THE UNIVERSITY OF NORTH CAROLINA
HIGHWAY SAFETY
RESEARCH CENTER

North Carolina Pedestrian and Bicycle Road Safety Assessment Guide

A guide for local agencies to improve pedestrian and bicycle safety

Prepared as part of North Carolina Department of Transportation Research Project 2016-14,
Coordinating Road Safety Reviews with Bicycle and Pedestrian Prioritization

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Executive Summary

The purpose of this guide is to help local agencies, in collaboration with state and regional partners, to improve pedestrian and bicyclist safety in their communities. The Guide specifically provides information on using a sound, data-driven process to 1) identify and prioritize pedestrian or bicycle safety problem locations, 2) further investigate those locations through road safety assessments, and 3) develop and prioritize safety improvement projects that will help to address the identified problems. At the core of this process is a road safety assessment (RSA), a formal, but qualitative safety examination of a roadway or intersection by a professional, multidisciplinary team. The guidance provided in this document builds on traditional road safety practices and audit processes by focusing on specific and unique safety needs of people walking or bicycling.

The guide describes an RSA process that local agencies and state and regional partners can use to perform a pedestrian or bicycle-focused RSA on state- or locally-owned streets. The process is outlined in four phases. The chart below summarizes the purposes and general activities to perform in each phase.

Phase 1 — Identify Safety Problems and Focus Area for RSA

Estimated Timeframe: 1-6 weeks*

Purpose: Identify locations that may have the most urgent safety needs based on a) crash history or b) the potential for future serious pedestrian or bicycle crashes. Prioritize RSA focus area.

- **Step 1** – Identify person/organization that will conduct the analysis
- **Step 2** – Identify and acquire data for analysis
- **Step 3** – Conduct safety analysis
- **Step 4** – Screen and rank problem locations

Outcome: From the list of prioritized candidate locations, one or more sites will be selected for further examination through a road safety audit.

Data Sources to Consider: Crash data, roadway, traffic volumes, land use, transit ridership

**Time needed to analyze data and identify sites depends on jurisdiction size, complexity of analyses, etc.*

Phase 2 — Prepare for Road Safety Assessment

Estimated Timeframe: Weeks 7-10

Purpose: Form the audit team and develop a complete understanding of site-specific issues and circumstances by reviewing additional data sources and speaking with stakeholders and experts before conducting the audit.

- **Step 1** – Identify Road Safety Audit team members
- **Step 2** – Compile Information for Focus Area
- **Step 3** – Hold final pre-audit briefing

Outcome: Detailed notes, materials and a plan for completing the road safety audit.

Possible Team Members: Engineer, planner, law enforcement, NCDOT

Phase 3 — Conduct Road Safety Assessment

Estimated Timeframe: Weeks 10-11

Purpose: Gain understanding of user needs and characteristics. Following specific guidelines and prompts, perform the RSA for the identified location. Identify safety issues and potential crash countermeasures.

The audit **prompts** are broken into the following major sections:

Characteristics and needs of pedestrians and bicyclists

Factors contributing to pedestrian and bicycle crashes and injury

Safety concerns along the roadway – Pedestrian and Bicycle
What facilities are available for walking and bicycling along the roadway, and what are the safety issues or opportunities for improvement?

Safety concerns at intersections and crossings – Pedestrian and Bicycle
Are pedestrians and bicyclists of all ages and abilities able to safely and comfortably cross from one side of the road to the other without too much delay?

Outcome: Field observations and problem diagnoses supplement safety analysis and other data, providing support for particular interventions and projects.

Considerations: A field audit may need to be at different types of day or days of the week; especially consider nighttime.

***See Checklists from full guide**

Phase 4 — Document Results and Recommendations

Estimated Timeframe: Week 12

Purpose: Summarize the findings from the safety analysis, data and information review, and road safety audit.

The key components of the RSA report include:

Description of the study area

- Crash statistics – types, time of day, locations, contributing factors
- Basic cross section, presence of transit, traffic and road user volumes
- Land uses and key destinations
- Plan information
- Complaints, history, other relevant details

Summary of safety issues identified and **descriptions of the measures proposed** to address them. Maps, photos and diagrams can be help illustrate safety issues.

List of RSA team members and agencies that participated

Outcome: Specific recommendations for engineering countermeasures, as well as education and enforcement programs, to address identified safety problems.

***Consult countermeasures resources from full guide**

The phases of the RSA are described in more detail in the full-length text of this guide. Users can review the descriptions of each phase of the RSA process to find out more about the data, steps, and outcomes for each phase; find help; see case examples from other North Carolina communities; learn handy tips and insights; and find other valuable resources with more information about pedestrian and bicycle safety and safety practices that you may not have known about. The ultimate goal is to improve safety in your community.

Acknowledgements

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CONTENTS

Figures

Tables

Purpose and Scope of this Guide

Communities across North Carolina are increasingly interested in creating safer networks for pedestrians and bicyclists. Addressing critical safety needs can reduce the toll on families and communities from fatal and serious injury crashes. North Carolina continues to experience a high number of pedestrian and bicyclist fatalities and injuries, with 192 fatal pedestrian collisions and 23 bicyclists killed just in 2015. At the same time, improvements can reduce safety barriers to walking and biking, and improve the livability and economic and social vitality of towns and cities. Although too numerous, crashes that result in severe injuries and fatalities are often widely dispersed. How do communities identify and prioritize the most important safety problems and develop safety projects to address the needs?

The purpose of this guide is threefold:

- To facilitate local agencies to use data to identify pedestrian and bicycle safety problem locations
- To help agencies investigate those locations through road safety assessments
- To help agencies document safety issues and potential solutions that may be used to develop and prioritize safety improvement projects

The guide defines a problem analysis and road safety assessment (RSA) process that local agencies can use in conjunction with North Carolina Department of Transportation (NCDOT) on state- or locally-owned streets. This RSA process is modeled after formal Road Safety Audits. Road Safety Assessments may meet the North Carolina DOT's definition of a Road Safety Audit if performed by qualified, independent audit teams that include a licensed engineer who can certify the audit report. Less formal assessments are still quite valuable for problem identification and project development, even if your group cannot fully meet these guidelines.

> *"An RSA is a formal safety performance examination of an existing or future road or intersection by an independent audit team. It **qualitatively** [emphasis added] estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users" (FHWA Road Safety Audit Guidelines, 2006).*

An RSA can be thought of as a ***quality of service and safety assessment*** for the users of the street. RSAs have been widely used in North Carolina and other states. Safety stakeholders have found RSAs to be helpful in diagnosing safety issues, identifying potential solutions, and preventing costly errors when building or reconstructing streets. This guide describes:

- The data and other resources available to help in initial problem identification
- Methods and metrics for screening and prioritizing locations for an RSA
- The preparation and conduct of an RSA and types of experts needed
- The product(s) of an RSA

The ***benefits*** of conducting an RSA primarily involve the identification of pedestrian and bicycle safety issues and prioritization of effective treatments. RSAs do not take the place of engineering studies. Instead, RSAs are qualitative assessments that consider roadway factors, user experience and behaviors, land use, and other conditions when identifying design and operational issues that may affect the safety of bicyclists, drivers, and pedestrians as they use the streets.

An RSA report or summary can serve as a ***plan for pedestrian or bicycle safety improvements*** for the purposes of developing a safety project. It can also help facilitate the development and submittal of proposals to incorporate high quality pedestrian or bicycle safety-focused improvements. RSAs can also facilitate inclusion of pedestrian and bicycle Complete Streets infrastructure within other types of projects. Finally, the RSA may help you and partners to identify local opportunities to make low-cost or operational improvements, enhance enforcement, and make other improvements that can be implemented quickly and at the local level. Such improvements may also be appropriate to apply proactively at other similar locations.

This guide outlines the ***RSA process*** in terms of phases and steps. (Through the rest of this guide, we use the terms assessment and audit interchangeably.) While there are similar objectives, data, processes, and issues to consider throughout the RSA process, there is no one-size fits all approach or method that will be appropriate for all sizes and types of jurisdictions. In one region, an MPO or RPO could take the lead on analyzing data, screening, and prioritizing locations across all the communities for further assessment. In a town, the police department, public health department or transit agency might take the lead. Similarly, various analysis approaches may accomplish the objectives. However, the overall process and objectives of each phase are the same. Phases incorporate classes of actions, which include individual steps and knowledge needed to conduct a comprehensive RSA. For maximum benefit, the collaborative RSA process will become a part of regular, enhanced, data driven practices to improve safety for your community.

The basic phases of the RSA process include:

Phase 1	Identify Safety Focus Area
Phase 2	Prepare for Road Safety Assessment
Phase 3	Conduct Road Safety Assessment
Phase 4	Document Results and Recommendations

The phases of the RSA are described in more detail in the following sections with the aim of ensuring that the intent of each phase is clear, that sources of data and other helpful resources are communicated, and that transportation professionals have the basic knowledge needed to initiate and follow-up to ensure a data-driven and well-supported RSA. This does not mean that local staff need to perform all the tasks themselves, but they should know where to turn for data and help from partners.

Even before "Phase 1," there is a need to engage partners to ensure a collaborative process, and to organize, especially if this type of work has not been performed before. Once initiated, enhance safety practices such as those described here may ideally become streamlined and self-sustaining through regular work processes, meetings and coordination.

Organize

The next two sections briefly describe the importance of involving different departments and agencies with an interest in pedestrian and bicycle safety in the process from the start. There are several tasks, skills, and types of roles that you will need to fill.

Identify Partners and Roles

Pedestrian and bicycle safety is the domain of many agencies and organizations and is the responsibility of all, including users of the system. Although safety projects submitted through various infrastructure improvement programs—including the Highway Safety Improvement Program (HSIP)—focus on engineering countermeasures, it is important to identify opportunities to collaborate across partner safety agencies and to take advantage of opportunities that arise through existing departmental activities. For example, those charged with enforcing traffic laws may be able to increase speed enforcement on corridors that are dangerous for pedestrians to cross, or conduct crosswalk public awareness and enforcement actions where motorists are failing to yield to pedestrians. Urban and regional planning processes can consider pedestrian and bicyclist needs in developing land use ordinances and Complete Streets design guidance that will lead to a more balanced and equitable transportation system.

An important initial step is to identify other professional partners and engage them in discussion about the desire to use a data-driven approach to prioritize pedestrian and bicycle safety needs, and to ask for their participation. This discussion can be initiated at any time, including through phone discussions or regular meeting of relevant partners including other departments such as law enforcement and public health, RPO/MPO staff, NCDOT division or regional safety engineers and others.

This initial meeting provides an opportunity to identify the departments, organizations or persons that may be involved; ***identify individuals to lead the needed tasks***; and to develop a schedule for preparation, conduct, and documenting results of the RSA.

The basic tasks or roles you will need to fill include the following, with notes about the Phases of the RSA process where each person plays a key role.

Coordinator – provides oversight for all steps of Phase 1, may lead/delegate RSA preparation (Phase 2), and performance (Phase 3), including identifying and inviting team members with the requisite skills and knowledge to contribute meaningfully.

Data acquisition and analysis – responsible for much of Phases 1 (analysis) and 2 (preparation for the RSA), including acquiring the relevant data types and analyzing the data to identify the focus location. Ensures data are compiled for the focus location in advance of the RSA. This person could also contribute to the pre-RSA briefing.

RSA leader – the overall coordinator may take on this role; responsible for leading the RSA (Phase 3). This person will also need to insure that observations are documented, may lead the post-RSA de-brief, and helps ensure RSA report completion in some form. The RSA leader ideally is skilled at facilitating team engagement and discussion, and may also contribute to the discussion.

RSA report development – responsible for ensuring an RSA report is completed (Phase 4). The report can vary in complexity, but needs to document the safety data, the traffic, roadway, and land use conditions, the issues observed, potential measures identified in the field and discussed by the team, and document who participated in the RSA. The entire team should, however, review the RSA summary before it is finalized.

Develop a Schedule

Developing a realistic schedule for the RSA process in advance will help keep your team on track throughout the process. Setting dates and key milestones as a group will make sure that the RSA does not get sidetracked when other high priority tasks come up.

The general timeline for the RSA process is flexible, but there is value in ***developing a realistic but short timeline***.

Helpful tip

Primary RSA stakeholders and RSA participants may be able to incorporate steps in the process into regularly scheduled meetings or tasks.

Identify opportunities to coordinate with existing staff and inter-departmental and inter-agency meetings to discuss tasks, roles, and schedules. It may be possible to incorporate planning meetings and sharing task results–such as findings from initial analyses, and identification of a focus area–into regular meeting schedules. It may even be possible to schedule the RSA itself in association with a regular meeting, as examples, a TAC meeting or meeting of a pedestrian and bicycle advisory board that will be attended by qualified planners, engineers, law enforcement, and other types of staff that may perform the RSA.

A period of 2-3 months should be sufficient for analyzing data, identifying the focus, completing the RSA and producing the report, even for a first RSA. In some cases where the study area is relatively small, you may shorten the timeline to less. If you feel that more than three months are needed, this may be an indication that the study area is too large, or that you need more help getting tasks completed. The example schedule below (Table 1) may be used as a starting point and is based on an approximate three-month timeline. A rate-limiting factor may be to get the RSA onto people's schedules, so consider setting a tentative date earlier in the process than indicated. However, you will want to know the focus area and have data ready to share before finalizing the date. The process may take less time once your team completes one or two RSAs.

Helpful tip

Regular Nighttime meetings of stakeholders and practitioners such as Transportation Advisory Committee meetings may provide opportunities to perform field review of conditions at night, when many pedestrian fatal collisions occur.

Table 1 Sample Road Safety Audit Preparation Timeline

Phase	Milestone or Activity	Week
1	Hold initial discussion with partners, define key roles	1
1	Collect, compile and analyze data	2-5
1	Hold interim (local) partners meeting to ID focus area	5
1	Invite RSA team & schedule pre-briefing and RSA	4-6
2	Compile/summarize data for RSA	7-10
2	Conduct Interviews with other stakeholders/non-team members (optional)	7-10
3	Conduct RSA and debrief	10-11
4	Complete RSA Report	12

The next sections describe Phases 1 – 4, or a set of basic tasks to carry out to complete the RSA process. Each phase is color-coded to help the user find the information they are seeking for the relevant phase. A bibliography of additional resources is provided at the end of this Guide, and many of these resources are also mentioned at relevant locations throughout the guide.

PHASE 1 – Identify Safety Problems and Focus Area

The primary objective of Phase 1 is to prioritize areas for an RSA. More specifically, the purpose of data analysis and other problem identification steps is to understand and identify key safety issues, and rank and prioritize safety problem locations that warrant further investigation through a road safety assessment. The goal of the analysis is to hone in on the locations that may have the most urgent safety needs based on a combination of demonstrated crash history and the potential for future serious pedestrian or bicycle crashes.

The basic steps in the safety problem identification and prioritization process are shown in Figure 1 and described further below.

Step 1
Identify person/organization to conduct the analyses

Step 2
Acquire the data for analysis

Step 3
Conduct safety analyses

Step 4
Screen and rank problem locations

Figure 1 Flow chart for safety problem identification process.

The data available, size of the jurisdiction and numbers of crashes, and resources available to conduct the analysis will ultimately shape the specific methods and complexity of analyses used.

Step 1 – Identify Person/Organization to Conduct the Analyses

In the initial meeting or communications, the local RSA coordinator can work with partners to identify which agency or person is best suited to conduct data analysis, or if a consultant familiar with NCDOT crash data and safety investigation processes should be hired to perform analyses and possibly other steps in the RSA process.

Once the person and organization with primary responsibility for data analysis is identified, they will take the lead in the remaining problem identification steps. They may need to coordinate with other partners to identify and collect the appropriate data (although many sources are described in Step 2). Meanwhile, others might be gathering community input about locations perceived to be unsafe, if this has not already been done through other planning efforts.

The NCDOT Safety Office may be able to provide assistance in screening for intersections or segments with a high frequency of pedestrian or bicycle collisions and in conducting strip analyses of all crashes that can be useful for completing the RSA. For more information, contact your NCDOT regional safety engineer or the central safety office.

Step 2 – Identify and Acquire Data for Analysis

The intent of data analysis is to determine what and where safety problems may exist, such as the locations of prior crashes, the types of crashes or crash patterns that are most prevalent, and other ***factors*** associated with those crashes. The ultimate goal is to prioritize one or more locations most in need of safety improvements and for performing an RSA. The RSA can help you to diagnose the specific safety problems and identify potential improvements to address those problems.

Primary Data Sources

The two key data types for analysis are ***crash data*** and ***roadway data***.

Key elements needed in crash data include ***crash type*** and specific ***location of the crash***, along with other variables describing the location characteristics, people and vehicles involved, and conditions present at the time of the crash. North Carolina sources for crash and roadway data are summarized in Table 2. Two key sources include crash typed and spatially-coded ***pedestrian and bicycle crash data***, and crash (and roadway) data available through NCDOT's Traffic Engineering Accident Analysis System (TEAAS). There is more information in Steps 3 and 4 on using these data for analysis and prioritization.

Figure 2 shows an interactive North Carolina pedestrian and bicycle crash map that includes all pedestrian and bicycle crashes reported to NC Department of Motor Vehicles for the stated years. The data behind this crash map (hereafter referred to as ***NCPedBike data***) are available for downloading and more in-depth analysis, and include variables from the TEAAS system resulting from crash reporting, along with ***latitude***

and longitude coordinates, and detailed crash types and crash groups, that are coded from review of hard copy crash reports (including review of the diagrams and narratives).

More information

Crash types are descriptions of the motor vehicle and pedestrian or bicycle maneuvers (relative to each other) leading up to the crash. An example is "Motor Vehicle Left Turn – Opposite Direction" to bicyclist type of collision. See Appendices A and B for more information. Geo-located and crash typed pedestrian and bicycle crash data can be downloaded in GIS formats from the NCDOT Bicyclist and Pedestrian Crash Map Web site.

NCDOT maintains statewide crash data through the TEAAS system for all reported crashes, including those that involved one or more motor vehicles and/or pedestrians or bicyclists. A crash is considered reportable by the State if it includes "a fatality, injury, property damage of $1,000.00 or greater, or property damage of any amount to a vehicle seized. A reportable crash must occur on a trafficway or occur after the motor vehicle runs off the roadway but before events are stabilized" (NCDOT, Division of Motor Vehicles, Traffic Records Branch 2012, p. 38). However, some local agencies may report crashes that do not meet these thresholds, and these are retained in the NCPedBike database if it seems clear that there was contact between and motor vehicle and a pedestrian or bicyclist. However, note that many more crashes– including bicycle only falls and crashes–may go unreported, even if a motor vehicle contributed to the crash, but did not make contact.

Location information, either latitude and longitude coordinates (as available in the NCPedBike data) or mile-posted locations (as available in the TEAAS data), are essential for identifying priority areas for an RSA. Crash type variables help to describe what happened in the events leading up to a crash, and are useful for identifying appropriate types of countermeasures to address certain patterns.

Many of the variables available for analysis, either from the NCPedBike data, or from TEAAS, are among those frequently associated with pedestrian or bicycle crash risk from prior studies. Crash type and latitude and longitude variables are included in the NCPedBike crash data. Variables that are available in one or both of the principle statewide pedestrian/ bicycle crash data sources include:

- Crash type–detailed description of crash scenario (NCPedBike database, see Appendix B for examples)
- Crash group–general grouping of similar crash types (NCPedBike data)
- Crash location (type) (intersection, non-intersection, or off-roadway such as parking lot) (NCPedBike; Road Feature includes intersection and non-intersection locations in TEAAS)
- Latitude and Longitude coordinates (NC PedBike)
- Pedestrian or bicyclist position (where they were walking/riding prior to the crash) (coded differently in NCPedBike and TEAAS)
- Bicyclist direction of travel (with or against traffic) (NCPedBike; may be possible to derive from TEAAS variables)
- Injury severity
- Traffic control type
- Speed limit of the road (may also be derived from the roadway inventory)

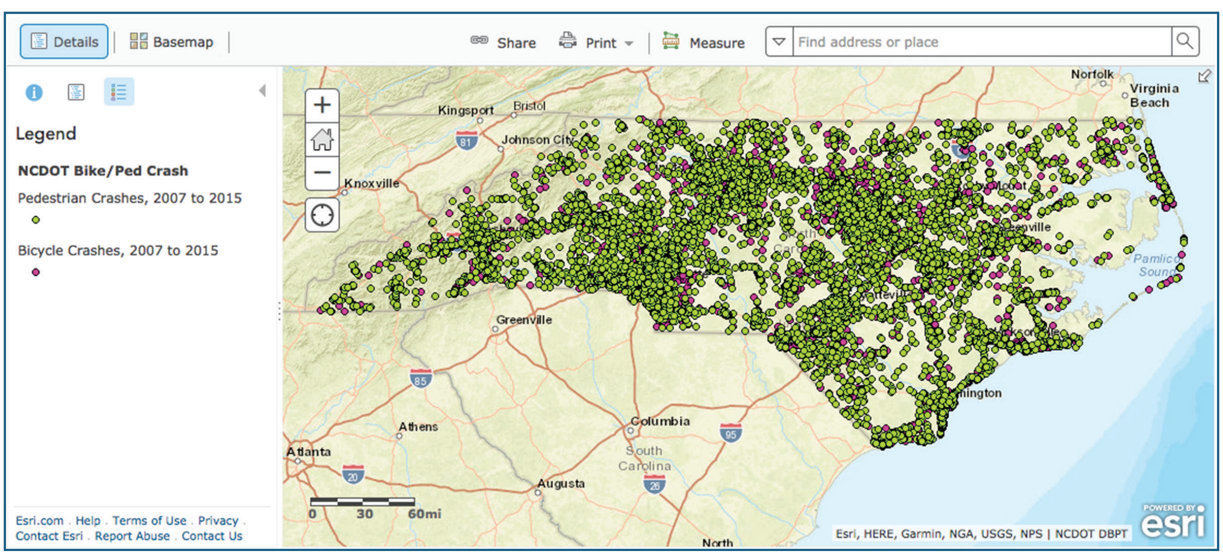

Figure 2 North Carolina bicyclist and pedestrian interactive crash map
(Map and data available at: https://ncdot.maps.arcgis.com/home/webmap/viewer.html?webmap=b4fcdc266d054a1ca075b60715f88aef)

- Road configuration (includes median presence and type)
- Road classification
- Number of thru lanes
- Development type indicators
- Time of day
- Light conditions
- Alcohol-use indicators
- Weather conditions
- Surface conditions

Discuss the goals and type of analysis to be performed with partners to determine the best data options. Both sources may be useful at different stages of the RSA analysis and process. If local analysts wish to join land use, transit, census, or other data types, it makes sense to use the geo-coded data (NC Ped/Bike data). If you will request DOT assistance in screening, then it makes sense to consult with the Safety office or other experts for assistance with when and how to use TEAAS data in the process.

NCDOT also maintains roadway inventory linkable to crashes in the TEAAS (milepost) system, and in several GIS-based layers. See Table 2 and Appendix A for more details. For those who need more information about crash and roadway data, see Appendix A, or consult with NCDOT Safety or Bicycle and Pedestrian Division staff.

Table 2 Primary NC data sources for analyzing pedestrian and bicycle crashes

Data type	Description	Source/Potential source
NC Pedestrian and Bicycle crash data (NC Ped/Bike data)	Includes crash or person variables from TEAAS data; crash type, location, position, and other variables from PBCAT crash typing; and latitude and longitude coordinates of the crash location. Typically, lags at least one year, due to time needed to obtain complete annual year of data, geocode and crash type all crashes. Crash IDs have been removed.	NCDOT Bicyclist and Pedestrian Crash Map, map and downloadable data available: https://ncdot.maps.arcgis.com/home/item.html?id=b4fcdc266d054a-1ca075b60715f88aef North Carolina Pedestrian and Bicycle Crash Data Tool Web site (NCDOT resource), query the data at: http://www.pedbikeinfo.org/pbcat_nc/
TEAAS	Includes crash data for all types of crashes reported to DMV statewide. May not include latitude/longitude coordinates but includes milepost location data for crashes on state-owned roadways. Data are linkable to roadway inventory in TEAAS. Does not include pedestrian or bicyclist crash type variables. Current to within one or two months (but may not be fully complete for most recent months). Crash IDs are available for requesting crash report copies.	Traffic Engineering Accident Analysis System (TEAAS) (NCDOT Resource): https://connect.ncdot.gov/resources/safety/Pages/TEAAS-Crash-Data-System.aspx
Roadway data – State-owned road network	Varied centerlines files including “Statewide System & Non-System Road Routes, A Route Layer for visual representation of attributes stored by County/Route/Milepost linear reference”	GIS Data Layers (NCDOT Resource): https://connect.ncdot.gov/resources/gis/pages/gis-data-layers.aspx

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Table 2 continued...

Data type	Description	Source/Potential source
Roadway data – Complete roadway network including local streets	If complete local network roadway inventory is unavailable from the jurisdiction, Integrated Statewide Road Network Data – current as of 2007, includes state and local road network centerline files. The Center for Geographic Information and Analysis maintains a listing of the status of the availability of street centerlines for all 100 counties	GIS Data Layers (NCDOT Resource): https://connect.ncdot.gov/resources/gis/pages/gis-data-layers.aspx The Center for Geographic Information and Analysis Web site: http://www.cgia.state.nc.us/Coordination/tabid/66/Default.aspx links to data that can be accessed online at: http://www.cgia.state.nc.us/Portals/7/documents/Access_LocalData_Online.pdf
AADT (Traffic volume) data for some segments	Annual Average Daily Traffic (AADT) Traffic Volume Map presents the [daily] traffic average for the year at specific points on North Carolina highways. Data is collected either annually or every two years at more than 40,000 locations throughout North Carolina.	Traffic Volume Maps (NCDOT Resource): https://connect.ncdot.gov/resources/state-mapping/pages/traffic-volume-maps.aspx
Transit use / proximity data (if transit present)	May include stop locations, boarding/alighting data by stop, total count of buses stopping, etc., depending on what local agency compiles/collects – may be available in GIS format.	Local and regional transit agency/agencies

Secondary Data Sources

Additional data sources are useful for comparing locations and understanding pedestrian and bicyclist crash risks, especially since bicycle and pedestrian crashes can be relatively scattered across many locations. ***Crash frequencies alone do not tell the full story about why crashes are occurring, or where they are likely to occur in future***, especially at any particular location. Sources of data for assessing these risks are summarized in Table 3.

Risk factors are characteristics of the roadway, environment, and users that contribute to crash potential, or that increase the severity of injuries that may result when crashes occur. The presence of one or more risk factors does not mean that crashes are certain to occur, but just as with disease, the presence of a certain characteristic, is associated with higher probability of a negative event or outcome. It may help to think about the analysis and prioritization process (Steps 3 and 4) in terms of identifying risks that suggest future crashes are likely, especially more severe crashes, and prioritizing one or more locations that exhibit more of these risks. The RSA itself aims to identify risk factors and crash type patterns that are treatable – or in other words, risks that can be targeted for effective safety improvements.

Exposure data

Exposure, a primary indicator of crash risk, is often estimated in terms of the numbers of vehicles and people passing through a location as these measures have been found to increase potential for crashes to occur. At the least, these types of data are needed for placing crash histories into more context to understand the normal level of crash risk in an area. Two of the most important variables associated with pedestrian or bicyclist crash frequencies are:

- Traffic volume (typically Average Annual Daily Traffic, or AADT)
- Pedestrian or bicycle counts or volume (AADP/ AADB)

If motor vehicle, pedestrian, and bicycle volume data are not available, you may consider collecting the data for at least one or a few priority locations, as the data will be needed to develop a safety project. Roadway user volumes are associated with potential numbers of interactions that may contribute to future crashes if no action is taken. The relationships among crashes and motor vehicle and/or pedestrian and bicyclist volumes are, however, generally not linear, and in some cases, relative safety even seems to improve at higher volumes of pedestrians or bicyclists. However, if there are high volumes of traffic, pedestrians and cyclists may be exposed to more conflicts and potentially crashes and such an area may warrant an RSA focus. As examples only, consider the following points:

- If there are also substantial numbers of people walking or biking in an area, this suggests a continued potential for future crashes. However, there may be many people walking in urban but lower speed areas, and risk of more severe injuries may be lower at such locations – another point for consideration in prioritizing locations.
- If there are relatively few people walking/biking in an area, but several severe injury pedestrian/bicyclist crashes, then the area may be relatively more hazardous to the people walking or biking, especially with respect to serious injury potential. Such an area may also deserve attention through examination of other data types and potentially an RSA to determine whether the situation was rather random, or whether people may continue to be exposed to crashes.

Helpful tip

NCDOT regional or central safety office may be able to provide assistance with collecting traffic, pedestrian, and bicycle counts for a limited number of high priority locations.

Surrogates for exposure data

Pedestrian and bicyclist count data are, however, not widely available across the state at the current time. Traffic volume data may be most available for arterial roads owned by the state, and less available for other types of streets. Alternative sources of existing data can help to serve as ***surrogate*** measures for understanding the potential for interactions among motorists, pedestrians and cyclists that may continue to contribute to future crashes. For example, pedestrian activity and crashes have been associated with certain types of ***land uses*** such as commercial areas and urban cores, residential, and mixed uses. ***Transit operations*** are also associated with greater activity and crash potential. Areas with ***lower car ownership*** or ***household/personal incomes*** (measures available from census data) may be associated with higher crash frequencies, due in part to greater dependence on walking/biking among such households. In fact, some of these types of factors have been associated with increased crash frequencies, even when volumes of traffic (of all types) are accounted for. Documenting these measures can help to justify a need for safety improvements. Roadway characteristics such as greater numbers of lanes or higher functional classes may also represent increased traffic and pedestrian exposure if traffic volume data are unavailable. ***Higher traffic speeds*** are also associated with greater potential for more severe injuries.

Other data types that are especially useful to increase understanding of pedestrian and bicyclist demands or needs for travel, and where making safety improvements may be a priority, include the following:

- Roadway characteristics (functional classes, numbers and types of lanes, median type/presence etc.) – available in sources from NCDOT mentioned in Table 1.
- Transit data
- Sociodemographic data
- Land use and planning data
- Speed data

Again, Table 3 summarizes sources for exposure data or surrogates.

The listed sources of data provide information about factors that have been often linked to pedestrian or bicycle crash tendencies in prior studies, and that can help to prioritize sites for an RSA. A table from FHWA's *How to Develop a Pedestrian and Bicycle Safety Action Plan* (Gelinne et al. 2017) is recreated as Table 4 below. This table provides some general links between the types of data you may have available, and the types of risk factors they may allow you to examine in one way or another.

Examples of how some NC jurisdictions have used these types of data to improve understanding of crash risks and safety priorities are shown in Step 4.

Table 3 Secondary data sources for pedestrian and bicycle crash analysis

Data type	Description	Source/Potential source
Transit use / proximity data (if transit present)	May include stop locations, boarding/alighting data by stop, total count of buses stopping, etc., depending on what local agency compiles/collects – may be available in GIS format.	Local and regional transit agency/ agencies
Census data – socio-demographic data	US census data – Includes population by age, household income, car ownership, commute mode shares, employment and other sociodemographic variables by census tracts and census block groups (subareas within defined census tracts)	Census data – contact local/internal GIS coordinator for local census data, or see next
	TIGER files – Shapefiles/geodatabase files already created for all states from most recent census or American Community Survey with variables relating to pedestrian and bicycle safety Census-tract-level data are available containing standard data items such as total population, total housing units, median age, population aged 16 and over, population aged 65 and over, race, average household size, and others. Block group level data are available containing housing units, children under 18 years of age, transportation to work, poverty status, per capita income and others	United States Census Bureau, Geography, TIGER/Line® with Selected Demographic and Economic Data Web site: http://www.census.gov/geo/maps-data/data/tiger-data.html
	Other Tiger files do not include demographic data, but contain the spatial data for boundaries, streets, etc., and geographic entity codes that can be linked to the Census Bureau's demographic data. More details are available on American FactFinder and other support Web sites such as http://dataferrett.census.gov/.	United States Census Bureau, American Fact Finder Web page: https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml U.S. Census Bureau, The Data Web: http://dataferrett.census.gov/
Land use / planning data	Land use and density information General (e.g. commercial, residential) and more specific land uses such as schools, parks, trails, specific types of businesses/attractors	Local land use plans and databases Economic data also available from state and national sources Building volumes
Public Input / Complaint data	May include safety problems or problem locations identified through public planning processes, ongoing complaint data collection or plans	Internal data and planning resources

Table 4 Data types that can help account for various types of risk associated with pedestrian or bicycle crashes
Adapted from: Gelinne et al. 2017, p. 21, Table 1

Data Types	Risk Types	Location Types
Crash Data		
Location Contributing factors and crash types Environmental and temporal factors	Time or Distance Exposed to Traffic Behaviors Speed Conspicuity	Intersections and Segments Corridors Areas System-wide Problems
Behavior and Observational Data		
Intersection conflicts Motor vehicle speeds Citations and convictions Use of bicycle lights/reflectors	Behaviors Speed Conspicuity	Corridors Areas System-wide Problems
Volume and Count Data		
Traffic volumes and projections Pedestrian crossing counts or estimates Bicycle counts and estimates	Volume and Type of Road Users Time or Distance Exposed to Traffic	Intersections and Segments Corridors
Roadway and Inventory Data		
Roadway characteristics (number of lanes, width, median or turn lanes) Pedestrian and bicycle facility and signal inventories (presence, type, condition) Lighting Parking location and type Intersection characteristics (number and type of lanes, curb radius, signal timing) Speed Limits	Time or Distance Exposed to Traffic Conflicting Movements and Designs Conspicuity Visibility Speed	Intersections and Segments Corridors Areas
Land Use Data		
Land use type Density and mix of uses Building volume/density and setback	Volume and Type of Road Users Time or Distance Exposed to Traffic	Corridors Areas

Table continued on next page. >

Table 4 continued...

Data Types	Risk Types	Location Types
Census and Population Data		
National Household Travel Survey Census Journey to Work Vehicle ownership	Mode Share by Road User Type Commute Mode Share	Areas
Transit Data		
Routes Stop or station locations and features Ridership Number of buses National Transit Database	Volume and Type of Road Users Conflicting Movements and Designs	Intersections and Segments Corridors Areas

Step 3 – Conduct Safety Analysis

The purpose of the crash data analysis is to characterize prevalent crash factors and crash types, and hone in on the location types where crashes are concentrated or most prevalent. A first step in a system-wide safety analysis is to determine how many total pedestrian or bicycle crashes have occurred in the jurisdiction over the past ten years, including how many pedestrians and bicyclists were seriously- or fatally-injured.

If relatively few crashes have occurred, there may not be enough crashes to draw firm conclusions about locations, crash factors, or crash patterns for a safety project. Nonetheless, it is important to consider that risk factors may be spread across the network, and many locations may be at risk of future crashes if nothing is done, especially as more people begin walking in an area. If walking and biking are desired, as they are by many communities, then there may be a need to plan for basic infrastructure. Those types of projects will require public input, planning, and other funding sources. See the Bibliography at the end of this Guide and consult with the NCDOT Division of Bicycle and Pedestrian Transportation about additional planning opportunities.

Alternative Risk Assessment

As already mentioned, just because there are few prior crashes does not mean the jurisdiction is safe for walking and cycling and there are a number of risk factors that can help assess future crash potential. There may be little infrastructure to support safe walking and biking. Further, significant safety issues such as high speed, high volume roadways, traffic signals that do not accommodate pedestrians and bicyclists, controlled crossings that are few and far between, and other issues may exist. These conditions can act as barriers to walking and biking for those who have a choice about when and where to walk. In such communities, few crashes may occur, but when crashes do occur, they may result in serious injuries or fatalities.

However, others ***may not have a choice*** but to walk, using walking to get to work, shopping, or school, or to begin or end each leg of their daily trips. Treating only high crash locations may leave many locations at risk of future crashes untreated (Gelinne et al. 2017).

Along with crash histories, agencies can use risk factors identified from prior research (e.g. higher traffic, larger numbers of lanes, higher speeds, transit, commercial land

Helpful tip

Being more proactive at identifying locations that require pedestrian or bicycle safety and connectivity improvements can also help to ensure that these needs are addressed when opportunities arise through operations and repaving or redevelopment projects, or other roadway infrastructure projects. Contact NCDOT regional safety engineers early to discuss the RSA. NCDOT can provide support to investigate locations, collect additional data, and support projects regardless of whether the location is on a state-maintained road or non-system facility.

uses, and others) to identify locations that may be in need of safety improvements. A number of resources are currently being developed to help agencies assess risk potential so that locations that may be more likely to experience future crashes can be treated in a more proactive fashion. Some of these resources are mentioned in the bibliography and other places in this Guide. We also highlight common risk factors in the next section on crash analysis.

Roadway Safety Assessments themselves may also be used ***proactively*** to identify safety problems and potential solutions before problems emerge. For example, RSAs could be conducted proactively at locations such as:

- A main road through a town
- A transit corridor or arterial with multiple pedestrian origins or destinations
- A school walk zone or corridor
- Plan-identified priority locations
- Locations with public complaints
- Locations or corridors where projects are planned for other reasons besides pedestrian and bicycle concerns (an RSA can be used on either an existing or planned road or improvement project and can help to ensure that the improved roadway will safely serve all types of users)

There are a few additional tools that can also be used to screen to identify potential problem locations if crashes are low in number, or to supplement crash analysis. One such tool is the *Pedestrian and Bicycle Intersection Safety Indices: User Guide.* The Index calculators can be used to screen and rank locations that may be priorities for an RSA (Carter, Hunter, Zegeer, & Stewart 2007).

Use of this tool may require making certain assumptions or collecting supplemental data such as from online digital imagery or field-collected data.

The *Systemic Pedestrian Safety Analysis Guidebook*, being developed under a National Cooperative Highway Research Program project (NCHRP 17-73; expected in summer 2018) will provide information on more risk-based, 'systemic' type analysis and treatment approaches that may help to more proactively improve pedestrian safety at many more locations.

Agencies could consider conducting regular risk-based screenings, rather than waiting for complaints or requests, which may inadvertently lead to some neighborhoods or streets receiving more attention than others.

Crash-based Safety Analysis

To conduct crash-based analysis of safety problems, analysts can make use of the existing crash data query tools and crash map if crashes are relatively few and scattered. However, it is recommended to download the data to conduct more in-depth analyses.

For most jurisdictions, it is probably best to ***use at least five years of data***, and ***10 years*** of data is recommended since the number of crashes may be too low to draw firm conclusions with fewer years of data. While up-to-date crash data is desirable, it is most important in this type of analysis to use more years of data, as trends do not typically change drastically year-to-year unless there are significant changes in circumstances.

Initially, it can be useful to identify factors associated with pedestrian or bicycle crashes jurisdiction-wide in order to better understand prevalent crash factors across the network. ***Descriptive statistics*** can help in determining what facility types and other characteristics might be the focus for an RSA. For example, if most bicycle collisions occur primarily at signalized intersections, an ***intersection focus*** may be warranted. If pedestrian crashes are widely dispersed at intersection and non-intersection locations along one or more corridors, perhaps a ***corridor*** is most important to consider. Where (and when) do more severe crashes tend to occur? Certain factors such as higher speeds and darkness may be associated with greater proportions of severe injuries when a crash occurs.

More information

Descriptions of some of the most prevalent pedestrian and bicycle crash types by location type for the entire state are summarized in Appendix A. Other descriptive analysis results from statewide data are summarized in reports on the North Carolina Pedestrian and Bicycle Crash Data Tool web site. These summaries can serve as a comparison or guide for exploring local safety issues.

Pedestrian and Bicyclist Crash and Injury Risks

As a reminder, risk factors are characteristics of the roadway, environment, and users that may contribute to crashes at a location or that increase the severity of injuries that result. It may help to think about these issues when thinking of which available variables (from crash, roadway, transit, land uses, etc.) to examine during analysis, and when prioritizing the RSA focus since some of these conditions are associated with more severe injuries; others may need to be observed in the field. These and related concepts will be brought up again in Phase 3.

Remember, risk principles and factors that increase ***exposure*** to potential crashes are important to consider for prioritizing a focus location or corridor, especially if there is no clear 'high crash' location that emerges. Some locations may experience a sudden 'surge' in crashes one year, but drop back to a low level a following year. It is important to place these kinds of fluctuations in some context to understand whether crashes are likely to continue to occur over time.

Numbers or volumes of road users – As described in Step 2, opportunities for conflict and crashes increase as the number or volume of motor vehicles, pedestrians and bicyclists increase. These are typically measured in Annual Average Daily estimates (i.e. AADT, AADP, or AADB).

Conflicting movements – Conflicts may be somewhat designed into the road system (i.e., numbers of lanes, unrestricted turning movements, lack of median, etc.); associated with road side characteristics such as land use, numbers of driveways, parking, and transit; or may result if the system is not working well to meet user needs (i.e., no pedestrian signals at signalized intersections, too far to walk for a controlled crossing, turning traffic that doesn't yield etc.).

Environmental risks – Environmental risks include such factors as darkness or insufficient lighting, bad weather that reduces visibility, decreases road friction and increases braking distance, and others that can interact with, and potentially magnify, the other types of risk. For example, pedestrians may have more difficulty judging gap distance and speed of vehicles at night. ***In North Carolina, 73 percent of pedestrian fatalities and 50 percent bicycle fatalities statewide occurred under conditions of darkness*** (data from NC Pedestrian and Bicycle Crash Data Tool, 2011-2015 crashes).

Traffic speed – All else being equal among potential RSA locations in terms of number and severity of collisions and other exposure factors, consider the speed limit or operating speeds of the roadway. Higher speeds strongly increase the chances of a fatal or serious injury in the event of a crash (Rosén, Stigson, & Sander 2011; Tefft 2013), and higher impact speeds also increase the expected numbers of fatal and injury crashes of all types (*Highway Safety Manual*, 1st edition).

Speed also increases the distance needed for drivers to detect a pedestrian or bicyclist and slow or come to a stop in order to avoid a crash (also called "stopping sight distance"). Motorists traveling at higher speeds also tend to be less likely to yield to pedestrians crossing at uncontrolled locations (Garder 2004; Bertulis and Dulaski 2014).

Behavioral risks – Behaviors such as failure to comply with traffic controls, speeding, or impairment by drivers, pedestrians, or bicyclists may also increase the potential for crashes, or of more severe injuries when crashes occur. Law enforcement can assist with identifying where and when they have noticed speeding problems, and other types of issues such as where alcohol-involved crashes may be concentrated. Variables indicating speeding, impairments, or failure to comply with traffic controls may be indicated in crash data, but may not be reported to the same degree everywhere. In addition, the RSA can be used to identify potential reasons for risky behaviors and violations that may stem in part from the roadway and built environment. In addition, given human nature, it is important to consider how to reduce the chances of injury and fatality, given the inevitable mistakes and human frailty.

Vehicle types and size – Significant numbers of heavy vehicles (trucks/buses) in the traffic stream further increase risk of injury to pedestrians and bicyclists.

Not all of the associated data types may be available for analysis, which is yet another reason to perform an RSA and involve multiple types of partners.

Again, talk with partners, including NCDOT and other agencies and departments, if data do not seem to be available for prioritizing locations.

More information

Issues that might be uncovered in an RSA, but not through data analysis include:

Traffic may be travelling much faster than the road is posted or planned to operate at certain times of day.

A transit stop may block approaching motorists' view of pedestrians crossing in front of the bus.

A dedicated or free-flow right turn lane may contribute to high-speed turns and drivers not yielding to bicyclists traveling straight through or to pedestrians who are trying to cross at an intersection.

Poor connectivity and inadequate facilities may lead to bicyclists riding wrong-way, against traffic on the roadway or on sidewalks.

Step 4 – Screen and Rank Problem Locations

Since the primary purpose of this effort is to identify a priority location for an RSA, a key focus will be to use crash location information along with roadway data and exposure measures (described in Steps 2 and 3) to help prioritize locations where crashes may continue to occur. If the NCPedBike (spatially-coded) data are used, analysts may conduct preliminary spatial analyses to identify the general distribution of crashes across the network and gain some understanding of corridors, neighborhoods, or intersections that may be problematic. Spatial explorations can include examining patterns of different crash types, light conditions, injury severity, and other associated crash factors such as alcohol involvement for a more thorough understanding of crash problems in the community. Remember however, not to dwell too long in these explorations, and that the focus is to identify and prioritize or 'rank' problem locations.

These initial visualizations are also useful to determine whether additional analyses or ranking procedures will be needed to prioritize sites for an RSA. For example, no one site may emerge from viewing a basic crash dot map as being especially more crash-prone than others, or there may be multiple sites that require additional analysis to prioritize. These additional analyses may require overlays or metrics that consider proportions of severe crashes, traffic volume, land use, transit, or population demographics to help prioritize.

The next step in identifying priority areas for attention may be as simple as creating crash maps and visually examining the crash patterns and the relationships with other risk types described above.

The NCPedBike data will allow analysts to identify crash hotspots as well as to create maps to visualize problems in the context of corridors, intersections, land uses, transit, populations, schools, and other spatial relationships to aid in prioritization. Data may be joined and exported into other software for more complex analyses or to develop additional ranking metrics. Basic analysis examples and resources are summarized below, but it is important that staff with appropriate skills and knowledge perform the analysis.

GIS-based Spatial Analysis

The descriptive analysis and preliminary spatial analyses may have suggested the type of focus area for ranking. Options include:

- Segments
- Intersections
- Corridors

There are several ways that locations with potential safety problems can be prioritized using spatial visualization, density or cluster analysis methods. As mentioned above, a simple dot map or crash density analysis using available tools in ArcGIS may be used to initially identify high crash locations, especially in smaller communities. However, dot maps will not be sufficient if crashes are abundant enough that they overlap each other when visualized in a map or if crashes are so widely dispersed that no one location clearly emerges. Data may be compiled or spatially joined with other data for more in-depth analysis in GIS or using other types of analysis software.

Some type of ***cluster analysis*** (Figure 3) or ***density analysis*** (Figure 4) may be preferable to simple dot maps to highlight potential areas of concern.

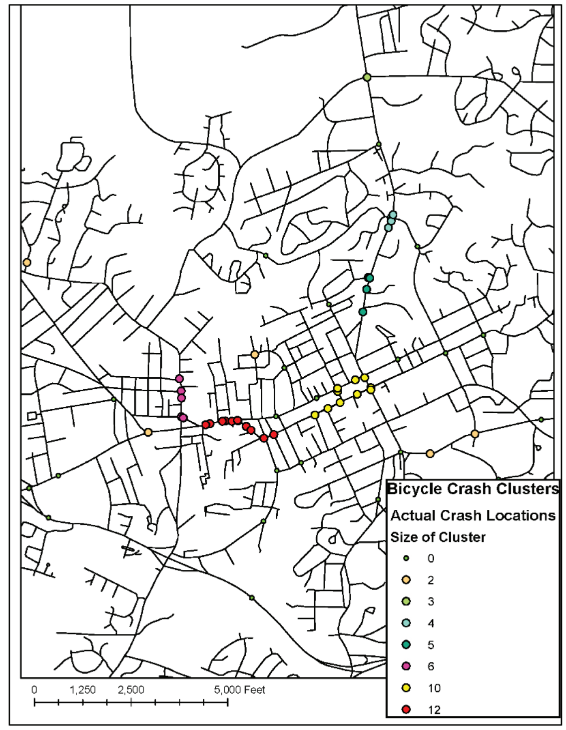

Figure 3 Bicycle crash clusters in Chapel Hill and Carrboro, NC 2001-2005
Source: Thomas et al. 2009; SANET software used to identify clusters

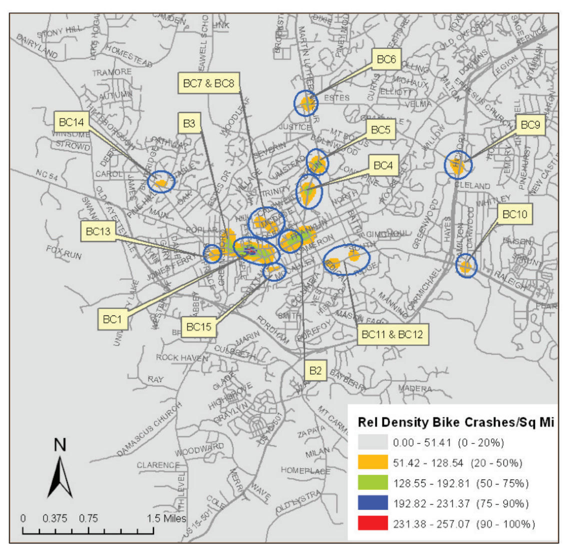

Figure 4 Area-based Kernel-density analysis of bicycle crashes, Chapel Hill, NC
Source: Thomas et al. 2009. Map produced using CrimeStat and ARCGIS (®Esri)

See the example in Figure 5 of a spatial buffer analysis, which allowed ranking of areas near schools by pedestrian crash frequency within 0.25 mile. Such analyses can be performed in case there is an issue or concern about child safety in the vicinity of schools, or in similar analyses for other types of facilities or populations.

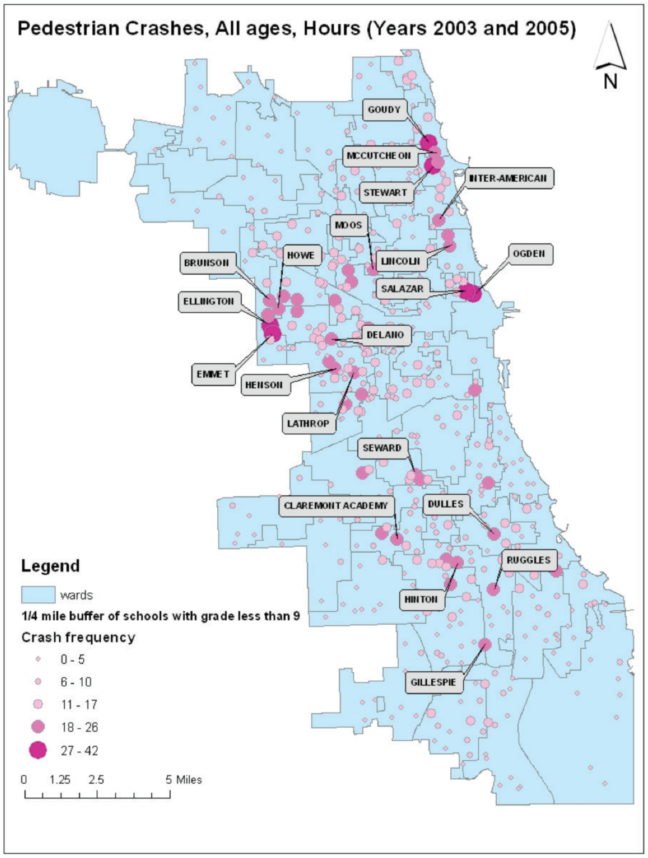

Figure 5 Identification and ranking of schools by pedestrian crash frequencies within 0.25 mi
Source: Thomas, Rodgman, & Pan 2007

The crash type, time of day, lighting conditions, and other patterns can be examined in conjunction with the location characteristics. Such patterns can be identified using mapping tools and visualization. More sophisticated analyses may be performed by using a combination of spatial joins of different data types, and analyses using either GIS-based tools or other data analysis software.

More information

SANET (A Spatial Analysis Along Networks), CrimeStat, and ARCGIS (© ESRI) are some of the spatial analysis and mapping tools that have been used to identify crash hotspots (Tolford, Renne, & Fields 2014; Thomas et al. 2007, 2009 and others).

More sophisticated, as well as more reliable, analyses and ranking methods may help to ensure more stable or less random locations are being identified as priorities. These methods and ranking procedures are described in the *Highway Safety Manual,* 1st edition.

However, if there is a corridor or area focus, and some consideration of land uses and pedestrian activity measures in analysis and prioritization, even if these are only qualitative, there may be a lower likelihood of identifying a spurious crash hot spot, even without these more sophisticated methods. Additional information on ***ranking and prioritization*** is provided in the next section.

Ranking/Prioritizing Locations

A simple prioritization matrix is described in FHWA's Bicycle Road Safety Audit Guidelines and Prompt Lists and adapted in Table 5.

Table 5 Example prioritization matrix for prioritizing RSA focus area
Adapted from Table 3, p. 32, Nabors et al., 2012

	Severity of Crashes			
Frequency of Crashes	**Possible/ Minor Injury**	**Moderate Injury**	**Serious Injury**	**Fatal**
Frequent	Moderately High	High	Highest	Highest
Occasional	Moderate	Moderately High	High	Highest
Infrequent	Low	Moderate	Moderately High	High
Rare	Lowest	Low	Moderate	High

If there is not a clear priority location after using simpler procedures, locations can also be prioritized based on rankings in one or more of the following measures—assuming bicycle or pedestrian crashes for each metric. You may consider other crash types (including motor vehicle only) in the rankings, however, which may help to justify a larger project. Some traditionally used rankings include the following:

- Total pedestrian and bicycle crash frequency–More appropriate for spot location or comparing areas of similar size/length with similar land uses and traffic volumes
- Crash frequency per mile–All pedestrian or bicycle crashes or certain types–may be useful for ranking similar corridors
- Crash rate per population–Population will need to be aggregated in some way to the intersection or length

of road. If pedestrian or bicycle counts are available for the locations, these can be used as the rate denominator instead. Crash rates per volume or per population can, however, be misleading, especially if population or volumes are low, or crashes are atypically high.

- Proportion of certain crash types (i.e., left-turning motorist strikes pedestrian/bicycle or ratio of severe injury crashes, etc.) to total pedestrian/bicycle crashes
- Equivalent Property Damage Only (EPDO) Average Crash Frequency
- Relative severity index

The above performance metrics and others are summarized in Thomas et al.'s 2015 report, Appendix A, and other sources such as FHWA's Highway Safety Improvement Program Manual (Herbel, Laing, & McGovern, 2010). Due to generally low frequencies compared to motor vehicle only crash types, these type metrics may be difficult to apply with respect to pedestrian or bicycle crashes. Other weaknesses are that the above metrics, on their own, do not properly account for exposure, or the random fluctuations of crashes. For example, crash rates based on volumes may be misleading as they are based on an assumption that crashes are linearly related in some proportion to traffic volumes, but significant research shows that this is rarely the case. Ranking based on more than one of these metrics may be one option.

Public input (including complaints) is also a valuable source of data on risk that may be helpful to identify locations for potential RSAs, but there is the possibility that such data may be biased or omit some areas if efforts are not made to gather input from all parts of the community.

Another approach to the above-mentioned ranking metrics, is to consider the locations that have higher frequency and/or severity of crashes or Relative Severity Index, which accounts for both frequency and severity of crashes, and in addition, several of the other risk factors (as previously discussed) that have been documented in prior research including:

- Higher volume of pedestrians or bicyclists. (Note that places with lower volumes can also warrant attention.)
- Higher traffic volume (AADT)
- Presence of bus stops and/or transit use
- Higher traffic speed or speed limit
- Household income (lower incomes), percentage below the poverty line, and/or low vehicle ownership
- Commercial land uses
- Presence/proximity of universities, schools and/or recreation facilities, which tend to be associated with crashes primarily through their effects on pedestrian, bicycle and motorist activity.

The above types of factors help to identify locations that may be expected to continue to experience pedestrian and bicycle crashes because the people, land uses, conditions, and traffic are present that typically increase exposure to crashes. There is less prior information available to base rankings for bicycle crashes, but in general, many of the risk factors are likely to be similar since they tend to increase exposure for both modes.

Use spatial ranking methods – from simple to more complex.

Figure 6 illustrates how Lenoir, NC used a map of pedestrian crash locations, overlain with spatial data on percent of residents below the poverty line to help prioritize among multiple corridors with crashes. The severity of crashes was also considered. Similar comparisons showed that neighborhoods along one corridor with a number of pedestrian crashes also had higher walking and biking mode shares than others. Thus, the community was able to use crashes (moderately high frequency, and high severity), along with surrogate estimates for pedestrian exposure, and the knowledge that the corridor was a commercial strip on both sides, with residential behind, to prioritize a corridor for an RSA. (Lenoir does not have transit.)

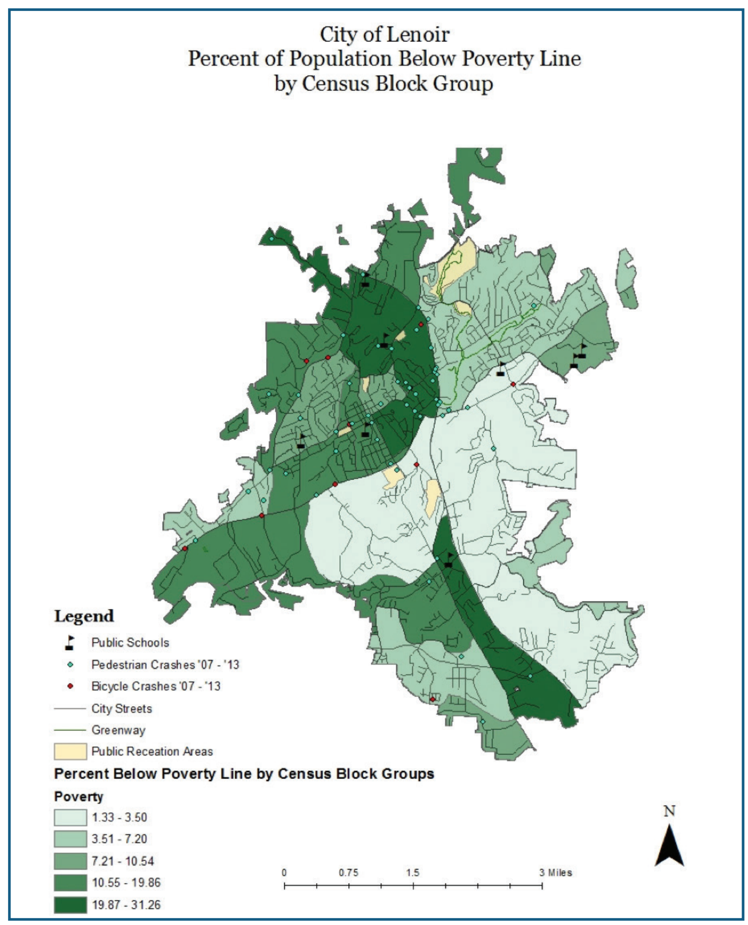

Figure 6 Overlay of pedestrian crash dot map with census data on poverty percentages

See Table 6 for a matrix of how relatively simple techniques may be applied to identify the top sites for an RSA. In the Table 6 example, relative rankings are used to compare locations. "High" crash (occasional, but severe) site (Site 1) is also a high speed and high traffic volume corridor with transit, high poverty, and low-vehicle ownership and mixed land use. This site might be prioritized over Site 2 that also has High crashes (frequent, but less severe injuries), and has fewer of the other high-risk characteristics. Tools are available to help agencies develop a transparent and data driven prioritization process and to document decision-making for any type of project. Once such tool is the ActiveTrans Priority Tool and Guidebook (Lagerwey et al. 2015).

Table 6 Example of combining crash-based and environmental and activity (exposure) risks to prioritize locations for RSAs

Metric	Site 1	Site 2	Site 3, etc.
Crash Frequency by Severity Ranking or other Crash based metric	High (occasional, but high severity)	High (frequent, but moderate injury)	Moderately High (frequent, but low severity)
Volume of pedestrians or bicyclists	Low	Moderate	Highest
Volume of Traffic	Highest	High	Moderate
Speed of traffic /Speed limits (More points for > 35 mi/h;	> 35	30 - 35	< 30
Land use – commercial, residential, mxed, institutional (schools, etc.) – associated with daytime or nighttime activity	Mixed	Residential	Commercial / institutional (Urban core)
Transit corridor/ bus stops present	Yes	Yes	No
High poverty/low income/ low vehicle ownership	Yes	No	No
Other (restaurants, alcohol vendors – nearby)	Yes	No	Yes
Higher population / employment density	Moderate	Low	High
Local input / Other (presence of multi-use path or other features associated with activity)	An inclusive public input process should be used to ensure equitable representation from different neighborhoods	An inclusive public input process should be used to ensure equitable representation from different neighborhoods	An inclusive public input process should be used to ensure equitable representation from different neighborhoods

Figure 7 illustrates a spatial analysis used by Greensboro City/MPO staff to identify and rank corridor segments by network-based pedestrian crash density, which helps to pinpoint particular segments and corridors better than the area-based spatial analysis shown earlier. In addition, staff performed a correlation analysis of roadway, land use, and population characteristics and identified factors that were associated with higher densities of pedestrian crashes (Tram and Tyler 2017). The analysts found that pedestrian crash hotspots were positively associated with proximity to bus stops (highest correlation), retail centers (second highest), industrial parks, single-family residential, multifamily residential, and higher speed limits. Increasing crash density was also positively associated with high poverty/ low car ownership areas, minority populations, and areas with higher percentages of under 18 population. These findings echo many of those found in a recent comprehensive review for a pending NCHRP *Systemic Pedestrian Safety Analysis Guidebook* and mentioned above. Besides identifying the highest crash density segments, these additional factors could also be considered in prioritizing locations for an RSA.

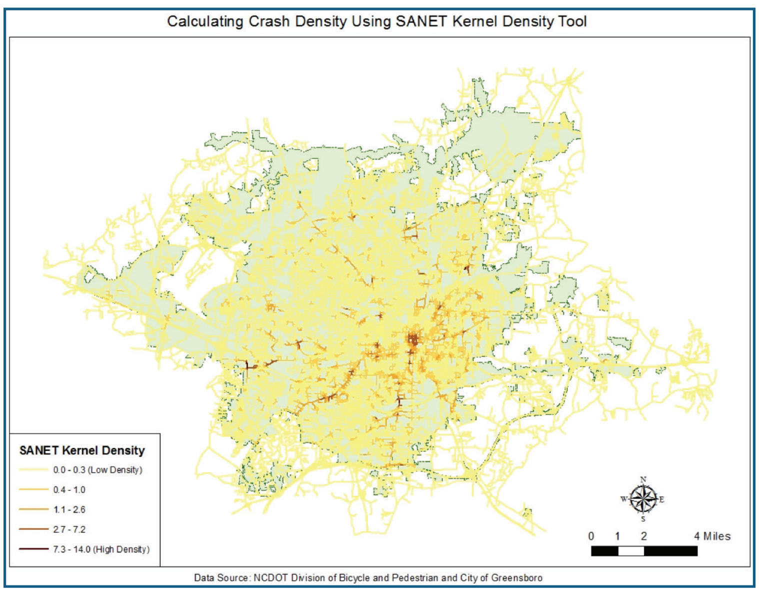

Figure 7 Greensboro MPO/City staff used network-based Kernel-density analysis to rank corridor segments by pedestrian crash density
Source: Truong & Meyer 2017. Software: SANET software, available from http://sanet.csis.u-tokyo.ac.jp/

Develop safety performance functions

If available data and other resources allow, users could also consider developing safety performance functions (SPFs)—model equations that identify crash relationships based on characteristics of locations where prior crashes have occurred, and which properly account for pedestrian/bicycle and traffic-related exposures. These prediction equations are useful to produce more reliable estimates (than simple crash frequencies, rates, or other metrics) for where crashes might occur in future. Such rankings could be used to prioritize RSA locations and potential safety improvement locations. This option could be applied at a regional level, or among cities that have significant crashes and other needed data. Such an approach requires more information than can be provided in this Guide, but in general, SPF models and related procedures to estimate potential future crashes are a method recommended by the *Highway Safety Manual*. At a minimum, such modeling requires crash data, roadway inventory, and some measures of auto and pedestrian or bicycle traffic. Built environment measures such as land use types and density, measures of transit activity and locations, and population characteristics have also proven useful to aid prediction and identify areas of potential concern. Consult Analysis and Screening Tools and Resources in the bibliography for more information.

TEAAS system network screening

There may also be a possibility of working through the TEAAS system to screen the network for high pedestrian or bicycle crash locations. Consult with NCDOT safety engineers to discuss this option.

Establish Road Safety Audit Focus Area

The end of Phase 1 is to ***prioritize a focus area or areas for the study*** that is manageable for one RSA. Consider these factors to finalize the segment or intersections (if more than one) for focus:

- Land use
- Roadway
- Crash patterns
- Other local knowledge

Aim to identify a length of corridor or group of intersections with similar land use and density, and similar road design (number of lanes, etc.) and traffic patterns. If a long roadway section is still being considered – longer than approximately 0.5 mile as a rule of thumb – consider dividing the RSA into multiple sections. The RSA team can finalize the focus area for the RSA through any type of meeting or coordination that the local team agrees to. In addition, it may be of value to discuss the location or corridor with NCDOT regional or state safety office at this point.

While it may be tempting to focus on a single intersection that seems to have a number of crashes, there may be similar problems at adjacent intersections along a corridor but where crashes have not yet happened. If the land uses, roadway type, and so forth seem similar, it may make sense to consider the road in that context since the crashes may move to other locations along the corridor in future. In addition, you may want to identify a project that is large enough to be worthwhile submitting for potential outside funding. However, there is certainly value in investigating particular problematic intersections, and there may be signal timing changes, or other measures that are relatively easy to implement locally.

Another key input in establishing your study area are ***future development projects***. If you know that a large, multiuse commercial development will be coming to the corridor, consider that when establishing your study boundaries. Large land use developments might result in an increase in pedestrian traffic, vehicle volumes, or both. (Consider separately reviewing land regulations, network plans, and road designs for positive and negative impacts on all modes of travel.)

Consider forthcoming road projects as well. If a road is scheduled for reconstruction, this is an opportunity to examine how those changes might affect pedestrians and bicyclists and ensure outcomes that meet local visions for active and all modes of travel. Remember that you can also perform RSAs proactively to review project scopes, plans, and designs and throughout key implementation stages to ensure that pedestrian and bicycle needs are met, even if those projects are primarily planned for other reasons.

To finalize the focus area for the audit, also consider ***the input of community stakeholders***, if input was not obtained through prior efforts. This is the time think about when and how to get input from residents, bicyclists, pedestrians, school officials and others who may have insights about the area being investigated. These stakeholders might have information that helps select among two or three highly ranked sites, or provide insights about the boundaries of a corridor and knowledge of pedestrian and bicyclist safety issues. Their input, if used, should be documented in the RSA and recommendations. Review the list of potential stakeholders to reach out to in Phase 2, the section Acquire Community Input.

As an alternative to more formal RSAs, ***consider conducting more frequent investigations by prioritizing high, medium, and more routine field visits***. Winston-Salem performs network screening using local data files. This was done most recently to help direct funding from a bond package. The City analyzed its crash locations and began prioritizing locations where crashes had occurred near schools.

Expand road safety reviews beyond formal RSAs

Finally, in addition to a more formal RSA screening and ranking process, consider also reviewing high crash locations or other safety concern areas during regularly scheduled inter-departmental meetings. Charlotte staff, for example, regularly review crash histories for high crash intersections, and then three investigators do on-site analysis of each intersection to try to identify types of conflicts and appropriate countermeasures.

Charlotte also uses a more risk-based approach to consider public requests for crossing improvements at uncontrolled locations. Staff apply criteria including considerations of the land use density, transit, and other indicators of high demand pedestrian areas. Other considerations may also help locations receive field review, including traffic volume and speed of the road, and being more than 600 feet from a controlled crossing opportunity.

Winston-Salem staff also perform their own audits and field reviews on three levels:

- Formal Audits: These are done in conjunction with large scale projects, typically using state funding. The City cited the Cloverdale Avenue project as one where formal audits were performed and documented as inputs to the final project. These are done very infrequently.
- Neighborhood Audits: These are done on a more regular basis, but are not as formal. The City reaches out to active neighborhood groups and offers to help lead audits of "problem" locations. The City staff go out into the field with residents and discuss problems and potential solutions. Findings are documented, and the City uses the results to help direct its projects.
- Informal Staff Reviews: The most frequent type of audit conducted are quick trips into the field to look at a location that has either experienced crashes or has been brought up by a council member or concerned citizen. These happen quite often (a few times a week), but findings may not be documented formally.

PHASE 2 – Prepare for Road Safety Assessment

Successful road safety audits hinge on the ability of a team to review available data sources in advance. Preparation before the audit will help ensure your team can make the best use of time in the field by gathering all available information that does not rely on first-person observation. This section of the guide will outline key considerations and pre-audit activities. As a side benefit, the preparation described in this section will help facilitate the RSA reporting and documentation performed following the audit.

The importance of data preparation can be illustrated through the following example.

When considering potential safety improvements along a half-mile section of arterial highway, a team might pile into a van and head straight to the site. Once they arrive and begin walking along the corridor, questions may start to arise:

- What are the latest traffic volumes along this corridor?
- Some of the parcels appear to be vacant, but are there plans for new development?
- We know there have been pedestrian crashes here, but what are the circumstances that may have contributed?

Some of these questions can be answered ahead of time based on local knowledge of the site, the use of on-line maps and network imagery, and by compiling crash and other existing data for the corridor.

The engineers on the audit team could spend time gathering speed or traffic, pedestrian and bicycle volume data, if these are not already available. Planners might have knowledge about future development and land use changes or a new road that might drastically change the travel patterns in the area. The local transit agency should be able to provide bus stop location, routes and numbers of buses using a stop, and boarding and alighting data. And team members can review pedestrian crash factors such as crash types, time of day, contributing circumstances, and other details from the completed crash analysis for the corridor.

When the audit team reviews such information in advance, they will be able to use their time in the field to answer important questions that cannot be gleaned from existing data sources. Those questions might include:

- Where and how are bus riders accessing bus stops and what are their travel patterns?
- How might the new convenience store on the corner impact pedestrian routes and the number of turning vehicles?
- Though many of the pedestrian crashes occur at the intersections, do we have midblock crossings near the transit stops that just haven't yet led to crashes?
- Are pedestrians and bicyclists using a center, two-way turn lane as a refuge area?
- Can pedestrians be seen at night?
- Are markings, signs, and signals in good condition and visible during all times of day/night?
- Are there adverse sidewalk, bikeway, or roadway surface conditions, or access points that need to be upgraded to ADA standards?
- Are pedestrian pushbuttons accessible?
- Are motorists yielding at crosswalks, including when making turns at intersections and driveways?

Phase 3 provides more information and guidance for the assessment and review considerations.

Figure 8 shows the three key steps that will take the team through the stages of preparing for the RSA.

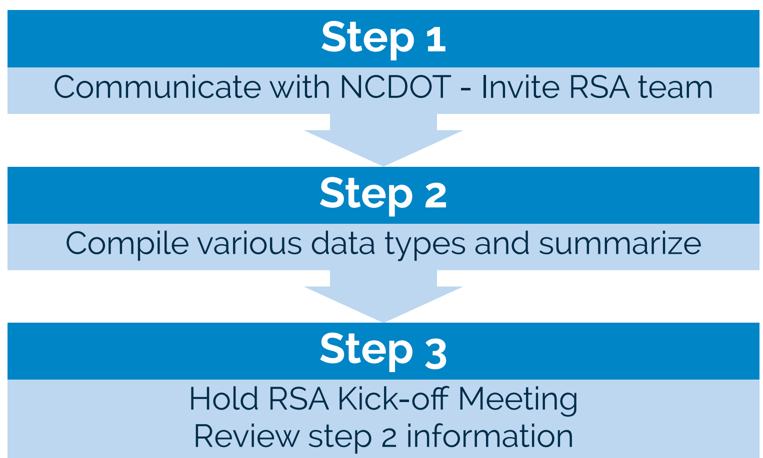

Figure 8 Chart for RSA Planning and Preparation Steps

Step 1 – Communicate with Partners and Identify RSA Team

Once you've identified a focus location, it may pay to communicate with the NCDOT Safety Office and other potential partners. Discuss your findings and seek input on an RSA. NCDOT can also likely provide assistance in identifying qualified team members unless a consultant is leading the effort.

Selecting the members of your road safety audit team can be a balancing act. On the one hand, you need to make sure you have critical professional expertise and representation of various stakeholder perspectives. On the other, you need to keep the group to a manageable size to ensure that everyone has a clear role and contributes to the RSA discussion.

Table 7 lists the basic skills and knowledge that will be needed to perform a successful pedestrian and bicycle safety-focused RSA, and the types of personnel that may be qualified to fill the roles.

Table 7 Basic skills and knowledge for performing an RSA

Skills and Knowledge needed	Who can fill these needs?
Data analysis	• Local planners / engineers / analysts • MPO/RPO personnel • Injury Prevention personnel • Law Enforcement personnel • Transit agency personnel • NCDOT safety / regional / division engineers & planners • Pedestrian / bicycle coordinator • Consultant transportation engineers / planners & analysts
Pedestrian and bicyclist user characteristics and needs	
Safety risk principles, conflicts, and crash types	
NC Complete Streets types, road design and operations	
Enforcement and rules of the road	
Transit operations and needs (if present or planned)	
Leadership	
Ability to identify effective, relevant countermeasures	
Writing/report development ability	
Knowledge of local plans	

In addition, participants in a formal RSA also ideally have the following characteristics.

Independent – An ideal RSA team will be independent from the location being reviewed. In particular, team members ideally should not have been involved in the planning, design, or operations of the location being audited. One approach might be to bring in professionals from other cities and towns or other NCDOT Divisions. It may also be possible to hire an outside group familiar with NCDOT safety investigation processes to provide an independent, unbiased perspective.

It may be difficult to find local team members who are truly independent from the location that is being examined, and bringing in experts from outside of the community may not always be a realistic option. However, team members should remain objective when considering a particular location. Including diverse representatives from the locality, region, and state may help you achieve a balance of perspectives on the functions and priorities of the street or highway.

Multidisciplinary – An RSA involves professional expertise. Some team members should have a knowledge base of design requirements for pedestrian and bicycle facilities as well as comprehension of safety impacts of design features. The team's combined skills and knowledge should include:

- Road safety
- Traffic operations
- Road design
- Cycling and pedestrian safety, operations and user characteristics
- Transit operations (if transit is present/planned in the area being audited)
- Enforcement and rules of the road

The FHWA guides also recommend including emergency medical response personnel (EMS), but this may not be essential. EMS representatives may have knowledge about prior crashes including pedestrian and bicyclist injuries that were not reported, and information about emergency response time, and could be invited to contribute this knowledge during Step 2. In addition, they should be consulted as the team begins to hone in on countermeasures, since some design measures may affect operations of emergency response vehicles.

Helpful tip

Contact the NCDOT Safety office or the FHWA resource center for assistance in identifying qualified RSA team members. Many consultants also have the requisite knowledge to analyze data, organize, and lead an RSA.

User perspectives – A successful road safety audit is dependent on a variety of user perspectives. If a team of engineers goes into the field, they may notice issues related to lane configuration, turning movements and signal timing, but might miss problems associated with land use and how pedestrians and bicyclists actually reach certain destinations, or issues that may arise with future development. Planners may help to bring that perspective. Planners and engineers may be familiar with pedestrian and bicycle crash types, but they may lack the regular field observation of interactions and user characteristics that law enforcement officers or other community representatives might provide.

As mentioned in Table 7, the following types of individuals from a mix of local, area, transit, consultants, injury prevention, or NCDOT staffs may provide the balance of knowledge and perspectives needed:

- Transportation/Land Use Planner

- Design and Operations Engineers
- Law Enforcement Officer
- Pedestrian or Bicycle Coordinator
- Traffic Safety Engineer

A single individual may encompass more than one role. Keeping the overall team size to the minimum size needed to achieve the knowledge base and balance of user perspectives will make it easier for everyone to participate fully and to share knowledge as well as to convene RSAs on a more regular basis, as needed.

There are also other stakeholders who will be able to provide valuable perspectives on the location but who are not typically included on the RSA team. An RSA team is typically limited to transportation and safety professionals. Several key stakeholders and partners are listed under Step 3 below. These stakeholders may share valuable insights into the problems, however, as the team gathers data in advance of the audit.

Step 2 – Compile Data and Information for the Focus Area

Summarize Pedestrian/Bicycle Crash Data for the Location

The outcomes of the pedestrian bicycle crash analysis and network screening were used to identify where the RSA should focus. At this point in the process, the team has established the area of study for the RSA. It is useful to go back to the crash analysis and pull out pieces of information relevant to the study area. Developing and reviewing this information in advance will help shorten the field time needed and focus the RSA to the right times, conditions, and location-based information that may be crucial to understanding what led to prior crashes. Figure 9 illustrates a crash map produced for an area-level RSA. Crash review could involve the following:

Crash types, severity, and location – Review the types of crashes that have occurred in the study area and where they occurred. Consider mapping and bringing into the field the crash locations with crash type descriptions. Crash types can help point your team toward the circumstances or conflicts that led to prior pedestrian and bicycle crashes and what some of the countermeasures might be. Information on the severity and specific locations of the crashes can also aid identification of key safety issues (e.g. a mismatch of the pedestrian/bicycle facilities with land uses, traffic speed and volume) or a preponderance of crashes at night. Any missing information on crash circumstances might be available from hard copies of crash reports. Agencies can also obtain and compile copies of all crash reports to fill in gaps in information.

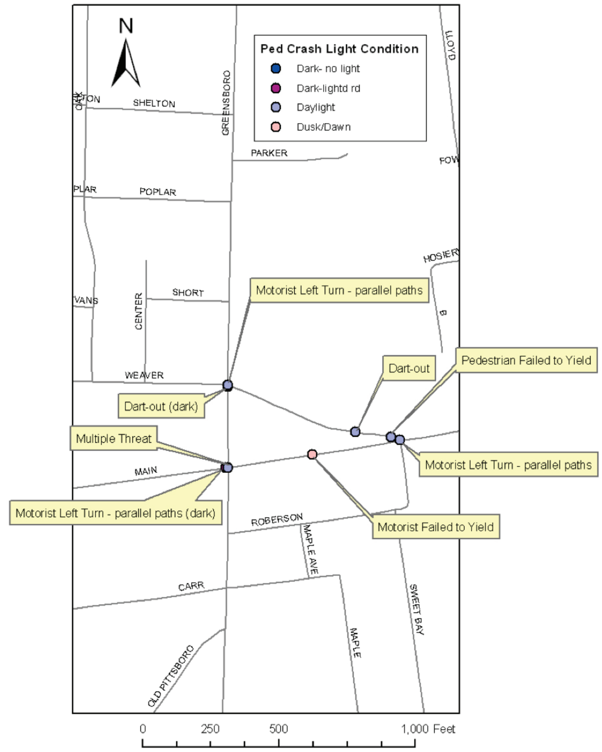

Figure 9 Example of crash type by light conditions map that could be brought into the field during the RSA. Source: Thomas et al. 2009

Time of day and lighting conditions – Reviewing the time of day when crashes occurred will help you determine when site visits need to take place. If the majority of crashes occurred at night, the team should plan to review visibility and other conditions after dark and may need to visit the site more than once. If crashes typically occurred during morning or afternoon rush hour, visit during those times as well as others to determine if there are different conditions, operational factors, and behaviors in evidence at different types of day.

Total crashes – While pedestrian and bicycle crashes were the primary focus of analyses, pay attention to general crash types and patterns that may exist in your study area. Conducting a strip analysis or intersection analysis of all crashes might reveal general safety problems that may benefit from similar improvements or that could contribute to pedestrian and bicycle crashes. This analysis may also lead to additional ideas for countermeasure solutions. For example, an area with a high concentration of left turns in and out of driveways might be a candidate for access management, which might have benefits for pedestrians and bicyclists as well.

Helpful tip

Consider seeking assistance from NCDOT with a strip analysis of all crashes for the defined study corridor.

Compile Roadway, Land Use, Population, Transit Information

Roadway and land use details are critical in developing an understanding of the study area, as they provide context for the safety data that has been compiled. Sources of these data were described in Phase 1, Table 2. You may already have analyzed crashes in relation to some of these data types. If you have not done so before now, mapping crashes in context of these other types of data can provide an easy way to visualize the context of safety data and other factors that may be associated users' exposure to risk of crashes and injury.

Current and planned land uses – Gather information on the types of development on this corridor. Different land uses and development types will generate different types of bicycling and walking trips, frequency of crossing needs, etc. Use planning documents to understand what kinds of future uses may impact the area. Consider all of these inputs in the context of the area types and street types presented in the North Carolina Complete Streets Planning and Design Guidelines. Try with your team to ***determine what area type and street type the location fits using the descriptions in the complete streets guidelines***. It may fall in between categories on different elements, but considering this now will help the team compare what is present to what would ideally be present, given the community's preferred facility type. You can return to this when seeking public input and when considering alternative countermeasures and designs.

Traffic and user characteristics – Data should be available about the amount and to some extent, types of traffic within your study area. This includes both motorized and non-motorized traffic. For motor vehicles, find the relevant traffic volume data to better understand how many vehicles use the road on a daily basis, including types of traffic such as transit and trucks. If data is not available for the precise study area, it may be necessary to make some assumptions or averages based on nearest locations. You may even be able to find out when traffic is at its peak, and when volumes are lower.

Helpful tip

NCDOT maintains traffic volume data for many locations on DOT-managed roadways. Review Step 2 for data sources.

Count data for pedestrians and bicyclists may also be available for a particular intersection or corridor. In the absence of count data, consider collecting the data, or using transit boarding and alighting data or number of buses stopping at locations along the corridor, and density of commercial land uses as proxies for pedestrian activity. ***Remember that NCDOT may be able to assist with traffic and pedestrian or bicycle counts***.

Current design and operational characteristics – Collect any relevant information about the configuration of the roadway, speed limits, traffic volumes, and transit. ***Much of this information can be found by using online mapping tools and streets imagery.*** (Be sure to check dates of imagery, and give credit to sources used in any published reports.) Make notes about the number of lanes, the presence of sidewalks, bike lanes, raised medians or center two-way, continuous turn lanes, and other roadway characteristics.

While speed limits are useful, ideally consider collecting operating speed data over a week, in advance of the RSA. Some data may be available from NCDOT based on GPS-equipped drivers that use the road. However, spot speed studies will ideally be collected in accordance with established engineering practices.

Locations of key destinations – Note the location of key destinations and generators in the study area. Pay attention to locations like transit stops, which can generate high concentrations of pedestrian traffic. Nearby multiuse paths might feed bicycle or pedestrian traffic into the study area. Convenience stores and commercial development generally, housing developments, or government buildings might also generate pedestrian, bicycle, and motor vehicle traffic.

Acquire Community Input

The RSA coordinator can also consider which other local stakeholders might have important knowledge of travel patterns or safety issues about the corridor in question if this input has not already been gathered. For example, business owners may observe unusual crossing behaviors or conflict patterns that are specific to a particular time of day, such as when delivery vehicles are loading/unloading and blocking a lane.

In the weeks leading up to the audit, consider sitting down with the types of individuals listed below to get their thoughts about your study area. An alternative is to ***invite community representatives to a portion of the pre-RSA briefing*** to express their knowledge and concerns about safety issues, who uses the corridor (i.e., school children, the elderly, visitors), paths of travel, etc. It may help to develop a list of questions to ensure the input stays focused. The list below provides a list of potential stakeholders to consult. This is also an opportunity to communicate with stakeholders about the corridor–that is, what Complete Streets area type the location is in, what street type it best fits and stakeholders' vision for the corridor. If there has been a recent multimodal, pedestrian or bicycle safety plan, some of the relevant information from the below types of stakeholders may already be documented and it may be less important to seek additional input.

School Representatives – In many cases, the area of interest will be located near a school or along a major route leading to a school. Talk with representatives from the school district about safety problems concerning the trip to or from school. They might have information about changes to bus routes or school districts that might affect safety in the area. Not only that, talk to representatives of specific schools, such as the school principal or parent groups, since they will have more information about safety concerns specific to one school or another.

Neighborhood Business and Community Representatives – Many residential neighborhoods or home owners associations, or bicycling organizations have an interest in improving safety along local streets. Consider reaching out to these organizations to find out what problems or safety concerns are reported by the local residents. Business owners and associations can also provide input, especially if the audit location is near commercial areas.

Law Enforcement Officers – You may have a member of local public safety agency on your audit team. If not, set up a meeting with the police officers who are assigned to your area of interest. You may also be able to reach out to the police department's traffic safety unit to find out what concerns have been identified by officers who spend most of their time dealing with traffic safety issues.

Transit Agency Representatives – Transit agencies will have a lot of information about transit routes and ridership and may have observed conflicts and safety issues along bus routes. If you have a chance to talk with transit vehicle operators, ask them about issues pertaining to access to transit stops, conflicts and other safety issues they have observed.

Local Officials – They may not always be available for a sit-down meeting, but local officials such as Town or City Council members can be excellent resources when preparing for an RSA. Involving these officials at the earliest stages of a project might help build support for a data driven approach, and for pedestrian and bicycle safety projects in the future.

Step 3 – Hold Pre-Audit Briefing

This final step of Phase 2, a pre-audit briefing, may occur the same day as the RSA (covered in Phase 3), or may occur sooner. However, preparations for the pre-audit briefing and the RSA will be completed during Phase 2.

Helpful tip

The RSA leader should ensure that team members contribute to the identification and discussion of issues and potential solutions in a balanced way since sharing perspectives is a key ingredient of a successful RSA.

Discuss Road Safety Audit Focus Area

In final preparation, plan to hold a pre-RSA meeting to review all of the information that has been collected about the location, and discuss roles and responsibilities, the scope, and schedule of the RSA. Ensure that if a preponderance of injury crashes occur at night, the team will visit the location during hours of darkness.

This pre-RSA meeting may occur the same day as the RSA, or earlier if there are more challenging issues to resolve. It is up to the coordinator or RSA leader to plan ahead for this meeting.

Helpful tip

Hold a pre-RSA team meeting to: (1) review identified pedestrian and bicyclist crash patterns and other data; and (2) ensure a consensus of the scope of the RSA and a general plan for conducting it.

Additionally, if input was gathered through interviews or in-person meetings with stakeholders, this is a time that team members can share what they learned with the rest of the group. As an alternative to conducting individual interviews, consider inviting representatives from groups listed above to the beginning part of the pre-RSA meeting so they can provide their input all at once.

Finally, in preparation for the RSA, consider whether the team will bring prompt lists, or questions developed with information from this Guide, or the FHWA RSA guides for pedestrian and bicycle-focused RSAs. There are also forms in Appendix B that may be useful for noting issues at specific locations. The objective of bringing prompts, crash summaries, and data collection sheets is to ensure the input provided stays focused on what and where the pedestrian and bicycle safety issues are for the focus area.

If you have selected an intersection for focus, make sure that your study area extends down each leg of the intersection, since crossings can sometimes occur downstream of the intersection itself or there may be issues relating to the approaches that obscure visibility or affect operations and safety. Resist the urge to expand your study area when you get into the field. Inevitably, you will notice items of interest that are beyond the original scope of the study, but make a note of these for later. Note these briefly for future assessment, but keep your focus on the established study area, unless it is clear that the focus area should expand for a more logical project that may come out of the RSA.

Discuss Roles and Responsibilities

There are key roles that the RSA team leader may assign for the RSA. The list below is not exhaustive, but provides some guidance for specific roles and responsibilities that different team members can fill.

- Leader/Facilitator – Remember that the RSA leader needs to be ready to facilitate discussions in the field and prompt participants to weigh in on various issues. The leader can also help to keep the team focused on the planned scope of the RSA and pedestrian/bicycle issues, while making note of other concerns or a potential need for other investigations.
- Recorder(s) – one person needs to take primary responsibility for documenting discussions and observations. The recorder can participate in the discussions. However, it is critical for at least one person to take notes and document observations to make sure important information is not lost. When it comes time to put the report together, the recorder's notes will be essential for describing the safety issues. Photographs are another good way to document issues. In some cases, teams may choose to have two recorders: one to document conversations and observations, and another to take photos or video to document what is being observed.
- Data manager – One person should be responsible for compiling and bringing along a copy of all of the pertinent information compiled during the lead up to the audit. Consider preparing a binder with maps and diagrams of crash locations and types, compiled pedestrian crash reports, a map of the study area, volume or speed data, any important information from pedestrian plans and design documents, input from other stakeholders, and anything else that may be relevant.
- Equipment person – Safety vests are recommended for RSAs (and required if NCDOT personnel are involved), although they may affect users' behaviors. There are several other pieces of equipment you might need to use on your audit. Examples include measuring wheels, a wheel chair, and camera. Consider having one person responsible for bringing these materials, particularly if that person has experience using them. This person could also be responsible for taking pictures or videos.
- Primary report author – While all team members should contribute to the report, one person will need to take the lead in drafting the initial RSA report. Everyone can agree on a basic outline at the Kick-off meeting. The report lead will need to ensure that they have access to all notes, data, images, from the RSA, and any other pre-RSA documentation so the author(s) can consult these in putting the report together. There is a template and suggested content guide for the RSA report under the Phase 4 section.

Source: www.pedbikeimages.org; Laura Sandt.

PHASE 3 – Conduct the Road Safety Assessment

The goal of the RSA is to observe and document issues with the roadway, operations, environment, and behaviors that may affect pedestrian and bicycle safety, and to begin to identify potential countermeasures to those safety issues.

This section describes general responsibilities for carrying out the road safety assessment. It also describes key principles, and an overview of issues that the RSA participants should look for, document, and consider when evaluating the safety and functioning of the road or intersection from the perspective of pedestrians or bicyclists. Both pedestrian and bicycle-focused prompt lists are also provided at the end of the Phase 3 section. These lists may be printed out and consulted or taken into the field as reminders of things to look for. The section also describes other key North Carolina and national resources that readers can consult for more in-depth information.

It may be worthwhile to drive through the location, making notes from the perspective of motorists, especially regarding visibility of pedestrians and bicyclists under various conditions (including at night), as well as general motorist perceptions of the area and expectations regarding interactions with these other modes. However, much of the RSA should be conducted on foot. If a bicycle-focused RSA is being performed, consider riding through the area and intersections from both side roads and the main road perspective. However, those performing the RSA should not be asked to ride through areas that they feel are unsafe. If some locations are perceived as too dangerous to cross, that is an indication that the street does not function well for pedestrians. This exercise, even if only theoretical, should increase the understanding of issues facing pedestrians and bicyclists.

User Characteristics and Needs

Pedestrians and bicyclists are considered vulnerable road users because they lack any protection in the event of a collision and tend to be more severely injured than motor vehicle occupants when struck. Besides the lack of protection, people walking and bicycling are smaller in profile, and, on average, slower than motor vehicles, increasing their chances of not being seen, and of being exposed to traffic at areas of conflict. Bicyclists and pedestrians also have different user and operating characteristics from each other, such as lateral space and clearance needs, walking /biking speed, signal clearance times and others. These include where and how they can share the space and cross a street. Therefore, separate guidance is provided for conducting RSAs focused on one or the other group. Your safety analyses and other information may suggest a focus on addressing safety problems for both pedestrians and bicyclists. If so, appropriate expertise for both user groups is needed, and more time may be required to thoroughly assess conditions for both modes.

In addition, any RSA should inherently consider all road users, their operational needs, traffic laws, behaviors and interactions to insure that any recommended solutions for one user group will not have adverse safety impacts for another group. Also, consider that although the area might meet all recommended practices and standards, it may still interact with land uses, and user perceptions and behaviors that then lead to safety problems. One of the main intents of the RSA is to uncover where the current designs and operations are not working safely as intended (Nabors et al. 2012).

Factors Contributing to Pedestrian and Bicycle Crashes and Injury

Exposure-related factors interact with each other and with user characteristics and perceptions to affect the system for all users. For example, a wider road or multilane crossing increases the amount of time it takes for a person walking or on a bicycle to get across the street, increases the lanes of traffic he or she is exposed to, and increases the length of the pedestrian crossing interval that is needed at a signalized crossing. But, larger roads may also send the message to drivers that this is a 'high speed' location where they are unlikely to encounter people on foot or bicycle, especially if there are no obvious signs of pedestrian and bicycle facilities.

More information

In preparation for the audit, team members can consult the Bicycle Road Safety Audit Guidelines and Prompt Lists and the Pedestrian Road Safety Audit Guidelines and Prompt Lists developed for the FHWA for more in-depth background about principles of bicycle or pedestrian safety, user characteristics, and detailed prompt lists. Other resources listed in the bibliography may also provide helpful information for consideration of issues and potential crash countermeasures.

For general guidance on the conduct of Road Safety Audits, consult FHWA Road Safety Audit Guidelines. As mentioned, data collection forms are provided in Appendix B of this report, which can be printed and brought into the field to facilitate note taking.

Older pedestrians or those with disabilities may walk more slowly than others, further increasing their exposure risk. Longer signal cycle lengths may, in turn, increase driver and non-motorist delay, potential frustration and non-compliance with traffic controls. Thus, it is important to bring a knowledgeable and balanced perspective to the RSA investigations. Other issues of this type are described below.

This Guide emphasizes ***safety and risk principles*** in analysis, preparation and conduct of an RSA. The following summary recaps types of factors that can potentially increase pedestrian and bicycle exposure to collisions and can interact in perhaps unexpected ways. Pay attention to these kinds of issues during the RSA.

Advancing Pedestrian and Bicyclist Safety: A primer for highway safety professionals, developed for NHTSA, describes some of the ways environment, roadway, and pedestrians, bicyclists, and motorists interact to increase risk of collisions (Brookshire et al. 2016). The following points have been adapted from that guide (unless otherwise noted), and while this section recaps some of the earlier discussion of risk factors, it is important to keep these concepts in mind when conducting the RSA.

Conflicts at crossing location — When the design of an intersection or other crossing location puts different road users in conflict, the risk of a crash may increase. Furthermore, conflicts or long delays may contribute to pedestrians and bicyclists opting to cross against a signal, or at other, unsignalized locations that might be even less safe if motorists are not expecting people there. Inadequate access control along the roadway also increases potential for conflicts.

Separation from traffic — Bicyclist and pedestrian safety may be negatively impacted by a lack of separation from traffic, especially as traffic volumes and speeds increase, and at night. Without adequate separation along the road, pedestrians may need to walk in the roadway. As a result, drivers may not see pedestrians in time to avoid a crash. Similarly, bicyclists who share travel lanes with motorists may not be noticed. Motorists may also not observe safe passing distances (at least 3 feet), and discomfort may increase as vehicle speeds and volumes increase. As a result, bicyclists may choose to ride on sidewalks (when available) or ride against traffic, placing themselves at possible greater risk of a crash at intersections and driveways.

Excessive vehicle speed — Drivers who speed or drive too fast for conditions increase their risk of a collision with a pedestrian or bicyclist and increase the risk of more severe injuries in the event of a crash. In addition, more jurisdictions are focusing on the role that absolute speed has on the severity of injuries. A number of studies have examined the impact of speed on pedestrian fatalities; all find similar relationships with the risk of fatality increasing considerably as speeds rise from the lower end of typical urban speeds. Speed limits, designs, amount of other traffic, perceptions of the area type, time of day, and the amount and type of enforcement and adjudication can affect the speeds that drivers select (Thomas et al. 2013).

Inadequate conspicuity — There are many root causes of poor conspicuity, from low light conditions to inadequate sight distance at crossing locations. If vulnerable road users cannot be seen by motorists, the risk of a crash or conflict can increase. Recall that a high percentage of pedestrian and bicyclist fatalities in North Carolina occurred under dark conditions. Empirical evidence also suggests that many bicyclists are not aware of or compliant with laws requiring bicyclists to use lights and/or reflectors when traveling at night. Thus, RSAs may need to be performed at nighttime. Even with enhanced lighting, there may be a need to consider stronger separation measures (traffic controls and separated walkways and bicycle facilities) if the corridor or area is used by pedestrians and bicyclists at night.

Poor connectivity — If direct connections are inadequate, time and distance that pedestrians and bicyclists are exposed to traffic may be increased as well. Land use and pedestrian and bicycle facility and connectivity policies that limit facilities, where crossings can be provided, or that do not provide alternate pathway connections are other ways that pedestrian and bicyclist safety can be affected and may need to be addressed.

Poor compliance with traffic laws and improper use of facilities — Improper behavior or noncompliance with established traffic laws by motorists, bicyclists, and pedestrians can increase the risk of conflict among these road users. Drivers may fail to yield to pedestrians at crosswalks, though the law requires them to do so. Pedestrians and bicyclists may cross against traffic signals. Poor compliance or behavior may stem from poor roadway design or a lack of knowledge about the purpose of laws and traffic control devices.

Helpful tip

Walking is the connection between all other modes, so it is likely that part of a person's trip will also involve a personal vehicle, public transit, or a bicycle. Designs for pedestrians should accommodate the links between modes, including transit stops and parking areas.

The risk factors above can be exacerbated by impairments of all types, as well as common distractions or inattention. Environmental factors such as weather, darkness, and road conditions can also affect crash risk. (Brookshire et al. 2016).

Pedestrian Road Safety Audits

When conducting the RSA, and during Phase 4, when making recommendations about treatments, ***consider the area type and street functions for help in choosing the right types of treatments*** and designs for the location. Consult North Carolina Department of Transportation Complete Streets Planning and Design Guidelines for more information. In addition, remember the impact that traffic speed has on vulnerable road users and the need for greater separation by space or through traffic controls for higher speed locations, or for measures that lower speeds to a more appropriate level for mixed use, urban and residential streets.

You may also consult other design resources, including AASHTO and NACTO guides. These and others are listed in the bibliography.

Pedestrian Characteristics

People walking in your community will have a range of abilities and needs. As you conduct a field assessment, consider how the surfaces, signals, and traffic will work (or not work) for: older adults; children; people with wheelchairs, strollers, or carts; and pedestrians with limited hearing or sight. Pedestrians can move about the environment in unexpected ways. They may change direction or walking speed abruptly (especially children). They may need to access transit stops that are often sited in unexpected, and midblock locations, or they may face crossings where push buttons are inaccessible and curb ramps are poorly designed or missing. Keep in mind that pedestrians will often choose the most direct route to their destination, and may cross at unexpected angles at intersections or cross at midblock locations if distances to nearest controlled crossing opportunities are too far.

Pedestrians may also attempt a midblock crossing if an intersection feels unsafe or there are no access ramps for pedestrians who must use a wheelchair. Intersections may not feel safe if there is a lack of pedestrian crosswalks for all legs, no pedestrian signals or inadequate responsiveness of push-buttons, motorists do not yield when turning, or approach speeds are high, and red light running (such as RTOR without stopping) is common.

Pedestrian Road Safety Audit Considerations

Conduct your field review ***under various times of day or traffic conditions***, do not assume that pedestrian volumes or safety risks peak when vehicle volumes are highest. It may be important to observe the corridor midday, on a weekend day, or during school dismissal times. It is also important to review the corridor during daylight and nighttime, especially if crash histories or land use and development type indicate that nighttime is a time for pedestrian activity. Consider whether pedestrians are conspicuous. Just because an area is lit and it seems like pedestrians would be visible to a driver does not mean that a driver will be looking for pedestrians or that pedestrians will stand out in contrast to their surroundings, oncoming headlights, and other traffic.

Consider ***not only where people are walking, but also where they aren't walking***. Perhaps there is an unmet need for new or improved pedestrian facilities. Sometimes, even where pedestrian facilities are present, you will see "desire lines" on unpaved surfaces that indicate a route that pedestrians prefer, because of either its directness or its perceived safety. The surrounding land uses and street types will indicate the roadway users present and expected at various time of the day or year to supplement spot counts. Be sure to observe any factors that are not obvious from land use or property data that your team collected pre-audit.

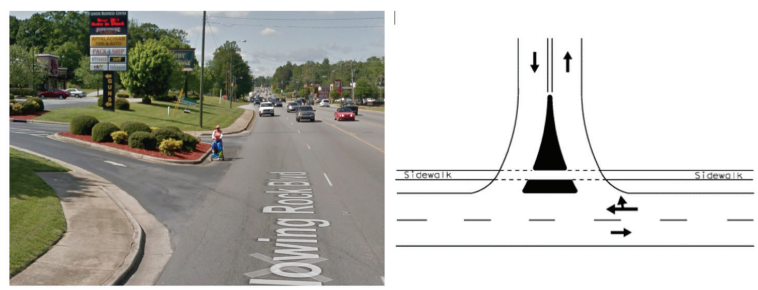

Figure 10 Locations like the driveway splitter island shown above are unlikely to be revealed by a review of crash data
Observing road user behaviors during a road safety audit may helps to identify potential safety treatments. This location was documented during the RSA in Lenoir, NC. Left image sourced from Google Maps ©

Figure 10 illustrates conditions observed in the field, and a potential design remedy to prevent pedestrians having to walk in the road next to traffic.

As you move through the field review site, be sure to note special circumstances that warrant additional safety considerations, because of either the built environment or the type of users who may be present (e.g., railroad crossing, presence of a school, ongoing or upcoming development, transit needs).

Finally, review the crashes along the corridor or those on a similar corridor and bring along crash summaries and maps to review in the field and try to understand the circumstances surrounding the crashes.

If desired, print and bring the pedestrian and bicycle-focused prompt lists found at the end of this chapter into the field as reminders of issues to look out for.

Bicycle Road Safety Audits

Bicyclist Characteristics

By the nature of bicycling being an active form of transportation that is exposed the elements, bicyclists would also prefer the most direct route possible that also minimizes delay. However, due to factors such as high traffic speeds and volumes, too close passing distances, intersection conflicts, lack of detection at signalized locations, lack of dedicated space to ride, and poor pavement quality, bicyclists will often go out of their way to find safer and more comfortable routes. Those that do bicycle on roads that aren't designed for them may do so in unpredictable ways such as weaving in and out of parked cars, crossing at non-intersection locations, riding on the sidewalk, and not obeying traffic control devices because they may be trying to avoid the hazards they perceive, and feel safer riding in these ways.

To create safer streets for all users, roadway designers should consider bicyclists of all ages and abilities when designing new and retrofitting existing streets. The designs should provide adequate separate operating space for bicyclists, or slow traffic speeds when bicyclists and motorists are expected to share lanes. Traffic volumes are also an important consideration. They should provide organized intersections to create predictable movements and improve motorist yielding, and they should be designed to connect destinations without undo delay or detours.

Bicycle Road Safety Audit Considerations

As you conduct a field assessment for bicyclist safety, even if you are not on a bicycle, try to ***put yourself into the mindset of someone who must travel this roadway by bicycle***. It may be important to conduct the assessment during daylight and nighttime and during peak and non-peak conditions. When you are out in the field, think about how all road users will experience the conditions. Consider the visibility, sight distance, separation from traffic, delays, street surface, and potential conflicts at driveways, intersections, and interchanges that you may face. Is it intuitive on how to ride safely and predictably on that roadway? Do you know how to safely cross a street or make a left turn?

Keep in mind the destinations and land uses nearby. Understand how bicyclists of different experience levels may ride or want to ride. For example, if the corridor is on a route to school, will child bicyclists be riding there? They may be operating on the sidewalk if there is not a protected bike lane. Also, consider how motorists will react to bicyclists on the roadway. Is adequate passing and sight distance provided for the speed of the roadway? Are bicyclist movements, particularly at intersections and crossings, predictable? Finally, review the crashes along the corridor or those of similar corridors and bring along crash summaries and maps to review in the field and try to understand the circumstances surrounding the crashes.

Follow-up

Finally, it is best to ***document results soon after the audit is completed***. The next phase describes the basic reporting needs.

There may be a need to ***continue discussion through a short, post-audit meeting*** to ensure that all notes and issues are documented, that any lingering issues are fleshed out in discussion, and that the person who will take the lead in drafting the RSA report has the notes and data needed.

Figure 11 Greenway underpass in Lenoir, NC does not connect to street network
Source: Google Maps ©

As a group, it is important for the RSA team to commit to helping ensure the RSA report is completed, and that all suggestions and perspectives on the issues are incorporated. The best multimodal solutions are likely to be identified earlier in the process if the team shares this commitment and responsibility.

Helpful tip

Trials of this process suggest that a post-RSA debriefing meeting is important to ensure observations and data are in order, to discuss any lingering issues, and to ensure that all are committed to a schedule for completing the RSA process.

Review the next phase for more information on completing the report, which at this stage should be largely a matter of compiling the relevant data, information, RSA results, and recommendations for potential improvements to address the identified safety issues.

Pedestrian-focused Prompt List

Along the Roadway

- Are pedestrian facilities present along the street? (e.g., sidewalks, side paths)
  - If so, do these provide a safe, accommodating, and predictable place for pedestrians?
    - Consider the speeds of vehicles, the sight distance, the slope, the street type and context, and roadway features such as parked cars and driveways. Do these facilities provide enough separation for comfort and safety? Is there a buffer between the walkable area and the street?
    - Are sidewalks (and ramps, if necessary) provided on both sides of a bridge?
  - If walkways are provided, do the designs meet current standards and best practices? (e.g. NCDOT Complete Streets Design Guidelines, AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, NACTO Urban Street Design Guide, Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way)
  - If there are no facilities present, is there a paved shoulder that is wide enough to accommodate pedestrians?
- Are pedestrian facilities continuous and provide for a network that connects destinations?
  - Does the roadway cross-section and/or pedestrian facility change frequently?
- Do objects in the right of-way, buildings, fences, etc. limit usable space on a sidewalk?
- Are the facilities adequately maintained including pavement condition, ramp condition, standing water, debris sweeping, and vegetation? Are there temporary or permanent obstructions? (e.g., poorly placed utility infrastructure, signs, furniture, bollards, etc.).
- Are bus stops sited properly?
  - Consider how bus stops are sited in relation to intersections or segments and whether they are located near destinations for pedestrians. Are there safe opportunities for pedestrians to cross the street? Do the buses themselves obscure drivers' view of passengers boarding or leaving the bus?
  - Is there a sufficient landing area for waiting passengers, passengers boarding/alighting, and pedestrians passing through?
- Is there pedestrian-level lighting along the street?
- Do the traffic characteristics or pedestrian facilities drastically change at the limits of the field assessment?
- Behaviors
  - Are there conflicts between bicyclists and pedestrians on sidewalks?
  - Do pedestrians routinely misunderstand or ignore pedestrian facilities?
  - Are motorists driving at appropriate speeds and yielding to pedestrians at any midblock crosswalks?

Pedestrian-focused Prompt List

Intersections and Crossings

- Is the number and type of crossings appropriate for the traffic and roadway conditions present to enable pedestrians to cross the street safely without extensive out-of-the-way detours?
- Are intersections designed to provide safe and predictable movements for all roadway users?
- Are turning movement conflicts minimized through geometric design or signal timing strategies such as leading pedestrian intervals or restricted turns?
- Are pedestrian signals present? If so, is the walk signal based on fixed time or pushbutton activation? Does the walk interval allow enough time for slower pedestrians (e.g., people in wheelchairs, older adults, and small children)?
  - If there are push buttons, consider their location and height. Are they accessible to all types of pedestrians?
- Is the sight distance adequate at intersections or other crossings for all road users?
  - Consider landscaping, topography, curves, parked cars, etc.
- Is the crossing distance minimized through geometric design?
  - Consider number of lanes, curb extensions, median islands, undesignated pavement, etc.
- Are turning speeds kept low?
  - Consider right-turn slip lanes, skewed intersections, wide corner radii, etc. that can increase speed and reduce visibility of pedestrians.
- Are the streets adequately maintained including pavement condition, standing water, sweeping, markings, drainage grates, manhole covers, and vegetation?
- Are pedestrian crossings adequately lit? Are pedestrians visible, with adequate sight distance, when crossing at night?
- Are crossing points for pedestrians well marked and signed? Is the paint on stop bars or crosswalks worn or missing? Can motorists recognize unmarked, but legal crosswalks?
- Are pedestrians able to cross a road safely at uncontrolled crossings including side streets and trails? Are there sufficient gaps in traffic that provide crossing opportunities for pedestrians?
- Behaviors
  - Are pedestrians crossing in safe a safe manner at predictable locations?
  - Are there a significant number of pedestrians crossing at midblock or uncontrolled locations (or other behaviors) that may suggest facilities are inadequate or perceived as unsafe?
  - Are motorists complying with speed limits?
  - Are motorists yielding to pedestrians at crosswalks and when turning?
  - Are there other types of risky behaviors or conflicts?

Bicycle-focused Prompt List

Along the Roadway

- Are bicycle facilities present?
  - If no separated facilities are provided, are speeds and traffic volumes low enough for bicyclists to safely and comfortably share the roadway with motor vehicles? [Overtaking collisions are the chief crash type resulting in fatal injuries to bicyclists nationally and in North Carolina.]
  - If facilities are present, do they provide a safe, accommodating, and predictable place for bicyclists? Consider the speeds of vehicles and bicyclists, the sight distance, the street type and context, potential bicyclist needs, and roadway features such as parked cars and driveways. Do these facilities provide enough separation for comfort and safety?
  - If so, do the designs meet current standards and best practices? (e.g., NCDOT Complete Streets Design Guidelines, AASHTO Bicycle Guide, NACTO Urban Bikeways Design Guide)
- Do other measures such as traffic calming devices or rumble strips interfere with the safe operation for bicyclists on the roadway?
- Are bicycle facilities continuous and provide for a network to connect destinations? Figure 11 illustrates a lack of connectivity between a greenway, multiuse facility and the street.
  - Are bicycle facility transitions designed to provide the roadway users with time to safely, visibly, and predictably merge?
  - Does the roadway cross-section and/or bicycle facility change frequently? How are transitions managed?
- Are the streets adequately maintained, including pavement condition, standing water, sweeping, markings, drainage grates, manhole covers, and vegetation?
- Behaviors
  - Are bicyclists riding in safe and predictable manners (e.g. with traffic, in the roadway, not the sidewalk, without weaving in and out of lanes or from sidewalk to roadway, etc.)?
  - Are motorists behaving in a safe manner including giving at least 3 feet lateral distance when passing and sufficient space when merging back into the same lane? Do motorists tailgate bicyclists?

Intersections and Crossings

- Is the intersection designed to provide safe and predictable movements for all roadway users?
- Are turning movement conflicts minimized through geometric design or signal timing strategies such as protected turns?
  - Are there separate turn lanes?
- Are driveways located near the intersection thus increasing potential conflicts?
- Are bicyclists detected at signalized intersections? If actuated, consider detector placement, sensitivity, or push button locations.
- Do the bicycle facilities continue through the intersection?
  - If so, are they designed to improve safety and visibility through proper design including placement, width, pavement markings, colored pavement, and more?
  - If not, do the facilities safely transition with adequate designs and markings to a shared facility prior to the intersection?
- Are conflict zones both at the intersection approach (typically when introducing a right-turn lane) and through the intersection identified through signs and pavement markings or colored pavement?
- Is the sight distance adequate at intersections (consider landscaping, topography, curves, parked cars, etc.)?
- Is the crossing distance minimized?
- Are turning speeds reduced? (Consider right-turn slip lanes, skewed intersections, wide corner radii, etc.)
- Are the streets adequately maintained including pavement condition, standing water, sweeping, markings, drainage grates, manhole covers, and vegetation?
- Are bicyclists able to cross a road safely at any uncontrolled crossings including side-streets and trails?
- Behaviors
  - Are bicyclists riding in safe and predictable manners (e.g. with traffic, in the roadway not the sidewalk, etc.)?
  - Are motorists behaving in a safe manner including yielding to bicyclists prior to and through the intersection?

PHASE 4 – Document Results and Recommendations

The RSA report is used to summarize the findings from the safety analyses (problem identification), corridor or intersection characteristics, and the RSA findings. While all team members should contribute to the report, one person will need to take the lead in drafting the initial RSA report. Everyone can agree on a basic format or outline at the pre-RSA meeting. Images, notes, and data from the RSA should be compiled in one location so the author(s) can consult them in putting the report together.

RSA Report Content

The key content of the RSA report will include:

- Description of the study area
  - Crash statistics–types, time of day, locations, contributing factors
  - Basic cross section, presence of transit, traffic and road user volumes
  - Land uses and key destinations
  - Plan information
  - Complaints, history, other relevant details
- Summary of safety issues identified and descriptions of the measures proposed to address them. Maps, photos and diagrams can be used to help illustrate safety issues.
- List of RSA team members and agencies that participated

It is most efficient to ***link the safety issues descriptions with the proposed solutions***. Short term and longer term solutions should be identified, so that these can be pursued through appropriate timelines, channels, and funding sources. Images can be used to help illustrate the potential countermeasures.

Figure 12 illustrates an efficient method to document safety issues and possible solutions from RSAs that was developed by the NCDOT Mobility and Safety Division. This format could be used with, or without a comprehensive written document. Materials including pedestrian and bicycle crash summaries, maps, TEAAS strip analysis summaries, speed study results and photos could be compiled to supplement this type of matrix or to go into a more comprehensive written report. The added advantage of this type of matrix is that additional columns of information can be added on countermeasures effectiveness, cost, and implementation considerations. Additional columns of data such as summary results of speed studies, traffic volumes, and other data could also be added.

Appendix D provides a very different example of a comprehensive pedestrian RSA report that resulted from the Lenoir, NC pilot process. Review other examples of pedestrian RSA reports available on FHWA's Pedestrian Road Safety Audits Web site.

Select Effective Crash Countermeasures and Designs

While it is beyond the scope of this guide to provide in-depth information on countermeasures, North Carolina, federal agencies and the National Cooperative Highway Research Program and other agencies have developed a number of guides that provide information on effective safety countermeasures, design, and practical guidance on where different types of countermeasures are most appropriate.

The primary consideration is to ***select countermeasures that address the identified problems and risk factors***, and that have documented safety benefits such as crash or speed reductions, provide separation of users in time or space, or enhance visibility and conspicuity. The second key consideration is that the countermeasure is appropriate for the conditions. For example, a warning sign is unlikely to have any effect on helping pedestrians cross a busy multilane road along a commercial area.

Location	Crash History/Potential (2007-2013)	Observed Problems	Possible Improvement Strategies
Bragg Boulevard at Mike and Johnson Street	9 Bike / Ped Crashes within 150' of the intersection.	Pedestrians crossing between bus shelters, away from signal	Provide crosswalk and push buttons on leg closest to transit stops Provide median islands at intersections and other crossing locations Provide leading pedestrian interval to walk phase (if conflicts with turning vehicles)
		Pedestrians crossing Bragg Blvd to go to the convenience store.	Exisitng Street lights are planned to be changed to LED.

Figure 12 Example of a simple spreadsheet template for capturing the findings of the RSA. A similar template is used by NCDOT Safety Unit, Safety Evaluation Group staff, and is useful to match documented crash history with field observations and recommended improvements.

Key resources, including North Carolina guidance available to help select effective and appropriate countermeasures, are listed in the bibliography.

Pedestrian crash countermeasures with known crash benefits are also listed in the Toolbox of Countermeasures and Their Potential Effectiveness for Pedestrian Crashes. Crash effectiveness information is more regularly updated on the CMF Clearinghouse Web site. You can also find information on countermeasures effectiveness, applications and images in sources such as PEDSAFE and BIKESAFE and North Carolina resources including the Complete Streets Planning and Design Guidelines. FHWA's Safe Transportation for Every Pedestrian (STEP) program is another source of information. These and other key resources for roadway design and countermeasures are listed in the Annotated Bibliography.

Additional information, including answers to frequently asked questions, assistance with new questions, access to webinars and training opportunities may be found on the PBIC's Web site.

When considering solutions, countermeasures might be categorized by expected crash reductions or other expected safety benefits, and according to:

- Low cost and short term
- Medium cost and short or medium term (no right-of-way acquisition; projects that can be accomplished through operations and/or paint and resurfacing projects)
- High cost and longer term (right-of-way acquisition may be required; moving/adding curb lines; medians/median islands; signals and/or beacons etc.) for which a project proposal may be developed

This type of information may help you and partners determine the right type of project and potential funding source, and which agencies should be involved. Lower cost countermeasures such as signal timing changes might be applied locally, whereas design and new traffic control devices will likely require a larger project and collaboration.

More information

See FHWA's Every Day Counts program Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations for insights on effective treatments for different types of risk patterns and conditions at uncontrolled locations.

Develop Safety Project(s)

Ultimately the value of the RSA is captured in the report and recommendations developed by the RSA partners. Developing a detailed and well-supported set of recommended improvements for an audit site can help justify investment in safety at the location of interest. Building on the findings, the regional organization, local agency staff, and NCDOT regional safety office staff and division offices can coordinate to develop a safety project or projects. Figure 13 illustrates midblock crossing improvements implemented at a number of transit stop locations along the corridor as an outcome of recommendations from RSAs conducted in Chapel Hill, NC. (In this figure, pedestrians activate the rapid flashing beacon (RRFB) warning light (upper image), which alerts motorists that a pedestrian is about to cross. The van is stopped at the advance yield bars (lower image). Advance yield bars help to provide motorists in an adjacent lane on multilane roads a better chance to observe and yield to a pedestrian in the crosswalk when another vehicle has already slowed or stopped to yield to the pedestrian.)

Figure 13 Several crossings near transit stop locations along Martin Luther King Jr Blvd in Chapel Hill, NC, were improved as a result of RSAs

In developing the RSA report and recommendations, remember to think comprehensively about solutions. For example, motorists do not always observe North Carolina's yielding laws. Follow-up observations may reveal that motorists are not yielding at improved locations as directed by State law, and enhanced enforcement, speed enforcement, or stop-control devices may be needed. An RSA provides an opportunity to identify needs for enhanced enforcement and community education, to re-evaluate appropriateness of speed limits, and to identify needs for improvement in planning and design policies, along with needed improvements to the roadway and transportation facilities.

More information

Remember to think about non-engineering solutions. Educational outreach and law enforcement and publicity may be needed to help create a safer environment, even if changes are made to the roadway.

Law enforcement programs are eligible for funding through the Governor's Highway Safety (GHSP) Office. Resources are available to help agencies develop effective strategies and programs that can achieve long-lasting behavior change and safety improvement. For more information about such measures, consult Watch for Me NC and *Countermeasures That Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices, Eighth Edition* (Goodwin, et al. 2015; watch for updated editions).

Source: www.pedbikeimages.org; Dan Burden. Charlotte, NC

Evaluate and Monitor Projects

If a safety project is developed and implemented, it is important to evaluate the impacts of the project. Measuring clear safety outcomes can provide useful information about whether the investment helped solved the problems, which can improve decision-making next time around. ***Contact NCDOT Mobility and Safety Evaluation Unit for assistance with evaluation***. It can take many years and many treatment locations to understand whether a treatment or package of treatments helped to reduce pedestrian or bicycle crashes (and a crash-based evaluation will be infeasible for most local agencies to carry out). However, observable measures such as traffic speed, yielding, conflicts, and pedestrian, bicyclist, and motorist compliance with traffic controls and rules may be used to evaluate whether a treatment is working as intended.

Monitoring of conflicts and other interactions and behaviors may reveal a need for additional countermeasures, including enhanced or automated enforcement or additional engineering measures. It may also be important to conduct educational or enforcement outreach, as examples, teaching users about how certain traffic controls are intended to operate, or reminding pedestrians and bicyclists that they are not very visible and to use well-lit crossing locations at night. These are things that may only be noticed if local practitioners follow-up on the RSA and project implementation.

Now that you have successfully completed the RSA process, be sure to follow up on RSA recommendations and actions.

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Assistance

NCDOT Division of Bicycle and Pedestrian Transportation, Web site
https://www.ncdot.gov/bikeped/

NCDOT Traffic Safety Unit, Web site
https://apps.ncdot.gov/dot/directory/authenticated/UnitPage.aspx?id=1338

NCDOT Mobility and Safety Field Operations Section, Web site
https://apps.ncdot.gov/dot/directory/authenticated/UnitPage.aspx?id=9685

Data

See Chapter 2, Tables 2 and 3, and Appendix A.

Guidance

Developing Guidelines and Documentation of Engineering Studies for Establishing NC Speed Limits

Findley, DJ., S. Warchol, T. Chase, & L. Thomas, NCDOT/NC/2017-10, North Carolina Department of Transportation, 2018 (expected).

This guide developed for NCDOT for use by state and local agencies provides data collection forms, procedures, and information for performing and documenting engineering studies of speed limits for consideration of posted speed limit changes.

"NCDOT can use the developed research products to provide consistency to the studies that engineers conduct to support recommended speed limits. The substantive portions of this report are included as appendices: Speed Limit Review Documentation Forms (Appendix A); Data Collection Terms (Appendix B); Summary of Speed-Related Research (Appendix C);

Background and Example Forms for Roadway Speed Limit Review (Appendix D); State Speed Study Practices (Appendix E)."

North Carolina Department of Transportation, Complete Streets Planning and Design Guidelines
available http://www.completestreetsnc.org/

The NC Complete Streets guide was intended to help the State and communities fulfill the NCDOT Complete Streets policy adopted in 2009, describes user needs and land use types and provides flexible guidance in selecting designs and target speed limits, for different street types within those contexts. Examples throughout the Guide illustrate selection of countermeasures appropriate to the area type and street functions.

***North Carolina Pedestrian Crossing Guidance* and flowchart**
Schroeder, B.J., S.W. Worth, and D.J. Findley, North Carolina Pedestrian Crossing Guidance, FHWA/NC/2014-15, North Carolina Department of Transportation, Raleigh, NC, July 2015, 79 pp. Available at: https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/Pedestrian_Crossing_Guidance.pdf

North Carolina Pedestrian Crossing Evaluation Guidance flow chart Available at: https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/FlowChart.pdf

This NC-specific resource provides a systematic decision-process to help select appropriate pedestrian crossing improvements for uncontrolled intersection approaches, midblock crossings, or signalized intersections that lack pedestrian signals and crosswalks. Systematic application of the tool can help provide a more consistent decision-framework for NC jurisdictions.

Note that although the guidance can be used to help assess shared use path crossings, it applies only to pedestrians and their characteristics. Thus, the RSA team should consider bicyclists' needs in a similarly systematic fashion.

NCDOT Planning Grant opportunities
https://www.ncdot.gov/bikeped/planning/default.html

National Resources

Analysis and Screening Tools and Resources

Pedestrian and Bicyclist Intersection Safety Indices: User Guide
Carter, D.L., W. W. Hunter, C.V. Zegeer, and J.R. Stewart, Publication No. FHWA-HRT-06-130, Federal Highway Administration, McLean, VA., 2007. Available https://www.fhwa.dot.gov/publications/research/safety/pedbike/06130/06130.pdf

CrimeStat IV
National Institute of Justice, statistical analysis and network screening software and manuals. Available https://www.nij.gov/topics/technology/maps/pages/crimestat-downloads.aspx

Evaluation of Four Network Screening Performance Measures
Gross, F., T. Harmon, M. Albee, S. Himes, R. Srinivasan, D. Carter & M. Dugas, Federal Highway Administration, Washington, D.C., 2016. Available at: https://safety.fhwa.dot.gov/rsdp/downloads/fhwasa16103.pdf

Guidebook to Identify High Pedestrian Crash Locations
FHWA guide, pending 2018.

Guide for Scalable Risk Assessment Methods for Pedestrians and Bicyclists
FHWA guide, pending.

Systemic Pedestrian Safety Analysis Guidebook
NCHRP guide, pending 2018.

Highway Safety Manual
1st edition, 2010. American Association of State Highway Transportation Officials.

Reliability of Safety Management Methods: Systemic Safety Programs
Gross, F., T. Harmon, G. Bahar & K. Peach, Federal Highway Administration, Washington, D.C., 2016. Available at: https://safety.fhwa.dot.gov/rsdp/downloads/fhwasa16041.pdf

Safety Performance Function Development Guide: Developing Jurisdiction-Specific SPFs
Srinivasan, R. and K. Bauer. Report No. FHWA –SA-14-005, Washington, DC: Federal Highway Administration Office of Safety, 2013. Available at: http://safety.fhwa.dot.gov/rsdp/downloads/spf_development_guide_final.pdf

SANET, Spatial Analysis Along Networks
software and manuals, Available http://sanet.csis.u-tokyo.ac.jp/

Behavioral Countermeasures

Advancing pedestrian and bicyclist safety: A primer for highway safety professionals
Brookshire, K., Sandt, L., Sundstrom, C., Thomas, L., & Blomberg, R. (2016, April). (Report No. DOT HS 812 258). Washington, DC: National Highway Traffic Safety Administration.

Countermeasures That Work: A highway safety countermeasure guide for State Highway Safety Offices
Eighth edition, Goodwin, A., L. Thomas, B. Kirley, B., W. Hall, N. O'Brien, and K. Hill, K. Report DOT HS 812 202, National Highway Traffic Safety Administration, Washington, DC, 2015, 437 pp. Available at: https://www.ghsa.org/sites/default/files/2016-12/812202-CountermeasuresThatWork8th_0.pdf

Bicycle Countermeasures Resources

BIKESAFE: Bicycle Safety Guide and Countermeasure Selection System
Sundstrom, Nabors et al., 2014, Federal Highway Administration, online tool, available www.pedbikesafe.org/bikesafe/index.cfm

The crash type information available in NC's pedestrian and bicycle crash databases, and the road characteristics described during the RSA, can be used to help identify countermeasures that can help treat those specific crash and conflict types. In addition, countermeasures to address other safety performance issues that might be identified during the RSA can be identified through a performance objective matrix.

Evaluation of Bicycle-Related Roadway Measures: A Summary of Available Research
Mead, J., A. McGrane, C. Zegeer & L. Thomas, PBIC and Federal Highway Administration, 2014 [Online]. Available at: http://www.pedbikeinfo.org/cms/downloads/06%2013%202014%20BIKESAFE%20Lit%20Review_FINAL.pdf

This document, a companion to BIKESAFE, provides summaries of safety research for bicycle-related roadway improvements included in BIKESAFE. The summaries cover crash-based studies and behavioral/operational studies of behaviors related to safety. Details of applications help interpret the findings.

Design Resources

The Design Resource Index
Developed by the Pedestrian and Bicycle Information Center (2015). Available http://www.pedbikeinfo.org/planning/facilities_designresourceindex.cfm

The Design Resource Index describes content of other design guidance documents and where information on each topic is located and is a useful resource for practitioners to find and compare design guidance from the MUTCD, AASHTO, and other sources. Other key pedestrian and bicycle facility design resources are listed below.

Designing Walkable Urban Thoroughfares
ITE & CNU [Congress for the New Urbanism], Washington, DC: Federal Highway Administration, and US Environmental Protection Agency, 2010. Available http://library.ite.org/pub/e1cff43c-2354-d714-51d9-d82b39d4dbad

TCRP Report 175: Guidebook on Pedestrian Crossings of Public Transit Rail Services
Fitzpatrick, K., J. Warner, M.A. Brewer, B.L. Bentzen, J.M. Barlow, & B. Sperry, Transportation Research Board, Washington, D.C., 2015. Available at: http://www.trb.org/Publications/Blurbs/172320.aspx

Guide for the Development of Bicycle Facilities
4th Edition, American Association of State Highway and Transportation Officials, Washington, D.C., 2012. Available through the AASHTO bookstore, https://bookstore.transportation.org/

Guide for the Planning, Design, and Operation of Pedestrian Facilities, American Association of State Highway and Transportation Officials
Washington, D.C., 2004, 127 pp. Available through the AASHTO bookstore, https://bookstore.transportation.org/

Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges: An ITE Recommended Practice
Mitman, M.F. and M.D. Ridgway, Pub. RP-039, Institute of Transportation Engineers, Washington, D.C., 2015, 30 pp. Available through ITE, http://www.ite.org/

Separated Bike Lane Planning and Design Guide
FHWA Report No. HEP-15-025, 2015. Available at: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/separatedbikelane_pdg.pdf

Urban Bikeway Design Guide
National Association of City Transportation Officials, New York, NY, n.d. [Online]. Available at: http://nacto.org/publication/urban-bikeway-design-guide/

Urban Street Design Guide
National Association of City Transportation Officials (NACTO), New York, NY, n.d. [Online]. Available at: http://nacto.org/publication/urban-street-design-guide/

Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way [PROWAG]
United States Access Board, n.d. [Online] Available at: http://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines

Pedestrian Countermeasures Resources

Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
Blackburn, L., C. Zegeer, & K. Brookshire, Report No. FHWA-SA-17-072, Washington, DC: Federal Highway Administration, 2017, Available at: https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/guide_to_improve_uncontrolled_crossings.pdf

PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System
Zegeer, Nabors, Lagerwey et al. 2013, Federal Highway Administration online tool, Available http://www.pedbikesafe.org/PEDSAFE/index.cfm

This guide provides 67 countermeasure descriptions, including effectiveness and application considerations, cost information, and selection guidance through several interactive tools that can make use of crash types and/or roadway information to help identify potentially appropriate countermeasures. Numerous case studies describe how jurisdictions have applied the various countermeasures.

Using PEDSAFE, the crash type information available in NC's pedestrian and bicycle crash databases can be used to help identify countermeasures that can help treat those specific crash and conflict types. In addition, countermeasures to address other safety performance issues that might be identified during the RSA can be identified through a performance objective matrix.

Evaluation of Pedestrian-Related Roadway Measures: A Summary of Available Research
Mead, J., C. Zegeer and M. Bushell, "Evaluation of Pedestrian-Related Roadway Measures: A Summary of Available Research," Pedestrian and Bicycle Information Center, 2014 [Online]. Available at: http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview_April2014.pdf

This document, a companion to PEDSAFE, provides a summary of safety research, including crash-based evidence and evidence from behavioral/operational studies, for pedestrian-related roadway improvements. Details of applications help interpret the findings.

Toolbox of Countermeasures and Their Potential Effectiveness for Pedestrian Crashes
Report FHWA-SA-014, U.S. Department of Transportation, Federal Highway Administration, 2013, [Online]. Available at: http://www.pedbikeinfo.org/collateral/PSAP%20Training/gettraining_references_pedToolboxofCountermeasures2013.pdf

This toolbox lists countermeasures with documented crash reduction effects on pedestrian crashes from one or more studies.

Application of Pedestrian Crossing Treatments for Streets and Highways
Thomas, L, N. Thirsk, C.V. Zegeer, NCHRP Synthesis 498, Transportation Research Board, Washington, DC, 2016. Available at: http://www.trb.org/Publications/Blurbs/175419.aspx

This synthesis of practice and research documents current application practices and safety effectiveness of pedestrian crossing treatments, and summarizes policies and planning practices that guide agencies in selection and application of pedestrian safety improvements.

Improving Pedestrian Safety at Unsignalized Crossings

Fitzpatrick et al. 2006, TCRP 112/NCHRP 562, Transportation Research Board; Washington, D.C., 2006. Available http://www.trb.org/Publications/Blurbs/157723.aspx

This study focused on the safety, operations, user perceptions, and practitioner inputs regarding four categories of traffic control devices at uncontrolled pedestrian crossings: marked crosswalk; enhanced, high-visibility or "active when present" (but yield-type) devices; red signal/warning device or warning beacon device (primarily pedestrian hybrid beacons (PHBs) and rectangular rapid flash beacons (RRFBs); and conventional traffic control signals. In general, the authors concluded that motorist crosswalk compliance (yielding) was consistently quite high: 94 percent or above at all sites tested, with an average of 97 percent or higher, for each of the signal control/red beacon type devices. Results were more mixed for the high visibility devices and warning flashing when activated types of beacons (yellow only indicators). The authors also developed recommendations for incorporation into the MUTCD and guidance that split primarily along speed limits (at 35 mi/h) with worksheets available for assessing locations at above 35 mi/h and those below 35 mi/h. (Fitzpatrick et al. 2006, Appendix A. Also consult Thomas et al. 2016). This research has also been considered in the NC Pedestrian Crossing Guidance.

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines

Zegeer, C.V., J.R. Stewart, H.H. Huang, P.A. Lagerwey, J. Feaganes, & B.J. Campbell, Report FHWA-HRT-04-100, McLean, VA, Federal Highway Administration, 2005, 112 pp. Available at: https://www.fhwa.dot.gov/publications/research/safety/04100/04100.pdf

This seminal study examined safety factors related to providing crosswalks at crossings with no stop or signal controls in place. The guidelines suggested in this report emerged from a study of 1000 marked and 1000 unmarked crosswalks at similar locations in 30 cities. The study found that higher vehicle traffic volumes, pedestrian volumes, and a greater number of lanes, were all associated with higher frequencies of pedestrian crashes. Raised medians and pedestrian crossing islands were associated with lower pedestrian crashes. The report provided guidance based on the findings, including a matrix outlining when crosswalks without additional treatments might be unsuitable (Zegeer et al. 2005, Table 11). The study recommends that marked crosswalks should not be used alone (i.e., without traffic-calming treatments, traffic signals and pedestrian signals when warranted, or other substantial crossing improvements) and should not be used under any of the following conditions:

- Where the speed limit exceeds 40 mi/h (64.4 km/h).
- On a roadway with four or more lanes without a raised median or crossing island that has (or will soon have) an ADT of 12,000 vehicles or greater.
- On a roadway with four or more lanes with a raised median or crossing island that has (or soon will have) an ADT of 15,000 or greater.

This guidance was also considered by Schroeder et al. in the North Carolina pedestrian crossing guide.

The report goes on to highlight some of the types of additional improvements that may help make uncontrolled crossings safer on higher volume, multilane roads. The findings were not intended to deter agencies from placing crosswalks at currently uncontrolled locations on multilane, higher speed, higher volume roads where pedestrians need to cross, but to carefully assess the location through engineering studies, and to consider that if a crossing is needed, what additional treatments are needed to make it a safe one (Thomas et al. 2016).

Road Safety Audit Guides

Bicycle Road Safety Audit Guidelines and Prompt Lists

Nabors, D., E. Goughnour, L. Thomas, W. DeSantis, M. Sawyer & K. Moriarty. Report No. FHWA-SA-12-018, Washington, DC: Federal Highway Administration, Office of Safety, 2012. Available at: http://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa12018/fhwasa12018.pdf

Pedestrian Road Safety Audit Guidelines and Prompt Lists
Nabors, D., M. Gibbs, L. Sandt, S. Rocchi, E. Wilson & M. Lipinski. Report No. FHWA-SA-07-007, Washington, DC: Federal Highway Administration Office of Safety, 2007. Available at: http://www.pedbikeinfo.org/cms/downloads/PedRSA.reduced.pdf

Safety Planning and Practice

Bicycle and Pedestrian Funding, Design, and Environmental Review: Addressing Common Misconceptions
Federal Highway Administration, August 2015. Available at: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/misconceptions.pdf

This document addresses common misconceptions about these topics that have sometimes led to a failure to consider pedestrian needs as fully as possible.

Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
Blackburn, L., C. Zegeer, & K. Brookshire, Report No. FHWA-SA-17-072, Washington, DC: Federal Highway Administration, 2017, Available at: https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/guide_to_improve_uncontrolled_crossings.pdf

How to Develop a Pedestrian and Bicycle Safety Action Plan
Gelinne, D., L. Thomas, K. Lang, C.V. Zegeer, & E. Goughnour, Report No. FHWA-SA-17-050, Washington, D.C.: Federal Highway Administration, 2017, Available at: https://safety.fhwa.dot.gov/ped_bike/ped_focus/docs/fhwasa17050.pdf

Incorporating On-Road Bicycle Networks into Resurfacing Projects (2016)
Publication no. FHWA-HEP-16-025, Federal Highway Administration. Available at: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/resurfacing/resurfacing_workbook.pdf

Pedestrian and Bicycle Transportation Along Existing Roads—ActiveTrans Priority Tool Guidebook
Lagerwey, P. A., M.J. Hintze, J.B. Elliott, J. L. Toole, & R.J. Schneider, NCHRP Report 803,Transportation Research Board, Washington, D.C., 2015. Tool and guide available at: http://www.pedbikeinfo.org/planning/tools_apt.cfm

Speed Management

FHWA Speed Management Safety [Web site]
https://safety.fhwa.dot.gov/speedmgt/

Jurisdiction Speed Management Action Plan Development Package
Thomas, L., R. Srinivasan, M. Worth, M.R. Parker Jr., and R. Miller. Report FHWA-Speed Management Action Plan Template, 2015. Available at: http://safety.fhwa.dot.gov/speedmgt/ref_mats/docs/fhwa_speedmanagactionplantemplate_final.pdf

Developing Guidelines and Documentation of Engineering Studies for Establishing NC Speed Limits
Findley, D.J., S. Warchol, T. Chase, & L. Thomas, NCDOT/NC/2017-10, North Carolina Department of Transportation, 2018 (expected).

APPENDIX A — More Details on Crash and Roadway Data

Crash Data

All North Carolina communities have access to a robust crash data source that contains information on crash types, other crash factors (e.g., as age of pedestrians, time of day or light conditions, and characteristics of the crash location).

Pedestrian and bicycle crash types have been coded for every pedestrian and bicycle crash statewide, starting in 1997 and continuing to current years. Crash types are descriptions of the motor vehicle and pedestrian or bicycle maneuvers (relative to each other) leading up to the crash. An example is "Motor Left Turn–Opposite Direction" to bicyclist type. This type of information is unavailable in TEAAS crash records, as DMV crash reporting only captures "pedestrian" or "bicycle" crash (First Harmful Event and Most Harmful Event) when pedestrians are involved. The crashes have also been geocoded since 2007, and latitude and longitude coordinates are included for the location of each crash. Crash types are useful in helping to identify the type of problem that is occurring and what types of countermeasures may be appropriate to help reduce those types. The crash location is essential for identifying where collisions may be concentrated, as well as the characteristics of the roadway, and area type (land use, etc.) where collisions often occur.

The crash typed and mapped pedestrian and bicycle crash data may be explored in an ArcGIS (© ESRI) crash map sponsored by NCDOT at: http://www.arcgis.com/home/webmap/viewer.html?webmap=b4fcdc266d054a1ca075b60715f88aef

The crash data can also be downloaded and opened in ARCGIS or other software for further analysis. Most agencies use GIS tools and mapping to explore various community characteristics (land use, zoning, population characteristics) and various community issues. These kinds of data are also useful in exploring pedestrian and bicycle crashes as prior research has shown that these characteristics are associated with amounts of walking and potential for conflicts.

In addition, users can produce basic queries and tables for the entire state, geographic region, counties, or cities on an interactive Web site sponsored by NCDOT, with data compiled by the University of North Carolina, Highway Safety Research Center. This Web site, which is updated regularly with the most recent coded and compiled data, can be accessed at: http://www.pedbikeinfo.org/pbcat_nc/

Figure 14 shows an example of the diagram and narrative from DMV-349 (the North Carolina standard crash report form) and the crash type information captured in the NCPedBike data available for download at NCDOT Bicyclist and Pedestrian Crash data map webpage: https://ncdot.maps.arcgis.com/home/item.html?id=b4fcdc266d054a1ca075b60715f88aef (Figure 8 in Phase 3 illustrates use of the crash type and other data to create RSA-focused crash maps.)

Roadway Inventory Data

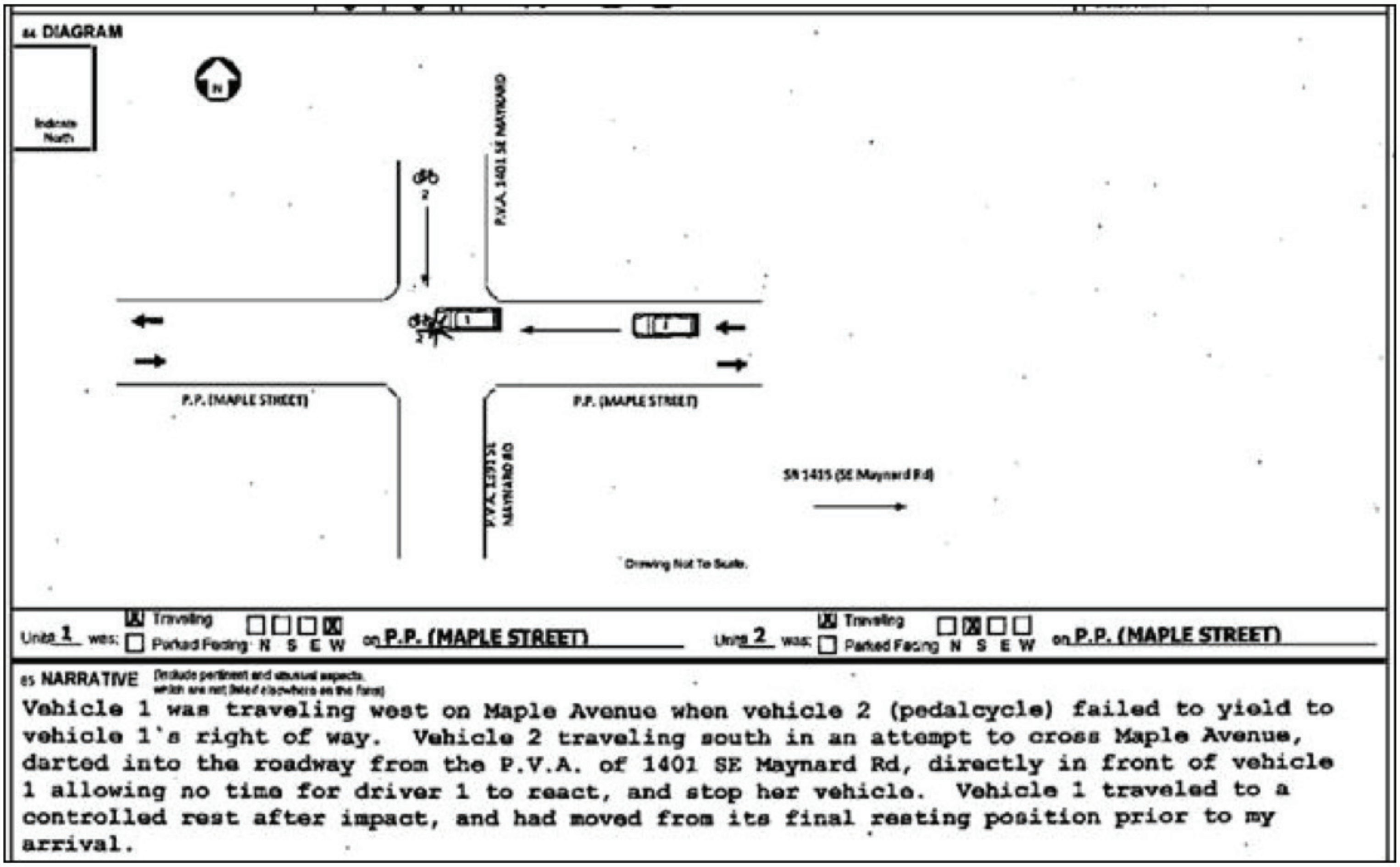
The second key data source is roadway inventory data. These data ideally contain variables on roadway design characteristics, speed limits, traffic volumes, and roadway functional classification. It is also useful to have access to a separate file for intersections that contains similar information. Data on facility placement (e.g., sidewalks, crosswalks, paths, bicycle facilities) and traffic control devices and operations is also desirable. A statewide database of roadway inventory data is being developed, but is not yet very comprehensive. For more information, see: https://connect.ncdot.gov/projects/BikePed/Pages/PBIN.aspx

NCDOT's roadway inventory data is available in several GIS layers and can be used in GIS-based analyses. (Some data files may not include all locally-owned streets.) The characteristics available vary for the different layers, and descriptions of each file are provided in meta-data documents on the Web site. Available attributes for one or more of the roadway shapefiles include designations of the roadway classification, configuration, number and types of lanes, and others.

For complete network data that includes locally-owned city streets, the Integrated Statewide Road Network Data, which are frozen at 2007, are also available. However, local jurisdictions may possess more up-to-date streets data files that include all city and state-owned streets within jurisdictional boundaries. Contact local GIS coordinators or other appropriate staff for information on the best source of data for the local and state streets network.

The State's roadway data are available in shapefile and geodatabase formats at: https://connect.ncdot.gov/resources/gis/pages/gis-data-layers.aspx

As mentioned below, traffic volume is a risk factor for pedestrian and bicycle collisions with motor vehicles. However, AADT estimates may not be available for all roads of interest in urban areas. The State conducts traffic surveys at over 40,000 locations across the state, on interstates, US Highways, and state routes, primarily, and uses the data and account for yearly traffic trends to develop the estimates of Average Annual Daily Traffic. The data represent traffic volumes at the point locations where counts were collected. For more information, and to access state traffic count data, see: https://connect.ncdot.gov/resources/State-Mapping/Pages/Traffic-Volume-Maps.aspx


84 DIAGRAM

Indicate North

P.V.A. 1401 SE MAYNARD

P.P. (MAPLE STREET)

P.P. (MAPLE STREET)

P.V.A. 1391 SE MAYNARD RD

SR 1415 (SE Maynard Rd)

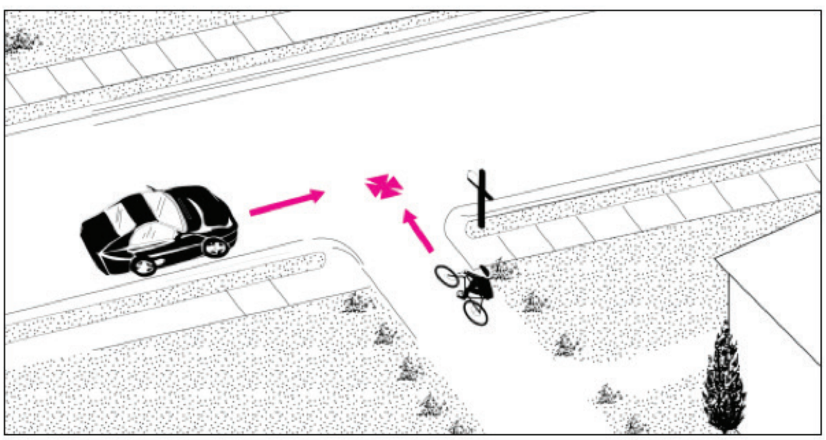
Drawing Not To Scale.

Units 1 was: [X] Traveling [ ] Parked Facing: N S E W [X W] on P.P. (MAPLE STREET)

Units 2 was: [X] Traveling [ ] Parked Facing: N S E W [X S] on P.P. (MAPLE STREET)

85 NARRATIVE (Include pertinent and unusual aspects, which are not listed elsewhere on the form)

Vehicle 1 was traveling west on Maple Avenue when vehicle 2 (pedalcycle) failed to yield to vehicle 1's right of way. Vehicle 2 traveling south in an attempt to cross Maple Avenue, darted into the roadway from the P.V.A. of 1401 SE Maynard Rd, directly in front of vehicle 1 allowing no time for driver 1 to react, and stop her vehicle. Vehicle 1 traveled to a controlled rest after impact, and had moved from its final resting position prior to my arrival.



Bicyclist Ride Out – Commercial Driveway or Alley crash type

Figure 14 Crash type variables available in the NC Pedestrian and Bicycle Crash databases (illustrated at bottom), captures information about the crash from the diagram, narrative and other data in the DMV-349 crash report (top image of part of the report)
The crash reports may still prove useful to download and compile for a specific location when conducting the RSA as they may provide additional details on roadway or environmental factors that contributed to prior crashes.

APPENDIX B — Common NC Crash Type Patterns

In North Carolina as a whole, the crash type groups that accounted for the largest numbers of pedestrian-motor vehicle collisions on the roadway network over the period 2008-2012 were as shown in the table below.

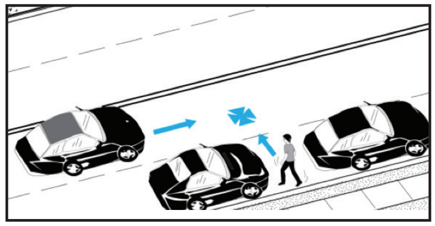
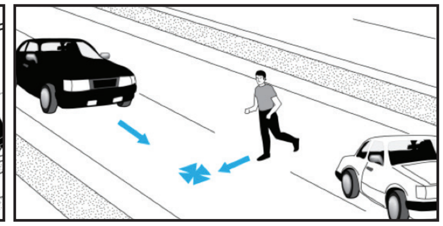
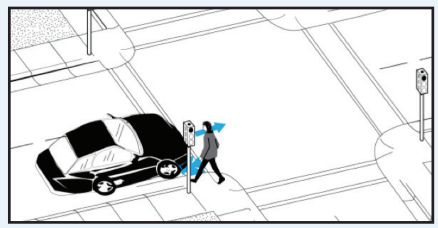
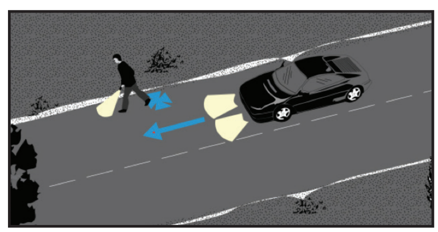
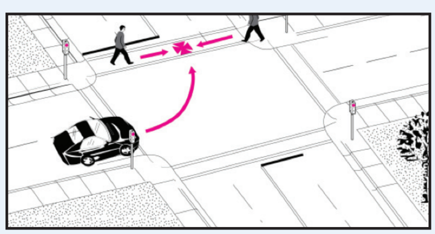
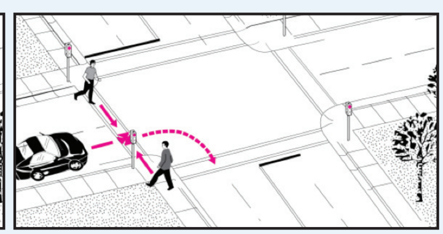
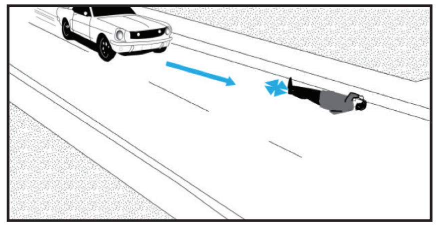
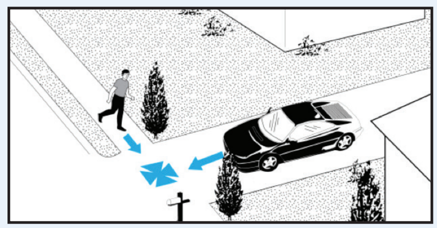
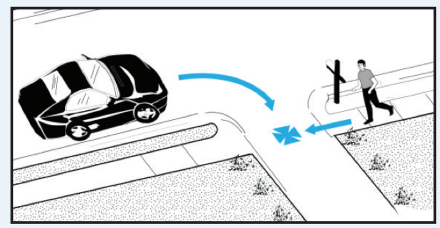
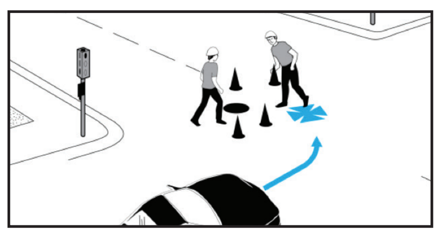
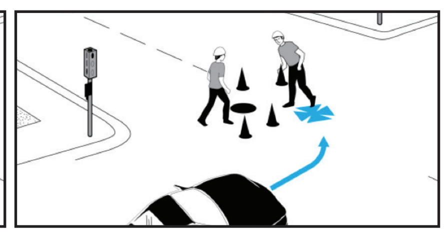
Pedestrian-Motor Vehicle Crash Type Group	% of Total On-Road Ped Crashes (N= 9192)	Examples of Crash Group
Pedestrian Crossing Roadway, Vehicle Not Turning–Midblock (includes Multiple Threat, Dash/Dart-out)	22%	 
Pedestrian Crossing a Roadway, Vehicle Not Turning–at Intersection (includes Motorist or Pedestrian Failure to Yield, Multiple Threat, and Dash/Dart-out)	15%	
Pedestrian Walking Along Roadway (facing or against traffic), struck from Behind or from Front–Midblock or Intersection	11.9%	
Pedestrian Crossing Roadway, Vehicle Turning–Intersection	9.9%	 

Table continued...

Pedestrian-Motor Vehicle Crash Type Group	% of Total On-Road Ped Crashes (N= 9192)	Examples of Crash Group
Pedestrian in Roadway, Unknown Circumstances–Intersection or Midblock	9.5%	 Pedestrian may have been walking, standing or lying in the road. Many (72%) of these collisions occur at night and/or involve pedestrian use of alcohol (34%). Lighting improvements, design measures, speed management, and more comprehensive interventions may be needed.
Pedestrian Crossing Driveway or Alley	2.5%	 
Pedestrian Working or Playing in Roadway–Intersection or Midblock	2.2%	 
Top 7 groups percent of Total	**73%**	

Note that this set of seven broad crash type groups, accounted for an average of 73 percent of all pedestrian collisions reported to have occurred on roadways statewide over a five-year period.

Crash types that accounted for a disproportionate number of those seriously injured are killed are those involving pedestrians struck by a motorist that was traveling straight through (not turning) - Pedestrian Crossing Roadway, Vehicle Not Turning. About 30 percent of all fatal and disabling injuries involved these types, but only 18 percent of total crashes were these types.

Note that a large number of pedestrian-motor vehicle collisions; around 30 percent, on average of the total reported occurred in parking lots, driveways, and other off-road areas. On average, 30 percent of off-roadway crashes involved backing vehicles. Another 26 percent involve unusual circumstances and often occur in parking lots at night. The numbers of parking lot collisions reported are no doubt a considerable understatement of the total, since many off-roadway collisions are not reported to law enforcement agencies. Off-roadway crashes are not the primary focus of this effort. Nevertheless, driveway and parking lot/deck design, and pedestrian and bicycle access to businesses from the street are issues that local planning organizations may also want to address to help reduce these numbers and improve the safety and connectivity for pedestrians and bicyclists. Lighting and security at night may also be needed in some situations.

The percentages of different crash groups by location type will vary for urban to more rural jurisdictions as the crash "exposure" for each community will be influenced by the numbers and distance between intersections and other variables for each community. More information on contributing causes for each crash group is available from PEDSAFE, under Crash Type Analysis (Zegeer, Nabors, & Lagerwey, 2013).

For ***bicycle-motor vehicle collisions,*** the ten crash groups shown in the table below accounted for 72 percent of all bicycle-motor vehicle collisions reported to the state from 2008-2012.

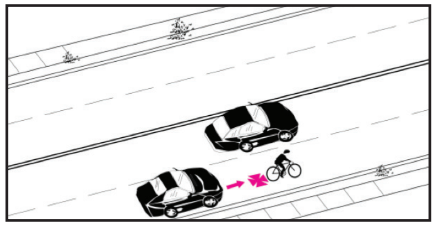
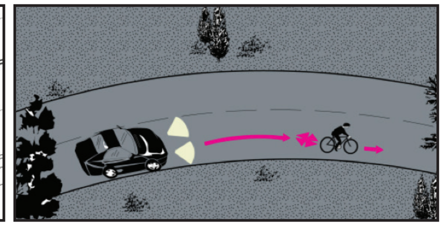
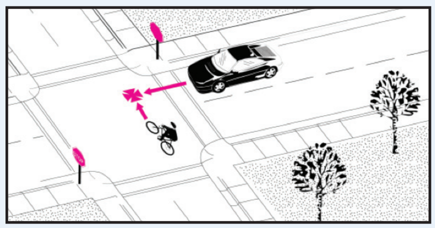
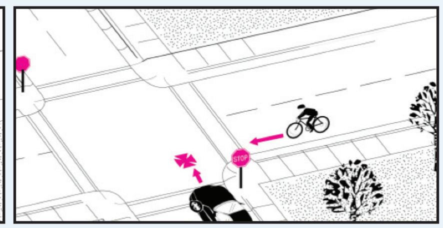
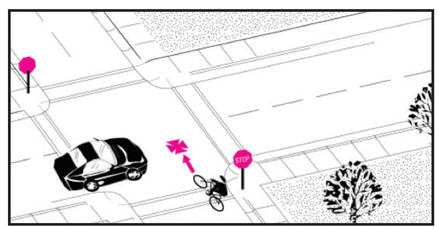
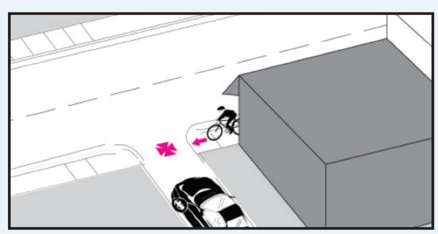
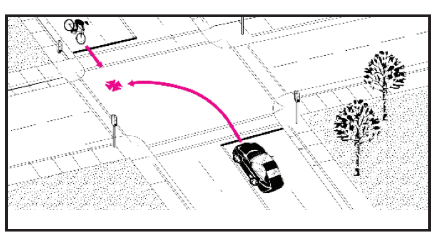
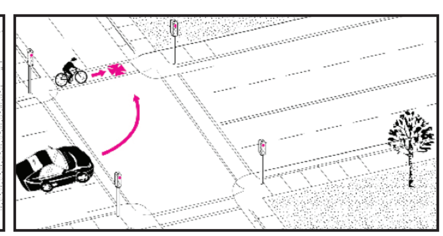
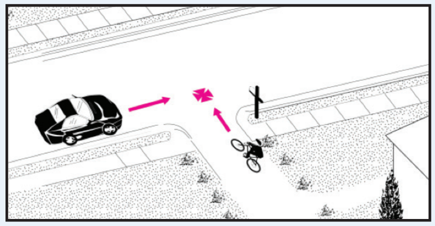
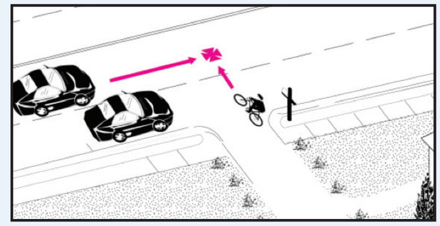
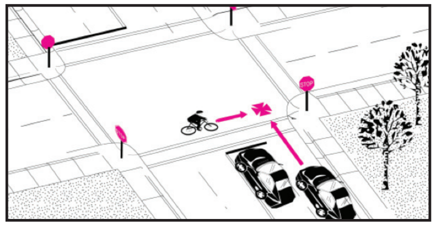
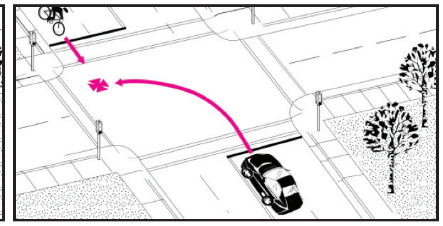
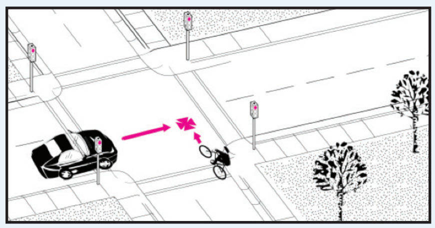
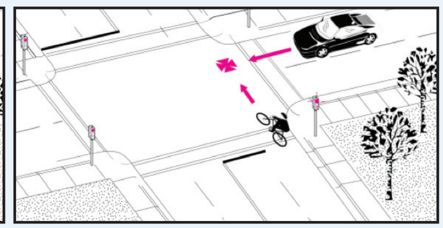
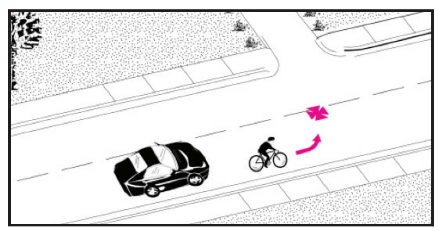
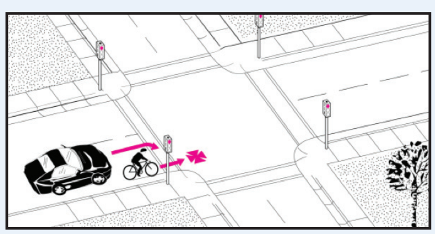
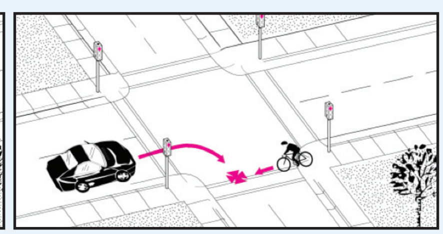
Bicycle-Motor Vehicle Crash Type Group	% of Total Bike Crashes (N=4889 crashes±)	Examples of Crash Group
Motorist Overtaking Bicyclist at Segment* or Intersection	19.2%	 
Motorist Failed to Yield - Sign-controlled Intersection	10.4%	 
Bicyclist Failed to Yield - Sign-controlled Intersection	6.6%	
Motorist Failed to Yield - Midblock	6.5%	
Motorist Left Turn / Merge - Intersection	6.3%	 

Table continued...

Bicycle-Motor Vehicle Crash Type Group	% of Total Bike Crashes (N=4889 crashes±)	Examples of Crash Group
Bicyclist Failed to Yield - Midblock	6.2%	 
Crossing Paths - Other Circumstances - Intersection	6.1%	 
Bicyclist Failed to Yield - Signalized Intersection	3.9%	 
Bicyclist Left Turn/Merge - Midblock	3.8%	
Motorist Right Turn/Merge - Intersection	3.1%	 
Top 10 Groups Percent of Total	**72.1%**	

Only 203 bicycle collisions were reported in off-road areas, so for convenience, the percentages reported in this table are for all bicycle-motor vehicle collisions statewide.

*Most—16.9% of the total Motorist Overtaking Bicyclist type—occur at segments.

Among the top crash types, those in which a bicyclist is disproportionately likely to be killed or severely injured, and which account for the largest numbers of those killed or injured include:

- Motorist overtaking Bicyclist – accounts for 37.6 percent of killed and severely injured across the state compared with 19.2 percent of all those struck. Note that 57 percent of these types occurred in rural areas suggesting a need for countermeasures on rural roads as well as urban streets. This is a challenge since rural roads cover many miles.

Bicyclists that ride out at either a midblock location, or a location that might be controlled by a stop sign in only the bicyclist's direction also have an increased likelihood of being severely injured or killed. Motorists may not be expecting bicyclists at these locations, and may be traveling at relatively high speeds.

These types include:

- Bicyclist Failed to Yield—Midblock—accounts for 8.2 percent of bicyclists killed and severely injured in the state, compared with 6.2 percent of all those struck.
- Bicyclist Failed to Yield—Sign-Controlled Intersection—accounts for 13.1 percent of bicyclists killed and severely injured compared with 6.6 percent of those struck.

Thus, countermeasures that help bicyclists access or get across streets and/or slow motorized traffic may be needed to reduce these types.

Note that the particular types that are most prevalent, and more prone to serious injuries may vary for each jurisdiction.

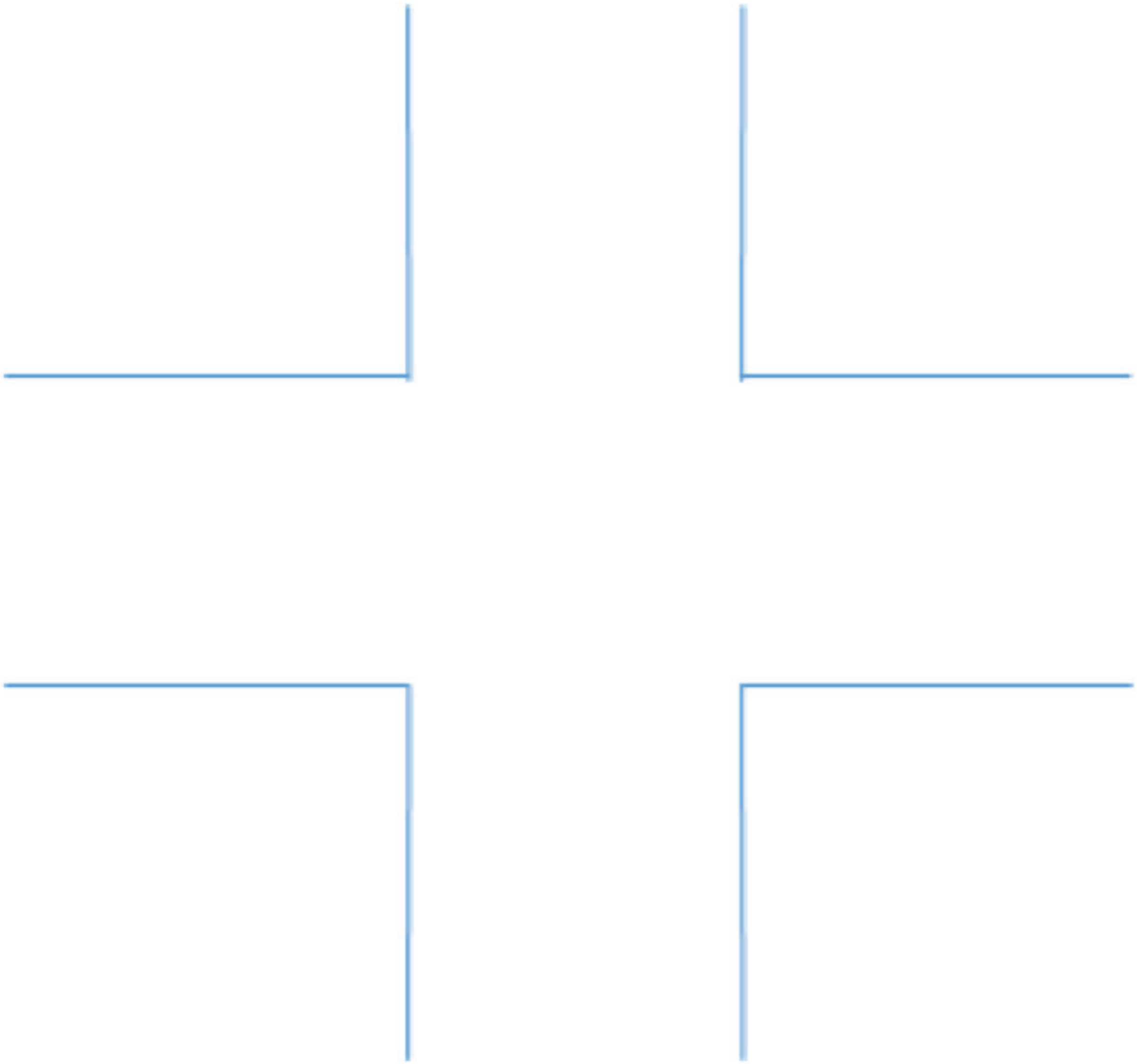
As for pedestrian crash and location types, the proportions for each jurisdiction will vary according to particular circumstances. However, the trends described above may help local jurisdictions identify issues or types that are even more prevalent than average in their own communities.

Crash types can be used to help identify specific types of conflicts and potentially appropriate countermeasures (review PEDSAFE and BIKESAFE referenced in the main text.). Field investigation through an RSA can help pinpoint the issues that may be contributing to crashes in an area.

APPENDIX C — Forms for RSA Data Collection

The following pages include template forms that can be used for data collection during the road safety audit.

Intersection



NOTES

LEGEND X – Confl ict ◯ – Maintenance Needed Ⓧ – Destination

Segment

NOTES

LEGEND X – Confl ict ◯ – Maintenance Needed ⓧ – Destination

Other

NOTES

LEGEND X – Confl ict ◯ – Maintenance Needed Ⓧ – Destination

APPENDIX D — RSA Report from North Carolina

The following provides an example of a comprehensive RSA report that was developed by agencies in North Carolina during piloting of this process.

US 321/Blowing Rock Blvd Pedestrian Road Safety Assessment

Participating Agencies:

Lenoir City

Western Piedmont COG

NCDOT

Facilitated by:

UNC Highway Safety Research Center

Field investigations held January 26, 2017

Final Report

October 16, 2017

Contents

Figures

Tables

US 321, Blowing Rock Boulevard Pedestrian-Focused RSA

Lenoir Area Characteristics and City-wide Pedestrian Crash Trends

The City of Lenoir is a growing community that consists of approximately 18,000 citizens. There is a growing need and interest by the citizens of Lenoir to have a safe environment to commute through bicycle and on foot. Lenoir has incorporated outdoor activities into the community such as the Overmountain Victory National Historic Trail (OVNHT). Additionally, visitors to the City, located in the foothills of the Appalachian Mountains, need safe ways to access restaurants and other services on foot or by bike.

From 2007-2014, 91 (73 pedestrian; 18 bicycle) collisions with motor vehicles were reported throughout Lenoir. Figure 1 illustrates combined pedestrian and bicycle statistics. See Appendix I Lenoir, City-wide Pedestrian and Bicyclist Crash Statistics, for details by mode. These 91 collisions resulted in 3 pedestrians and 1 bicyclist being fatally injured and 8 more disabling-type injuries over the eight years. (Note that more recent data were obtained from NCDOT, and additional fatalities have occurred, including one on the study corridor.) The study corridor crashes are described below. An average of 9.1 pedestrian and 2.4 bicycle collisions occurred per year, yielding a population-based rate of 5.1 pedestrian collisions per 10,000 residents per year and 1.3 bicycle collisions per 10,000 residents per year. The pedestrian collision rate per population is higher than the rates for several of the top 10 NC cities with higher collision frequencies.

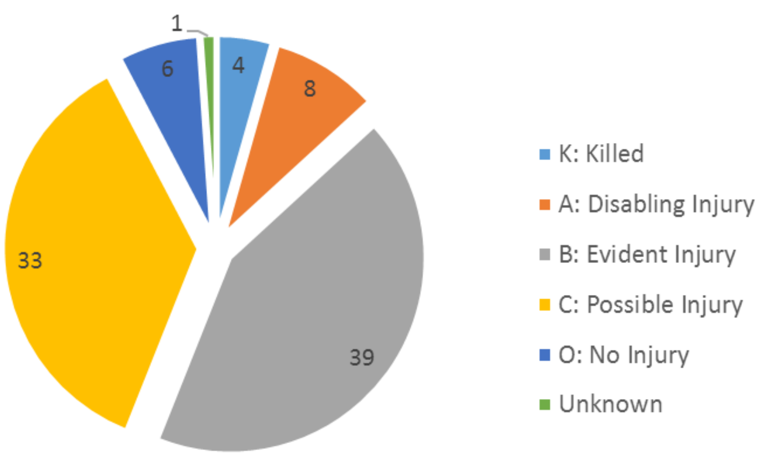


Figure 1. Lenoir pedestrian and bicycle crashes by injury severity, 2007-14 (N = 91, 73 pedestrian; 18 bicycle).
Source: North Carolina Pedestrian and Bicycle Crash Data Tool query page: http://www.pedbikeinfo.org/pbcat_nc/_pedquery.cfm

Since there were relatively few bicycle collisions (18 over five years) the remainder of this report focuses on pedestrian crash trends City-wide, and identification of pedestrian issues along the focus corridor. Although pedestrian collisions were widely-dispersed across many locations throughout the City, the

City-wide statistics do illustrate some trends or contributing factors for how pedestrian collisions have more commonly occurred in Lenoir.

A few common pedestrian collision types include parking lot and backing vehicle crashes (backing vehicle were also mostly in parking lots. Combined, these accounted for 33%; Table 1). Crashes involving unusual circumstances such as personal disputes were also fairly common and accounted for 13% of pedestrian crashes. These also often occurred in parking lots.

Crashes in parking lots can be affected by design, including driveway connections that allow high speed motor vehicle traffic to enter the parking lot, and pedestrian connections or lack of these between the roadway and store access. Walkways and motor vehicle circulation patterns within the parking lot itself can affect backing and other collision types within the parking lot. Lighting and security measures in parking lots may also help to reduce unusual types such as the dispute-related incidents.

Table 1. Lenoir Pedestrian Crash Group by Location Type, 2007-2014.

Crash Type by Crash Location	Intersection	Intersection-Related	Non-Intersection	Non-Roadway	Total
Backing Vehicle	0	0	1	10	11
Bus-Related	0	0	1	0	1
Crossing Driveway or Alley	0	0	3	0	3
Crossing Roadway - Vehicle Not Turning	0	5	10	0	15
Crossing Roadway - Vehicle Turning	1	0	0	0	1
Dash / Dart-Out	0	0	3	0	3
Off Roadway	0	0	0	13	13
Pedestrian in Roadway - Circumstances Unknown	1	0	4	0	5
Unusual Circumstances	1	0	6	6	13
Walking Along Roadway	1	0	7	0	8
Total	4	5	35	29	73

This RSA summary focuses, however, on roadway collisions and risks, since these may be treated with countermeasures and designs undertaken through road projects. Parking lot issues must be addressed through local policies, plans, and enforcement.

- The primary collision types that have occurred on the city-wide road network include ones in which a pedestrian was crossing the street and was struck by a motor vehicle that was not turning (15 or 21% of the total). Two-thirds of these took place at non-intersection locations. These findings suggest that there may be insufficient gaps and opportunities for pedestrians to cross safely at intersections, where pedestrians may be more expected.
- The second most common type was pedestrians being struck while walking along the roadway (8 or 11% of the total were this type). Sidewalks or paths are the most important countermeasures for this type of collision.
- Another factor that appears to play a role in pedestrian collisions in Lenoir, particularly severe collisions, is occurrence at night. Dark conditions (lighted, unlighted, and dark but unknown

lighting) were present in 27 (37%) of total collisions. Dark, lighted roads in particular accounted for 56 percent of fatal and disabling type pedestrian crashes, and dark unlighted roads accounted for another 22 percent (Figure 2). Pedestrians may have difficulty judging gaps and motorist speed at night, and motorists may have difficulty seeing pedestrians with existing lighting levels, oncoming headlights and other conditions.

- Eight of the 27 nighttime collisions also involved pedestrian use of alcohol. Two daytime collisions involved driver use of alcohol (data not shown).

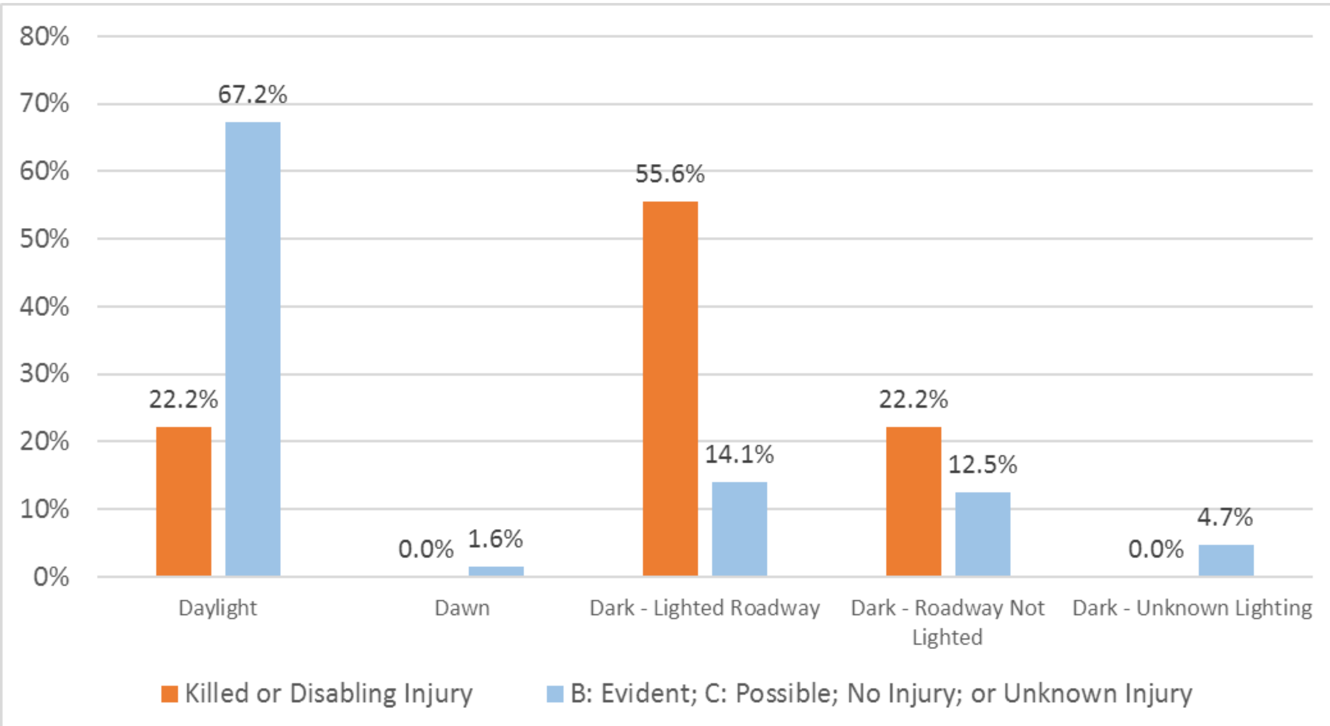


Figure 2. Lighting conditions and percentage of Lenoir pedestrian collisions by PAR-indicated severity (n = 73 total collisions).

US 321 Focus Corridor Description

Although as mentioned, crashes occurred at widely dispersed locations throughout the City, a few corridors were observed to have more prior crashes that included pedestrian fatalities. The data used to identify the focus area included:

- Crash data from NCDOT's spatially coded pedestrian and bicycle crash data (available at https://ncdot.maps.arcgis.com/home/webmap/viewer.html?webmap=b4fcdc266d054a1ca075b60715f88aef)
- Data from the US census on commute mode share, and demographic characteristics. These data were used to understand which areas of the City may have higher pedestrian demand and dependence on walking or cycling, and thus continuing potential for future pedestrian collisions.

- Local planning processes and knowledge of the area also informed the decision to focus on pedestrian issues along the selected route while not dismissing the need for safe and connected bicycle facilities. In this area, it is observed that bicyclists tend to use alternate routes.

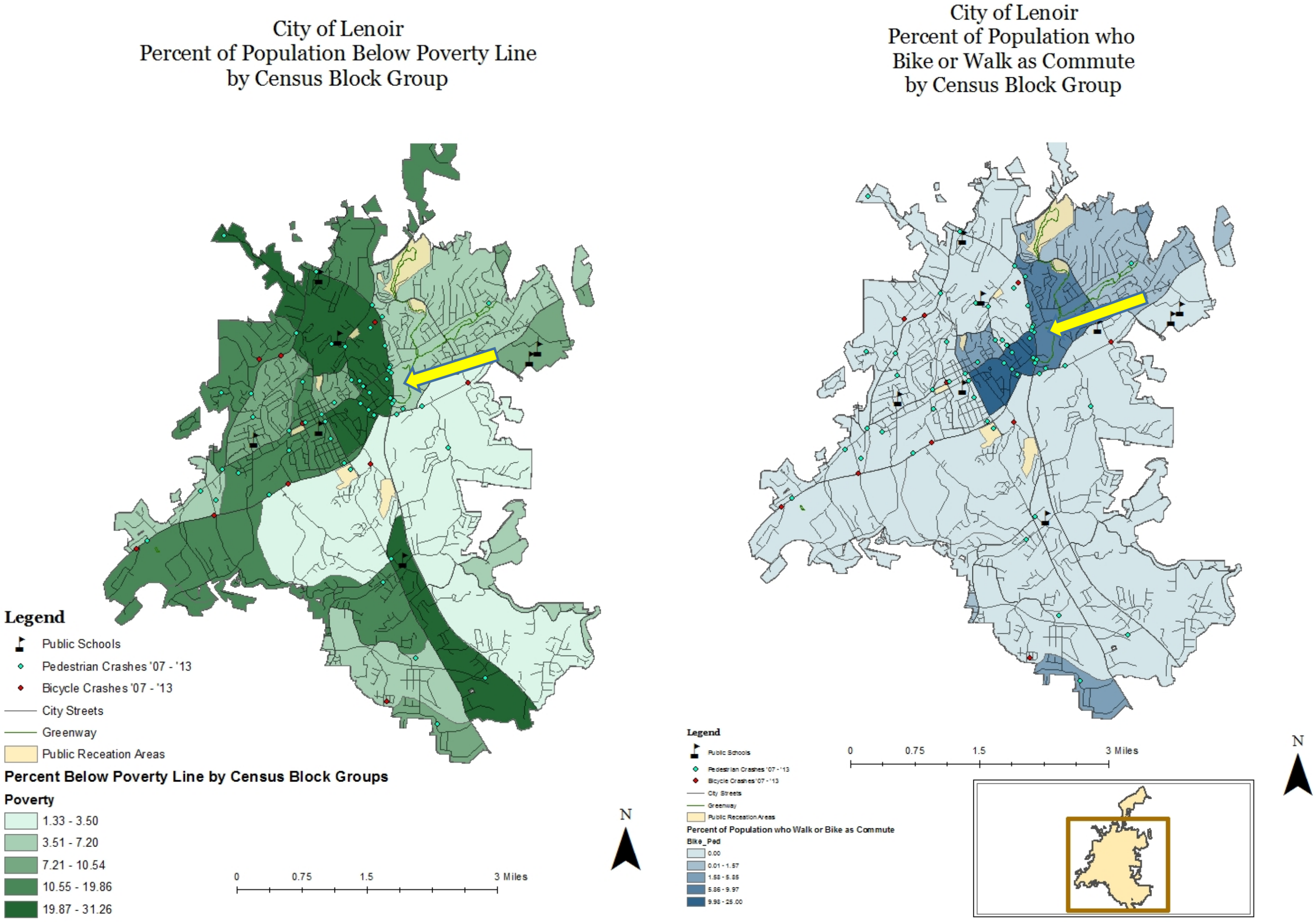


Figure 3. Percent of Residents Below Poverty Line (left) and Walking and Biking Mode Share (right) and pedestrian and bicycle crashes (2007-13). The yellow arrows point to the US 321 study corridor.

The maps in Figure 3 highlight corridors where prior pedestrian and bicycle crashes were more concentrated. The crash frequency and severity (including two pedestrian fatalities between 2010 – 2016), land use and population characteristics all suggested that US 321, Blowing Rock Boulevard, the area highlighted by the yellow arrows in Figure 3 is a priority for pedestrian safety assessment. In addition to higher than average pedestrian crash frequency, the area is home to low-income and minority neighborhoods, which often reflect low car ownership and higher amounts of walking and biking (Figure 3). In fact, the neighborhoods along this corridor are marked by higher pedestrian and bicycle mode shares than most other areas of town, except for downtown (also Figure 3).

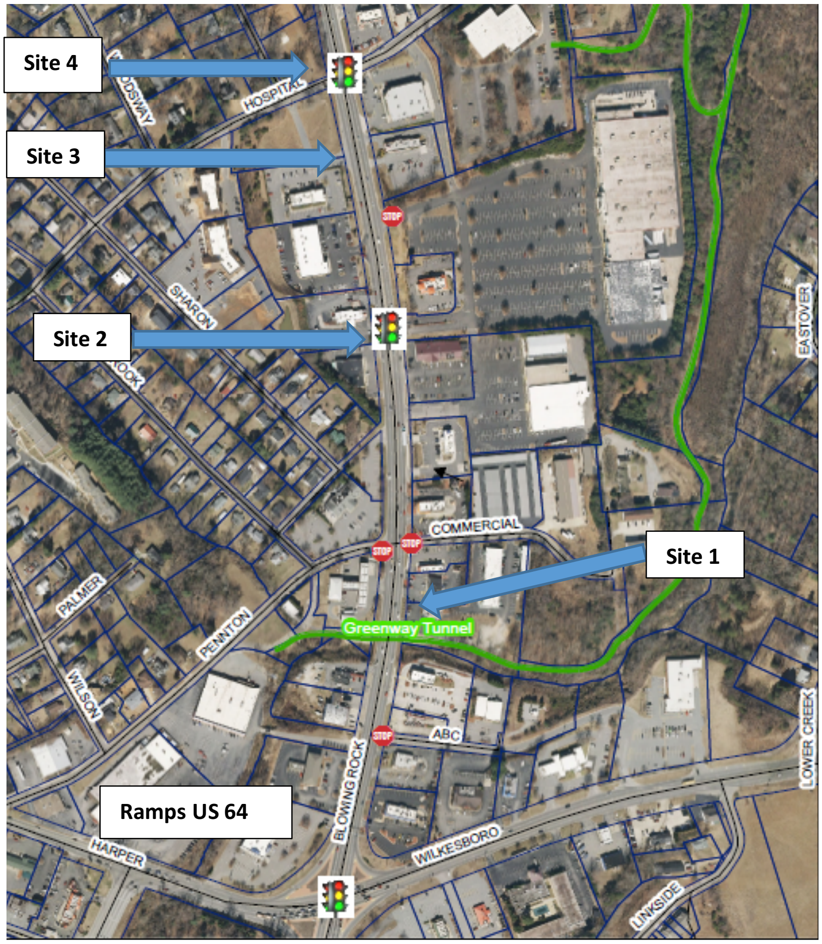


Figure 4. US 321 Study Corridor, from Wilkesboro/Harper Ave (US 64) to Hospital Avenue.

Because of land use changes on either end of this section (lower density and less commercial), the area selected for focus includes a fairly consistent section of roadway from US 64/Harper Avenue ramps to just beyond Hospital Avenue, a distance of about 0.55 miles. The corridor is illustrated in Figure 4.

The pedestrian collisions for this corridor reflect patterns observed for the community as a whole and are shown in Table 2 and Figure 5. Crashes from 2008-16 were used in the analyses below,[1] and results are as follows:

- The most common roadway crash type for the corridor was pedestrian attempting to cross at an unmarked, midblock location and being struck by a motor vehicle that was traveling straight through (Table 2). This crash type commonly leads to severe injuries[2]. Two pedestrians have been killed on this corridor in this type of collision within between 2010 and 2016, including a child of three years, and most recently a woman of 47 years in 2016. This pedestrian was killed while trying to cross the road in the early morning hours near a signalized junction with two busy commercial driveways. The location has a traffic signal, but no pedestrian signal or crosswalks.
- Another collision involved a pedestrian crossing the street who was struck by a vehicle turning out of a commercial driveway.
- Two others happened on Hospital Ave near the intersection with Blowing Rock Blvd. One of these involved a pedestrian walking along Hospital (which has no sidewalk), while the other involved a pedestrian crossing Hospital, struck by a through motor vehicle.

[1] Because pedestrian crashes are relatively scarce, it is common to use more years of pedestrian crashes to analyze and better understand trends, especially if infrastructure has not changed very much over a longer time period.

[2] Nationally, through motor vehicles striking crossing pedestrians at non-intersection and uncontrolled intersection approaches accounted for more than 26 percent of all pedestrian fatalities. In North Carolina, pedestrians struck in this crash type at non-intersection locations accounts for an average of 31 percent of pedestrians killed in the State.

- Similar to the City as a whole, four pedestrians have also been struck in parking lots along this corridor (Table 2).

Table 2. Pedestrian Collision Statistics for US 321/ Blowing Rock Blvd. from US 64/Harper Avenue to Hospital Avenue, 2008-16. [3]

Ped age/gender	*Injury*	*Crash Type*	*Crash location*	*Light*	*Ped Alcohol*	*Driver Alcohol*	*Crash Year*
Roadway collisions							
Male 56	Disabling	Ped Crossing/through motorist	Non-intersection	Dark,lighted (10 pm)	Yes	No	2008 (Aug 11)
Male, 3 yrs	Killed	Ped Crossing/through motorist	Non-intersection	Dark,lighted (4 am)	No	No	2010 (Jul 27)
Male, 22	Evident	Ped Crossing/through motorist	Non-intersection	Daylight (7 pm)	No	Unknown (Hit & Run)	2008 (Jun 16)
Female, 20	Possible	Pedestrian Crossing – Through Motorist	Intersection, signal (no ped signal, crosswalk)	Daylight (5 pm)	No	No	2015 (Apr 11)
Female, 47	Killed	Pedestrian Crossing – Through Vehicle (Eastwood Village)	Intersection, signal, no ped signal or crosswalk	Dark, lighted (6:05 am)	Pending	?	2016 (Apr 28)
Female, 41	Possible	Pedestrian Crossing- Struck by vehicle turning out of PVA	Non-intersection	Daylight (6:45 pm	No	No	2016 (Sep 29)
Male, 21	Possible	Walking Along Roadway (ON Hospital Dr – within 125 ft of 321)	Non-intersection	Daylight (4 pm)	No	Unknown (Hit & Run)	2009 (Nov 25)
Female, 15	Possible	Pedestrian crossing, struck by through vehicle (On Hospital leg)	Unclear how close to intersection	Dark, lighted (12 am)	No	No	2016 (Nov 5)
Off-roadway / parking lot collisions							
Male, 46	No injury	Backing – parking lot	Non-roadway	Daylight (10 am)	No	Yes	2013 (Sep 10)
Female, 16	Evident	Off roadway – parking lot	Non-roadway	Daylight (1 pm)	No	No	2012 (May 27)
Male, 18	Possible	Dispute-related – Parking lot	Non-roadway	Dark, lighted (10 pm)	No	No	2007 (Oct 31)
Male, 57	Possible	Backing veh – Off roadway	Non-roadway	Daylight (10 am)	No	Unknown (Hit & Run)	2009 (Apr 16)

[3] The data for 2008-14 were obtained from crash data records acquired from NCDOT and enhanced with crash type and spatial coordinates by UNC-HSRC. See https://ncdot.maps.arcgis.com/home/webmap/viewer.html?webmap=b4fcdc266d054a1ca075b60715f88aef. Data for 2015 and 2016 crashes were provided by Carrie Simpson, NCDOT, Transportation Mobility & Safety Division.

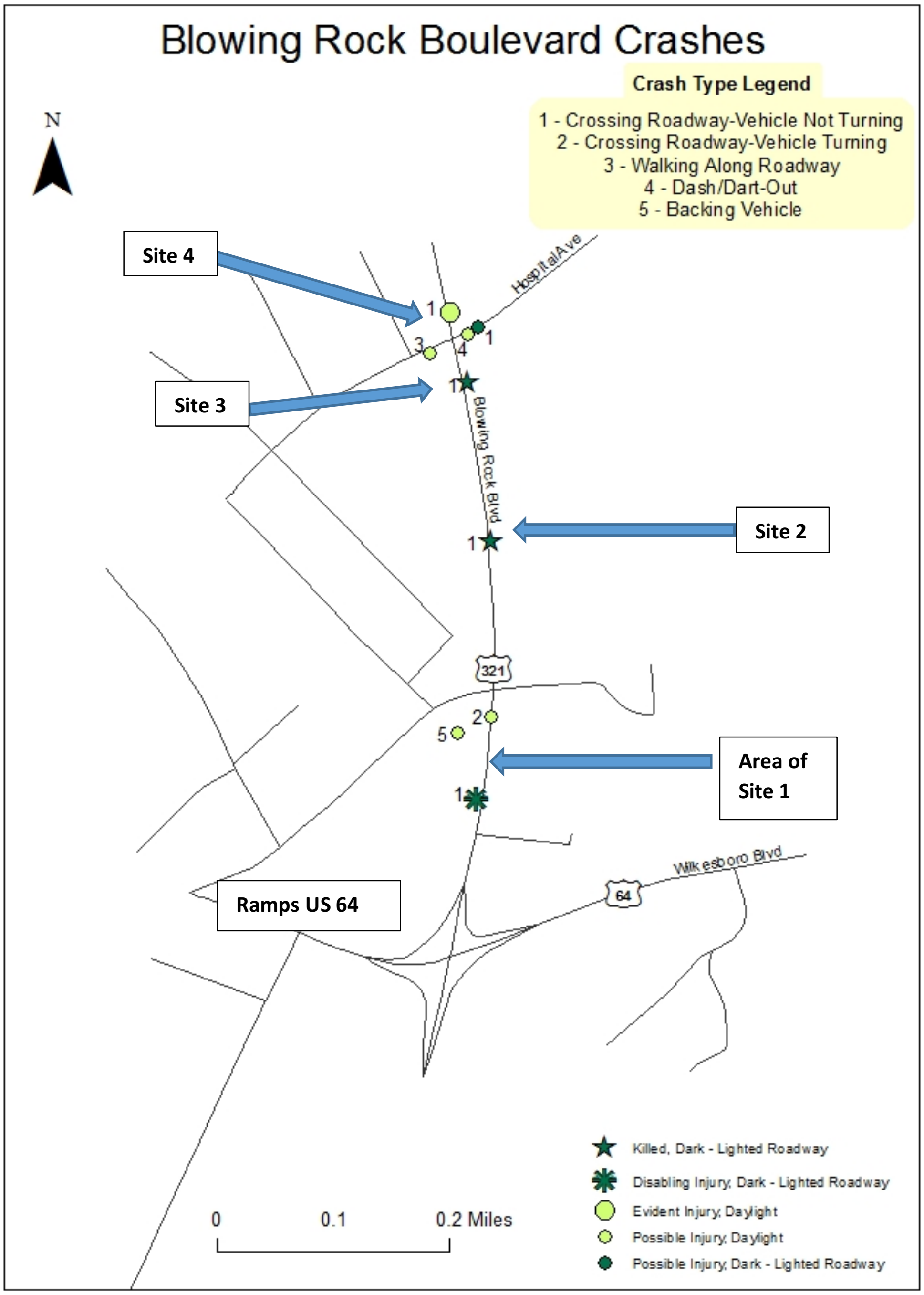


Figure 5. Map showing pedestrian collision crash types, injury severity, and lighting conditions that occurred from 2008-2016 along study corridor.
[Note the backing vehicle crash occurred in an adjacent parking lot. Other parking lot crashes further from the roadway are not shown.]

An analysis of TEAAS data by the NCDOT Safety office showed there were 232 total reported crashes of all crash types over five years (2012-2016), dominated by frontal and rear-end motor vehicle to motor vehicle types. In addition, 33 percent of the collisions were indicated to be driveway-related, 18.5 percent of all collisions occurred at night, and 17.2 percent under wet weather conditions. See Appendix for more details of total crashes. See Appendix II Corridor-wide Total Crash Statistics

Other characteristics of the corridor, land use and population suggest that pedestrian crashes may continue to happen along this corridor and are not simply random events although the precise locations may move around. These risks include the following:

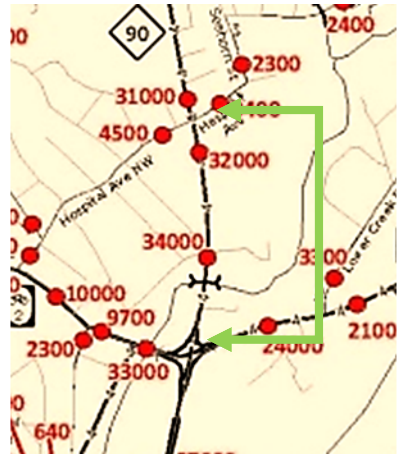


Figure 6. 2015 traffic volumes (AADT) on study corridor.

- The road carries a high volume of traffic (Figure 6), up to 35,000 AADT as of August 2016.[4]
- The speed limit is 45 mph.
- The road has a five-lane cross-section for most of the length, including a continuous two-way center turn lane. This type of road design, combined with many driveways, generate significant numbers of conflict points. Pedestrians may also be induced to use the center turn-lane as a stopping point or refuge in crossing, although it provides no physical protection.
- The area is marked by commercial strip development with many potential pedestrian trip generators and destinations immediately adjacent to the corridor. These include a variety of restaurants, visitor accommodations, shopping, and an ABC store (Figure 7). Residential areas are located just beyond these commercial properties. Thus, both the development type and population characteristics suggests that there may be significant pedestrian need to cross US 321.
- Just beyond the commercial strips on the west side are, as mentioned above, lower income neighborhoods with a higher than average rate of walking.
- A pedestrian/bicycle greenway passes underneath the corridor toward the southern end, and access to the street is possible if greenway users move to a commercial driveway, but the greenway does not have direct connections to US 321 (refer again to Figure 4).
- Sidewalks are intermittent.
- There are no pedestrian signals or marked crosswalks for the entire half-mile length of the study section.

Note that most of the above information was identified and documented through on-line resources, including NCDOT traffiic volume data, Google© streets imagery, as well as U.S. census and land use data that most jurisdictions can access or maintain internally.

[4] NCDOT AADT Mapping Application, Traffic Survey Last Updated: August 28, 2017, http://ncdot.maps.arcgis.com/apps/webappviewer/index.html?id=5f6fe58c1d90482ab9107ccc03026280

Figure 7. Typical section of US 321 study corridor, Lenoir. (© Google 2017, 2016 Image capture)

Road Safety Assessment Results

The purpose of the Road Safety Assessment was to assess pedestrian safety issues through qualitative, professional assessments of the challenges facing pedestrians and motorists for safe interactions along the corridor. Crash data were used to identify and prioritize the corridor for the RSA, but crash analyses do not provide the full picture of safety issues. The RSA or field investigation offered an opportunity to identify specific pedestrian safety concerns, and to discuss potential solutions to improve safety for pedestrians and potentially all modes of traffic, that use US 321 through this section.

The summary below describes issues at specific locations and corridor-wide issues along with potential countermeasures and design improvements that were identified during and following the RSA.

In addition to the countermeasures mentioned below, enhanced traffic enforcement of speed limits and motorist yielding to pedestrians at signalized intersections (and later, at other pedestrian crossings) may be considered. Also, the jurisdictional partners may consider lower speed limits since higher impact speeds correspond to a rapidly increasing risk of fatality when a pedestrian is struck. Because a number of the collisions along the corridor have occurred at night, and pedestrians may not be noticed until an instant before impact, impact speeds may correspond highly with operating speeds under these conditions.

On/Off Ramps from US 64, Wilkesboro Blvd

Although this beginning section of the corridor was not a focus of the RSA, if the corridor undergoes major retrofits, well-designed pedestrian crossings should be added on all legs of this intersection with US 64 / Harper Ave NW. Consider approach angles, stopping distance, and design speed of the free-flow right turn lanes in design of pedestrian crossing treatments. See images in Figure 8.

Figure 8 Junction with US 64/Wilkes Blvd/Harper Ave NW and study corridor from aerial image (©Google Maps 2017, and image by Stacey Whalen, Lenoir.)

The next location with specific issues documented was along an overpass of and near the greenway that passes beneath US 321.

Spot Specific - Location 1, Greenway underpass (shown on maps in Figure 4, Figure 5)

Problem	Potential Countermeasures
The greenway underpass does not connect directly with US 321, but there are connecting driveways. This limits access to those walking/cycling along the greenway, especially persons with disabilities, to businesses and residences accessible from US 321.	Consider providing wayfinding signage for greenway/tunnel crossing of US 321 and provide ADA-accessible sidewalks/paths to connect to 321.
There is no sidewalk either side of US 321 through this section, which includes the overpass of the greenway (Figure 9, Figure 10). Goat paths in Figure 9 show where pedestrians frequently walk along this section.	• Consider relocating guardrail on the east side of US 321 so that sidewalk may be placed through this section. • Consider options for similarly providing sidewalk on west side as well.
There are also no crossings in this area.	See Corridor-wide issues

Figure 9 The greenway (underpass) does not connect directly with US 321, and safe access by all persons is also limited due to gaps in the sidewalk.
Note the goat path on US 321 indicating pedestrian use, with guardrail on outside of pedestrian path (referred to as Spot Location 1 in RSA summary below).
(©Google 2017, 2016 Image capture)

Figure 10. Westside US 321; sidewalk needed on this side of roadway as well.
(©Google 2017, 2016 Image capture)

Spot Specific Location 2 – Eastwood Village Shopping Center traffic signal (shown on maps, Figure 4, Figure 5)

Problem	**Potential Countermeasures**
Signalized intersection, but no pedestrian signals or crosswalks (Figure 11). There are turn lanes from both directions of US 321 and traffic turning in/out of the commercial properties; conflicts are likely and it may be challenging for pedestrians to determine a safe time to cross US 321.	• Consider installing pedestrian signals and marked crosswalks for US 321 crossings of this signalized junction with commercial driveways. If commercial driveways are treated as 'street' connections in design (no level sidewalk crossing), may add crosswalks and pedestrian signals to these legs as well, or consider other driveway improvements.
There are no sidewalks or ADA-accessible landings along the sections of US 321 leading to this junction.	• Consider adding sidewalks and ADA-accessible curb ramps on both sides of US 321 at this location. • Consider adding sidewalks into shopping centers / business front doors to provide a pedestrian path and reduce parking lot crashes.
Turning movements may conflict with pedestrian right-of-way if unrestricted by signal phasing.	Consider adding a Leading Pedestrian Interval (LPI) when pedestrian signals are installed to help pedestrians gain prominence in the crosswalk and encourage yielding by turning motorists. See PEDSAFE, http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=47 for description of Leading Pedestrian Interval.
Did not visit at night; investigate visibility of pedestrians at this location at night. Consider oncoming headlight glare.	Consider enhancing nighttime lighting at crossing locations. Research has found that vertical illuminance of 20 lx at 5 ft., placed at least 3 m (10 ft) in advance of the crosswalk better-illuminates pedestrians in the crosswalk, and creates reasonable detection distances in most cases (NCHRP 17-73 interim report citing Gibbons, Edwards, Williams, & Andersen, 2008) (see below, under Corridor-wide issues for an illustration of crosswalk lighting recommendations from this report).

Figure 11 Signalized junction, left/right turn lanes and no pedestrian signals or crosswalks on US 321 junction with Eastwood Village. A visitor was killed when trying to cross near the intersection during early morning hours.

Spot Specific Location 3 – Lenoir Business Center drive and Ruby Tuesday drive (shown on maps Figure 4, Figure 5)

Problem	Potential Countermeasures
No pedestrian provision through splitter island – pedestrians forced into edge of street (See Figure 12 to capture a pedestrian at this driveway).	Consider revising the crosswalk/curb-cuts at the Lenoir Business Center driveway. Retrofit the channelizing island to provide a pedestrian crossing path. We discussed that the driveway slope may present an issue and other design options may be considered. (Also see Figure 12 standard design for driveways with splitter island).
Vehicles may turn in/out at high speed due to wide radii.	Considering narrowing curb radii on both entering and exiting sides of driveway to slow motor vehicle turning speeds and narrow crossing distance.
No detectable curb warnings although driveway is designed like a connecting street.	See notes and images below on other potential driveway improvements for driveways throughout the corridor.
Sidewalk abuts the back of the curb near Ruby Tuesday/ Lenoir Business Center, which puts pedestrians very close to US 321 traffic.	If the corridor is redesigned, consider adding planted greenstrips/buffers between the walkway and the roadway.
Further north, there is a right-turn deceleration lane on SB US 321 to Ruby Tuesday driveway. The team is not sure of the impact of the deceleration lane on pedestrians, but the driveway itself adds	There is another driveway entrance (but which is right-in, right-out only) 125' from Hospital Avenue to this commercial property. Consider closing this driveway or also making it right-out.

Problem	Potential Countermeasures
another point of potential conflict and is about 200 ft from Hospital Avenue. One participant mentioned that TXDOT uses right-turn deceleration lanes as a pedestrian consideration so that right turners can safely wait in the auxiliary lane, clear of through traffic, while pedestrians are present in, or near, the driveway.	Consider other driveway improvements as mentioned elsewhere.

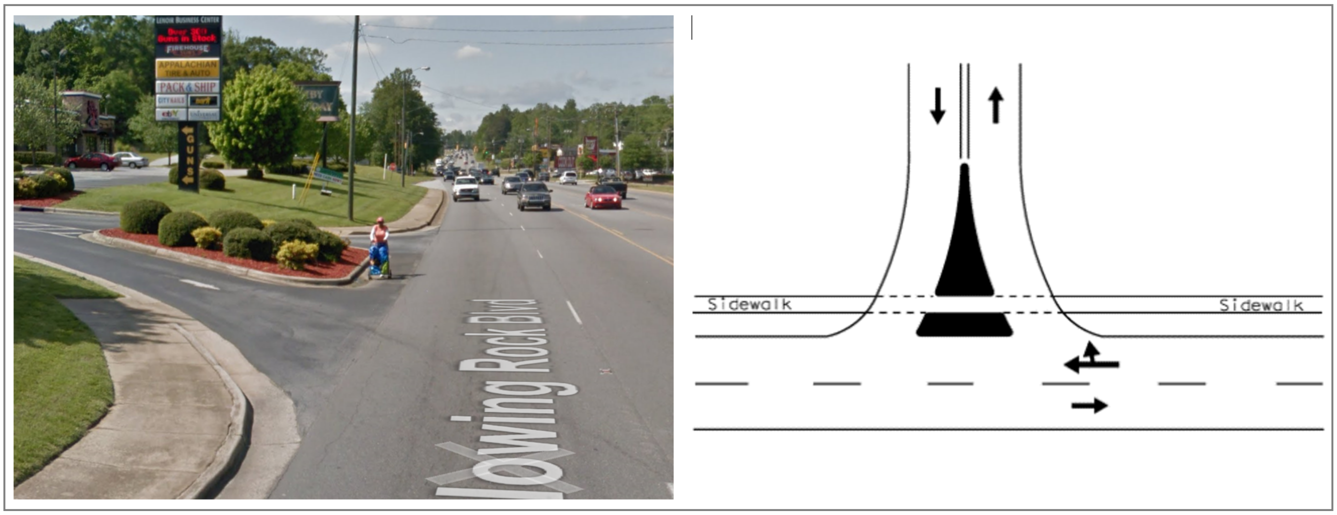


Figure 12 Driveway splitter Island with no pedestrian access at Lenoir Business Center driveway (left) and potential design solultion (right).

Spot-specific Location 4 – Hospital Ave (shown on maps Figure 4, Figure 5)

Problems	Potential Countermeasures
No pedestrian signals at this busy signalized intersection. There are sidewalks on the east side, but maintenance and accessibility improvements are needed. Four pedestrian crashes have occurred on the various legs of this intersection between 2008-16.	Planned intersection improvements include sidewalks for all legs, pedestrian signals and pedestrian crosswalks for all legs.

Problems	Potential Countermeasures
We observed a substantial left turn volume on the westbound leg of Hospital Ave.	Consider using an LPI (Leading Pedestrian Interval) when the Hospital Ave pedestrian signal is implemented on the south leg to allow pedestrians to establish presence in crosswalk before turning motor vehicle traffic is released.
We did not visit at night; investigate lighting conditions and visibility of pedestrians at night	Consider lighting enhancements as needed.

Figure 13. Hospital Ave is a signalized intersection slated for operational and pedestrian improvements. (©Google, Image capture 2017)

Additional issues were identified that apply to the corridor as a whole. These are described in the next table.

Corridor-Wide Issues

Problems	**Potential Countermeasures**
High traffic volume and lack of controlled crossings make it difficult for pedestrians to cross. There are only two signalized intersections within the more than ½ mile corridor (illustrated on Figure 4), and neither has pedestrian signals or crosswalks. There are no marked or controlled pedestrian crossings for this entire length of roadway at present, but improvements are planned at Hospital Ave (as noted above). NCDOT crossing guidance suggests that if distances are greater than 400 feet to a signalized intersection or 300 feet to another unsignalized crossing opportunity, conditions merit further consideration.[5] Other considerations such as sight distance and demand also apply.	In addition to improvements at the signalized locations (mentioned in Spot issues above), consider identifying key pedestrian crossing areas (through observation and counts) and implementing midblock crossing improvements. • A package of pedestrian crossing treatments for this corridor might include: median or median island with high visibility pedestrian crosswalks, advance stop yield bars and signs, and Rectangular Rapid Flashing Beacons or Pedestrian Hybrid Beacons to address the various types of risk and crashes that have occurred. See Figure 15. These treatments each have pedestrian CMF estimates available and are expected to reduce pedestrian crashes. [6]For example, the area near the greenway, near the ABC store, or other highly frequented destinations may merit additional pedestrian crossing opportunities. • Traffic signals, if merited by traffic or pedestrian volumes, may also be considered.
Fatal and disabling injuries have occurred predominantly at night.	• Lighting conditions should be further assessed and enhancements for any crossing/crosswalk improvements considered, especially at non-signalized locations. See Figure 16. • Corridor-wide lighting enhancement may also be warranted given the dispersed nature of crossing opportunities.
Five-lane cross-section, including a continuous, two-way, left turn lane, combined with numerous driveways (as shown in Figure 7) create many potential conflict points for motor vehicle to motor vehicle and motor vehicle to pedestrian or bicycle. Note that 92 crashes with front impacts and 90 rear-end crashes occurred on the corridor within 5 years.	• A continuous raised median with appropriate intermittent left-turn lanes could be considered as an alternative to median crossing islands for pedestrians. Continuous medians can also help to reduce conflicts and crashes for motor vehicle to motor vehicle collisions. Medians significantly reduce left turn conflicts with bicycle and pedestrian traffic, and conflicts with motorized traffic that can occur with the current TWLTL design. There are numerous estimates for expected crash reductions associated with adding raised medians or adding a median to replace a TWLTL (see the CMF Clearinghouse). [7]

[5] *North Carolina Pedestrian Crossing Guidance*, Schroeder et al., 2015, p. 9 https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/Pedestrian_Crossing_Guidance.pdf

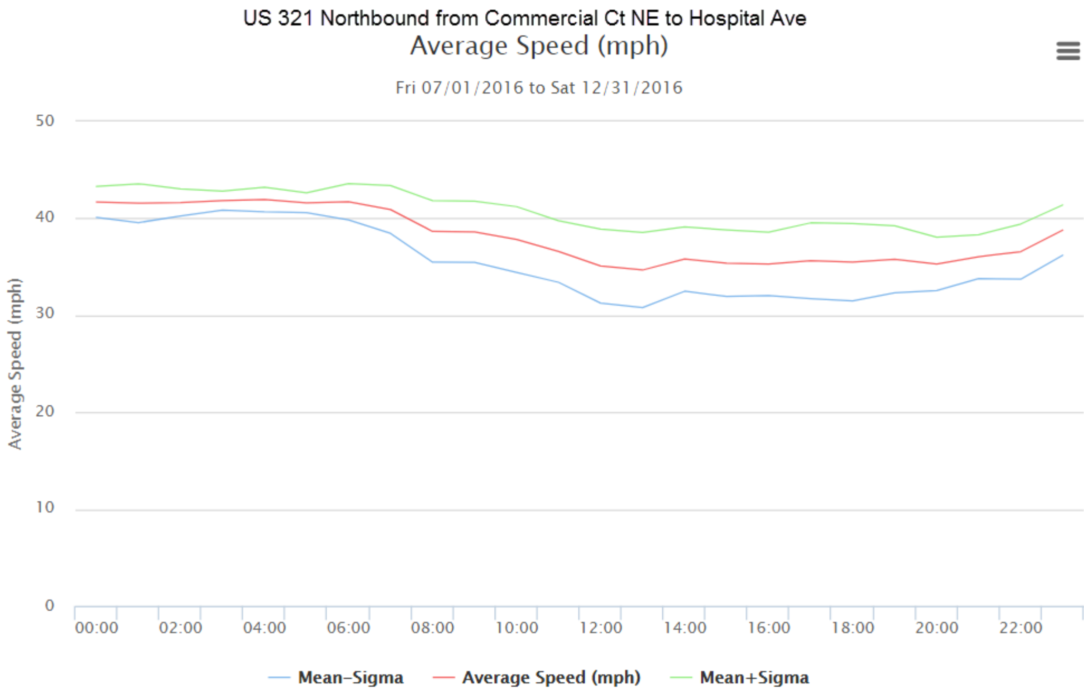
[6] See *Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments*, http://www.trb.org/Main/Blurbs/175381.aspx

[7] See the CMF Clearinghouse, http://www.cmfclearinghouse.org/

Problems	Potential Countermeasures
	• If raised medians are used, pedestrian crossings should be added to the design at appropriate locations and other crossing enhancements considered, as above.
The relatively high speed limit (45 mph) for this development type means that pedestrians are at high risk of severe and fatal injuries if struck by cars traveling near those speeds. This situation – with little opportunity for braking – can occur, especially at night during lower volume times and traffic is flowing at speed, and when pedestrians are not very visible. As shown in Figure 14, which contains data from iPeMS, a tool NCDOT uses for real time traffic data, average speeds from a sample of traffic for a section of this corridor vary from above 40 mph between midnight to 6 am, to around 33 – 36 mph during daytime hours.	• Conduct spot speed studies to obtain more specific data on free-flow speeds along the corridor. Consider speed enforcement if motorists are traveling above limits at times when speeding is most problematic. • Consider the land uses, pedestrian demand, driveways, and other factors to determine appropriate limit. Consult *North Carolina DOT Complete Streets Planning and Design Guidelines* for guidance on the appropriate speed limit for the street type. • *Guidelines and Documentation of Engineering Studies for Establishing North Carolina Speed Limits* is currently being developed and should be released by NCDOT in 2018 as a resource for establishing speed zones. • FHWA's U.S. Limits2 also provides an expert tool that may be consulted as a resource for establishing speed zones.
Sidewalk gaps at many locations throughout the corridor.	Consider completing sidewalks along both sides of corridor, and on intersection approach legs from side streets.
Numerous commercial driveways with potential conflict areas	• At the junctions of sidewalks and driveways, consider marking driveways to delineate the pedestrian zone (see example in Figure 17). • Alternatively, consider raising driveway crossings to the sidewalk level (which is accepted practice) to slow motor vehicle turning movements and encourage yielding to pedestrians walking along the roadway (Figure 18).
Wide curb radius and very wide driveways at some locations (i.e. Mayflower Seafood entrance) may allow vehicles to turn into driveways at high speeds. This can create an issue for pedestrians crossing the driveway.	• Consider narrowing curb radius and create continuous sidewalk level crossings across driveways. • Consider splitter/median islands (with pedestrian crossing access) such as at Eastwood Shopping center entrance. • Consider consolidating some driveways.

Figure 14 shows that average operating speeds, derived from probe data, tend to be higher at night than during daytime hours. There is also greater variability in speeds during the daytime (+ / - sigma lines), which may reflect turning movements, as well as slowing and braking for such movements. The data in

Figure 14 do not replace professional engineering speed studies, but do provide suggestive evidence that average travel speeds are high for such a mixed use corridor where pedestrians have no crossing facilities and many segments with no sidewalks to ensure they have a space to walk separated from traffic.



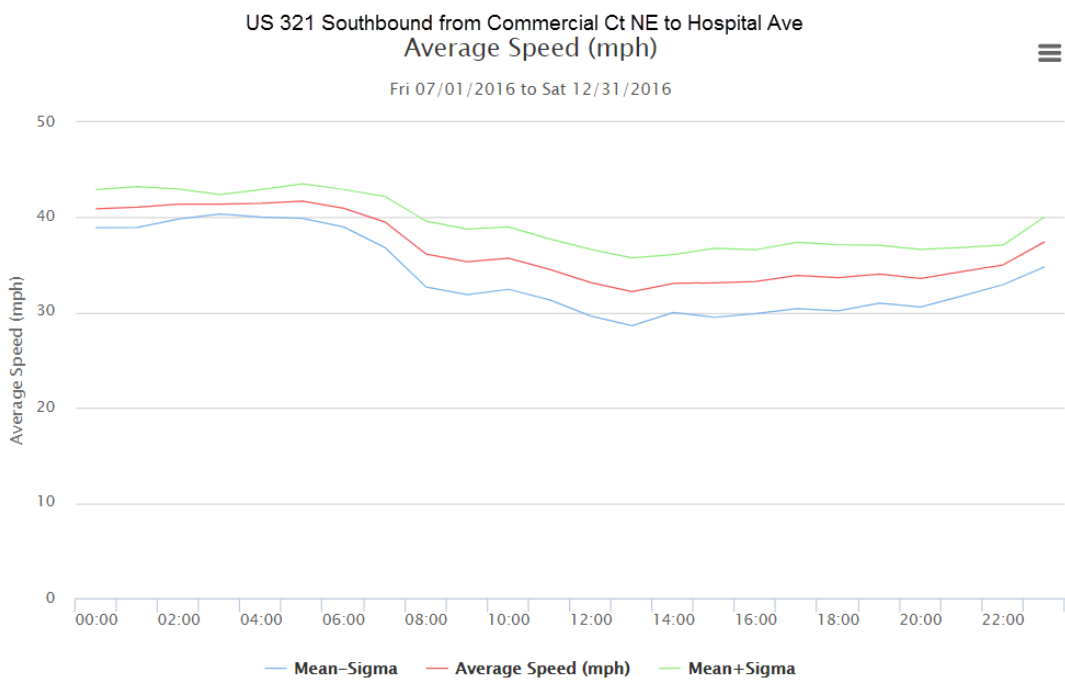


Figure 14 Average operating speeds between Commercial Ct and Hospital Ave derived from vehicle probe data (northbound – top; and southbound – bottom) from iPeMS (provided by NCDOT). These data provide an approxiomation of speeds on the corridor and do not replace spot speed studies, but do show how average speeds for the sample tend to be higher at night than during the daytime.

Figure 15. Package of potential midblock pedestrian crossing treatments to address multiple threat crash risk, crossing distance, and lack of gaps (pedestrian activated flashing signal) on higher volume, multi-lane street.
Another choice for a higher speed road, especially if motorist yielding is unreliable, may be a pedestrian hybrid beacon or PHB.
(Source PEDSAFE, Toole Design Group,
http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=13).

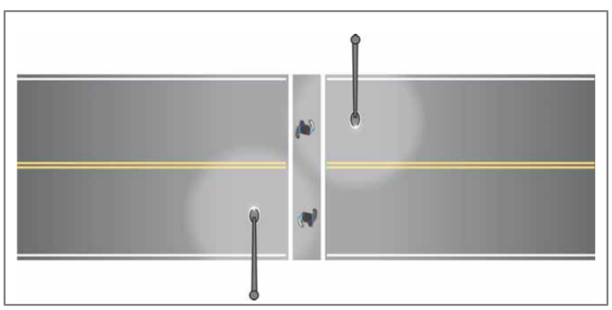


Figure 16 Recommended lighting configurations for midblock pedestrian crosswalks.
Source: Gibbons, Edwards, Williams, & Andersen 2008, p.13 as cited by NCHRP 17-73 Interim Report

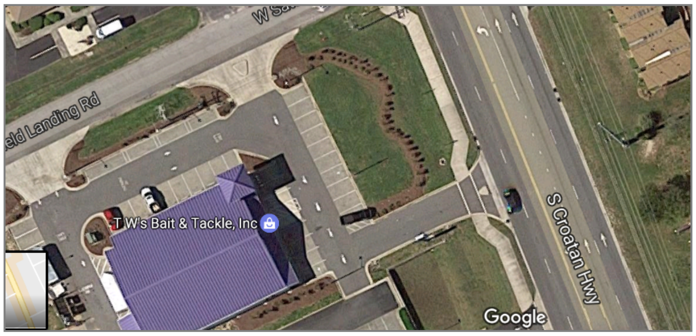


Figure 17 Example of potential pedestrian zone delineation across driveways from Kill Devil Hills, NC. (©Google 2017, image capture 2016).

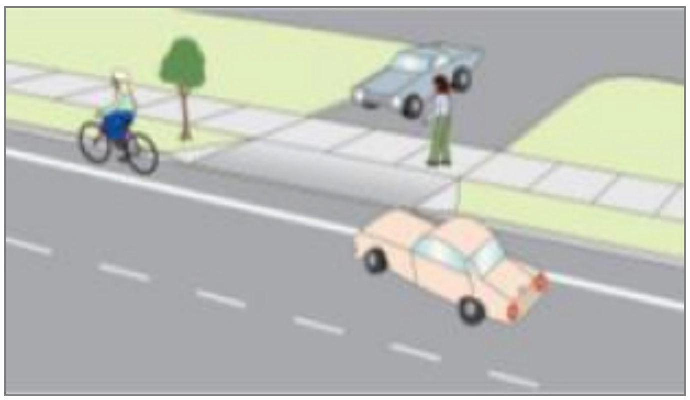


Figure 18 "Driveways built like driveways encourage low-speed turns and encourage motorists to yield to pedestrians."
Source: PEDSAFE, available at http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=20)

Summary of Key Recommendations

Although there are a number of issues regarding driveway designs and access management along the corridor, the most urgent items for consideration are as follows:

- Provide controlled and safer crossing opportunities for pedestrians, since pedestrians crossing the corridor, especially under dark conditions, are leading to serious and fatal injuries. Providing pedestrian signals and crosswalks at the two currently signalized intersections would help, since turning movements and designs likely make it difficult for pedestrians to cross at these locations, even with a green traffic signal indication.

- There seems also a need to provide additional crossing opportunities at midblock, or at other currently uncontrolled intersection approaches at key pedestrian attractor locations since there are long spans between the two signalized locations. F.
- Design changes may include the use of intermittent median islands with pedestrian crossings, combined with other treatments such as advance stop/yield markings and signs, pedestrian hybrid beacons that can be activated when pedestrians need to cross, and lighting enhancements. Alternatively, continuous medians (with pedestrian crossings and enhancements provided at key pedestrian crossing locations could be considered by the Town and DOT. Pedestrian counts or estimates from the land use data can be used to determine if crossing locations meet suggested FHWA warrants for PHBs which are easier to meet than warrants for traffic signals (but these can include consideration of older/younger pedestrians and other factors). See North Carolina Pedestrian Crossing Guidance, p. 8, paragraphs 1 and 2 for information on procedures to use when sidewalk facilities are or are not present (https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/Pedestrian_Crossing_Guidance.pdf). Ideally, connected sidewalks will be developed to connect crossing locations within the same project. See next.

- As mentioned, sidewalks should be connected throughout the corridor and on side streets approaching the intersection, and parking lot and driveway designs should be considered.
- The speed limit is high for a pedestrian environment. Complete Streets guidelines provide suggestions for target operating speeds for different land uses and street types. Further investigation of the traffic speed during both peak and off-peak times also seems warranted. Whether or not speed limits are altered, there may be a need for enhanced enforcement.

Other recommendations:

- The lack of access control and frequent driveway-related motor vehicle to motor vehicle crashes suggests that all modes may experience safety (and perhaps operational benefits) from improved access control measures such as provision of a continuous raised median, driveway consolidation and potentially other measures, but as mentioned above, pedestrian crossings should be provided at regular intervals or key crossing locations.
- Additional investigation of lighting conditions is also important, considering the prevalence of pedestrian injury at night.

- Consideration could be given to also providing pedestrian crossing opportunities at the ramp crossings and signalized junctions with US 64 at the southern end of the segment (but which was outside the RSA focus area). US 64 seems to have similar land uses, and in time may also experience more pedestrian collisions.

Appendix I Lenoir, City-wide Pedestrian and Bicyclist Crash Statistics

Table 3 Pedestrian Injuries, Lenoir City-wide, 2007-14

Lenoir Pedestrian Injury	***Crash Year***								***Total***
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2007-14**
K: Killed	0	0	2	1	0	0	0	0	3
A: Disabling Injury	0	1	2	2	0	1	0	0	6
B: Evident Injury	5	3	4	3	4	4	3	5	31
C: Possible Injury	2	4	6	1	8	4	3	0	28
O: No Injury	0	0	0	0	0	1	3	0	4
Unknown Injury	0	0	0	0	1	0	0	0	1
Total	7	8	14	7	13	10	9	5	73

Table 4 Bicyclist Injuries, Lenoir City-wide, 2007-14

Lenoir Bicyclist Injury	***Crash Year***							***Total***
	2007	**2008**	**2010**	**2011**	**2012**	**2013**	**2014**	**2007-14**
K: Killed	0	0	1	0	0	0	0	1
A: Disabling Injury	0	0	1	1	0	0	0	2
B: Evident Injury	0	0	1	2	4	1	0	8
C: Possible Injury	1	1	0	2	1	0	0	5
O: No Injury	0	0	0	0	1	0	1	2
Total	1	1	3	5	6	1	1	18

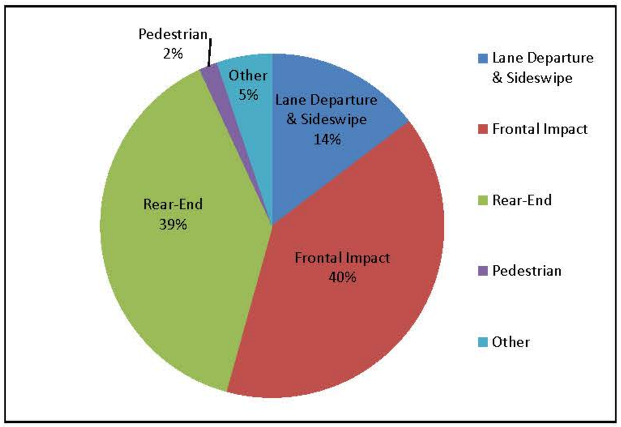
Appendix II Corridor-wide Total Crash Statistics

Corridor Crash Statistics for US 321/Blowing Rock Blvd, from 200 feet N of US 64 (Wilkesboro Blvd) to N of Hospital Ave. (Summary provided by Carrie Simpson, NCDOT Mobility and Safety from Strip Analysis).

Summary of Total Reported Crashes on US 321 (Blowing Rock Blvd) from 200' N of Wilkesboro Blvd to 150' N of Hospital

MP Range: 14 - 14.46 (0.46 miles)
5 Year Crashes (1/1/2012-12/31/2016)

Crash Type Summary	Crashes	% Of Total
Total Crashes	**232**	**100.0%**
Lane Departure & Sideswipe	34	14.7%
Frontal Impact	92	39.7%
Rear-End	90	38.8%
Pedestrian	**4**	**1.7%**
Other	12	5.2%



Crash Severity	Crashes	% of Total
Fatality (K-Injury)	1	0.4%
Injury Disabling (Class-A)	0	0.0%
Injury Evident (Class-B)	15	6.5%
Injury Possible (Class-C)	48	20.7%
Property Damage Only	168	72.4%

Time of Day	Crashes	% of Total
12am - 6am	7	3.0%
6am - 12pm	48	20.7%
12pm - 6pm	131	56.5%
6pm - 12am	46	19.8%

Peak Hour of Crashes	Crashes	% of Total
4 - 5 pm	26	11.2%
2 - 4 pm	24	10.3%
12 - 1 pm	22	9.5%

Month of Crash	Crashes	% of Total
January	18	7.8%
February	17	7.3%
March	17	7.3%
April	15	6.5%
May	23	9.9%
June	12	5.2%
July	24	10.3%
August	11	4.7%
September	27	11.6%
October	19	8.2%
November	26	11.2%
December	23	9.9%

Contributing Factors	Crashes	% of Total
Night Crashes (Codes 4-6)	43	18.5%
Wet Crashes (Codes 2-3)	40	17.2%
Alcohol / Drug Involvement	1	0.4%

Yearly Crash Totals	Crashes	% of Total
2012	32	13.8%
2013	41	17.7%
2014	47	20.3%
2015	58	25.0%
2016	54	23.3%

Driveway-Related Crashes	Crashes
Bojangles	13
Wendys	9
Belk/Shopping Center	7
Burger King	6
Arbys	5
KFC	5
Fast Stop	4
First Citizens Bank	4
Hannahs BBQ	4
Taco Bell	4
Ajs	2
Lenoir Business Center	2
Mayflower	2
Papa Johns	2
Advance Auto	1
Big Lots	1
Days Inn	1
Rite Aid	1
Ruby Tuesdays	1
Tractor Supply	1
Waffle House	1
Total	**76**

Extra Data	
Annual ADT	35,800
Total Crash Severity Index	3.34
Total Crash Rate (100MVMT)	769.42

Appendix III RSA Participants

The team held a kick-off meeting the morning of the RSA, January 26, 2017. The team leader, Jenny Wheelock had previously distributed analysis of the corridor and presented background information about the corridor and land uses, user characteristics, and crash history and the team discussed the corridor and objectives of the RSA before going into the field.

Participants included:

Team Leader, Jenny Wheelock, Planning Director, City of Lenoir

Stacey Whalen, GIS Analyst, Planning, City of Lenoir

Charles Beck, Public Works Director, City of Lenoir

Carrie Simpson, PE, Traffic Safety Project Engineer, Safety Evaluation Group, North Carolina Department of Transportation (NCDOT)

Daniell Bagley, Traffic Safety Project Engineer, Safety Evaluation Group, NCDOT

Jimmy Hamrick, P.E., High Country and Foothills Regional Traffic Engineer, NCDOT

Cody Moneymaker, Averi Ritchie, Western Piedmont COG

Project team consultants:

Libby Thomas, Senior Research Associate, UNC Highway Safety Research Center

Kristen Brookshire, Research Associate, UNC Highway Safety Research Center