vehicles speeding above limits (typically 35 mph). Over the longer term, as development continues on these streets, there is an increasing need to address the design issues. There is little separation of users such as provision of space to walk/bike or places to safely cross streets that are needed in developed areas. There tend to be few turn lanes, poor intersection configurations, sight distance issues, and inadequate lighting in some areas, among other potential issues.

Design and engineering countermeasures for these types of routes include (but are not limited to):

- Roundabout (or mini-roundabout) intersection designs.
- Gateway treatments at rural to urban transition areas.

³³ Assuming that crashes would remain at a similar level if the roads are untreated. Estimates controlling for regression toward the mean and traffic volumes, such as E.B. methods, may yield lower estimates of effect.

- Traffic calming measures (lateral or vertical shifts or narrowing/ curb extensions – creative design approaches may be needed).
- Chevron pavement markings or optical speed bars at gateway areas.
- Increase pavement friction and/or improve drainage to reduce wet surface-related crashes.³⁴
- Improved delineation or reconfiguring of some intersections (skewed, poor alignment, etc.).
- Turn lanes may be needed (more analysis required) at some locations.
- Pedestrian and bicycle facilities (space to walk or ride) and crossing treatments.
- Paved shoulders or pedestrian and bicycle facilities would also increase buffer zone to fixed objects.

As with urban, multi-lane roads, measures including enforcement and publicity may be needed to complement design and engineering improvements or to improve compliance when changes cannot be made to the roadway or street right away.

Table 9 describes countermeasures to treat speeding-related crash issues on urban, two-lane corridors. Again, measures that reduce travel speeds may be expected to have effects on reducing the occurrence of more severe crashes of all types. Problem diagnosis is required for each route to determine the specific issues and types of solutions needed, but consistent application of designs, signs, and markings for similar road and area types may help to improve driver recognition of appropriate speeds.

³⁴ NCHRP. (2004). *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan, Volume 12: A Guide for Reducing Collisions at Signalized Intersections, NCHRP Report 500, Volume 12*. Washington, D.C.: Transportation Research Board. Available at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v12.pdf

Table 9. Countermeasures and Crash Effects (CMFs) for Urban Two-lane Corridors. ³⁵

Table 9 Countermeasure/ Strategy - Urban Two-lane	CMF (with standard errors) CMF Crash Types	Issues Addressed	Links to More information
Conduct speed studies, limit review, and potentially implement changes to limits or speed zones.	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Rural to urban high to low-speed transition areas. ▪ Other speed zones that may not reflect area type and context. 	12
Gateway treatments	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Rural to urban high to low-speed transitions. 	36, 14
Repl. Stop-controlled Intersection with Roundabout (one-lane)	0.22 (0.07 s.e.) Injury	<ul style="list-style-type: none"> ▪ Skewed angle intersections; sight distance issues. ▪ Roadway drop-offs at intersecting roadways. 	18, 37
Repl. Signal-controlled intersections with Roundabouts (one-lane)	0.451 (0.115 u.s.e) Injury and Fatal	<ul style="list-style-type: none"> ▪ Poor delineation of skewed junctions. ▪ Angle collisions frequent. ▪ Intersection crashes – particularly those related to speeding (too fast or exc. limits). 	18, 19
Mini-roundabout	0.18 CMF (no s.e. estimate) (Alternatively, estimate CMFs)*	<ul style="list-style-type: none"> ▪ Skewed angle intersections. ▪ Intersection crashes. ▪ Speeding, running stop signs. ▪ Roadway drop-offs at intersecting roadways. ▪ Poor delineation. ▪ Angle collisions. ▪ Speeding on lower-volume and neighborhood streets. 	21, 27

³⁵ See *Speed Management Toolkit* for more crash modification factors (expected) by location type and crash type.

³⁶ Forbes, G. (2011). *Speed Reduction Techniques for Rural High-to-Low Speed Transitions, A Synthesis of Highway Practice. NCHRP Synthesis 412*, Washington, D.C.: Transportation Research Board. Available: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_412.pdf

³⁷ Srinivasan, R., et al. (2011), *Evaluation of Safety Strategies at Signalized Intersections, NCHRP Report 705*, Washington, D.C. Transportation Research Board.

Table 9 Countermeasure/ Strategy - Urban Two-lane	CMF (with standard errors) CMF Crash Types	Issues Addressed	Links to More information
Realign skewed intersections	See more information link.	<ul style="list-style-type: none"> ▪ Skewed angle intersections. 	20
Speed humps/tables/cushions	0.6 (0.16 a.s.e.) Serious, Minor injury (Or estimate CMFs) *	<ul style="list-style-type: none"> ▪ Drivers speeding – sight distance and other issues due to curves, intersections, and other. 	21, 27
Raised crosswalk	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Speeding through intersections. ▪ Need for slowing speeds for pedestrian crossing. 	21, 27
Lateral shift / chicane, Or Create consistently 'curvy' alignment	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Drivers speeding. ▪ Straight alignments that result in high inferred design speed; or straight alignments alternating with curvy alignments resulting in too high speed at curves. 	21, 27
Center median island	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Drivers speeding – wider roads. ▪ Need for pedestrian refuge. 	21, 27
Curb extension /Neckdown - midblock/section (consider innovative design where no curb exists)	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Curves on many (stop-controlled) T or Y-intersection approaches; curves or grades may also affect sight distance at numerous driveways in some sections. 	21, 27

Table 9 Countermeasure/ Strategy - Urban Two-lane	CMF (with standard errors) CMF Crash Types	Issues Addressed	Links to More information
Bulb-out - intersection	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> Speeding through intersections – pedestrian area. 	21, 27
Speed display/feedback devices	0.54 (0.17 a.s.e.) Total crashes – while in place (Or estimate CMFs) *	<ul style="list-style-type: none"> Drivers speeding inadvertently (grades/ misperception). 	38
Increase pavement friction	0.599 (0.082 s.e.) Total crashes	<ul style="list-style-type: none"> Wet surfaces/weather related “too fast” crashes. 	26
Chevron pavement markings, optical speed bars at gateways	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> Rural to urban high to low-speed transitions. 	21, 27
Sidewalks and bike lanes	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> Ditches and numerous fixed objects; frequent road departure crash types. No sidewalks, shoulders or other space for bikes or for pedestrians to walk (separation of users). 	
Enhance street lighting	Seek appropriate CMFs through the HSM , ³⁹ or CMF Clearinghouse ⁴⁰	<ul style="list-style-type: none"> Nighttime crashes (especially too fast). 	Lighting is not known to be a speed-reducing measure.

³⁸ Elvik, R., Hoye, A., Vaa, T., and Sørensen, M. (2009). *Handbook of Road Safety Measures*, Second Edition. Emerald Group Publishing: Bradford, GBr, 1137 pp.

³⁹ AASHTO (2010). Highway Safety Manual. 1st edition. Washington, D.C.: American Association of State Highway and Transportation Officials. Available: <http://www.highwaysafetymanual.org/Pages/default.aspx>

⁴⁰ Crash Modification Factors Clearinghouse. Federal Highway Administration. Website, managed by UNC Highway Safety Research Center. See <http://www.cmfclearinghouse.org/>

Table 9 Countermeasure/ Strategy - Urban Two-lane	CMF (with standard errors) CMF Crash Types	Issues Addressed	Links to More information
<ul style="list-style-type: none"> ▪ Improve enforcement and adjudication on high-crash corridors. ▪ Enforce closer to limit (especially if limits are changed). ▪ See other measures in Table 7 for Urban Multi-lane 	See references for information	<ul style="list-style-type: none"> ▪ Speeding above limits. ▪ Injury and speeding-related crashes. 	32, 41, 42

Table 10 shows target crash reductions for treatment of the top 11 urban two-lane roads. If suitable combinations of treatments are implemented to reduce total crashes by an average of 20 percent, and severe crashes by an average of 30 percent for the top 11 priority corridors, the following crash savings may be obtained:

- ❖ **Target Crash Reductions for Urban Two-lane Roads** - An estimated savings of 19 severe (fatal, disabling, and evident injury) crashes and 97 total crashes, at a potential crash cost savings of around \$1 million may be realized (
- ❖
- ❖
- ❖ Table 10).⁴³

⁴¹ *Ibid.*

⁴² Preusser, D.F., Williams, A.F., Nichols, J.L., Tison, J., and Chaudhary, N.K. (2008). *Effectiveness of Behavioral Highway Safety Countermeasures*. NCHRP Report 622, Washington, D.C: Transportation Research Board. Available: http://www.nap.edu/openbook.php?record_id=14195

⁴³ Again, the assumption is that crashes would remain at a similar level if the roads are untreated. Estimates controlling for regression toward the mean and traffic volumes, such as E.B. methods were not used since volume data were not uniformly available. Estimates of expected effects (CMFs) may also need to be locally adjusted.

Table 10. Target Crash Reductions for Treatment of 11 Urban Two-lane Roads.

Crash Type / Severity	Crashes targeted	% Crash reduction target	Five-year Crash Savings	Avg. Monetary costs (urban)	Potential Five-year Crash-cost savings*
Total crashes	485	20%	97	\$15,000 avg.	± \$319,000
KAB-severity	63	30%	19	F = \$1,600,000 Injury= \$23,000 (this estimate is on the low side since includes A,B, and C-type)	\$1.06 million to \$1.45 million

*It may be reasonable to include more years of savings if the countermeasures will have a longer useful life.

±Since these routes were identified for having higher rates of injury crashes, the total crash estimate may over-estimate potential impacts due to potential regression toward the mean effect.

Countermeasures for Rural Two-Lane Roads

The 18 rural two-lane routes prioritized for review (Table 25) have an average of 14.1 percent severe crashes compared to 12.7 percent for all rural two lanes and accounted for 13 percent of all the County’s severe crashes.

Calming speeds on rural, two-lane roads is a significant challenge, given the many miles of roadway and the relatively widely dispersed nature of the problem. Since only routes with the most severe crash histories and higher traffic volumes are likely to be treated with engineering countermeasures in any given year, a community-based enforcement campaign may be an essential ingredient of a comprehensive approach to reduce speeding-related crashes on rural roads.

Design and engineering Countermeasures for rural two-lane routes and their intersections include (but are not limited to):

- Replaced stop-controlled intersection with one-lane roundabout / mini-roundabout.
- Replace signal-controlled intersection with one-lane roundabout.
- Lane narrowing treatments (transverse in-lane rumble strips and painted median) on major road approaches to intersections with smaller, two-lane, stop-controlled roads. Narrowing treatment may be warranted on the larger roads to slow drivers on the main road, uncontrolled approaches – especially where speeding and sight distance issues may be present. As already mentioned, roundabouts or mini-roundabout are another more effective, but also more costly approach to managing speeds and reducing severe crashes at intersections.
- Lateral shift/chicane or lane narrowing treatments at high to lower-speed transition areas (such as near residential areas, schools).
- Wider lane lines (NC experimental; assess effects on travel speeds).
- Safety edge treatment (to mitigate, improve recovery of road departures).
- Other treatments intended to reduce or mitigate road departure, nighttime, or curve-related crashes such as rumble strips, improved curve delineation, warning signs, and

barriers as appropriate. Implement NC has a roadway departure plan for systematic implementation of countermeasures to reduce road departure crashes on road sections or curves meeting the screening criteria. However, few rural two-lane roads may meet the current criteria, so supplemental enforcement and speed-reducing countermeasures may be needed.

- Spot treatments such as systematic addition of paved shoulder width and edge treatments on and near curves may be a further approach to complement other systematic improvements that may be implemented through the Roadway Departure (crash reduction) Plan. Such an approach may be implemented more widely than corridor-long shoulder improvements, and may have the added advantage of not leading to higher speeds that could occur if shoulders were widened for an entire corridor. However, crash modification factors and speed effects for this type of addition of shoulder width seem to be unavailable (evaluation need).
- Consider lowering speed limits and enhancing speed enforcement for routes or sections with multiple curves, curves/grades, or other issues that cannot be sufficiently treated through a spot safety approach.
- Other implementations such as improving shoulders without widening pavement, visually narrowing the road by eliminating the centerline (low-volume roads) or other experimental treatments may help to slow speeds.
- Considering traffic volumes and other factors (e.g. importance as transportation corridors, bicycle routes, change in development or traffic patterns), some of the routes may warrant inclusion in capital improvement projects for significant upgrades and re-design such as flattening curves, adding or improving paved shoulders with sufficient space for pedestrians and bicyclists, adding sidepaths, or other treatments. The effects on travel speed of such upgrades are, however, unknown. The [Interactive Highway Safety Design Model](#) may be used to estimate safety performance of alternate designs.⁴⁴

Again, speed enforcement and publicity measures are needed to supplement engineering treatments. It may be possible to target a larger number of rural routes that have higher than average frequencies of severe and speeding-related crashes for supplemental, high-visibility enforcement. The goal is to deter speeders, so using publicity or other means to enhance effectiveness is essential.

Table 11 describes countermeasures to treat speeding-related crash problems on rural two-lane corridors, along with some of the problem types treated by each countermeasure.

⁴⁴ Interactive Highway Safety Design Model (IHSDM). Available at <http://www.fhwa.dot.gov/research/tfhrc/projects/safety/comprehensive/ihsdm/>

Table 11. Countermeasures and Crash Effects (CMFs) for Rural, Two-Lane Corridors.

Table 11 Countermeasure/ Strategy - Rural Two-lane	CMFs (with std. errors)	Problem Types treated	Links to More information
Conduct speed studies, limit review, and potentially implement changes to limits or speed zones.	No CMFs available	<ul style="list-style-type: none"> ▪ High to low-speed transition areas (such as schools or neighborhoods). ▪ Other speed zones that may not reflect area type and context. ▪ Many curves, and curve/grade –related sight-distance issues, narrow lanes, poor shoulders. 	12
Repl. Stop-controlled Intersection with Roundabout (one-lane)	0.13 (0.03 s.e.) Injury crashes	<ul style="list-style-type: none"> ▪ 21% of the most severe rural crashes occurred at intersections. ▪ Speeding along the corridor. 	18, 37
Repl. Signal-controlled intersections with Roundabouts (one-lane)	0.259 (0.066 u.s.e) Injury and Fatal (estimate from suburban locations)	<ul style="list-style-type: none"> ▪ 21% of the most severe rural crashes occurred at intersections. ▪ Speeding along the corridor. 	18, 19
Mini-roundabout	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ 21% of the most severe rural crashes occurred at intersections. 	21
Transverse (in lane) rumble strips on minor-leg, stop-controlled intersection approaches, 3 and 4 leg, intersections	0.785 (0.107 u.s.e) - KAB-severity per intersection per year	<ul style="list-style-type: none"> ▪ 21% of the most severe rural crashes occurred at intersections. ▪ Speeding along the corridor. 	45 Use in areas where noise is not a concern; high stop-sign running crashes might be an indication (FHWA).

⁴⁵ Srinivasan, R., Baek, J., and Council, F., "Safety Evaluation of Transverse Rumble Strips on Approaches to Stop-Controlled Intersections in Rural Areas." Presented at the 89th Annual Meeting of the Transportation Research Board, Washington, D.C., (2010)

Table 11 Countermeasure/ Strategy - Rural Two-lane	CMFs (with std. errors)	Problem Types treated	Links to More information
Reduce lane width using longitudinal rumble strips and painted median (major approaches)	0.8 (no s.e.)	<ul style="list-style-type: none"> ▪ 21% of the most severe rural crashes occurred at intersections. ▪ Speeding along the corridor. 	46
Speed humps/tables/cushions	0.6 (0.16 a.s.e.) Serious and Minor Injury (Alternatively, estimate CMFs)*	<ul style="list-style-type: none"> ▪ Developed or other areas (school zones, etc.) where significant measures are needed to reduce speeds. 	21, 27
Lateral shift / chicane (consider for use at end of transitions areas such as near residential areas or town limits)	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Developed or other areas (school zones, etc.) where significant measures are needed to reduce speeds. 	21, 27
Other type of pinch point or narrowing design	No CMFs available (Estimate CMFs)*	<ul style="list-style-type: none"> ▪ Need to slow speeds along a corridor. 	21, 27
Shoulder rumble strips	0.71 (0.09 s.e.) Injury and Fatal	<ul style="list-style-type: none"> ▪ Road departure crash types. ▪ Poor shoulders, little recovery opportunity. 	Effects on speed unknown. Noise considerations in developed areas. Consult NC Road Departure Plan.

⁴⁶ FHWA (2010). Crash Impact of Smooth Lane Narrowing with Rumble Strips at Two-Lane Rural Stop-Controlled Intersections. FHWA Tech Brief. Available: <http://www.fhwa.dot.gov/publications/research/safety/10047/index.cfm>

Table 11 Countermeasure/ Strategy - Rural Two-lane	CMFs (with std. errors)	Problem Types treated	Links to More information
Centerline rumble strips	0.88 (0.03 s.e.) Injury and Fatal	<ul style="list-style-type: none"> ▪ Sections where crossing center-line crash types are a problem (need further analysis). 	Effects on speed unknown. Noise considerations in developed areas. Consult NC Road Departure Plan. ⁴⁷
Routinely Implement Safety edge with resurfacing	0.943 (0.057 u.s.e) All Severities	<ul style="list-style-type: none"> ▪ Road departure crash types. ▪ Poor shoulders, little recovery opportunity. 	Not a speed-reducing measure
Wider lane lines (6" instead of 4")	0.702 ⁴⁸ (no s.e.) Fatal, Serious, and Minor Injury	<ul style="list-style-type: none"> ▪ Edge lines may not show up well in adverse weather or at night. ▪ 42% of SR crashes and 48% of severe crashes at night on rural roads. 	Not known to be a speed-reducing measure. Ensure that the measure does not increase speeds. NC DOT is presently evaluating the treatment in some NC counties.

⁴⁷ The Safety Edge Pavement Treatment (FHWA website). See http://safety.fhwa.dot.gov/roadway_dept/pavement/safedge/brochure/

⁴⁸ "Users of this CMF should be aware that some TRB reviewers expressed concern that the magnitude of safety effect shown by the CMFs from this study is larger than would be intuitive based on knowledge of the countermeasure." (CMF Clearinghouse)

Table 11 Countermeasure/ Strategy - Rural Two-lane	CMFs (with std. errors)	Problem Types treated	Links to More information
Increase pavement friction	Thus far, not found effective for rural, 2-lane	<ul style="list-style-type: none"> ▪ Wet weather, “too fast” crashes. 	49
Improve lighting at key locations such as intersections with a high frequency of nighttime, severe or speeding-related crashes.		<ul style="list-style-type: none"> ▪ 42% of SR crashes and 48% of severe crashes occurred at night on rural roads. 	
<ul style="list-style-type: none"> ▫ Lower the speed limit corridor-wide and enforce. ▫ Lower limit in speed zones and enforce. ▫ Add paved shoulders near curves and grades to provide space for bicyclists and pedestrians and to reduce run-off-road at these locations. 	No CMFs available	<ul style="list-style-type: none"> ▪ Narrow lanes, poor shoulders, fixed objects near the roadway, and little recovery opportunity. ▪ Many curves. ▪ Roads do not meet 55 design standards; many features requiring lower speeds. ▪ Sight distance issues at intersections, driveways, etc. due to ext. curve and curve/grade combinations. ▪ No space for pedestrians or bicycles – especially problematic where sight distance is compromised (curves/grades). 	
Randomly target high visibility enforcement to larger proportion of high crash corridors	0.69 (no s.e.) Fatal crashes 0.87 (no s.e.) Injury crashes	<ul style="list-style-type: none"> ▪ Widespread speeding and related crashes. ▪ Resource limitations; need for sustainable program. ▪ Need for supplemental enforcement and deterrence on high crash corridors. 	30
Publicity related to enforcement	Estimate for urban area	<ul style="list-style-type: none"> ▪ Speeding and related crashes. ▪ Need for supplemental enforcement and deterrence. 	30

⁴⁹ Harkey, D.L., et al. (2008). *Accident Modification Factors for Traffic Engineering and ITS Improvements*. NCHRP Report 617. Washington, D.C.: Transportation Research Board.

Table 12 shows target crash reductions for treatment of priority rural, two-lane roads. Implementing treatments for the top 18 priority corridors that average 30 percent reductions in severe crashes and 20 percent reductions in total crashes, the following crash and cost savings may be realized:

- ❖ **Target Crash Reductions for Rural, Two-lane Roads** – An estimated savings of 66 severe crashes and 235 total crashes would be equivalent to crash cost savings of from \$6 million to \$10 million (Table 12).

Table 12. Target Crash Reductions for a Priority List of Rural, Two-lane Roads.

Crash Type / Severity	Crashes targeted	% Crash reduction target	Five-year Crash Savings	Avg. Monetary costs (rural)	Potential Five-year Crash-cost savings*
All Crashes	1438	20%	235	\$27,000	\$6,345,000
K	17	30%	5	\$1,700,000	\$8,500,000
AB	187	30%	61	\$31,000	\$1,891,000
KAB	204				\$10,391,000

Systematic Speed Management Approach within Other Safety Programs

Roadway Departure and Curves

While roadway departure crashes occur at a variety of locations, many road departures occur at curves, particularly on rural routes. Sections with at least three severe curve-related crashes or nine or more total curve-related crashes were identified (bolded route numbers in Table 27 and Table 28 in the Appendices). These sections could be priorities for speed limit and safety review for the section or corridor to determine whether speed-reducing measures or engineering countermeasures outlined in the North Carolina Road Departure (Safety) Plan are appropriate.

The Roadway Departure Plan recommends systematic, progressive treatment packages of the following measures to address increasing appropriate crash thresholds:

- Centerline Rumble Strips To Reduce Head-On and Opposing-Flow Sideswipe Crashes.
- Edge and Shoulder Rumble Strips To Reduce Road Departure Crashes.
- Alignment Delineation To Reduce Night Road Departure Crashes.
- Select Tree Removal in Rural Areas To Reduce Future Tree Crash Occurrences.

It is not at present clear whether many of the curves or road sections in Randolph County will meet the volume and other warrants for systematic treatment under the North Carolina Road Departure Plan. There may be opportunities to broaden the application to treat some sections and curves with greater than expected severe crashes that meet geometric and other risk considerations, if not precise crash thresholds delineated in the Road Departure Plan.

There is also a need to determine how speed managing measures may complement the Road Departure treatment plans. Since many of the lower-volume roads and locations may not meet

warrants for treatment under the Roadway Departure Plan, speed management measurements should be considered to reduce risk of serious crashes. Further diagnosis, including speed limit review, should be performed to determine whether limits are appropriate. In some cases, there may be a need for speed zoning of particular sections or even for corridor-wide adjustment of speed limits to send a more consistent message to drivers about appropriate speeds. Enforcement improvements may be among the countermeasures needed.

Pedestrian Plans, School Zones

Speeding in neighborhoods and school zones is a significant concern for most communities due to the vulnerability of pedestrians, bicyclists, children, and senior citizens. A systematic speed management approach can also be used help select appropriate countermeasures to address speeding issues near schools or on local streets.

Table 26 in [Appendix B](#) ranks Randolph County schools according to severe and speeding-related crashes within one mile of school properties. Pedestrian plans and areas of concern mentioned in public input processes should also be consulted for areas where speed and safety reviews may be needed.

Highway Safety Improvement Program (HSIP)

In addition to focusing on the corridors identified through network screening as having potential speeding and safety issues, sections and intersections identified through the HSIP (spot safety program) could be subjected to similar systematic diagnosis and review for potential speeding-related safety issues. Speeding has not been included in the State's screening process up to now, but may be contributing to crash occurrence or crash severity at the problem locations. Measurement of the problem should incorporate conducting speed studies.

The following chapter describes an Action Plan to prioritize and implement selected strategies and countermeasures from the foregoing systematic, proactive, and comprehensive approaches and to sustain an effective program.

Chapter 4. Multi-year Implementation Plan

Speeding is a complex issue and problem that interacts with varied human cultural, economic and political, environmental, and roadway issues. This chapter describes a Plan of Action Items to enable the State and County stakeholders to arrive at locally-acceptable solutions to reduce speeding, crashes, and serious injuries and to sustain a cooperative approach to speed management. Commitment to the process and consideration of varied points of view by all partners is essential to success. The sections following the Action Items outline more details for ranking and selecting specific countermeasures, and for implementing, evaluating and renewing the Plan.

Detailed Proposed Implementation Actions

This section outlines speed management actions the county, NCDOT, injury prevention, and other partners can take to reduce serious injury crashes. Tables 13 through 18 outline six Action Items for the County, State, and City partners to implement. The issues that could be addressed by the strategies and countermeasures within each of the below action items were detailed in Chapter 3. This list was developed with input from stakeholders, and describes organizational roles and potential strategies or countermeasures that may be implemented under each Action Item. Further implementation steps for the systematic treatment approach (Action Items 4 and 6) follow Action Item 4 (Table 16).

Table 13. Action Item 1 - Speed Limit Setting.

<p>Action Item 1</p>	<p>Develop a County Council/task force to engage on speed limit setting and safety, coordination of design and enforcement for existing roads, and to work toward a consistent limit setting process and outcomes throughout the County. (Proactive)</p>
<p>Leadership:</p>	<p>Injury prevention (e.g. County Public Health Dept.) and NCDOT Safety and Mobility</p>
<p>Others needed:</p>	<p>NCDOT Division and District Office, NCDOT Safety and Mobility Office, local government representatives (elected officials), NCDOT Communications Office (pos.)</p>
<p>Schedule:</p>	<p>5 – 8 years</p>
<p>Strategies (Comprehensive and Proactive):</p>	<ul style="list-style-type: none"> ▪ Set appropriate speed limits for the roadway design, context, and users to improve safety, enforceability and credibility of speed limits on new and existing roads. <ul style="list-style-type: none"> - Develop a collaborative speed limit setting process with local governments and law enforcement. Seek public input about safe and appropriate speeds. - Involve elected officials and other stakeholders. ▪ Consider using NCDOT’s Complete Streets guidelines (NCDOT, 2012) and collaborative processes to guide implementation and design (e.g. determine road types and target operating speeds/speed limits, and appropriate design). ▪ Consider using fewer different speed limits, for example 25, 35, and 45 mph in urban areas to help improve driver comprehension.
<p>Implementation steps</p>	<ol style="list-style-type: none"> 1. Recruit appropriate stakeholder representatives to task force. 2. Schedule first meeting. 3. Set future meeting schedule and agenda. 4. Coordinate with Action Item Planning Groups 2 and 3 (potentially others) 5. Set goals. 6. Determine strategies and processes. 7. Implement strategies and processes. 8. Document outcomes.

Table 14. Action Item 2 - Build Support through Communications and Publicity.

<p>Action Item 2</p>	<p>Frame the Speeding and Safety Problem through a Public Information and Education Program to build support for effective policies and comprehensive strategies, to seek funding, and to improve effectiveness of enforcement and engineering countermeasures. (Comprehensive approach)</p>
<p>Lead:</p>	<p>Injury prevention (e.g. County Public Health Dept.)</p>
<p>Others needed:</p>	<p>NCDOT Communications Office, NCDOT Communications Office, DA's office, Law Enforcement (communications), Local government representatives (elected officials), NC DOT Safety and Mobility Office (pos.)</p>
<p>Timeline:</p>	<p>5 – 8 years</p>
<p>Strategies: (Comprehensive)</p>	<ul style="list-style-type: none"> ▪ Ensure that speed limits, including statutory maximums, are well-communicated to drivers. ▪ Improve and increase communications about the safety reasons for effective policies and strategies, to improve public and political support. ▪ Seek additional funding to increase enforcement in rural and urban areas. ▪ Increase visibility/conspicuity of enforcement to enhance deterrent effects. ▪ Work toward gaining State authority to utilize automated (photo) speed enforcement as an enforcement tool. ▪ Draw on local creativity and resources (schools, businesses, partners such as Community Transportation Partners) to support and develop locally-tailored education, awareness, and enforcement strategies to enhance speed-deterrent effects of enforcement programs and potentially to target some of the top crash issues (rural, curves, nighttime).
<p>Implementation steps</p>	<ol style="list-style-type: none"> 1. Recruit appropriate stakeholder partners for communications task force. 2. Schedule first meeting. 3. Set future meeting schedule and agenda. 4. Coordinate with Action Item Planning Group 1. 5. Set goals. 6. Determine strategies and programs. 7. Implement strategies and programs. 8. Document outcomes.

Table 15. Action Item 3 - Develop Proactive Speed and Safety Review Process for New Roads.

<p>Action Item 3</p>	<p>Develop an inter-agency speed and safety review process to assess plans, designs, and built roads/upgrade projects to ensure that new projects meet sound speed management design and safety principles for the area land uses and intended purposes of the road. (Proactive)</p>
<p>Lead:</p>	<p>Piedmont Triad Regional Council-Transportation Advisory Commission</p>
<p>Others needed:</p>	<p>NCDOT: Transportation Planning Branch, Division, Roadway Design, Safety and Mobility, Bicycle and Pedestrian Division County and local planning staff; elected officials; Law enforcement representatives</p>
<p>Timeline:</p>	<p>5 years</p>
<p>Work underway</p>	<ul style="list-style-type: none"> ▪ NC DOT has adopted a Complete Streets Policy (and encourages local governments to pursue Complete Streets) and has developed design guidelines for implementation that could be used as a framework for speed limit setting and review in a proactive manner. ▪ County Comprehensive Transportation Plan is under development.
<p>Strategies: (Proactive)</p>	<ul style="list-style-type: none"> ▪ Coordinate with transportation and land use plans in setting limits and designing roads. ▪ Set or revise speed limits early in the new project planning process to provide adequate safety for the land use, road type, and users expected, and to determine appropriate design. (Use the NCDOT Complete Streets approach (NCDOT, 2012) as a possible implementation framework and for design guidance.) ▪ Conduct design, construction, and implementation reviews of all new and pending projects, including maintenance and operations projects to ensure that: <ul style="list-style-type: none"> - Design is matched to elicit speeds close to the intended speed limit (self-enforcing). - Operations features are coordinated with target speeds. - Facilities are provided to separate different weight and speed of users in time and space on roads with intended speeds much above 25-30 mph. ▪ Prioritize designs in new projects that manage speeds such as narrower and fewer lanes, roundabout intersection designs, tight turn radii at intersections, and shifts in travel ways (context-dependent).
<p>Implementation steps</p>	<ol style="list-style-type: none"> 1. Recruit appropriate stakeholder partners for communications task force. 2. Schedule first meeting. 3. Set future meeting schedule and agenda. 4. Coordinate with Action Item Planning Group 1. 5. Set goals. 6. Determine strategies and programs. 7. Implement strategies and programs. 8. Document outcomes.

Table 16. Action Item 4 - Develop Systematic Screening and Prioritization Process.

Action Item 4	Review existing speed limits, conduct additional diagnosis, and develop treatment plans for prioritized lists of problem corridors. (Systematic approach)
Lead:	Leadership: NCDOT Safety and Mobility Regional Field Unit
Others needed:	NCDOT Division, Municipal staffs and decision-makers, Regional Planning Organizations, Municipal Planning Organizations, local law enforcement/law enforcement liaison, elected officials, courts officials
Timeline:	5 years
Work Underway:	Road Safety team visited a number of problem corridors and began diagnosis. RSA report summarizes findings and recommendations.
Strategies (Systematic):	<ul style="list-style-type: none"> ▪ Conduct speed and engineering studies and additional diagnosis steps as per all safety programs, and described in next section. ▪ Consider an injury minimization approach to speed limit setting. ▪ Utilize the US Limits tool for expert guidance in speed limit setting for speed zones. ▪ Consider whether statutory maximum limits are appropriate for entire corridors or whether entire corridors or portions of corridors should be changed. ▪ Identify alternate, feasible countermeasures from lists in Table 7, Table 9, Table 11, and other sources.
Implementation steps	<ol style="list-style-type: none"> 1. Recruit appropriate stakeholder partners for task force. 2. Schedule first meeting. 3. Prioritize corridors for further diagnosis. 4. Establish diagnosis procedures – for example determine if independent RSA teams will be used to conduct audits. 5. *See “Selection and Ranking of Countermeasures” and other steps following Action Items. 6. Coordinate with planning group for Item 3.

***Action Item 4 - Step 5. Selection and Ranking of Countermeasures**

Detailed steps for Selection and Ranking of Countermeasures for Action item 4, (systematic diagnosis and treatment of existing problems) include:

- 5.1 In coordination with other owners/stakeholders: Finalize priority list of routes or areas for speed and safety review. The lists for different corridor types and area types (sections and intersections in the HSIP list, Road Departure Plan and others) could be coordinated with or even combined into one prioritization list if appropriate. In addition, more routes may be added if some on the lists have already been treated or upgrades are pending.
- 5.2 Diagnose the problem for each corridor or focus area.
 - a. Along with speed and engineering studies, diagnosis may involve conducting Roadway Safety Audits s in cooperation with local government and law

- enforcement, conducting speed studies and other engineering assessments. Consider hiring independent audit teams to conduct RSAs.
 - b. Determine the area (land use) and roadway context (purposes and users of the road, what types of conflicts and crashes may occur based on existing design).
 - c. If changing the limit is an option, determine what speed limit should be set based on the roadway context, types of conflicts and crashes that may occur (injury/fatality risk).
 - d. Assess credibility of the speed limit to drivers.
- 5.3 Again, in collaboration with other stakeholders, determine appropriate speed limit and whether changes in the limit for the corridor are warranted based on safety concerns, the environmental context, and considering enforcement and other concerns regarding speed limit credibility. Coordinate with local agency representatives.
- a. Assess rural to urban transition areas or other speed zone changes if relevant.
- 5.4 Complete diagnosis and identify alternate countermeasures. If the recommendation is to change speed limits, consult and coordinate with local governments, stakeholders groups, law enforcement, judiciary and educators to implement.
- a. Determine what design and engineering changes can be made to the roadway to improve credibility of the limit, and bring operating speeds more in line with desired limits (self-enforcing designs), reduce speed variance, or achieve other speed management objectives.
 - b. Determine what other engineering safety improvements are needed.
 - c. Determine whether enforcement enhancements are needed to increase compliance with limits (including any changed limits).
- 5.5 Conduct **feasibility assessments** on alternate measures.
- 5.6 Finalize the list of feasible countermeasures for the corridor or area. Combinations of multiple countermeasures may be needed.
- 5.7 Identify funding sources and levels and perform **economic assessments** for alternate, feasible treatment options and priorities within each program/funding area.
- 5.8 Identify the most appropriate set of countermeasures for each corridor or location.

These steps are discussed in Chapters 5, 6, 7, and 8 of the recently published the *Highway Safety Manual (HSM)*. Error! Bookmark not defined.

Step 5.5 Feasibility Assessments. The intent of a feasibility assessment is to consider how likely the measure is to be implemented, and implemented well, taking financial and non-financial constraints and issues into consideration. This is also a time to consider opportunities exist to facilitate implementation. Some of the considerations may include:

- Barriers to implementation, local acceptability.
- Funding sources available.
- Current and future land uses along and near the corridor.
- Lifespan of the project.

- Applicability to multiple locations or need for consistent application of low-cost signs, markings, and design elements to improve driver comprehension and acceptance of limits.
- Potential for long-term improvement of compliance with speed limits (self-enforcing designs).
- Need for additional enforcement to supplement engineering measures.

Stakeholders may conduct feasibility assessment early in the Plan implementation process. For example, Plan implementers could select countermeasures and strategies that might be applied on a widespread basis to improve driver perceptions of appropriate speeds to drive on different types of roads. Such measures could then receive priority.

Step 5.7 Economic Assessments. The intent of the economic analysis is to compare the benefits and costs of alternative countermeasures using the most appropriate estimates of expected safety effects available, once the problems and feasible alternate solutions have been identified. Chapter 7 of the [HSM](#) has a detailed discussion on how economic assessments can be conducted. Appendix D shows some examples using simplified assumptions (that future crashes will be the same as current crashes, barring any treatment).

Each funding source should be considered separately in order to maximize the effectiveness of each program area. Other economic considerations include the ability to utilize planned maintenance or operations projects to restripe or make other speed management design or engineering improvements. Non-traditional funding sources may also be available to implement some types of improvements or programs.

Finally, the systematic approach may be strengthened by considering overall objectives of the program and whether systematic application of similar measures to similar locations (if appropriate, based on individual diagnosis) may increase effectiveness of certain types of measures – for example, those that aim toward improving self-enforcing, self-explaining roadways. Thus, measures for individual locations should not perhaps be considered in isolation but as part of an overall approach. Linkage of the systematic approach with proactive strategies and decisions may be important.

Implementation Steps following Project Approval

Once treatment locations and countermeasures are approved, the following process steps should be performed:

- 6.1 Design project(s) and allocate appropriate funding sources and/or pursue grants or private funding.
- 6.2 Develop implementation schedule, assign tasks.
- 6.3 Finalize safety targets or other goals.
- 6.4 Identify measures of effectiveness and develop evaluation plan.
- 6.5 Implement and complete evaluation.
- 6.6 Communicate results to decision-makers and the public.

More details of these and other implementation processes are described in the NCHRP Guide for Reducing Speeding-Related Crashes, Section VI.³²

Table 17. Action Item 5 - Develop a Corridor-focused Targeted Enforcement Program.

Action Item 5	Develop a corridor focused, high visibility enforcement and adjudication effort. (Systematic process and Comprehensive treatment)
Lead:	State Highway Patrol and NCDOT Safety and Mobility
Others needed:	Injury Prevention (Communications experts), local law enforcement, elected officials, courts officials
Timeline:	1 - 2 years
Strategies: (Comprehensive)	<ul style="list-style-type: none"> ▪ Randomly target enforcement to a larger number of select corridors with high frequencies and proportions of severe crashes. ▪ Coordinate with engineering (Action Item 4) to enforce high crash roads where changes cannot be implemented right away. ▪ Tighten adjudication of citations on targeted corridors and publicize the effort to maximize deterrent effects. ▪ Enhance deterrent effects of any type of speed enforcement program with publicity.
Implementation steps	<ol style="list-style-type: none"> 1. Recruit appropriate stakeholder partners for task force. 2. Schedule first meeting. 3. Set future meeting schedule and agenda. 4. Coordinate with Action Item Planning Groups 1 and 4. 5. Set goals. 6. Determine strategies, policies, and procedures and implementation needs. 7. Implement strategies and programs. 8. Document outcomes.

Table 18. Action Item 6 - Implement Speed and Safety Review through Other Safety Plans and Programs.

Action Item 6	Implement speed and safety reviews within the HSIP program, within the NCDOT Roadway Departure Plan and with any Pedestrian Safety Plans developed in future. (Systematic approach).
Lead:	NCDOT Safety and Mobility
Involved:	Law enforcement agencies, NCDOT Division engineers, Local agency staff
Schedule:	3 – 5 years; longer term
Work underway:	<ul style="list-style-type: none"> ▪ Roadway Departure Implementation Plan (NCDOT, 2009) ▪ HSIP priority intersection and section lists (NCDOT, 2012) ▪ Intersections with Pedestrian Safety issues (Asheboro)
Strategies (Systematic)	<ul style="list-style-type: none"> ▪ Incorporate routine diagnosis of speeding issues into the HSIP program, Pedestrian and Bicycle safety programs, and the NC Roadway Departure Safety Plan implementation program. ▪ Assess whether corridor-level speed management issues are contributing to spot safety problems.
Implementation Steps	<ol style="list-style-type: none"> 1. Identify existing and needed opportunities for coordination. 2. Schedule meetings as needed or piggy-back on existing 3. Identify needs including but not limited to: <ol style="list-style-type: none"> a. Speed studies. b. Data and project plan sharing. c. Law enforcement assistance for particular corridors or areas. d. Innovative strategies. e. Research/evaluation needs.

Evaluation Plan

Since the goals of the plan are to reduce fatal and injury crashes and to improve speed compliance, the primary measures of program effectiveness are safety measures:

- Changes in crash frequency and severity and changes in speeding-related crashes.
- Changes in operating speed distributions (average speed, 85th percentile speed, percentage of speeders X miles above limit).

The program will be evaluated with respect to changes in crashes, especially more severe crashes and speeding-related crashes compared with trends absent the program. Speed measurements provide earlier feedback than crash trends and are a good indicator of safety risk. See more about Safety Effectiveness Measures below.

Other measures are essential to provide and additional support for program effectiveness and knowledge to help sustain program efforts. These include:

- The type, number and locations of treatments implemented.

- Other program processes instituted, policies adopted or other institutional change.

Table 33 in Appendix D provides a Program Evaluation Matrix that describes these and other potential measures of effectiveness.

Safety effectiveness measures. Speed measurements will be performed at baseline (before any countermeasures are implemented) and used throughout the Plan Implementation period to track progress and provide early indications of safety effects. Speed measurements may include:

- On-going speed monitoring of a representative sample of the roads covered by the Plan.
- Speed measurements, taken before and after countermeasures are implemented on specific corridors.

The timing of crash-based evaluations will depend on when and how many measures are implemented, and the availability of sufficient years and number of crashes for evaluation. Additional technical assistance is available to help determine appropriate evaluation methods to control for other trends and safety programs.

Countermeasures evaluation. It may be important to evaluate specific countermeasures to provide additional information about program effects. More information about safety evaluation of countermeasures is included in Appendix D. Table 34 in Appendix D is a matrix with potential measures of effectiveness for individual countermeasures or comprehensive strategies.

Plan evaluation. At the end of the implementation period, perform an assessment of whether the crash reduction targets and speed compliance goals of the overall Plan were met. Communicate results to decision-makers and the public, and use results to help develop ambitious targets for an updated Plan.

Consult with the technical assistance team if help is needed in developing appropriate measures of effectiveness and evaluation protocols.

Action Plan Update

The plan will be a working document, with additional implementation actions, schedules, and other updates incorporated as needed during the five-year plan period.

At the end of five years, following plan evaluation, update the plan incorporating lessons learned from the evaluation and implementation experiences, as well as from an updated problem assessment process.

Additional References

AASHTO (2010). *Highway Safety Manual, 1st edition*. American Association of State Highway and Transportation Officials: Washington, D.C.

Child Fatality Task Force (2012). Teen Road Safety in North Carolina: Putting Best Practice into Action. <http://www.ncleg.net/DocumentSites/Committees/NCCFTF/Reports and Data/Teen Road Safety, Dec 2012.pdf>

Countermeasures That Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices. (2011). 6th ed., Publication no. DOT HS 811 444, Washington, D.C.: NHTSA.

Crash Modification Factors Clearinghouse. U.S. Department of Transportation, Federal Highway Administration. <http://www.cmfclearinghouse.org/>

Donnell, E.T., Himes, S.C., Mahoney, K. M., and Porter, R.J. (2009). Understanding speed concepts: Key definitions and case study examples. *Transportation Research Record* 2120: 3-11.

Donnell, E.T., Hines, S.C., Mahoney, K.M., Porter, R.J., McGee, H. (2009). *Speed Concepts: Informational Guide*. Report No. FHWA-SA-10-001, Washington, D.C.: Office of Safety, Federal Highway Administration.

Eccles, K.A., R. Fiedler, B. Persaud, C. Lyon, and G. Hansen (2012). *Automated Enforcement for Speeding and Red Light Running. NCHRP Report 729*, Washington, D.C.: Transportation Research Board.

Elvik, R., Høy, A., Vaa, T., and Sørensen, M. (2009). *Handbook of Road Safety Measures, Second Edition*. Emerald Group Publishing: Bradford, GB, 1137 pp.

Engineering Countermeasures for Reducing Speeds (2009): A Desktop Reference of Potential Effectiveness. FHWA Office of Safety website. http://safety.fhwa.dot.gov/speedmgt/ref_mats/eng_count/

FHWA (2008). Guidance Memorandum on Consideration and Implementation of Proven Safety Countermeasures; <http://safety.fhwa.dot.gov/policy/memo071008/>

FHWA. (n.d.) Interactive Highway Safety Design Model (IHSDM). <http://www.fhwa.dot.gov/research/tfhrc/projects/safety/comprehensive/ihsdm/>

FHWA (n.d.). Roadway Safety Audits. Webpage and resources. <http://safety.fhwa.dot.gov/rsa/>

FHWA. (n.d.). Speed Management Safety. Webpage and resources. <http://safety.fhwa.dot.gov/speedmgt/>

Forbes, G.J., T. Gardner, H. McGee, R. Srinivasan, Ph.D. (2012) *Methods and Practices for Setting Speed Limits: An Informational Report*. Washington, D.C.: Federal Highway Administration, Office of Safety.

Hauer, E. (2010). Lessons learned from other countries. White Papers for “Toward Zero Deaths: A National Strategy on Highway Safety,” White Paper No. 9.

http://safety.transportation.org/doc/web9_Lessons_Learned_White_Paper.pdf

Managing Speed: Review of current practice for setting and enforcing speed limits. (1998). Committee for Guidance on Setting and Enforcing Speed Limits, Transportation Research Board, Special Report 254, National Research Council. Washington, D.C., National Academy Press.

National Center for Injury Prevention and Control. Adding Power to Our Voices: A Framing Guide for Communicating about Injury. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention; 2008 (revised March 2010).

<http://www.cdc.gov/injuryNCHRP>

NCDOT. (2012). *North Carolina Department of Transportation Complete Streets Planning and Design Guidelines.* <http://www.completestreetsnc.org/>

NHTSA (2011a). *Countermeasures that Work.* Publication no. DOT HS 811 444, U.S. Department of Transportation, National Highway Traffic Safety Administration.

<http://www.ghsa.org/html/publications/countermeasures.html>

NHTSA (2011b). *Summary of State Speed Laws.* Eleventh Edition. Current as of February 1, 2010. DOT HS 811 457. U.S. DOT National Highway Traffic Safety Administration.

NHTSA. (2006). *Uniform Guidelines for State Highway Safety Programs.* Highway Safety Program Guidelines No. 19. National Highway Traffic Safety Administration.

Preusser, D.F., Williams, A.F., Nichols, J.L., Tison, J., and Chaudhary, N.K. (2008). *Effectiveness of Behavioral Highway Safety Countermeasures.* NCHRP Report 622, Washington, D.C: Transportation Research Board.

http://www.nap.edu/openbook.php?record_id=14195

Randolph County Speed Management Plan – Field Visits: Summary and Speed Management Plan Recommendations, Conducted February 10 – 14, 2013, authored by Libby Thomas, UNC Highway Safety Research Center.

Shinar, D. (2007). *Traffic Safety and Human Behavior.* Bingley, UK: Emerald Publishing Group, Ltd., 813 pp.

Speed Management: Road Safety Manual for Decision-makers and Practitioners. (2008). Geneva: Global Road Safety Partnership.

http://www.who.int/roadsafety/projects/manuals/speed_manual/en/

Srinivasan, R., et al. (2011), *Evaluation of Safety Strategies at Signalized Intersections,* NCHRP Report 705, Washington, D.C.: Transportation Research Board.

Srinivasan, R., Parker, M., Harkey, D., Tharpe, D. & Sumner, R. (2006). *Expert System for Recommending Speed Limits in Speed Zones: Final Report.* National Cooperative Highway Research Program, Washington, D.C.: Transportation Research Board.

onlinepubs.trb.org/onlinepubs/trbnet/acl/NCHRP%200367_FinalReport.pdf

Thomas, L.J., R. Srinivasan, L.E. Decina, and L. Staplin (2008). Safety effects of automated speed enforcement programs: Critical review of international literature. *Transportation Research Record 2078*:117-126.

U.S. DOT. (2008). *Speed Enforcement Camera Systems: Operational Guidelines*. Publication No. DOT HS 810 916. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration and Federal Highway Administration.
<http://ntl.bts.gov/lib/30000/30100/30166/810916.pdf>

U.S. DOT, NHTSA website. General traffic safety marketing guidance.
<http://www.trafficsafetymarketing.gov/TOOLS/Branding>

USLimits2. FHWA. A Tool to Aid Practitioners in Determining Appropriate Speed Limit Recommendations. <http://www.uslimits.com/>

Appendix A

Below is information from the Highway Safety Manual (AASHTO, 2010) referred to in Chapter 1 that allows users to predict the expected change in fatal and injury crashes that might be obtained from reductions in average operating speeds.

CMFs for Fatal and Injury Crashes due to Changes in Operating Speeds

The Speed Management Toolkit (Tables 9 and 10) show estimates of expected injury and fatal Crash Modifications (CMFs) for given changes in average operating speeds for different initial operating speeds, based on AASHTO, 2010, p. 3-57, Table 3E-2.

Those tables may be used in conjunction with expected travel speed reductions for different speed-reducing measures (if there are no crash-based CMFs available) to estimate expected changes in injury and fatal crashes. Figure 3 illustrates the magnitude of crash reduction effects for changes of average operating speeds of only one or two miles per hour (mph). Proportional reductions are expected to be greater where initial average operating speeds are lower but small changes can also have a significant impact on higher speed roads, especially if there are large numbers of injury and fatal crashes.

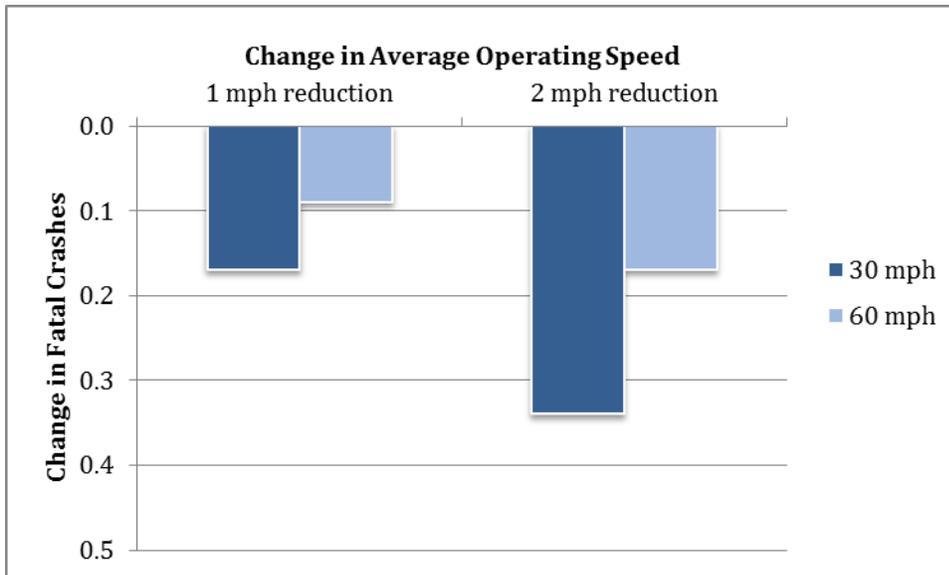


Figure 3. Expected fatal crash reductions for small average speed reductions at lower and higher initial speeds. (Based on data in Table 3E-2 from Highway Safety Manual, 2010).

A one to two mph reduction in average operating speed could reduce fatal crashes by from 17 to 34 percent, respectively (initial average speed of 30 mph, darker blue bars) or 9 to 17 percent (initial average operating speed of 60 mph, light colored bars) (estimates from Highway Safety Manual, p. 3-57, Table 3E-2).

Appendix B

Appendix B information provides additional detailed analysis results, supplementing results in Chapter 2. Table 23, Table 24, and Table 25, in particular, provide lists of urban and rural corridors which, based on high proportions of severe and speeding-related crashes, might be prioritized for early speed limit and safety review.

Countywide Analysis Results

Nearly 16,000 (15,739) crashes were reported from Randolph County for the five year period (Figure 4).

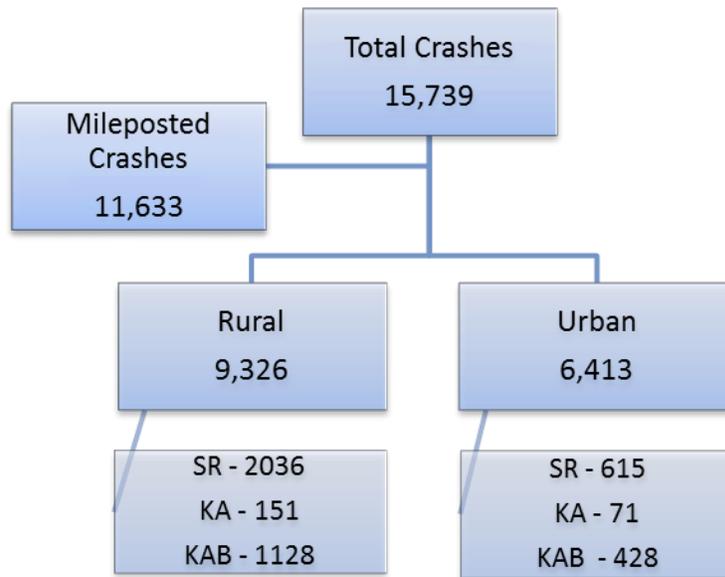


Figure 4. Distributions of Speeding-related, and Injury Crashes by Rural and Urban Locations.

SR = speeding-related crashes; KA = fatal and disabling injury crashes; KAB includes fatal, disabling, and evident injury crashes.

Table 19 shows the proportion of crashes that could be matched to each road classification type (right-most column). Matching was lower than expected on US highways, which should all be mileposted, suggesting that there are unresolved issues with the data. These issues could affect the validity of some of the results.

Table 19. Randolph County Reportable Crashes by Road Classification and Numbers Located to Routes.

Road Class.	Total Reported				Matched to Roadway				% of reported crashes matched to roadway
	Not Speeding -related	Speeding -related	% Speeding -related	Total crashes	Not Speeding -related	Speeding -related	% Speeding -related	Total	
missing				1,124	911	5		916	81.5%
Interstate	383	194	33.6	577	335	176	34.4	511	88.6%
US	4,375	437	9.1	4,812	3,093	225	6.8	3318	69.0%
NC	1,526	202	11.7	1,728	1,317	183	12.2	1500	86.8%
SR	4,242	1,691	28.5	5,933	3,474	1,426	29.1	4900	82.6%
Local	1,357	116	7.9	1,473	433	35	7.5	468	31.8%
PVA	54	1	1.8	55	12	0	0	12	21.8%
Private	15	1	6.2	16	3	0	0	3	18.8%
Other	19	2	9.5	21	4	1	20.0	5	23.8%
Totals	11,971	2,644	16.8	15,739	9582	2,051	17.6	11,633	73.9%

The next tables show distributions of different key environmental and driver factors subdivided by Rural or Urban locations. Results are shown separately for speeding-related (SR) and severe (fatal and disabling severity) crashes.

Overall, Randolph County observed nearly 22 percent of crashes (21.8%) to be speeding-related in rural parts of the County compared to an average of 15.8 percent in rural areas Statewide. In urban areas of the County, nearly 10 percent (9.6%) of crashes were thought to be speeding-related, compared to 5.6% of crashes in urban areas Statewide. (These data are not shown in the tables.) See Table 20 for comparisons by crash characteristics.

The County experienced a slightly lower than average percentage of crashes that involved fatal or serious injuries in rural areas (2.0%) compared to the State as a whole (2.5%). In urban areas of the County, the proportion of crashes involving fatal or serious injuries was slightly higher at 1.1 percent of all crashes, compared to 0.9 percent for the State as a whole. See Table 21 for comparisons by crash characteristics.

Table 20. Speeding-related (SR) Crash Characteristics in Randolph County, NC with Statewide comparisons.

Road Type	Randolph SR Rural Crashes	Percent of County Rural SR Crashes	Percent of NC Rural SR Crashes	Randolph SR Urban Crashes	Percent of County Urban SR Crashes	Percent of NC Urban SR Crashes
2L Undiv	1727	84.8	75.5	302	49.1	36.7
ML Div	231	11.4	18.9	199	32.4	35.9
ML Undiv	31	1.5	2.6	82	13.3	15.5
Other	47	2.3	3.0	32	5.2	11.9
Ambient Light						
daylight	1092	53.6	57.7	370	60.2	56.7
dusk	40	2.0	1.9	14	2.3	2.7
dawn	42	2.1	2.3	12	2.0	2.1
dark - lighted roadway	33	1.6	1.5	83	13.5	23.6
dark - roadway not lighted	824	40.5	36.2	134	21.8	14.2
Road Surface Condition						
dry	1078	52.9	45.9	222	36.1	36.9
wet	517	25.4	32.8	276	44.9	43.0
water (standing)	41	2.0	2.9	38	6.2	4.9
ice	194	9.5	8.9	30	4.9	7.0
snow	144	7.1	6.9	40	6.5	5.7
slush	41	2.0	1.7	9	1.5	2.0
gravel, mud, etc.	13	0.6	0.6	.	.	0.1
Crash at Curve						
Not at curve	797	39.1	46.1	431	70.1	72.2
At curve	1239	60.9	53.9	184	29.9	27.8
Intersection						
Intersection-Related	150	7.4	6.7	67	10.9	15.3
Non-Intersect.	1886	92.6	93.3	548	89.1	84.7
Teen-Involved						
No teen driver(s)	1539	75.6	78.5	477	77.6	79.7
Teen driver(s)	497	24.4	21.5	138	22.4	20.3
Alcohol-Involved						
No alcohol-involved	1774	87.1	90.1	556	90.4	89.2
Alcohol-Involved Crash	262	12.9	9.9	59	9.6	10.8

Table 21. Fatal (K-severity) and Disabling-Injury (A-severity) Crash Characteristics in Randolph County, with Statewide (NC) comparisons.

Road Type	Randolph Rural KA Severity Crashes	Percent of County Rural KA Crashes	Percent of NC Rural KA Crashes	Randolph Urban KA Severity Crashes	Percent of County Urban KA Crashes	Percent of NC Urban KA Crashes
2L Undiv	151	83.0	79.0	46	64.8	32.7
ML Div	17	9.3	13.8	9	12.7	32.9
ML Undiv	13	7.1	5.3	12	16.9	25.7
Other	1	0.6	1.9	4	5.6	8.7
Ambient Light						
daylight	88	48.4	54.9	38	53.52	54.1
dusk	2	1.1	2.3	5	7.04	2.7
dawn	4	2.2	1.6	1	1.41	1.5
dark - lighted roadway	4	2.2	1.6	15	21.13	26.9
dark - roadway not lighted	83	45.6	39.5	12	16.90	14.5
Surface Conditions						
dry	167	91.8	86.2	58	81.69	85.6
wet	10	5.5	11.4	12	16.90	12.9
ice	3	1.7	0.8	.	.	0.5
snow	1	0.6	0.4	.	.	0.1
Crash at Curve						
No	112	61.5	59.1	54	76.06	82.2
Yes	70	38.5	40.9	17	23.94	17.8
Intersection						
Intersection-Related	38	20.9	17.4	16	22.5	29.9
Non-Intersection	144	79.1	82.6	55	77.5	70.1
Teen-Involved						
no teen driver(s)	159	87.4	85.4	60	84.5	86.8
teen driver(s)	23	12.6	14.6	11	15.5	13.2
Alcohol Involved						
No Alcohol	128	70.3	73.1	56	78.9	76.9
Alcohol involved	54	29.7	26.9	15	21.1	23.1

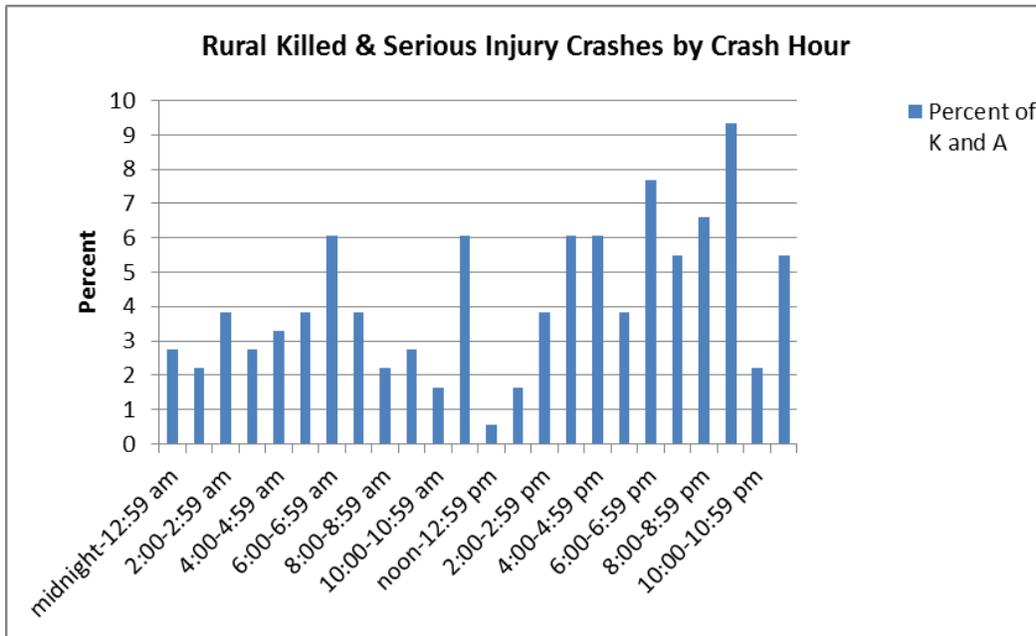


Figure 5. Rural Killed and Disabling Crashes by Crash Hour, 2007-2011.

Prior Speed Studies. Speed data were collected from 1998 to 2012 on a number of routes throughout the County. The studies were for corridors that were identified through preliminary screening for this project, and which had prior speed studies because of crash histories or requests by residents. A simple scatter plot of the data (no consideration to time trend) shows the speed limits by the associated average 85th percentile point speeds at the study locations. A trend line fitted to the data shows that there is a positive association between the limit and the 85th percentile speeds. Most of the 55 mph limits are not posted but are statutory limits. There were relatively few studies where posted speeds were 35 mph (that were not indicated to be advisory speeds), but, the dispersion across locations appears wider at the lower speed limits.

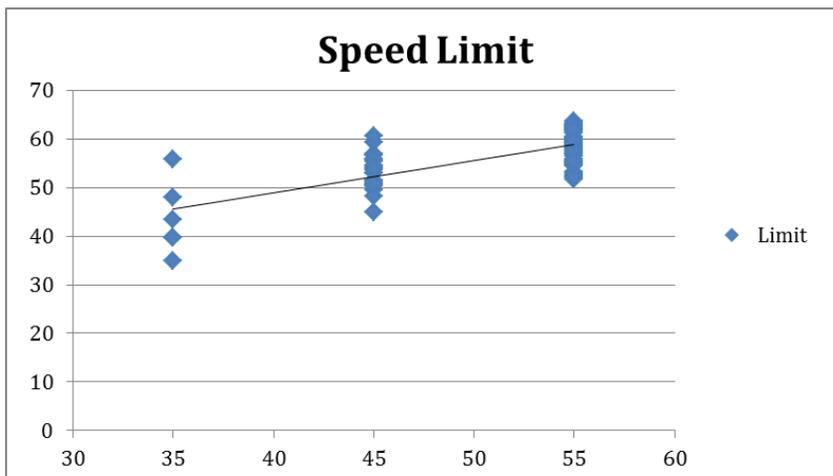


Figure 6. Scatter plot of 85th percentile (point) speeds by speed limit for a select group of roads.

Corridor Screening Methods

Network screening. There are many ways to screen a network to identify corridors or sections that may need safety treatment. The more advanced methods make use of safety performance functions and the empirical Bayes method in order to identify segments. These advanced methods are intended to address potential bias due to regression to the mean (RTM). To use such methods, there is a need for traffic volume data for all segments in the network. In North Carolina, traffic volume data are not available for significant sections of the state secondary system. Hence, safety performance functions and EB methods cannot be used for these types of roads.

Considering this limitation, the screening approach made use of the following measures:

- Proportion of crashes that were speeding-related.
- Proportion of crashes with more severe injuries
- Rate of more severe injury crashes per mile of roadway length.
- Rate of speeding-related crashes per mile. (In the final results, this measure was not used to prioritize treatments, since the rate of KAB per mile seemed more useful for the main objective to reduce fatal and injury crashes.)

Traffic volumes were not considered directly by the screening method, but will of course form part of additional analysis and diagnosis. The screening method used in this Plan adopted a proportions or percentage of crashes by crash type (speeding-related or severe) approach. Kononov (2002) found that looking at the percentage distribution of crashes by crash type can reveal the “existence of crash patterns susceptible to correction” that may or may not be accompanied by the overrepresentation in expected or expected excess crashes from the Empirical Bayes (E-B) methods of screening.⁵⁰ The E-B methods, which are considered state of the art with respect to controlling for traffic volume and other trends, also require traffic volume data to implement.

The screening approach made use of the following measures:

- Proportion of crashes that were speeding-related.
- Proportion of crashes with more severe injuries.
- Rate of more severe injury crashes per mile of roadway length.
- Rate of speeding-related crashes per mile.

In order to reduce the possible bias due to Regression Toward the Mean (RTM), or the influence of one or two-years with more severe crashes, five years of data were included. In addition,

⁵⁰ Kononov, J. (2002), Identifying Locations with Potential for Collision Reductions: Use of Direct Diagnostics and Pattern Recognition Methodologies, *Transportation Research Record* 1784, pp. 153-158.

since routes were the starting point (instead of segments) for these analyses, possible bias due to RTM may be reduced by including larger units of analysis.

To conduct this screening, mileposted routes were identified and grouped for analysis as shown in Table 22. This grouping was used so that routes with similar location types (rural or urban), geometric characteristics (divided or undivided and number of lanes), and general traffic volume ranges were compared to each other.

Table 22. Analysis Matrix and Roadway Miles for Screening for Speeding-related Crash Problems by Corridor.

Road type	Urban No Access control (miles)	Urban Partial control (miles)	Urban Full control (miles)	Rural No control (miles)	Rural Partial control (miles)	Rural Full control (miles)	Row totals	Row % of Total
Two-lane	164	3.7	0.1	1480	0.00	0.09	1647.9	89.7
Multi-lane, undivided	14	--	--	7	--	--	21	1.1
Multi-lane, divided*	4	0.3	22	27	13.40	68.70	135.4	7.4
Ramps	9	--	--	18	--	--	27	1.5
Service road	0.3	--	--	4.7	--	--	5	0.3
Column totals	191.3	4.0	22.1	1536.7	13.4	68.8	1836.3	100
Column % of Total	10.4	0.2	1.2	83.7	0.7	3.8		

*By median or other positive barrier

Comparisons were made within each category of roads to identify corridors with higher than average proportions of speeding or of severe of crashes for that category.

Tiers based on proportion of crashes

For the screening, routes with at least 10 total crashes were initially selected. Secondly, those routes that had higher than average proportions of combined killed (K), disabling (A-type), or evident (B-type) injury crashes (severe group or KAB in the tables), and/or of speeding-related crashes compared to the entire group were identified.

Routes were also ranked based on the rate of severe or speeding-related crashes per mile, but, as mentioned, only rate severe per mile was used in the ultimate prioritization of corridors.

Tier 1 = Routes with higher than the average proportion of severe and higher than the average proportion of speeding + pedestrian or bicycle crashes.

Tier 2 = Routes with higher than average proportion of severe crashes, but not a higher than average proportion of speeding + pedestrian or bicycle crashes.

Tier 3 = Routes with higher than the average proportion of speeding + pedestrian or bicycle crashes, but not higher than the average proportion of severe crashes.

Implications of the Tiers

Tier 1 - The crash data suggest that Routes in Tier 1 have indications of both a crash severity problem, and a speeding problem and may merit further assessment.

Tier 2 - Routes in Tier 2 have indications of a crash severity problem, but not a clear indication of speeding (greater than average). These findings suggest a potential mismatch between operating speeds and the driving environment resulting in a high severity of crashes, even if it is not yet clear that operating speeds are in excess of current limits and/or too fast for conditions. Additional review is warranted to consider whether speed limits are set appropriately or whether other changes to the roadway or enforcement may be needed.

Tier 3 - Routes in Tier 3 have indications of a speeding problem, but as of yet, this has not seemed to translate to a higher than average proportion of severe crashes for that route. However, such routes may warrant additional review, which could proactively prevent such speeding from resulting in a greater number of severe crashes in time.

The screening based on severe crashes per roadway mile was used to rank the corridors within each tier based on proportions of severe and speeding + pedestrian or bicycle crashes.

The numbers and percentages of crashes by route type and of the County total reported in the following sections are approximate and based on mileposted crashes only. Additionally, a few crashes are counted more than once since they were linked to multiple intersecting routes as well as the main “on route.”

Corridor Screening Results

The focus of analysis results was on non-freeway routes with greater roadway mileage extents and crashes. These routes or areas include:

- Urban, multi-lane, but not physically-divided corridors.
- Urban, two-lane corridors.
- Rural, two-lane roads.

Results of the screening for the above three types of corridors, which are recommended for further diagnosis are shown in Table 23, Table 24, and Table 25. Other route types may have speeding-related crash problems as well, but could not be easily identified without comparison to a larger reference group.

Urban, Multi-lane Corridors

Table 23 lists the priority corridors for speed and safety review (Action Item 4) as identified screening of urban, multi-lane, but undivided roads. The route numbers in bold type were also identified as corridors of concern for safety or mobility/congestion reasons through public input processes for the Randolph Comprehensive Transportation plan (CTP). It is suggested that all six corridors should be reviewed for proper speed limits and safety concerns relating to exceeding limits or inappropriate speed for conditions.

Table 23. Prioritized List of Urban Multi-lane Routes for Speed and Safety Review.

Route ID	AADT range	Total Crashes	Fatal no.	Severe Crash no.	Severe Crash proportion	Severity Index	Speeding-related no.	Speeding-related proportion	Total Crashes per Mi.	Corridor Length in miles	Severe crashes per Mi	Tier
40001707	2900 - 7000	92	2	6	0.07	5.2	4	0.04	76.2	1.207	5.0	1
40001950	9700	37	0	2	0.05	3.0	3	0.08	36.9	1.003	2.0	1
40001451	3900	61	0	5	0.08	2.8	0	0.00	152.5	0.4	12.5	2
40001009 [±]	10,000 – 23,000	450	1	29	0.06	4.3	16	0.04	159.1	2.828	10.3	2
29000220*	10,000 – 26,000	247	2	15	0.06	4.4	7	0.03	93.4	2.644	5.7	2
20000064	20,000 – 32,000	907	1	37	0.04	3.7	40	0.04	185.3	4.895	7.6	3
Subtotals	--	1788	6	94	0.05	--	70	0.04	--	13.232	--	--
Prop. of all Urban Multilane	--	0.98	1.0	1.0	--	--	0.97	--	--	0.97	--	--
All Urban Multilane	--	1824	6	94	0.05	4.0	72	0.04	--	13.621	5.2	--
Prop. Of County Total	--	0.12	0.06	0.06	--	--	.03	--	--	.007	--	--
County Total	--	15,739	101	1556	--	--	2804	--	--	1836	--	--

[±] Route numbers beginning with: 4= State Secondary roads, 2= US Highways

*There seem to be errors in the data associated with US 220 access-controlled freeway which was opened within the past few years. Crashes attributable to that road may have been incorrectly placed on the business (old US 220) which is not access-controlled.

Current NCDOT HSIP section warrants for urban non-freeway routes are for a minimum total crashes of 20, and a minimum crashes per mile rate of 40 (NCDOT, Traffic Safety Systems Section, HSIP Program, Safety Warrants, 2012). All of the ranked, urban four-lane, undivided routes in Tiers 1-3 in the table meet or far exceed that threshold for total crashes, with the exception of 40001950.

Urban, Two-lane Corridors

Preliminary screening selected routes with the following:

- At least 10 total crashes.
- Tiers as described above by proportion of severe & speeding + pedestrian or bicycle, and ranked by severe crashes per mile.

The initial group of 28 corridors accounted for:

- 928 total crashes (45 percent of the total urban two-lane crashes).
- 96 severe crashes (56 percent of urban two-lane, KAB-severity crashes).
- 149 speeding-related + pedestrian or bicycle crashes (56 percent of urban two-lane, speeding-related crashes).
- 31 percent of urban, two-lane roadway miles (Table 24).

It may be infeasible to include 28 corridors for speed reviews and diagnosis and treatment within a five-year plan. One way to further prioritize routes for review would be to start with Tier 1, which has both a higher than average percentage of severe crashes and a higher than average proportion of speeding-related crashes.

However, Tier 2 corridors which have an above-average proportion of severe but not of speeding crashes accounts for a larger *number* of severe crashes, a larger number of total crashes, has a higher average severe crash per mile rate, and lower total mileage to treat. Therefore, a further minimum threshold of two severe crashes per mile was applied to Tiers 1-3 and reduced the number of corridors to a more feasible number of 11 corridors, highlighted in darker shades in Table 24. Route numbers in bold type were also identified through the County's Comprehensive Transportation Plan.

Table 24. Prioritized List of Urban Two-lane Routes for Speed and Safety Review.

Route ID	AADT	Total Crash no.	Fatal Crash no.	Severe Crash no.	Severe Crash proportion	Severity Index	Speeding-related Crash No.	Speeding-related proportion	Corridor Length in miles	Total Crashes per mi	Severe Crashes per mi	Speeding-related Crashes per mi	Tier
40001451	3300 - 3900	36	0	3	0.08	3.47	6	0.17	1.03	34.99	2.92	5.83	1
40002261	1500 - 5900	69	0	10	0.14	6.44	10	0.14	3.85	17.94	2.60	2.60	1
40001564	1500-3200	32	0	8	0.25	6.14	8	0.25	3.87	8.26	2.06	2.06	1
40001004	2400-9000	41	1	5	0.12	7.59	11	0.27	2.98	13.78	1.68	3.70	1
40002189	970-1800	12	0	1	0.08	11.02	3	0.25	0.64	18.75	1.56	4.69	1
30000022	2200 - 3000	29	0	4	0.14	2.53	5	0.17	3.16	9.18	1.27	1.58	1
40001556	3100-6000	20	0	2	0.10	3.22	4	0.20	2.47	8.11	0.81	1.62	1
40001558	4800	18	0	2	0.11	7.68	4	0.22	2.66	6.76	0.75	1.50	1
40003252	3100 - 6000	17	0	2	0.12	12.53	9	0.53	2.76	6.16	0.72	3.26	1
20000064	12,000 – 23,000	15	0	2	0.13	4.45	1	0.07	0.20	74.62	9.95	4.97	2
40001952	4600-6900	85	1	11	0.13	4.33	10	0.12	1.53	55.44	7.17	6.52	2
40002344	4200-6100	29	0	5	0.17	5.34	2	0.07	0.72	40.28	6.94	2.78	2
40001577	7800-8900	82	0	8	0.10	3.44	4	0.05	2.52	32.54	3.17	1.59	2
40001443	1500 - 3300	29	0	4	0.14	3.30	2	0.07	1.28	22.64	3.12	1.56	2
30000049	6600 – 19,000	62	0	7	0.11	5.83	6	0.10	2.43	25.51	2.88	2.47	2
40002183	2600-3000	18	0	3	0.17	3.88	1	0.06	1.36	13.19	2.20	0.73	2
40001462	6100-8600	22	0	2	0.09	6.80	2	0.09	1.24	17.67	1.61	1.61	2
40002237	4200-5400	28	1	2	0.07	7.14	4	0.14	0.72	39.11	2.79	5.59	3
40001547	5000 - 12,000	88	0	6	0.07	4.03	17	0.19	3.03	29.00	1.98	5.60	3
40001595	9000-13,000	70	0	5	0.07	4.62	11	0.16	2.76	25.36	1.81	3.99	3
40001748	unk	19	0	1	0.05	3.73	5	0.26	0.70	27.22	1.43	7.16	3
40001504	2400 - 3200	15	0	1	0.07	3.96	3	0.20	1.36	11.05	0.74	2.21	3
40001619	3400 - 5000	23	0	1	0.04	3.25	3	0.13	1.76	13.06	0.57	1.70	3
40001566	1100 - 1600	14	1	1	0.07	6.94	3	0.21	2.00	6.98	0.50	1.50	3
40002345	4200	12	0	0	0.00	3.47	2	0.17	0.69	17.51	0.00	2.92	3
40002119	1200 - 2900	20	0	0	0.00	3.22	3	0.15	1.06	18.83	0.00	2.82	3
40001610	1400 - 2000	11	0	0	0.00	3.02	5	0.45	1.96	5.61	0.00	2.55	3
40003255	2,100	12	0	0	0.00	1.62	5	0.42	0.43	27.98	0.00	11.66	3

Route ID	AADT	Total Crash no.	Fatal Crash no.	Severe Crash no.	Severe Crash proportion	Severity Index	Speeding-related Crash No.	Speeding-related proportion	Corridor Length in miles	Total Crashes per mi	Severe Crashes per mi	Speeding-related Crashes per mi	Tier
Subtotals	--	928	4	96	--	--	149	--	51.18	--	--	--	--
Prop. of Urban 2Ln	--	0.45		0.56	--	--	0.56	--	0.31	--	--	--	--
Totals for Urban 2Ln	--	2,083	7	171	0.08	4.47	268	0.13	163.84	--	1.04	1.64	--
Prop. Of County Total	--	.13	0.07	0.11	--	--	0.10	--	.09	--	--	--	--
County Total	--	15,739	101	1556	--	--	2,804	--	1,836	--	--	--	--

Rural, Two-Lane Results

To prioritize speed and safety review through screening, routes with at least 10 total crashes were initially selected.

- Then routes with higher than average severe or SpPB proportions of crashes were identified, ranked by tiers, and within tiers, ranked by severe crashes per mile.
- The top five corridors for high rate of severe per mile were also selected if they were not already identified in the high proportion screening.

Approximately 31 percent (466 routes) of 1473 numbered and mileposted routes had one or more crashes in the five-year study period. Of the routes with at least 10 total crashes, 39 routes had higher average percentages of both severe and speeding/ped-bike-related crashes (Tier 1) as indicated from crash data and 33 had higher than average severe crashes but not speeding/ped-bike-related (Tier 2). Because of these large numbers and an even larger number of routes identified in Tier 3, (higher than average speeding/ped-bike-related only), only Tiers 1 and 2 were included in further prioritization, along with consideration of rate of severe crashes per mile.

The final selection included only routes with an average of greater than two severe crashes per mile in addition to the above criteria. See Table 25 for the prioritized list of routes. Again, route numbers in bold represent corridors also identified through the CTP public input.

Table 25. Priority List of Rural Two-lane Routes for Speed Limit and Safety Review.

Route	AADT (max.)	Total Crashes	Fatal Crash no.	Severe Crash no.	Severe Crash proportion	Severity Index	Speeding-related Crash no.	Speeding-related Crash proportion	Corridor Length in miles	Severe Crashes per mile	Tier	Other
40002226	1,900	11	1	5	0.45	10.58	4	0.36	1.65	3.02	1	only those with KAB rate / mi of > / = 2
40002111	1,600	16	1	6	0.38	12.33	7	0.44	2.04	2.95	1	
40001144	5,000	75	0	12	0.16	3.76	19	0.25	4.48	2.68	1	
40001534	800	11	0	4	0.36	11.25	4	0.36	1.86	2.15	1	
40001408	3,900	105	0	17	0.16	5.63	37	0.35	8.05	2.11	1	
40001009	14,000	40	0	6	0.15	4.52	3	0.08	0.64	9.33	2	only those with KAB rate / mi of > / = 2
40002149	4,400	22	1	5	0.23	8.15	4	0.18	1.24	4.03	2	
40002183	3,000	30	1	6	0.20	7.53	6	0.20	1.61	3.72	2	
40001150	5,400	14	0	3	0.21	8.53	0	0.00	0.85	3.53	2	
40001007	4,400	33	1	5	0.15	5.76	7	0.21	1.58	3.17	2	
40002218	1,400	10	0	2	0.20	3.22	1	0.10	0.84	2.39	2	
20000064	19,000	219	6	32	0.15	6.30	29	0.13	13.45	2.38	2	
40002345	4,200	19	0	3	0.16	3.34	3	0.16	1.44	2.09	2	
40001004	9300	247	2	32	0.13	5.60	48	0.19	15.42	2.07	2	
40002417	750	13	0	4	0.31	10.25	2	0.15	1.99	2.01	2	
40002270	8,300	48	0	5	0.10	4.08	1	0.02	0.52	9.58	n/a	KAB per mile > 2, not in Tier 1 or 2, but >= 5 KAB
20000311	15,000	303	3	35	0.12	5.24	23	0.08	6.94	5.05		
29000220	14,000	222	1	22	0.10	4.24	16	0.07	10.40	2.12		
Subtotals	--	1,438	17	204	0.141	--	214	0.148	75.00	2.85	--	--
Prop of all Rural 2Lane	--	0.24	0.28	0.26	--	--	0.14	--	0.05	--	--	--
All Rural 2Lane	--	6,045	61	772	0.127	5.09	1495	0.247	1,479.88	0.52	--	--
All Rural 2Lane prop. of County total	--	0.38	0.60	0.50	--	--	0.53	--	0.81	--	--	--
County Total	--	15,739	101	1556	--	--	2804	--	1837	--	--	--

In addition to the crash screening results, the following routes were indicated per the Randolph County CTP, Jan 2012 survey responses, to have safety or congestion concerns. These route numbers, when found in the screening priority lists, are highlighted in bold below and in the Tables above, as they may receive extra priority for speed limit review and safety assessment based on their importance to local drivers. Note that some routes span urban and rural corridors and/or change from two to multi-lane, but may appear in only one of the lists. When routes span rural to urban zones or change geometries, it may be important to assess the different section types and transition areas.

- I-85
- US 220
- **US 311**
- **US 64**
- NC 42, Salisbury Street
- **NC 49**
- **NC 22**
- NC 62
- **Fayetteville Street (US Business 220)**
- **Old Liberty Road (SR 2261)**
- **Presnell Street (SR 1462)**
- Zoo Parkway/NC 159
- **Academy Street (SR 1950)**
- **McDowell Road (SR 1150)**
- **Caraway Mountain Road (SR 1004)**

Other Area Types

Crash Issues Near Schools

Spatial analyses revealed a list of schools where: 1) high frequencies of severe; or 2) high frequencies of speeding, pedestrian, and bicycle crashes occurred near school sites in the County.

These school properties are ranked and prioritized in Table 26 and illustrated in Figure 7 and Figure 8. The high crash school neighborhoods might be targets for additional investigation of whether area-wide speed calming or other engineering countermeasures are warranted. In addition, the affected schools could be a focus for enhanced enforcement and publicity efforts and outreach.

Sections with Curve-related Crash Problems

Finally, road sections with crashes indicated to occur on curves are shown in Table 27 (severe crashes), and Table 28 (total crashes). The sections with higher frequencies may warrant

additional investigation and consideration for speed limit review and potentially other treatment.

Table 26. School properties ranked by five-year number of Severe and Speeding-related crashes within One Mile of School Property.

PROP NUM	PROP Street	Description	Severe Crash Count	Speed Crash Count
524	HOLLY ST	Baseball, Basketball, V-ball, Shelter	56	64
5746	TRINITY HIGH SCHO	High school	30	72
5457	BRAXTON CRAVEN RD	Elementary School	29	87
5105	ARCHDALE RD	Middle School	24	53
100	SWAIM ST	Elementary school	19	27
6068	SUITS RD	Elementary school	16	13
4901	TABERNACLE SCHOOL	Elementary school	15	15
1	US HWY 311	Soccer field (part)	14	14
286	EASTERN RANDOLPH	High School	14	13
1	CLARK AVE	Ball field for elementary school	12	18
1	PINE ST	Across road from elem school	12	16
1509	HOPEWELL FRIENDS	Middle School	8	8
1	NC HWY 22 N	Baseball field (part)	7	14
5302	FOUSHEE RD	Middle School	7	3
204	HIGHFILL ST	BB/FB field next to elem school	7	2
4528	NC HWY 22 S	Elementary School	6	11
3557	GRANGE HALL RD	Elementary school	4	2
3493	RAMSEUR JULIAN RD	Middle school	2	8
1	OLD COX RD	Wooded area adjoining zoo	1	7
1	OLD PLANK RD	Lighted Baseball field adjac. to school	1	5
		Totals	284	452

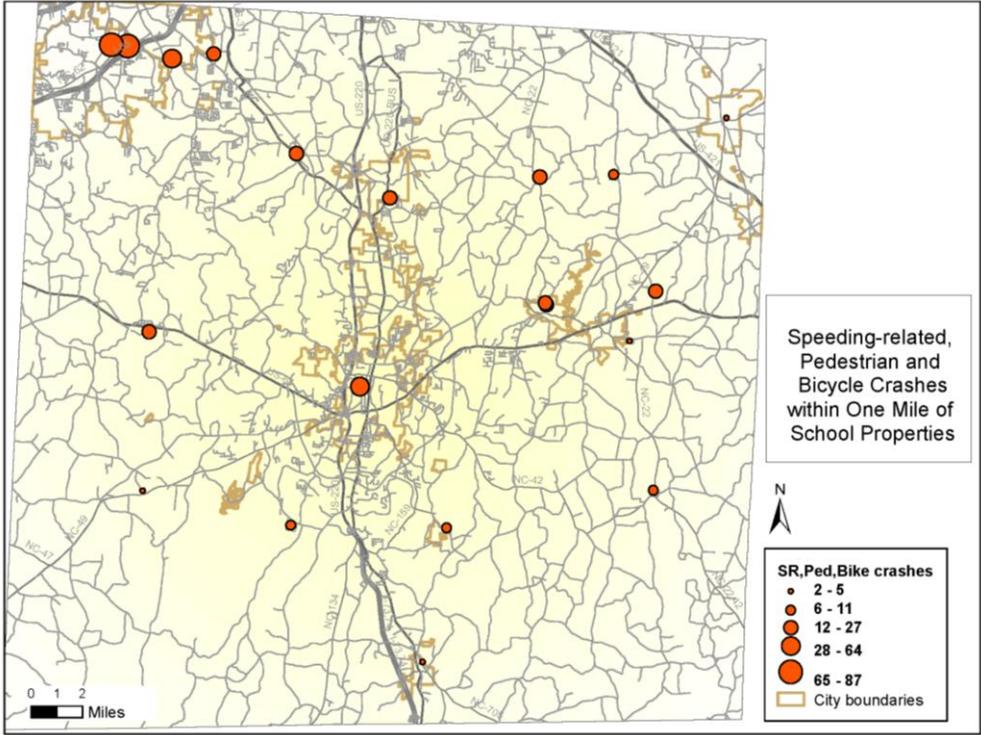


Figure 7. Speeding-related or Pedestrian or Bicycle Crashes within One Mile of School Properties.

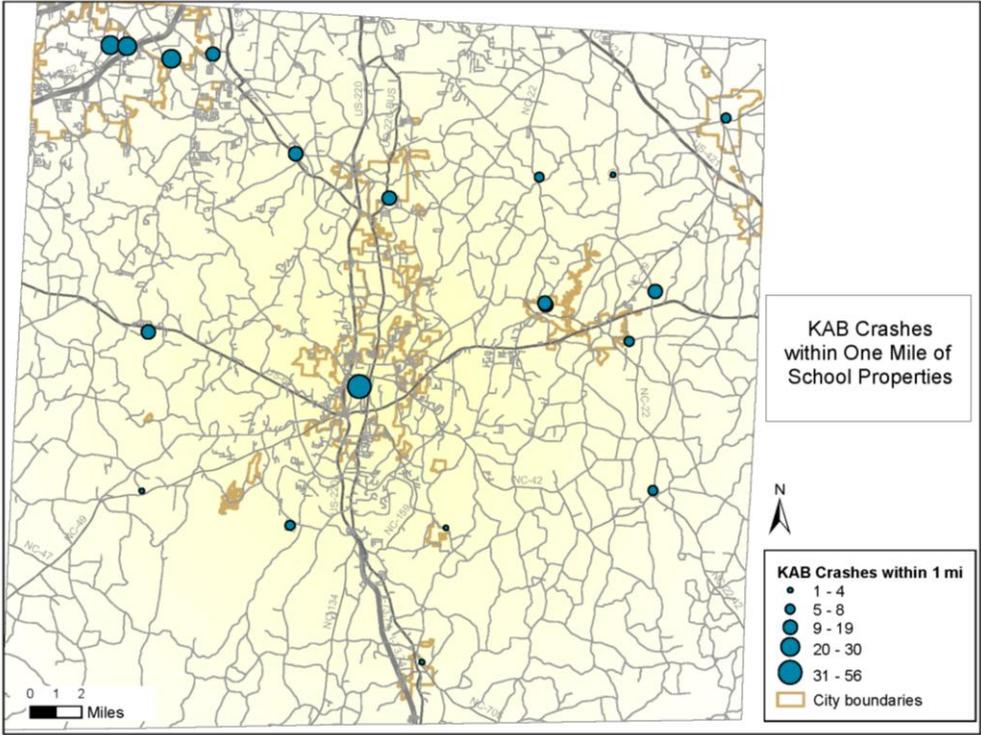


Figure 8. Number of Crashes with Fatal (K), Disabling (A), or Evident (B) severity of injuries within one mile of school property.

Table 27. Road Segments with Three or more Severe crashes indicated to occur at a Curve.

Route	Freq. KAB on Curve	RTE type	Beg Inters	End Inters	Beg Mp1	End Mp1	Speed limit	AADT estimate (2011)	Segment Lngth	Crashes mileposts
SR-1004	8	2L	40001539	40001413	11.85	13.45	55	1500	1.60	12.688;12.968;12.46; 12.768;12.368;12.86; 12.568;12.838
SR-2149	4	2L	40002150	40002261	0.47	1.67	55	3200	1.20	1.06;1.26;0.95;1.335
SR-2261	4	2L	40002442	40002440	14.14	14.49	55	1100	0.35	14.204;14.304;14.284; 14.204
SR-2839	4	2L	40002972	30000159	2.67	3.31	55	1300	0.64	3.29;3.17;2.77;2.702
SR-1114	3	2L	40001248	40001142	7.80	11.44	55	1100	3.64	10.38;8.22;11.18
SR-1518	3	2L	40001504	40001514	3.76	5.59	55	2100	1.83	4.28;4.25;4.68
SR-2111	3	2L	40002132	40002136	0.00	0.74	55	1600	0.74	0.54;0.64;0
SR-2116	3	2L	40002115	40002111	0.77	1.44	55	2100	0.67	1.37;1.37;1.41
SR-2226	3	2L	40002225	40002141	0.82	1.66	35	1900	0.83	1.624;1.36;0.92
SR-2261	3	2L	40002132	30000022	8.61	9.06	55	1400	0.45	8.71;8.86;8.71
SR-2261	3	2L	40002149	40002183	1.90	2.00	35	3600	0.10	1.99;1.917;1.996
Total KAB target	41									

There were 85 roadway segments with five or more crashes on curves. Table 28 includes 31 road segments with eight or more crashes of any severity on curves. All types were included, since angle and other collision types could conceivably be related to the presence of the curve.

Table 28. Road Sections with Eight or More Any Severity Crashes at Curves.

Route	Freq All on Curve	RTE Type	Beg Inters	End Inters	Beg Mp1	End Mp1	SPDD Limit	AADT estimate (2011)	Seg-ment Lngth	Crashes mileposts
SR-1004	30	2L	40001539	40001413	11.85	13.45	55	1500	1.602	12.518;12.688;11.968;13.268;12.868;12.968;12.668;12.768;12.468;12.968;13.168;12.768;12.868;12.468;12.568;11.918;13.168;12.868;12.868;12.568;12.768;12.368;12.868;13.068;12.748;12.868;12.038;12.568;12.838;12.868
SR-1114	16	2L	40001248	40001142	7.80	11.44	55	1100	3.643	8.89;10.88;10.38;8.29;9.38;10.38;10.58;9.18;9.88;8.22;10.48;11.18;9.78;10.29;9.09;10.28
SR-1952	14	2L	29000220	40001989	0.26	0.34	35	6000	0.083	0.322;0.326;0.307;0.317;0.326;0.317;0.319;0.302;0.318;0.324;0.312;0.317;0.322;0.311
SR-2327	12	2L	20000064	30000042	0.30	0.66	35	8600	0.359	0.658;0.324;0.332;0.33;0.311;0.363;0.305;0.63;0.33;0.629;0.334;0.33
SR-1518	11	2L	40001504	40001514	3.76	5.59	55	2100	1.829	0;4.28;0;4.25;4.95;4.38;4.85;3.769;3.88;4.68;3.88
SR-1144	10	2L	40001203	40001162	1.74	2.23	55	3100	0.491	1.928;1.828;2.078;1.828;1.878;1.838;2.028;1.783;1.828;1.928
SR-1004	10	2L	40001608	40001566	1.04	1.54	45	3900	0.497	1.14;1.28;1.24;1.501;1.14;1.08;1.18;1.34;1.34;1.18
SR-1408	10	2L	40001542	40001548	2.08	2.67	55	2400	0.591	2.592;2.671;2.371;2.28;2.58;2.571;2.652;2.08;2.647;2.571
NC-42	9	2L	40002197	40002192	2.13	2.18	35	13000	0.053	2.133;2.133;2.133;2.133;2.133;2.145;2.133;2.154;2.133
SR-1950	9	4L	40001955	29000220	1.29	1.48	35	9700	0.187	1.359;1.457;1.353;1.331;1.35;1.446;1.322;1.361;1.35
SR-2839	9	2L	40002972	30000159	2.67	3.31	55	1300	0.639	3.29;3.27;3.19;3.17;2.77;2.77;2.702;2.702;2.69

Route	Freq All on Curve	RTE Type	Beg Inters	End Inters	Beg Mp1	End Mp1	SPDD Limit	AADT estimate (2011)	Segment Lngth	Crashes mileposts
SR-1748	9	2L	3000062	40001595	0.00	0.70	25	0	0.698	0.6;0.5;0.4;0.4;0.3;0.2;0.2;0.2;0.2
SR-2261	9	2L	40002450	40002442	11.99	13.10	55	900	1.112	12.804;12.19;12.29;12.704;12.12.29;12.19; 12.604;12.19
SR-2149	9	2L	40002150	40002261	0.47	1.67	55	3200	1.205	1.06;1.26;1.26;0.95;1.552;0.65;1.06;1.335;0.55
SR-2834	9	2L	37000159	40002830	2.52	3.75	55	0	1.232	3.685;3.684;3.681;3.641;3.641;3.541;3.491;3.141;2.521
SR-1162	9	2L	40001142	40001214	0.60	2.02	55	530	1.422	1.37;1.52;1.3;1.42;1.52;1.3;1.52;1.12;1.4
SR-1547	9	2L	40001549	40003106	6.20	7.68	55	1300	1.481	6.58;6.48;6.48;6.48;6.38;7.63;7.43;7.23;7.13
SR-2611	9	2L	40002610	40002614	1.41	3.01	55	810	1.604	2.814;2.814;2.814;2.814;2.714;2.704;2.614;1.74;1.54
NC-22	8	2L	40002991	30000042	6.31	6.42	55	2000	0.108	6.411;6.33;6.33;6.33;6.33;6.33;6.33;6.33
SR-2834	8	2L	40002830	40002824	3.79	4.11	55	0	0.314	3.941;3.941;3.941;3.841;3.841;3.841;3.841;3.841
SR-3255	8	2L	40001444	40001442	1.68	2.08	35	2200	0.408	0.29;0.29;1.89;1.884;2.002;1.878;1.978;1.854
US-311	8	2L	40001514	40001941	1.81	2.28	55	13000	0.468	2.012;1.912;1.912;1.962;2.212;2.012;1.912;2.012
I-85	8	DCL	80003890	40001619	0.52	0.99	55	21000	0.470	0.89;0.99;0.89;0.89;0.79;0.89;0.99;0.372
SR-2261	8	2L	40002442	40002440	13.10	13.73	55	1100	0.632	13.104;13.304;13.304;13.504;13.504;13.304;13.404;13.404
SR-2116	8	2L	40002115	40002111	0.77	1.44	55	2100	0.673	1.37;1.37;1.41;0.87;1.41;0.779;1.17;1.37
SR-2261	8	2L	40002183	40002128	2.00	2.69	35	1500	0.686	2.224;2.2;2.624;2.129;2.429;2.224;2.058;0

Route	Freq All on Curve	RTE Type	Beg Inters	End Inters	Beg Mp1	End Mp1	SPDD Limit	AADT estimate (2011)	Seg-ment Lngth	Crashes mileposts
I-85	8	DCL	80003898	80003901	1.66	2.37	70	52000	0.709	1.86;2.06;2.06;2.06;2.06;1.84;2.06;2.16
SR-1408	8	2L	40003118	40003117	5.15	5.93	55	1500	0.779	5.356;5.836;5.836;5.256;5.836;5.636;5.856;5.456
SR-1553	8	2L	40003249	40003232	2.30	3.32	55	0	1.022	3.125;3.125;2.825;2.805;2.725;2.605;2.505;2.405
SR-1542	8	2L	40002048	40001543	0.11	1.20	55	0	1.091	0.91;0.81;0.71;0.71;0.602;0.4;0.302;0
SR-2615	8	2L	40002619	40001003	0.97	2.23	45	870	1.257	2.22;2.22;2.19;1.82;1.82;1.72;1.42;1.02
Total all-sev. crash target	307									

Appendix C

Countywide Proactive Approach - Additional Considerations

Consider the future as well as current land uses when planning and designing new projects and roadway improvements. Density of development, area type, connections to existing streets, and multi-modal transportation needs should be carefully considered in the design and intended operating speed of new roads. Figure 9 illustrates the planned growth areas from the County's 2009 Growth Management Plan.

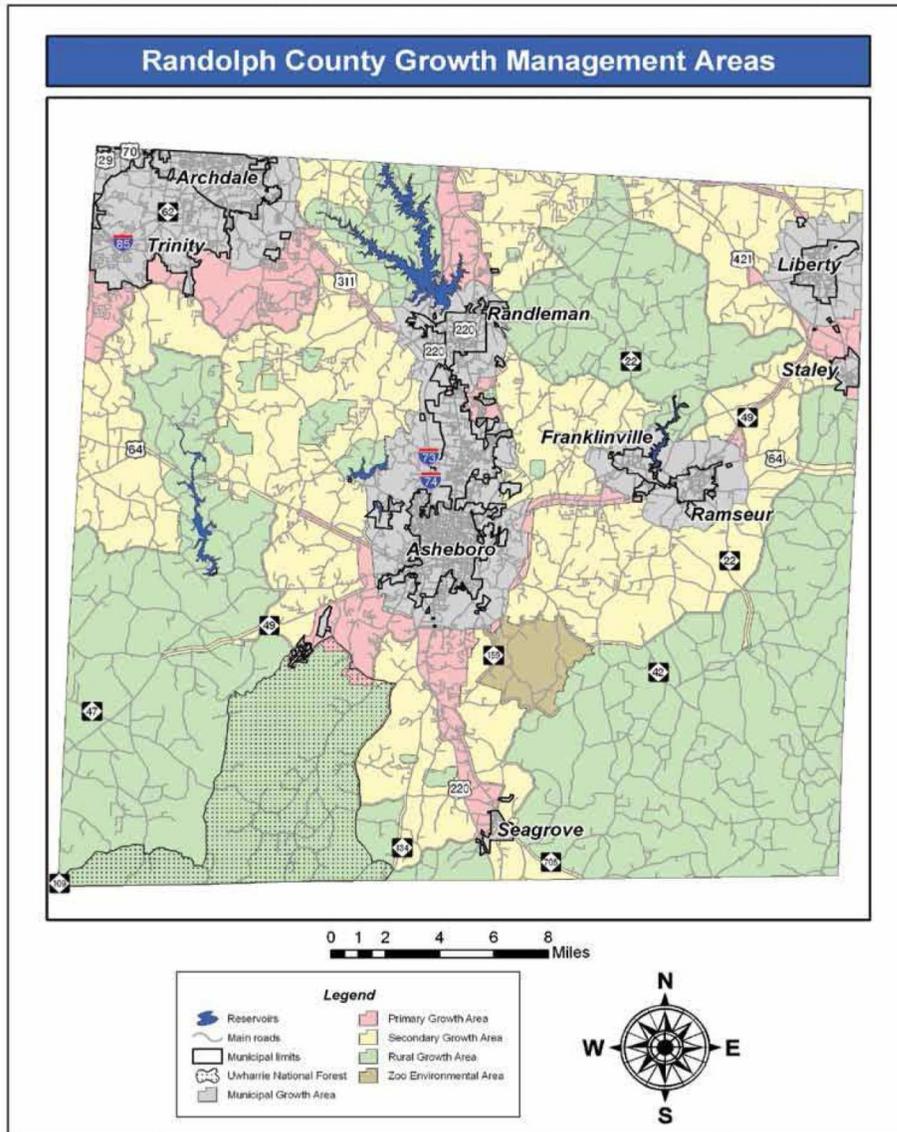


Figure 9. Randolph County Growth Management Areas.

Countywide Comprehensive Approaches - Additional Considerations

Some view speeding as a problem of the few, but in fact it is a population-level problem. The research shows that drivers of all ages speed – some by high levels and often, and some infrequently or by small degrees. However, each increment of speeding by many drivers adds to an overall increase in risk of more severe crashes. Low levels of speeding have a significant effect on expected fatal and injury crashes. This risk in turn translates to tragedy for the individuals that are involved. Many safer countries have adopted an approach to safety management that puts the human at the forefront of decisions about infrastructure, speed-limit setting, and other policies with an aim to reduce the chances of a fatality or life-altering injury when inevitable human mistakes occur. For more information on different approaches to speed management, see *Methods and Practices for Setting Speed Limits: An Informational Report* (Forbes, et al., 2012) available on FHWA’s speed management website, and *Lessons Learned from Other Countries*, a white paper prepared by Dr. Ezra Hauer as part of *Toward Zero Deaths: A National Strategy on Highway Safety* (Hauer, 2010).

Consider that despite their inexperience, young drivers (ages 16 to 19) accounted for only one-fourth of rural speeding-related crashes in the County as indicated by crash data, and a lower percentage of severe crashes. As evidence by the other 75 percent, many older and more experienced drivers also do not correctly anticipate the need to slow (below the 55 mph maximum limit) at many locations or situations (curves, grades, before intersections, rainy weather, at night, etc.) leading to numerous “too fast for conditions” types of crashes. In addition, a significant body of research evidence shows that drivers often do not anticipate certain risks or slow in time to avoid a crash (7). Finally, there will also continue to be a new cohort of inexperienced drivers each year who may perceive that the statutory limit of 55 is a safe and reasonable speed throughout county rural roads.

The default, statutory 55 mph rural speed limit may not send the right message to drivers of any age or experience level, since there are many exceptions where lower speeds are warranted. Unanticipated situations, perhaps exacerbated by distracting thoughts or actions and other situations that often lead to serious crashes. Urban areas also have many issues with road designs that may not match safe operating speeds for the environment, at least under certain conditions or times.

Younger drivers also learn from their parents and peers, and the cultural norms in general. North Carolina has a long history of glorifying speed, as exemplified through the history of stock car racing, which emerged in the State. The axiom that “everyone speeds” is rings literally and figuratively true as both national data, and data from a Statewide survey reveal. Eighty-five percent of surveyed North Carolina drivers admitted to speeding more than 5 mph above the limit on low speed (30 mph) roads (Final Report, NHTSA-GHSA Statewide Telephone Survey (July 12 – 21, 2010). ***Five miles per hour may translate to between 64 and 78 percent more fatal crashes than would occur if everyone were traveling at the speed limit or lower*** (from AASHTO Highway Safety Manual estimates, p. 3-57).

Solutions: Consequently, a population-wide, injury-prevention approach to speed limit setting policies, communications, and enforcement is needed to address the social and behavioral elements of speeding and resultant severe crashes.

According to a report by the NC Child Fatality Task Force, policies, laws, and credible and consistent enforcement applied to the entire population are also the most effective means to attempt to reduce speeding among younger drivers (Child Fatality Task Force, 2012).⁵¹ Measures that single out young drivers such as fear-based approaches do not tend to work among that population. While the messenger, messages, and format may target specific groups of drivers (age groups, cultural or ethnic groups), the over-arching context should be about enforcing rules that apply to everyone, in order to reduce injury and achieve norms of safe speed behavior. In that context, enforcement policies, practices and messages should reinforce the notion that enforcement is about reducing speeding to save lives, not about punishing drivers. There also needs to be a strong perception, cultivated through a highly visible program and improved publicity, that enforcement may be encountered anytime, anywhere to help achieve the deterrence needed.

Other approaches that include rewarding drivers for safe behavior such as through lower insurance premiums, or, potentially other locally developed programs, also show promise (NHTSA, 2011).

Systematic Approach - Additional Countermeasures Considerations

Road diets. Among the most promising and proven measures, for multi-lane roads with traffic volumes up to around 15,000 and sometimes higher, and where other conditions allow, road diets provide a low-cost treatment with a fairly high certainty of expected crash reductions and speed calming. (The costs may increase depending on whether constructed features such as medians or median-islands are added, extent of changes needed at intersections, and so on.)

Assuming that each of the three lower-volume, but multi-lane roadways is a good candidate for a road diet, approximately one-half of the target crash reductions might be achievable through implementing road diets alone (Table 30). In addition, there may be lower-volume sections of some of the other roads that could be suitable for road diets.

Traffic calming. If/when the number of through motorized lanes is reduced, other treatments may become more feasible if speeding is still an issue. Such treatments might include bulb-outs at intersections, single-lane roundabout intersection designs, raised pedestrian crossings and others. Shifting alignments by using median islands, shifting on-street parking, or chicanes may

⁵¹ Child Fatality Task Force. (2012). Teen Road Safety in North Carolina: Putting Best Practice into Action. [http://www.ncleg.net/DocumentSites/Committees/NCCFTF/Reports and Data/Teen Road Safety, Dec 2012.pdf](http://www.ncleg.net/DocumentSites/Committees/NCCFTF/Reports%20and%20Data/Teen%20Road%20Safety,%20Dec%202012.pdf)

also be appropriate depending on context. Bicyclists' concerns should be considered in treatment selection.

Traffic calming treatments may be needed on some state roads where such treatments have not ordinarily been implemented. But, traffic calming measures (lateral shifts, pinch points, vertical devices) have been shown to slow speeds and may be among of the few ways to consistently slow speeds in areas such as transitions from rural to more develop areas or on lower-volume urban streets. These are decisions that should be jointly made between NCDOT and local road users.

Lower travel speeds. Traffic calming options on wider roads with more traffic may be challenging, but treatments, such as the ones listed below, have been successful in some situations and should be considered to help to slow speeds where needed, such as at town limits / transition areas or throughout corridors as needed. A combination of multiple treatments may be needed.

- Gateway treatments.
- Medians or median islands, perhaps in conjunction with gateways at the end of transition zones, and as pedestrian refuge islands.
- Reductions in lane width through re-striping.
- Wider lane line stripes.
- Use of roadway markings such as converging chevrons, optical speed bars or other perceptual measures.
- Enhanced enforcement, closer to limit.

Speed reduction effects. A combination of measures that lower average operating speeds by 2 mph, assuming an average initial operating speed of 40 mph can be expected to reduce injury crashes by 14 percent and fatal crashes by 27 percent (From AASHTO, 2010, p. 3-57). These or other estimates for other expected change in speed might be used for cost-benefit analyses as shown in Table 30 in lieu of more specific crash reduction estimates for particular countermeasures. For example, some gateway treatment combinations have lowered travel speeds by up to five mph.

Intersection treatments. Although not explicitly a speeding-related treatment, the potential need for intersection treatments and measures to separate different types and speed of users at crossing/junctions and along the roadway also must be determined through field assessment and further diagnosis.

- Crossing treatments and pedestrian signals may be needed to ensure that pedestrians have safe places and times to cross roadways when operating speeds are above 25 mph.

Provide separated facilities by user type. In a similar vein, separated space to walk/cycle along the road (and potentially or for other types of traffic such as large trucks) may be needed, depending on target operating speeds.

Currently pending roadway improvements also provide an ideal opportunity to implement speed and safety review on actual planned street and roadway improvements (at various stages in the processes from plans to nearly completed construction).

Future opportunities may include Safe Routes to School Plans, small area economic/transportation plans, and others.

While specific crash reduction targets are not appropriate for these types of strategies, long-term trends should reflect improved safety performance.

Curve treatments. Spot treatments, such as enhanced curve delineation, *have* had good success in reducing crashes at the locations treated (Srinivasan et al., 2010b) and may be successful if consistently and systematically applied. However, it is unclear whether there are spillover effects (positive or negative) to untreated curves (or other “hot spots”) with either similar or different radii and other characteristics. In addition, signs, barriers, and other fixed objects have the potential themselves to become roadside hazards for fixed object type crashes if not carefully implemented, and are costly to maintain.

Design consistency. In general, *consistency of design* is likely to be a more reliable safety measure than use of signs and other spot treatments to try to slow drivers from their normal operating speeds in advance of exceptional features (sharp curves, etc.) (AASHTO, 2010; Donnell et al., 2009).

Appendix D

Economic Analysis Examples

The below economic analysis examples supplement plan prioritization materials for Chapter 4.

- **Countermeasure: Target high visibility enforcement to a larger proportion of the network (or select corridors) where serious crashes occur by randomly allocating existing enforcement levels.** (The number of corridors that can be targeted, and expected numbers of crashes on those corridors, will affect the estimates of crash reductions.)
- **Estimated crash savings** - approximately 28 fatal and disabling-injury crashes and approximately 1100 total crashes for a monetary savings of \$18 to \$22 million, before implementation costs (Table 29).

Table 29. Estimated Crash Reductions from Randomly Targeted, but Highly Visible Enforcement that covers 60% of network crashes or 70% of Fatal and A-type crashes. ⁵²

Crash Injury Severity	5 Yr Num. Crashes Expected if No Treatment	Exp Crash Reds.	Avg. 5 Yr Crash Savings	Avg. Costs / Crash	Monetary Savings
Fatal and Disabling-type crashes (KA)	17 (70% of total)	16%	28	\$660,000	\$18,480,000
Total crashes	9444 (60% of total)	12% ⁹	1133	\$20,000	\$22,660,000

Countermeasure: Convert four lane, lower volume roads (Road Diet from four-lane cross-section) **to two lanes, plus other uses** (turn lanes, parking or bicycle lanes).

Estimated crash savings: 190 total crashes in five years, and 14 severe crashes at a crash cost savings of 825,000 to 1.75 million (Table 30).

⁵² Newstead, Cameron, & Leggett (2001). The crash reduction effectiveness of a network-wide traffic police deployment system. *Accident Analysis and Prevention* 33: 393-406. And, supported by theory (Shinar, D. (2007). *Traffic Safety and Human Behavior*. Bingley, UK: Emerald Publishing Group, Ltd., 813 pp.)

Table 30. Cost-benefit analysis of Road Diet Implementations. (Assuming three corridors with AADT < 10,000 can be treated, with low range and high-range estimates of effect.)⁵³

Crash Injury Severity	5 Yr No. of Crashes Expected if No Treatment	Exp Crash Reds	Exp. Five Yr Crash Savings	Avg. Monetary Costs per Crash	Exp. 5-yr Crash Cost Savings	Countermeasure Costs	Estimated Crash Costs Saved
All	190	29% (low est.)	55	\$15,000	\$825,000	Minimal – if through resurfacing*	\$825,000 low range
Fatal	2	47% (high est.)	0.9	1,600,000	1,504,000	Minimal – if through resurfacing	1.75 million high range (not including PDOs)
Disabling	2		0.9	85,000	79,900		
Evident	<u>11</u> 14		5.1	32,000	<u>165,440</u> 1,749,340		

*Other improvements such as medians or refuge islands could further reduce crashes, but add to costs.

Table 31 illustrates economic analysis for curve-related treatments. Note that economic analysis should consider the expected useful life of treatments to determine crash/cost benefits.

⁵³ CMF estimates from Crash Reduction Factors for Traffic Engineering and ITS Improvements”, NCHRP Project 17-25 Final Report, Washington, D.C., National Cooperative Highway Research Program, Transportation Research Board, (2008)Delineation.” Report No. FHWA-HRT-09-045, Federal Highway Administration, Washington, D.C., (2009)

Table 31. Estimated Crash Reductions for Curve-related Crashes (assuming 12 curves with the highest frequencies of KAB crashes or 35 curves with the highest number of total crashes can be treated).⁵⁴

Crash types used in estimate	Crashes expected with no Treatment (5 yrs)	% Crash reduction target	Five-year Crash Savings	Avg. Monetary costs	Potential Five-year Crash-cost savings*	Countermeasure Costs	Cost benefit
Total crashes	31 road segments 307 Crashes (assume 35 curves)	18% (all non-intersection)	55	\$27,000 (average rural crash cost)	\$1,485,000	\$300 - \$1600 per curve Est. total \$56,000 – high range	26: 1
KAB-severity	11 road segments 41 crashes (assume 12 curves)	25% Fatal and injury; nighttime	10	\$31,000 (average B-injury crash cost – rural ; lowest severity rep. in crash target)	\$310,000	\$300 - \$1600 per curve Est. total \$19,200 high range	16: 1 (not incl. other severity of crashes)

*It may be reasonable to include more years of savings if the countermeasures will have a longer useful life.

Table 32 shows the potential crash and economic savings for implementing automated speed enforcement and associated publicity in zones within one mile of County schools.

⁵⁴ Srinivasan, R., Baek, J., Carter, D., Persaud, B., Lyon, C., Eccles, K., Gross, F., Lefler, N., "Safety Evaluation of Improved Curve Delineation." Report No. FHWA-HRT-09-045, Federal Highway Administration, Washington, D.C., (2009)

Table 32. Estimated Crash Reductions from Automated Speed Enforcement (ASE) Deployed within One mile of Schools.⁵⁵

Crash Injury Severity	Crashes Expected - No Treatment (5 years assumed)	Exp Crash Reds.	Avg. 5 Yr Crash Reds.	Avg. Costs/Crash	Monetary Savings
Fatal and A-type	50	15%	7.5	\$660,000	\$4,950,000
B- and C-type	985	15%	147.75	\$22,000	\$3,250,500
ASE only – economic savings					\$8,200,500
Fatal and A-type	50	25%	12.5	\$660,000	\$8,250,000
B- and C-type	985	25%	246.25	\$22,000	\$5,417,500
ASE + publicity – economic savings					\$13,667,500

Program Evaluation Measures

Table 33 describes potential performance measures for program evaluation, not including specific safety assessment.

⁵⁵ Moon, J.P. and J. E. Hummer. "Estimating the Longer-Term Safety Effects of Speed Enforcement Cameras in Charlotte, NC." TRB 89th Annual Meeting Compendium of Papers CD-ROM. Washington, D.C. 2010

Table 33. Example Program Evaluation Matrix

Program elements	Intermediate Measures	Process Measures	Barriers to Implementation overcome	Lessons Learned
Proactive process: Coordinate with local government to set appropriate speed limits on urban roads managed by the State	<ul style="list-style-type: none"> - Speed studies conducted. -Number of locations identified that warranted change. - Meetings/communications held. - Concerns documented. 	<ul style="list-style-type: none"> - Number of locations warranting changed limits that were changed. - Number of Safety improvements implemented. - Enforcement tolerance (evidence of change). - Speeding convictions as charged. - Driver speeding or speed compliance. -Self-reported driver attitudes toward speeding or speeding countermeasures. 	e.g. Change to existing practice or policy	
Systematic Process: e.g. Review existing speed limits and conduct roadway safety assessments for prioritized lists of corridors.	Meetings, organizational structure, procedures developed, integration with existing programs.	Number of corridors with speed and safety assessments.	e.g. Time, staffing limitations	
Specific Countermeasures: e.g. Increase randomly targeted enforcement to a larger number of high crash corridors	Document deployment strategy.	Officer-hours deployed by location.	e.g. Allocating existing resources or increasing enforcement resources	
Specific Countermeasures: Implement 3 road diets	Document number of potential road diets.	Number Planned. Number Pending. Number Implemented.	e.g. Community resistance to change	
Systematic Process: e.g. Review existing speed limits and conduct roadway safety assessments for prioritized lists of corridors.	Meetings, organizational structure, procedures developed, integration with existing programs.	Number of corridors with speed and safety assessments.	e.g. Time, staffing limitations	

Countermeasures evaluation. In order to properly estimate the safety performance of a treatment, it is necessary to select the appropriate study design and statistical analysis technique. Selection of the appropriate study design and statistical analysis technique depends

on many factors including the nature of the treatment, how it has been implemented, and data that are available for the evaluation. The following documents discuss the issues associated with different types of study designs:

- AASHTO, *Safety Effectiveness Evaluation*, Chapter 9 of the [HSM](#).
- Gross, Persaud, and Lyon, [A Guide to Developing Quality Crash Modification Factors](#), Report FHWA-SA-10-032, December 2010.
- Carter, Srinivasan, Gross, and Council, [Recommended Protocol for Developing Crash Modification Factors](#), Final Report from NCHRP Project 20-07 (Task 314), February 2012.

Observational before-after studies and cross sectional comparisons may be used. These two study designs are also discussed further in the separate Speed Management Action Plan Template, Appendix B.

It is important to recognize that crash analysis may not be feasible or sufficient under many situations. For example, if sufficient number of sites and years of crash data are not available to provide a statistically reliable estimate of the safety effectiveness of a treatment, then it will be prudent for the analyst to consider surrogate measures such as average speed to obtain further insight into the effectiveness of a treatment.

Table 34 describes potential measures for safety evaluation of countermeasures.

Table 34. Example Countermeasure or Program Safety Evaluation Matrix.

Countermeasure	Short term measures	Longer-term measures	Crash cost outcome
Speed and crash-lowering countermeasure (e.g. road diet)	-Before and after speed measurements at target and comparison sites (similar untreated locations).	-Follow-up speed measurements over time. -Crash-based evaluation (at least three years after crash data)	Crash cost savings over useful life compared with countermeasure cost
Other countermeasures (e.g. signal upgrade, change in phasing)	-Other safety surrogate measures (e.g. compliance, conflicts). Identify control/reference sites for crash evaluation.	-Crash-based evaluation (at least three years after crash data). *May be difficult to evaluate treatments implemented at only a few locations.	Crash cost savings over useful life compared with countermeasure cost
Targeted enforcement	-Percentage of drivers complying with limit at target and comparison sites. -Number of citations and time spent enforcing at target and comparison sites (process measures).	- Percentage of drivers complying with limit. - Change in frequency or severity of crashes (if sufficient years, sites available).	Crash cost savings

For More Information:

Visit <http://safety.fhwa.dot.gov/>

FHWA, Office of Safety

Guan Xu
gxu@dot.gov