



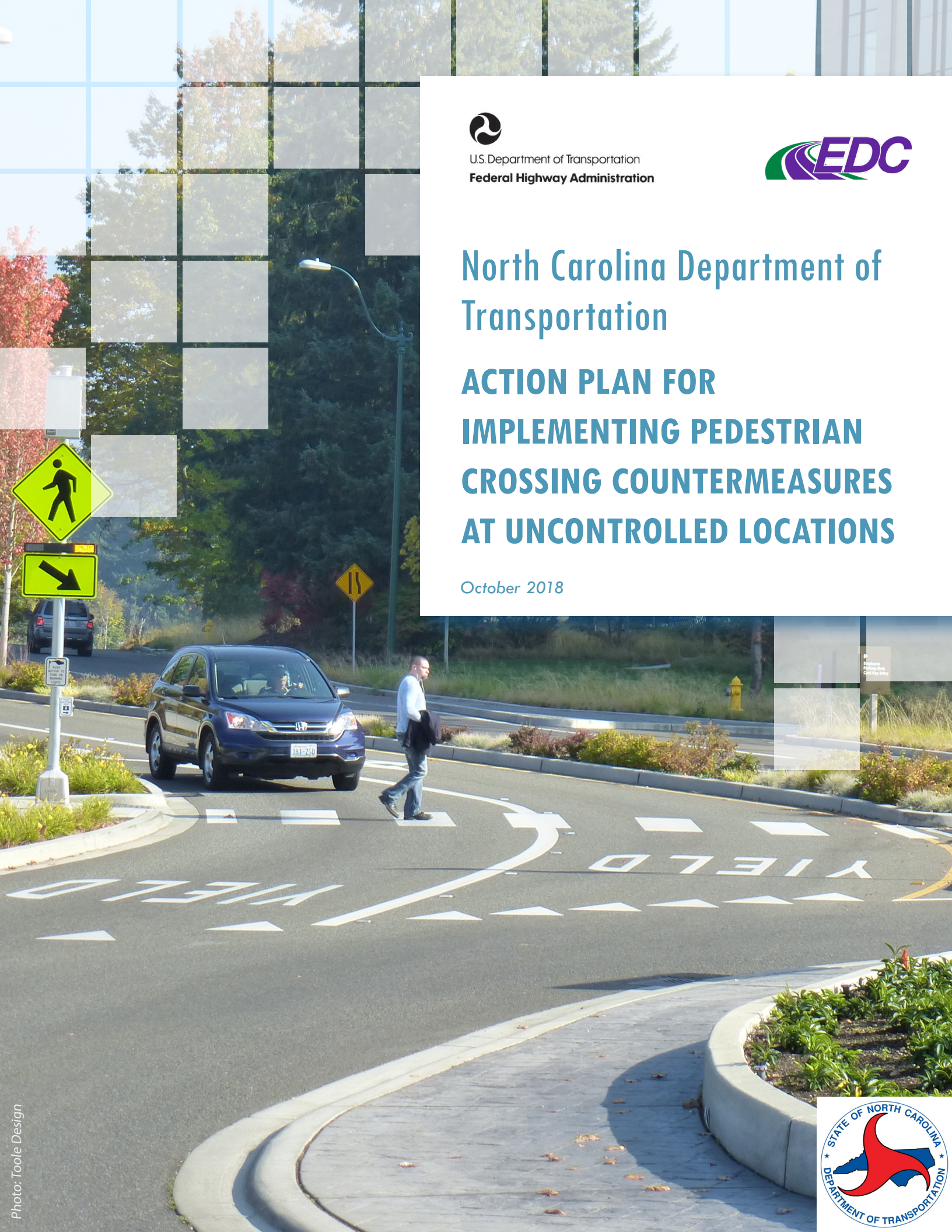
U.S. Department of Transportation
Federal Highway Administration



North Carolina Department of Transportation

ACTION PLAN FOR IMPLEMENTING PEDESTRIAN CROSSING COUNTERMEASURES AT UNCONTROLLED LOCATIONS

October 2018



Acknowledgments

This Safety Plan was developed by a group of dedicated individuals that are committed to reducing the number of lives taken prematurely on our nation's roadways.

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List of Abbreviations

AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ADT	average daily traffic
CMF	crash modification factor
CRF	crash reduction factor
EDC	Every Day Counts
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
GIS	geographic information system
HSIP	Highway Safety Improvement Program
HSP	Highway Safety Plan
MUTCD	Manual on Uniform Traffic Control Devices
NHTSA	National Highway Traffic Safety Administration
PHB	Pedestrian Hybrid Beacon
RSA	Road Safety Audit
SHSP	Strategic Highway Safety Plan
STBG	Surface Transportation Block Grant
STEP	Safe Transportation for Every Pedestrian
TZD	Toward Zero Deaths
VZ	Vision Zero

Executive Summary

State Participation in STEP Planning Initiative

This Safety Action Plan (“Plan”) has been developed as part of the Safe Transportation for Every Pedestrian (STEP) initiative and targets specific countermeasures for improving pedestrian safety at uncontrolled intersections. STEP is a Federal Highway Administration (FHWA) effort which is part of the Every Day Counts (EDC) initiative. The North Carolina DOT (NCDOT) is leading this initiative in coordination with the FHWA North Carolina Division Office and the North Carolina Department of Health and Human Services.

STEP has five stages: Not Implementing (#1); Development Phase (#2); Demonstration Stage (#3); Assessment Stage (#4); and Institutionalized (#5). States self-assess to determine their stage, and then decide if they would like to move up to the next stage. North Carolina is currently in the Assessment Stage (#4) with an intent of moving to the highest stage - the Institutional Stage (#5) - through the implementation of the recommendations of this plan.

A full day work session was held at NCDOT to review existing practices and policies impacting crossings across the state to develop the recommended actions reflected in this Plan. A review of the current use of the countermeasures and pedestrian safety processes was conducted before the full day work session and modified as necessary at that session.

Priority Recommendations

This Plan recommends actions that when implemented are likely to reduce the number and rate of pedestrian crashes, fatalities, and injuries on NCDOT’s extensive state highway system. NCDOT has taken actions in the past several years, specifically with the development of the Bicycle and Pedestrian Plan and its creation of a Pedestrian Crossing Guide. The NCDOT is committed to improving safety for all travel modes, including pedestrians. This commitment is reflected in the agency mission statement and statewide vision statement for its bicycle and pedestrian plan:

“North Carolina is a place that incorporates walking and bicycling into daily life, promoting safe access to destinations, physical activity opportunities for improved health, increased mobility for better transportation efficiency, retention and attraction of economic development, and resource conservation for better stewardship of our environment.”¹ NCDOT is poised to take steps to implement that vision by following STEP recommendations in this plan (recommendation numbers match those in the body of the plan):

RECOMMENDATION #5: NCDOT should continue to move to a more quantitative analysis of pedestrian crashes including meshing hospital admittance data with official crash reports and exploring the use of specific safety benefits expected from pedestrian safety projects estimated through crash reduction factors.

¹ NCDOT. WalkBikeNC Plan. (2013). Retrieved from <https://www.ncdot.gov/bikeped/walkbikenc/pictures/ProjectSummary.pdf>

RECOMMENDATIONS # 6: NCDOT should continue to develop a statewide, comprehensive non-motorized count program. It should also seek opportunities to work with MPOs and Regional Councils of Government to collectively expand current counting programs statewide. This could include NCDOT becoming a repository for data collected by other agencies in the state. As the state considers options for collecting pedestrian count data it should also consider how the data can be used in safety analyses.

RECOMMENDATION #8: NCDOT should conduct analyses that result in critical intersections or “hot spots” identified proactively. Such a systemic analysis can use the criteria established in the NCDOT Pedestrian Crossing Guide. GIS would be the most appropriate tool for identification of key intersections while a prioritization tool such as the ActiveTrans Priority Tool² could be helpful for establishing priorities.

RECOMMENDATION #9: NCDOT should tie together all the crosswalk elements from across the department’s resources and place them together for a one comprehensible policy statement and procedure. This should include the Department’s Pedestrian Crossing Guide.

RECOMMENDATION #11: NCDOT should review its recommended detailed pedestrian crossing guidance process and flowchart in light of the guidance for the five STEP countermeasures. The NCDOT Pedestrian Crossing Guide (after any modifications are made) can be used to help prescribe the preferred treatments of the top priority intersections identified and prioritized as part of the systemic analysis recommended in this plan.

RECOMMENDATION #12: NCDOT will assess its current policies for installing high visibility marked crosswalks which currently supports them under many circumstances. Language from the Complete Streets Guide recommending the application of high visibility crosswalks should also be assessed and folded into a recommended comprehensive crosswalk policy/procedure. NCDOT will simultaneously consider high visibility crosswalk markings at uncontrolled crossing locations identified in HSIP applications.

RECOMMENDATION #15: NCDOT will assess its current practices for installing illumination at primary crossing points and develop a policy. The policy should consider the role of crossing beacons as a substitute treatment in the absence of illuminated crossings.

RECOMMENDATION #19: Using the same supportive language as developed for mid-block crossings, NCDOT will develop guidance for refuge islands at uncontrolled intersections.

RECOMMENDATION #20: NCDOT will continue to implement current policy on use of beacons consistent with its pedestrian crossing guidance. In addition, it will continue its full day training and workshop that covers pedestrian crossing guidance includes recommendations on the installation of PHBs and RRFBs.

RECOMMENDATION #21: NCDOT should continue to use road diets while making general criteria for their use more readily available in NCDOT resources. Guidance and design materials should also incorporate the pedestrian concerns and benefits of road diets.

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2 Pedestrian and Bicycle Information Center. ActiveTrans Priority Tool: A Model Methodology for Prioritizing Pedestrian and Bicycle Improvements on Existing Roads. 2014. Retrieved from http://www.pedbikeinfo.org/training/webinars_PBIC_LC_120414.cfm

RECOMMENDATION #23: NCDOT will update manuals where needed to reflect national best practices. More specifically, the Pedestrian Crossing Guide is an excellent resource and could be selectively updated to consider the STEP recommendations made in this plan.

RECOMMENDATION #24: NCDOT will improve its consideration of STEP measures as part of its project development process for highway projects. Of the five countermeasures, enhancing crosswalks are the most universally viable option for projects because of the low cost and ease of implementation. However, if certain state highway projects are considered for road diets or involve reconstruction, additional small to moderate-scale STEP measures (pedestrian refuge islands and corner bump-outs) may become feasible. Also, NCDOT will consider including minor STEP treatments as part of resurfacing projects since they add only a small fraction of the overall cost of the project.

The recommendations in this Plan provide a roadmap for reducing the number and rate of pedestrian crashes, fatalities and injuries. Building a safe and connected pedestrian network requires consideration of topics beyond what is included in this Plan, however, at its heart, this Plan will allow for the consideration of pedestrian safety improvements specifically for uncontrolled intersections to be incorporated in other state DOT plans and documents.

1

Introduction and Background

Pedestrians are among the most vulnerable road users, accounting for approximately 16 percent of all roadway fatalities nationally in 2016, per the Fatality Analysis Reporting System (FARS). Pedestrians are especially vulnerable at non-intersection locations where 72 percent of pedestrian fatalities occur. In the State of North Carolina, pedestrians account for approximately 14 percent of all roadway fatalities¹.

What is STEP

The Safe Transportation for Every Pedestrian (STEP) is a Federal Highway Administration (FHWA) initiative which is part of the Every Day Counts (EDC) Round 4 effort. EDC is a FHWA-State Department of Transportation (DOT) collaboration which focuses on underutilized innovations. This Safety Action Plan (“Plan”) has been developed as part of the STEP initiative and targets five specific countermeasures (described later in this guide) for improving pedestrian safety at uncontrolled crossings (uncontrolled intersections or mid-block crossings). STEP was identified as part of the fourth round of EDC innovations because of the cost-effectiveness of the countermeasures it offers with known safety benefits.

Every Day Counts (EDC)

The STEP initiative is part of EDC. In 2009, the Federal Highway Administration (FHWA) launched Every Day Counts (EDC) in cooperation with the American Association of State Highway and Transportation Officials (AASHTO) to speed up the delivery of highway projects and to address the challenges presented by limited budgets. EDC is a state-based model to identify and rapidly deploy proven but underutilized innovations to shorten the project delivery process, enhance roadway safety, reduce congestion and improve environmental sustainability.

Proven innovations through EDC facilitate greater efficiency at the state and local levels, saving time and resources that can be used to deliver more projects for the same money. By advancing 21st century solutions, the highway community is making every day count to ensure our roads and bridges are built better, faster and smarter.

HOW IT WORKS

Through the EDC model, FHWA works with state and local transportation agencies and industry stakeholders to identify a new collection of innovations to champion every two years. Innovations are selected collaboratively by stakeholders, taking into consideration market readiness, impacts, benefits and ease of adoption of the innovation. After selecting the EDC technologies for deployment, transportation leaders from across the country gather at regional summits to discuss the innovations and share best practices. These summits begin the process for states, local public agencies and Federal Lands Highway Divisions to focus on the innovations that make the most sense for their unique program needs, establish performance goals and commit to finding opportunities to get those innovations into practice over the next two years.

Throughout the two-year deployment cycle, specifications, best practices, lessons learned and relevant data are shared among stakeholders through case studies, webinars and demonstration projects. The result is rapid technology transfer and accelerated deployment of innovation across the nation.

¹ NHSTA, “FARS Data Query: 2016 Data.” Fatality Analysis Reporting System (FARS) Encyclopedia. (2017). <https://www-fars.nhtsa.dot.gov/QueryTool/QuerySection/SelectYear.aspx>

Why Create this Pedestrian Safety Action Plan?

The purpose of this Plan is to provide specific recommendations for improving conditions for walking at uncontrolled pedestrian crossing locations, which occur where sidewalks or designated walkways cross a roadway at a location where no traffic control (e.g., traffic signal or stop sign) is present. These common crossing types occur at intersections (where crosswalks may be marked or unmarked) and at non-intersection or midblock locations (where crosswalks must be marked). Overall, uncontrolled pedestrian crossing locations often correspond to higher rates of pedestrian crash than controlled locations, often due to inadequate pedestrian crossing accommodations.²

By focusing on uncontrolled crossing locations, the North Carolina Department of Transportation (NCDOT) will address a significant safety problem and improve crossing comfort for pedestrians of all ages and abilities. Recommendations in this Plan follow STEP guidance for implementing lower-cost countermeasures that can be deployed based on specific needs. They have a proven record of reducing crashes and represent underutilized innovations that can have an immediate impact.

This Plan also builds on existing State goals for improving safety, examining existing conditions, and using a data-driven approach to match countermeasures with demonstrated problem locations. Plan recommendations are structured to allow for immediate implementation.

State Participation in STEP

NCDOT is leading this initiative in coordination with the FHWA North Carolina Division Office. This Plan recommends actions that when implemented can help reduce the number and rate of pedestrian-related crashes, fatalities, and injuries on the North Carolina state highway system.

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2 FHWA. Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations. (2018).

How this Safety Action Plan was Developed

This Plan is intended to be used in conjunction with the two US DOT, FHWA publications below (FHWA also features on-line for its Safe Transportation for Every Pedestrian program).

EDC GUIDE FOR IMPROVING PEDESTRIAN SAFETY AT UNCONTROLLED CROSSING LOCATIONS (2018) (EDC GUIDE)

This guide assists State or local transportation or traffic safety departments that are considering developing a policy or guide to support the installation of countermeasures at uncontrolled pedestrian crossing locations. This document provides guidance to agencies, including best practices for each step involved in selecting countermeasures. By focusing on uncontrolled crossing locations, agencies can address a significant national safety problem and improve quality of life for pedestrians of all ages and abilities. Agencies may use this guide to develop a customized policy or to supplement existing local decision-making guidelines.

FHWA HOW TO DEVELOP A PEDESTRIAN AND BICYCLE SAFETY ACTION PLAN (2017) (FHWA HOW TO)

The purpose of this guide is to assist agencies in developing and implementing a safety action plan to improve conditions for bicycling and walking. The plan lays out a vision for improving safety, examining existing conditions, and using a data-driven approach to match safety programs and improvements with demonstrated safety concerns. This guide will help agencies enhance their existing safety programs and activities, including identifying safety concerns and selecting optimal solutions. It will also serve as a reference for improving pedestrian and bicycle safety through a multidisciplinary and collaborative approach to safety, including street designs and countermeasures, policies, and behavioral programs.

The Plan report also references other FHWA publications, American Association of State Highway Transportation Officials (AASHTO) guides, the Manual on Uniform Traffic Control Devices (MUTCD), and relevant State publications for additional information. A complete list of referenced documents and other resources is found at the end of this document.

The three-part process used to develop this Plan helps insure that recommended actions represent the best use of agency resources:

1. **Discovery:** Current policies, plans, design guidance, prioritization methodologies, crash data and implementation strategies were identified and assembled with the assistance of NCDOT staff.
2. **One-day Work Session:** NCDOT staff along with representatives from FHWA and North Carolina Department of Health and Human Services met to review materials assembled during the Discovery phase, and to develop the recommended actions reflected in this Plan.
3. **Draft and Final Plan:** Based on the one-day work session, a draft Plan was developed, reviewed by NCDOT, revised and finalized.

The completed plan will allow for the consideration of pedestrian safety improvements to be incorporated in other NCDOT plans and documents, including, but not limited to: Strategic Highway Safety Plan, Long Range Transportation Plan, Roadway Design Manual.

The recommendations in this Plan provide a roadmap for reducing the number and rate of pedestrian crashes, fatalities and injuries. The recommendations identify current policies and practices that should be continued, as well as others that should be modified or added to better facilitate implementation. The target audience for this plan is diverse and includes: roadway designers, district engineers, division traffic engineers,

safety engineers and planners, program managers, MPO planners, and NCDOT managers.

Building a safe and connected pedestrian network requires consideration of topics beyond what is included in this Plan. Other engineering-based countermeasures exist for signalized intersections and for walking along streets and highways. Pedestrian crossings near schools are not specifically addressed in the Plan and will be subject to other State guidance. Crossing requirements per the Americans with Disabilities Act (ADA) are not specifically addressed in this Plan, although ADA requirements must be addressed as part of any pedestrian crossing improvements project. Resources and further guidance are provided at the end of this Plan.

2

Mission, Goals, and Recommendations

Vision and Mission

The transportation system should accommodate people of all ages and abilities, including people too young to drive, people who cannot drive, and people who choose not to drive. Pedestrians can be expected to walk along and across all roadways, except where prohibited. Walking is an important element of a multimodal transportation system that supports all users. Well-designed, well-maintained facilities, with low crash frequencies and severities, are important to creating safe and convenient walking conditions.

The NCDOT is committed to improving safety for all travel modes, including pedestrians. This commitment is reflected in the agency mission statement and statewide vision statement for its bicycle and pedestrian plan:

NCDOT Mission Statement: “Connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina.”¹

WalkBike NC Vision Statement: “North Carolina is a place that incorporates walking and bicycling into daily life, promoting safe access to destinations,

physical activity opportunities for improved health, increased mobility for better transportation efficiency, retention and attraction of economic development, and resource conservation for better stewardship of our environment.”²

RECOMMENDATION #1: NCDOT’s support for bicycling and walking is covered through existing policy statements and plans. This commitment to safety should be reflected in all NCDOT activities.

Goals

The NCDOT recognizes the importance of setting clear, measurable goals for improving pedestrian safety as a way of monitoring progress in reducing fatalities, injuries, and crashes. This is reflected in its long-range transportation plan³ where the first goal listed is “Make our Transportation Network Safer”. More specific to safety, the Strategic Highway Safety Plan (SHSP)⁴ establishes the following goal: “Cut the fatalities and serious injuries in North Carolina in half based on the 2013 figures, reducing the total annual fatalities by 630 fatalities and the total serious injuries by 1,055 serious injuries before 2030”. If applied directly to pedestrian safety, this would have an immense impact on the safety of pedestrians.

1 NCDOT. Home Page — Website. Retrieved from <https://www.ncdot.gov/about-us/our-mission/Pages/default.aspx>
2 NCDOT. WalkBikeNC Plan. (2013). Retrieved from <https://www.ncdot.gov/bikeped/walkbikenc/pictures/ProjectSummary.pdf>
3 NCDOT. 2040 Plan. Retrieved from <https://www.ncdot.gov/performance/reform/2040Plan/>
4 NCDOT. Strategic Highway Safety Plan. (2014). Retrieved from http://www.ncshsp.org/wp-content/themes/SHSP_Custom/pdfs/SHSP_Complete.pdf

RECOMMENDATION #2: Support the existing goals for pursuing safety in North Carolina.

pedestrian counts. The Division of Bicycle and Pedestrian Transportation (DBPT) within NCDOT will be responsible for leading this effort.

Performance Measures

Performance measures are a way to measure the effectiveness of agency policies, projects and programs. They can be a measurement of outcomes (e.g., reduction in number of pedestrian injuries and fatalities), or they can be a measurement of production items (e.g., the number of curb ramps installed). They serve as a tool for building agency accountability. Deciding what to measure is important since it will guide the allocation of resources as agencies strive to meet performance measure objectives.

The WalkBike NC plan identified several related performance measures including pedestrian and bicyclists crash and fatality rates per capita – both state trends and comparisons to other states. NCDOT also works with FHWA to establish and track safety performance measures as part of the Highway Safety Improvement Program (HSIP). The following performance measures are used to track and measure safety performance as five-year rolling averages:

- » Number of fatalities
- » Rate of Fatalities per 100 million VMT
- » Number of serious injuries
- » Rate of serious injuries per 100 million VMT
- » Number of non-motorized fatalities and serious injuries

RECOMMENDATION #3: NCDOT should continue to measure the effectiveness of agency policies, projects and programs impacting pedestrian safety. It will eventually expand its measures to include more evaluations of education and encouragement programs, the most vulnerable pedestrians (for example, ADA, children or senior citizens), and will consider establishing crash rates based on

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Prioritizing Pedestrian Crossing Improvements

Data Collection and Analysis Individual Crash Location Analysis

Pedestrian crashes, especially those involving fatalities, are frequently scattered and might be relatively rare at any given individual location. Consequently, to improve pedestrian safety requires identification of problem roadway segments as well as intersection and mid-block locations (note: this is not referring to controlled intersection and midblock crossing locations). A simple mapping of crash locations involving pedestrians will quickly identify high crash locations (likely only a few) and corridors. Typically, five (5) years of crash data is appropriate, though in rapidly changing areas three (3) years might be sufficient.

The NCDOT maintains a database of all motor vehicle crashes, including those involving pedestrians. Through a contractual partnership with NCDOT, the Highway Safety Research Center (HSRC) administers the NC Crash Data Tool. This involves yearly updating, geocoding, analyzing, and maintaining approximately 900 bicycle collision reports and 2,600 pedestrian collision reports on average. Agencies across the state are routinely using the crash data tool for information.

NCDOT is working with HSRC to mesh hospital admittance data with official crash reports. Also, there is an effort on follow-up reporting to improve the accuracy of injury outcomes. This overall effort is currently in year one (1) of three (3).

RECOMMENDATION #4: NCDOT should continue to collect and map pedestrian crashes and to use the NC Crash Data Tool. NCDOT should ensure that an explanation of crash data, and the crash data tool and its uses and availability is included in all related pedestrian safety activities such as Safe Routes to School activities, complete streets workshops, and pedestrian design workshops. The DBPT within NCDOT will be responsible for leading this effort.

System-wide Crash Analysis

To conduct more sophisticated analyses of pedestrian crashes, additional data sets are needed. Detailed data, including crash location, time, demographic information about the individuals involved in the crash, and whether drugs or alcohol were involved, are extremely useful to determine whether there are patterns to pedestrian crashes, and if so, to select the best countermeasures to address them. Analysis of detailed data can provide information on where crashes occur, when they occur, and characteristics of the victims.

It can also be helpful to categorize crashes by type. This is known as pedestrian crash typing and was pioneered by the National Highway Traffic Safety Administration in the 1970's to better define the sequence of events leading up to crashes and the orientation of both the pedestrian and motorist

when the crash occurred. While there are over 60 specific pedestrian crash types, pedestrian crashes can generally be sorted into twelve crash type groupings for selecting countermeasures. Crash typing categorizes all crashes based on situational and behavioral circumstances and is a way to target countermeasures in engineering, education and enforcement programs at very specific types of crashes.

NCDOT currently reports its pedestrian crashes by one of twelve crash types – dart-out, walking along roadway, standing in roadway, etc.

RECOMMENDATION #5: Continue to move to a more sophisticated analysis of pedestrian crashes including meshing hospital admittance data with official crash reports and exploring the use of specific safety benefits expected from pedestrian safety projects estimated through crash reduction factors. The DBPT within NCDOT will be responsible for leading this effort.

Once categorized, NCDOT and others can use this information to select countermeasures, focus resources, and develop a systemic analysis approach (pro-active) for identifying and prioritizing locations for improvements (see the section - Selecting Countermeasures and Prioritizing Locations for Improvements for further discussion).

Pedestrian Volume and Behavior Analysis

Pedestrian counts along with field observations (e.g., driver yielding, conflicts, and pedestrian assertiveness) can be very useful in understanding pedestrian behavior and in considering the need for facilities. Counts and behavior studies, when combined with crash data, can also provide insights into specific crash causes and potential “best-fit” countermeasures, and allow the determination of pedestrian crash rates. On-site observations will often reveal behavior patterns that lead to design changes. Before and after counts

can be used to measure success which can be used to help secure funding for additional improvements at other locations. Pedestrian counts are also important to assess when and where signals, stop signs and marked crosswalks should be used.

NCDOT is in the beginning stages of establishing a statewide bicycle and pedestrian count program. North Carolina State University’s Institute for Transportation Research and Education (ITRE), NCDOT, and local agencies are working in partnership to install and monitor continuous bicycle and pedestrian count systems on sidewalks, roadways, and shared use paths across the state. Several MPOs are using counters for justification of pedestrian projects and NCDOT has documented counts before starting projects and after project completions.

RECOMMENDATION #6: NCDOT should continue to develop a statewide, comprehensive count program. It should also seek opportunities to work with MPOs and Regional Councils of Government to collectively expand current counting programs statewide. This could include the NCDOT becoming a repository for data collected by other agencies in the state. As the NCDOT considers options for collecting pedestrian count data it should also consider how the data can be used in safety analyses. The DBPT within NCDOT will be responsible for leading this effort.

Engineering Studies

There are many factors which can affect crossing opportunities including motorist approach speeds and volumes, motorist yielding, roadway configuration (width or roadway, number of travel lanes, etc.), and classification of vehicles, in addition to the volume and assertiveness of pedestrians and bicyclists mentioned above. NCDOT evaluates crossings as part of projects and requests. It also has the Municipal School Transportation Assistance program which does consider pedestrians when reviewing and analyzing school studies.

As part of the engineering studies, sight distances should also be evaluated. Motorists must be provided sufficient stopping sight distance to be able to see, react, and yield to crossing pedestrians. Likewise, pedestrians require sufficient sight distance to identify and judge gaps in traffic. Where sight distance is limited, efforts should be made to increase the stopping sight distance by removing parking or other sight obstructions, or to install curb extensions to allow pedestrians to wait closer to the edge of the roadway. Where stopping sight distance cannot be provided, active warning devices should be provided in advance of the intersection, in conjunction with a Pedestrian Hybrid Beacon or traffic signal.

NCDOT currently has established guidance for the consideration of unsignalized mid-block crossings including an engineering study in the Traffic Engineering Policies, Practices, and Legal Authority (TEPPL)¹, but does not have a complete engineering guide for uncontrolled intersections.

RECOMMENDATION #7: NCDOT should develop engineering guidance for uncontrolled intersections to complement the procedure for mid-block crossings in the TEPPL and coordinate that effort with the NCDOT Municipal School Transportation Assistance program. The DBPT within NCDOT will be responsible for leading this effort.

Prioritizing Pedestrian Crossing Improvements and Systemic Analysis Approach

A pre-defined methodology for prioritizing pedestrian improvements ensures that resources are allocated in a way that best meets goals to reduce pedestrian injuries and fatalities. The prioritization methodology should be:

- » Responsive to NCDOT and community values: Decisions should be based on the NCDOT’s mission and goals.
- » Flexible: Rather than being a rigid, “one-size-fits-all” tool, a prioritization methodology should be flexible and allow practitioners to choose the most appropriate approach that reflects agency goals and resource availability.
- » Transparent: A prioritization process should be broken down into a series of discrete steps, each of which can be easily documented and explained to the public.

NCDOT commissioned a research study (North Carolina Pedestrian Crossing Guidance²) which provides a detailed process and flowchart of how uncontrolled intersections and mid-block crossings should be evaluated for markings and crosswalk enhancements. The NCDOT will initiate an evaluation of a crossing location:

- » At the request of a municipality or citizen; or,
- » At pedestrian crash hot spot locations identified through crash analyses; or,
- » To proactively and systematically review existing crossing locations as part of a basic needs assessment and inventory.

Many areas may have low pedestrian crash rates, but still have a high incidence for pedestrian crashes. Emerging methodologies identify these sites based on roadway characteristics combined with land use features of the area. In some cases, it may be possible to select countermeasures to address these crash factors before pedestrian crashes occur. Systemic analysis considers factors such as roadway design characteristics and traffic control devices, lighting

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1 NCDOT. Traffic Engineering Policies, Practices, and Legal Authority (TEPPL). Retrieved from https://connect.ncdot.gov/resources/safety/Tepp/Pages/Tepp-Topic-Original.aspx?Topic_List=P10

2 NCDOT. Pedestrian Crossing Guidance. (2015). Retrieved from https://connect.ncdot.gov/resources/safety/Tepp/TEPPL%20All%20Documents%20Library/Pedestrian_Crossing_Guidance.pdf

conditions, vehicle speeds, and nearby pedestrian destinations. Combinations of these factors will also help identify countermeasures to address and prevent pedestrian crashes.

The NCDOT Pedestrian Crossing Guidance process can be used proactively as suggested in the study. However, in practice the process is reactive and begins with a field study from the appropriate NCDOT division office. If the field study reveals a significant need, the location would be submitted as a project and monitored quarterly.

RECOMMENDATION #8: NCDOT should conduct analyses that result in critical intersections or “hot spots” proactively identified. Such a systemic analysis can use the criteria established in the pedestrian crossing guidance document, but the approach should include consideration of marked crosswalks (or potential locations of marked crosswalks) on the state’s primary system of highways. GIS would be the most appropriate tool for identification of key intersections while a prioritization tool such as the ActiveTrans Priority Tool³ could be helpful for establishing priorities. The DBPT within NCDOT will be responsible for leading this effort.

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3 Pedestrian and Bicycle Information Center. ActiveTrans Priority Tool: A Model Methodology for Prioritizing Pedestrian and Bicycle Improvements on Existing Roads. 2014. Retrieved from http://www.pedbikeinfo.org/training/webinars_PBIC_LC_120414.cfm

4

Marked Crosswalks at Uncontrolled Locations

Marked Crosswalk Policy

Marked crosswalks delineate optimal or preferred location for a pedestrian to cross a street, and indicate to motorists where to expect pedestrians. Pavement markings must follow one of the types as shown in the MUTCD. The MUTCD indicates that new marked crosswalk installations at uncontrolled locations should follow an engineering study before installation can take place.

Marked crosswalks help to improve pedestrian safety and the connectivity of the pedestrian network. A marked crosswalk policy creates a consistent approach for the evaluation and installation of marked crosswalks. Uniform and consistent application of marked crosswalks can help increase predictability for both pedestrians and drivers. A marked crosswalk policy should:

1. Identify what factors are taken into consideration during evaluation of proposed marked crosswalks at uncontrolled locations (e.g., traffic volume, traffic speeds, crashes, destinations, roadway design, etc.); and,

2. Establish the primary types of crossing treatments to be considered for any marked crosswalk location (including high visibility crosswalks); and,
3. Determine a prioritization process for how crosswalk marking is implemented. Inputs to this prioritization may include locational data such as transit stops, school walking routes, senior walking routes, high collision locations, and midblock locations with high numbers of pedestrians crossing the street.

FHWA's Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (2018) provides options for crossing improvements, once an agency has determined where to install a marked crosswalk.

NCDOT has the elements of a detailed marked crosswalk policy: the Complete Streets Guide¹ provides good solid guidance, the midblock crossing guidance² has the essential elements of a policy, and finally there is a very good process for staged consideration of crosswalks and crosswalk enhancements from the Pedestrian Crossing Guidance study/flowchart.

1 NCDOT Complete Streets Planning and Design Guidelines. Retrieved from: http://www.completestreetsnc.org/wp-content/themes/CompleteStreets_Custom/pdfs/NCDOT-Complete-Streets-Planning-Design-Guidelines.pdf

2 NCDOT. Standard Practice for Crosswalks — Mid-Block (Unsignalized) Signing; Traffic Engineering Policies, Practices, and Legal Authority (TEPPL). Retrieved from https://connect.ncdot.gov/resources/safety/TEPPL/TEPPL%20All%20Documents%20Library/C-36_pr.pdf

RECOMMENDATION #9: NCDOT should tie together all the crosswalk elements from across the department's resources and place them together for a one comprehensible policy statement and procedure. This should include the other more detailed crossing guidance such as the Department's Pedestrian Crossing Guide. The DBPT within NCDOT will be responsible for leading this effort.

Inventory and Evaluation of Marked Crosswalks at Uncontrolled Locations

A systematic inventory of conditions at existing marked crosswalks, and potential locations, is necessary for prioritizing locations and selecting countermeasures. This also will eventually require a complete list of existing marked crosswalks locations (lack of a complete list should not delay making improvements at known problem locations). The review of existing marked crosswalks should be based on the guidelines in the marked crosswalk policy. The results can be used to create a strategy for making improvements at marked crosswalks at uncontrolled locations.

NCDOT does not have a complete list of locations where there are marked crosswalks at uncontrolled locations on State highways. This is understandable in part because the state has the largest state-controlled highway system in the country. NCDOT does assess marked crosswalk conditions upon request, but does not have a complete assessment of marked crosswalks.

RECOMMENDATION #10: NCDOT should conduct an inventory and assessment of marked crosswalks by targeting its 15,000 miles of primary state highways using the Guide for Improving Pedestrian Safety at Uncontrolled Locations for guidance. An initial estimate of the number of crossing locations could be obtained from NCDOT ADA/Section 504 program. The DBPT within NCDOT will be responsible for leading this effort.

Selecting Countermeasures and Prioritizing Locations for Improvements

The goal of this improvement strategy is to improve pedestrian crossing facilities at uncontrolled marked crosswalks so that they will operate as designed, with drivers yielding to pedestrians and pedestrians crossing safely. Rather than just deciding whether marked crosswalks should or should not be provided, the improvement strategy asks what are the most effective measures that can be used to help pedestrians safely cross the street. Improvements are typically divided into three types of interventions: simple measures, moderately complex measures, and complex measures. The more complex the measure the more time, money, and coordination among different divisions may be required.

Simple measures include sign replacement and enhancement, high visibility crosswalk remarking, advance stop bars, curb ramps, and lighting adjustments. Moderately complex measures include rectangular rapid flash beacons (RRFBs), pedestrian refuge islands (where no rechannelization of lanes is required), curb extensions, lighting additions, and changes in pedestrian circulation. Complex measures include Pedestrian Hybrid Beacons, Road Diets, crossing islands (where re-channelization is required), raised crosswalks, and intersection redesign. After prioritizing locations using the prioritization methodology as described earlier, they could be further organized according to complexity.

NCDOT has not prioritized locations and systematically selected countermeasures for improving pedestrian crossing facilities at uncontrolled locations; however, it does have an excellent guide for crossing measures that is much more detailed and prescriptive than Table 1 in this plan. There are slight differences between the two, for instance, the STEP guidance (Table 1) suggests using enhanced crosswalk treatments as standard treatments with nearly all marked crosswalk installations while the NCDOT evaluation/flowchart

calls for their use primarily when there are higher motorist speeds and higher volumes of motor vehicles and pedestrians. As another example, the NCDOT crossing guidance uses pedestrian crossing volumes as a criterion for one of its steps in its process while the STEP Table 1 does not.

RECOMMENDATION #11: NCDOT should review its recommended detailed pedestrian crossing guidance process and flowchart considering the guidance for the five STEP countermeasures. The NCDOT Pedestrian Crossing Guidance (after any modifications are made) can be used to help prescribe the preferred treatments of the top priority intersections identified and prioritized as part of the systemic analysis recommended earlier in this plan. The DBPT within NCDOT will be responsible for leading this effort.

5

Toolbox: Pedestrian Crossing Countermeasures at Uncontrolled Locations

Introduction - Selecting Countermeasures

The results of the crash analysis, road safety audit, and/or stakeholder input provide a better understanding of the potential factors influencing crashes at uncontrolled crossing locations. The countermeasures listed in this guide can improve the visibility of crossing locations and reduce crashes, and they each address at least one additional safety concern associated with a higher incidence of collision and/or severe injury. In all cases, the countermeasures, when implemented, should follow MUTCD and other relevant AASHTO, FHWA and State guidance.

Table 1 includes a comprehensive matrix and list of STEP pedestrian crash countermeasures suggested for application at uncontrolled crossing locations per roadway and traffic features. The countermeasures are assigned to specific matrix cells based on safety research, best practices, and established national guidelines. When a pedestrian crossing is established, the countermeasure options in the cells should be reviewed before selecting the optimal group of crossing treatments. Previously obtained characteristics such as pedestrian volume, operational speeds, land use context, and other site features should also be

considered when selecting countermeasures. It should be noted that NCDOT has incorporated these factors into an operational flowchart (Pedestrian Crossing Guidance¹) to help guide countermeasure selection. NCDOT will also reference the MUTCD and other national, State, and local guidelines when making the final selection of countermeasures.

1. Enhancements at Marked Crosswalks

Locations with marked crosswalks can increase safety with high visibility pavement markings, advanced stop bars and warning signs, in-street pedestrian crossing signs, illumination, curb extensions and tighter curb radii.

High Visibility Crosswalk Markings

High visibility crosswalk markings ensure that drivers see the crosswalk, not just the pedestrian. Two parallel lines indicating a marked crosswalk can be almost invisible to the motorist at uncontrolled locations. When a decision has been made to use crosswalk markings, high visibility markings such as ladder style (“piano keys”) or continental markings (“zebra”) should be used at locations without positive traffic control, and are advised at locations with positive traffic control (signals, stop signs).

¹ NCDOT. Pedestrian Crossing Guidance. 2015. Retrieved from https://connect.ncdot.gov/resources/safety/Tepp/TEPPL%20All%20Documents%20Library/Pedestrian_Crossing_Guidance.pdf

NCDOT has a policy to install high visibility marked crosswalks at mid-block crossing locations based on language in TEPL. They are also recommended at some legs of an uncontrolled locations based on the Complete Streets Guide.

RECOMMENDATION #12: NCDOT will assess its current policies for installing high visibility marked crosswalks which currently supports them under many circumstances. Language from the Complete Streets Guide recommending the application of high visibility crosswalks should also be assessed and folded into a recommended comprehensive

Table 2. Application of pedestrian crash countermeasures by roadway feature.

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	① 2 4 5 6	① 5 6 7 9	① 5 6 7 9	① 4 5 6 7 9	① 5 6 7 9	① 5 6 7 9	① 4 5 6 7 9	① 5 6 7 9	① 5 6 9
3 lanes with raised median (1 lane in each direction)	① 2 3 4 5	① ③ 5 7 9	① ③ 5 7 9	① 3 4 5 7 9	① ③ 5 7 9	① ③ 5 7 9	① ③ 4 5 7 9	① ③ 5 7 9	① ③ 5 9
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	① 2 3 4 5 6 7 9	① ③ 5 6 7 9	① ③ 5 6 9 7 9	① 3 4 5 6 7 9	① ③ 5 6 7 9	① ③ 5 6 9 7 9	① ③ 4 5 6 7 9	① ③ 5 6 9	① ③ 5 6 9
4+ lanes with raised median (2 or more lanes in each direction)	① ③ 5 7 8 9	① ③ 5 7 8 9	① ③ 5 8 9	① ③ 5 7 8 9	① ③ 5 7 8 9	① ③ 5 8 9	① ③ 5 7 8 9	① ③ 5 8 9	① ③ 5 8 9
4+ lanes w/o raised median (2 or more lanes in each direction)	① ③ 5 6 7 8 9	① ③ 5 6 7 8 9	① ③ 5 6 8 9	① ③ 5 6 7 8 9	① ③ 5 6 7 8 9	① ③ 5 6 8 9	① ③ 5 6 7 8 9	① ③ 5 6 8 9	① ③ 5 6 8 9

Given the set of conditions in a cell,

- # Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.
- Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

- 1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
- 2 Raised crosswalk
- 3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
- 4 In-Street Pedestrian Crossing sign
- 5 Curb extension
- 6 Pedestrian refuge island
- 7 Rectangular Rapid-Flashing Beacon (RRFB)**
- 8 Road Diet
- 9 Pedestrian Hybrid Beacon (PHB)**

*Refer to Chapter 4, 'Using Table 1 and Table 2 to Select Countermeasures,' for more information about using multiple countermeasures.

**It should be noted that the PHB and RRFB are not both installed at the same crossing location.

This table was developed using information from: Zegeer, C.V., J.R. Stewart, H.H. Huang, P.A. Lagerwey, J. Feaganes, and B.J. Campbell. (2005). Safety effects of marked versus unmarked crosswalks at uncontrolled locations: Final report and recommended guidelines. FHWA, No. FHWA-HRT-04-100, Washington, D.C.; FHWA. Manual on Uniform Traffic Control Devices, 2009 Edition. (revised 2012). Chapter 4F, Pedestrian Hybrid Beacons. FHWA, Washington, D.C.; FHWA. Crash Modification Factors (CMF) Clearinghouse. <http://www.cmfclearinghouse.org/>; FHWA. Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE). <http://www.pedbikesafe.org/PEDSAFE/>; Zegeer, C., R. Srinivasan, B. Lan, D. Carter, S. Smith, C. Sundstrom, N.J. Thirsk, J. Zegeer, C. Lyon, E. Ferguson, and R. Van Houten. (2017). NCHRP Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. Transportation Research Board, Washington, D.C.; Thomas, Thirsk, and Zegeer. (2016). NCHRP Synthesis 498: Application of Pedestrian Crossing Treatments for Streets and Highways. Transportation Research Board, Washington, D.C.; and personal interviews with selected pedestrian safety practitioners.














































crosswalk policy/procedure. NCDOT will simultaneously consider and/evaluate guidance for application of high visibility crosswalk markings at uncontrolled crossing locations identified in HSIP applications.

Advance Yield Bar and Yield Here for Pedestrians sign

A multiple threat crash results when a driver in one lane stops to let the pedestrian cross, blocking the sight lines of the driver in the other lane of a multi-lane approach, who then advances through the crosswalk

and hits the crossing pedestrian. If advance yield or stop lines and ‘Yield Here to Pedestrians’ R1-5/ R1-5a or ‘Stop Here for Pedestrians’ R1-5b/R1-5c signs are used in advance of a crosswalk, they should be placed together and 20 to 50 feet before the nearest crosswalk line; parking should be prohibited in the area between the yield line or stop line and the crosswalk. The MUTCD requires R1-5 signs when yield or stop lines are used in advance of a crosswalk with an uncontrolled multi-lane approach.

Table 2. Safety issues addressed per countermeasure.

Pedestrian Crash Countermeasure for Uncontrolled Crossings	Safety Issue Addressed				
	Conflicts at crossing locations	Excessive vehicle speed	Inadequate conspicuity/visibility	Drivers not yielding to pedestrians in crosswalks	Insufficient separation from traffic
Crosswalk visibility enhancement					
High-visibility crosswalk markings*					
Parking restriction on crosswalk approach*					
Improved nighttime lighting*					
Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line*					
In-Street Pedestrian Crossing sign*					
Curb extension*					
Raised crosswalk					
Pedestrian refuge island					
Pedestrian Hybrid Beacon					
Road Diet					
Rectangular Rapid-Flashing Beacon					

*These countermeasures make up the STEP countermeasure “crosswalk visibility enhancements.” Multiple countermeasures may be implemented at a location as part of crosswalk visibility enhancements.

NCDOT currently has a policy to install advance yield bars and pedestrian signs at mid-block crossing locations.

RECOMMENDATION #13: NCDOT will continue to implement its current policy to encourage the use of advance yield bars and pedestrian signs at mid-block crossings. The DBPT within NCDOT will be responsible for leading this effort.

In-street Pedestrian Crossing sign

In-street signs are placed in the middle of the road at a crossing and are often used in conjunction with refuge islands. These signs may be appropriate on 2-lane or 3-lane roads with speed limits of 30 mph or less. On higher-speed, higher-volume, and/ or multilane roads, this treatment may not be as visually prominent; therefore, it may be less effective (drivers may not notice the signs in time to stop in advance of the crosswalk). For such roadways, more robust treatments will be needed. MUTCD Section 2B.12—In-Street and Overhead Pedestrian Crossing Signs contains additional information about these signs.

NCDOT marginally supports in-street yield signs in the complete streets guidelines under mid-block crossings – “Include a vertical element (such as landscaping, paddles, or other) on pedestrian refuges to ensure visibility to motorists;”

RECOMMENDATION #14: NCDOT will formulate a broader usage policy for when and where to install in-street pedestrian crossing signs at uncontrolled locations. The DBPT within NCDOT will be responsible for leading this effort.

Illumination

Up to half of pedestrian crashes occur at night. Lighting greatly increases the driver’s ability to see pedestrians crossing the road.

NCDOT does not have a policy for the provision of lighting at established pedestrian crossings at uncontrolled locations; however, there is some brief

supporting language for their use in the Complete Streets Guidelines.

RECOMMENDATION #15: NCDOT will assess its current practices for installing illumination at primary crossing points and develop a policy. The policy should consider the role of crossing beacons as a substitute treatment in the absence of illuminated crossings. The DBPT within NCDOT will be responsible for leading this effort.

Curb Extensions

Curb extensions extend the sidewalk or curb face into the parking lane or shoulder at an intersection, thus improving sight distance between the driver and pedestrian. They are typically designed to extend no further than the edge of a parking lane or shoulder. They are also known as neckdowns, bumpouts or bulbouts. They are most commonly applied at intersections where they are intended to reduce the pedestrian crossing distance, slow right-turning vehicles, improve visibility between motorists and pedestrians, and provide more space for landscaping or storm water management, among other features. When trees are planted on curb extensions, they can be an effective treatment to visually narrow a street and thus create traffic calming effects.

NCDOT Traffic Engineering Standard Practice for mid-block crossings encourages the use curb extensions at these crossings. There are also numerous illustrations in the Complete Streets Guide featuring curb extensions under several street typologies.

RECOMMENDATION #16: NCDOT will continue to implement its current practice for encouraging the use of curb extensions for mid-block crossings. As the relevant section of the Traffic Engineering Policies, Practices, and Legal Authority (TEPPL) covering curb extensions is updated, curb extensions should also be recommended for uncontrolled intersections where appropriate (most applications are best suited to locations where on-street

parking is present). The DBPT within NCDOT will be responsible for leading this effort.

Tighter Curb Radii

Tighter curb radii can improve sight lines between driver and pedestrian, shorten the crossing distance, bring crosswalks closer to the intersection, and slow right-turning vehicles. Intersection design will determine whether best practices for meeting ADA requirements can be applied. For example, tight curb radii will usually allow for two ramps at each corner as opposed to just one. The appropriate radius should be calculated for each corner on a case by case basis, considering the design vehicle.

NCDOT has established standards for curb radii used for its turning templates for designing intersections. There is also some language in the Complete Streets Guide which discusses the trade-offs between larger radii and the challenges that exist for designing for pedestrians and accessibility.

RECOMMENDATION #17: The impacts of larger radii on pedestrian crossings should be reflected in any standards or guidance developed by NCDOT. Guidance should address when it is perfectly appropriate to use smaller radii and where it might be applicable given additional site considerations. The DBPT within NCDOT will be responsible for leading this effort.

2. Raised Crosswalks

Raised crosswalks function as an extension of the sidewalk and allow a pedestrian to cross the street without stepping down to street level. A raised crosswalk is typically a candidate treatment on 2-lane or 3-lane roads with speed limits of 30 mph or less and AADTs below 9,000. Raised crossings are generally avoided on truck routes, emergency routes, and arterial streets. For retrofit projects, drainage needs to be evaluated and revised as necessary. See MUTCD Section 3B.25—Speed Hump Markings for additional information about markings that can be used alongside raised crosswalks.

NCDOT does not have a policy which restricts the use of raised crosswalks; however, in practice, there are only a few raised crosswalks on secondary highways. This treatment is not included in the Pedestrian Crossing Guidance or flowchart.

RECOMMENDATION #18: NCDOT will evaluate existing locations with raised crosswalks and develop criteria/guidance for their use and application (as a tool for special situations). The DBPT within NCDOT will be responsible for leading this effort.

3. Pedestrian Refuge Islands

A pedestrian refuge island is typically constructed in the middle of a 2-way street and provides a place for pedestrians to stand and wait for motorists to stop or yield. This countermeasure is highly desirable for midblock pedestrian crossings on roads with four or more lanes and should be considered for undivided crossings of four or more lanes with speed limits of 35 mph or greater and/or annual average daily traffic (AADT) of 9,000 or greater. Median islands may also be a candidate treatment for uncontrolled pedestrian crossings on 3-lane or 2-lane roads where the street is wide and/or where vehicle speed or volumes are moderate to high. Consideration should be given to creating a two-stage crossing with the island to encourage pedestrians to cross one direction of traffic at a time and look towards oncoming traffic before completing the second part of the crossing. The minimum pedestrian refuge island width is approximately 6 feet. MUTCD Sections 3B.10—Approach Markings for Obstructions, 3B.18—Crosswalk Markings, and 3B.23—Curb Markings provide additional information.

NCDOT supports the use of refuge islands for mid-block applications and includes general recommendations for their use in the complete streets guide.

RECOMMENDATION #19: Using the same supportive language as developed for mid-block crossings, NCDOT will develop guidance for refuge islands at

uncontrolled intersections. The DBPT within NCDOT will be responsible for leading this effort.

4. Pedestrian Hybrid Beacons (PHBs) and Rectangular Rapid Flash Beacons (RRFBs)

PHBs are a candidate treatment especially for roads with three or more lanes that generally have AADT above 9,000. PHBs should be strongly considered for all midblock and intersection crossings where the roadway speed limits are equal to or greater than 40 mph. Refer to Table 1 for other conditions where PHBs should be strongly considered and MUTCD Chapter 4F-Pedestrian Hybrid Beacons for their application.

At some uncontrolled crossings, particularly those with four or more lanes, it can be difficult to achieve compliance with laws that require motorists to yield to pedestrians. Vehicle speeds create conditions in which very few drivers feel compelled to yield. One type of device proven to be successful in improving yielding compliance at these locations is the Rectangular Rapid Flash Beacon (RRFB). RRFBs are a pedestrian crossing sign combined with an intensely flashing beacon that is only activated when a pedestrian is present.

RRFBs are considerably less expensive to install than mast-arm mounted signals. They can also be installed with solar-power panels to eliminate the need for a power source. RRFBs should be used in conjunction with advance yield pavement lines and signs. They are usually implemented at high-volume pedestrian crossings, but may also be considered for priority bicycle route crossings or locations where bike facilities cross roads at mid-block locations.

In December 2017, FHWA terminated the Rectangular Rapid Flashing Beacon Interim Approval IA-11, due to a patent dispute. On March 20, 2018 FHWA announced that the patent dispute had been settled, allowing its production by all manufacturers. This led the Federal Highway Administration to issue Interim Approval (IA-21).

RRFBs must be in accordance with FHWA's Interim Approval (IA-21), issued on March 20, 2018. All agencies must resubmit requests to FHWA to use the RRFB following the standard interim approval process.

NCDOT pedestrian crossing guidelines present beacons as viable options when other countermeasures are deemed inappropriate by its evaluation-driven flowchart.

RECOMMENDATION #20: NCDOT will continue to implement current policy on use of beacons consistent with its pedestrian crossing guidance. In addition, it will:

- » Continue its full day training and workshop that covers pedestrian crossing guidance includes recommendations on the installation of PHBs and RRFBs; and,
- » For RRFBs, NCDOT should reapply for Interim Approval statewide, if it has not already done so; and,
- » Include explicit descriptions of the benefits of the beacons in the Pedestrian Crossing Guidance (or update existing materials with new descriptions and research-based benefits).

The DBPT within NCDOT will be responsible for leading this effort.

5. Road Diet

A Road Diet, also called a lane reduction or road rechannelization, is a technique in transportation planning whereby the number of travel lanes and/or effective width of the road is reduced in order to achieve systemic improvements. A frequently-implemented Road Diet involves converting a 4-lane, undivided roadway into a 3-lane roadway with a center turn lane. This is a candidate treatment for any undivided road with wide travel lanes or multiple lanes that can be narrowed or repurposed to improve pedestrian crossing safety.

After conducting a traffic analysis to consider its feasibility, a Road Diet may be a good candidate for use on roads with four or more lanes and traffic volumes of approximately 20,000 or less. In some cases, Road Diets have been implemented on roads with AADTs of up to 25,000. By reducing the width of the roadway, pedestrians benefit from shorter crossing distances and often bike lanes or streetscape features can be added. Road Diets are often effectively accomplished during pavement resurfacing and enable the implementation of many of the other countermeasures discussed above.

NCDOT has used road diets in the past, but the popularity is questionable. NCDOT maintains a list of completed road diet projects and most have been four-lane undivided that were modified to three lanes.

RECOMMENDATION #21: NCDOT should continue to use road diets while making general criteria for their use more readily available in NCDOT resources. Guidance and design materials should also incorporate the pedestrian concerns and benefits of road diets. The DBPT within NCDOT will be responsible for leading this effort.

6

Policy Recommendations

"Institutionalization" is the integration of pedestrian considerations into agency policies, plans, projects and programs. The intent is to make walking and pedestrian safety a "mainstream" activity.

The following implementation strategies provide a roadmap for implementation of this Plan through institutionalization, with the intent of making pedestrian safety a routine part of all NCDOT activities.

Policy and Planning Documents

In addition to FHWA, AASHTO and MUTCD guidance, NCDOT has developed agency policy and planning guidance on transportation related topics. They define approaches to solving safety problems, setting priorities and providing decision making guidance. Policy and planning documents provide a means to increase awareness of pedestrian safety issues while also providing specific objectives for reducing injuries and fatalities.

At any given time, one or more policy, planning and other agency documents are undergoing revisions and updates. This is the ideal time to make changes that begin to institutionalize pedestrian considerations and safety.

The following documents and policies are either being revised, are scheduled to be revised, or are completely new documents.

- » NCDOT Long-range Transportation Plan
- » NCDOT Strategic Highway Safety Plan
- » Walk/Bike NC
- » Policies: Complete Streets Policy, Greenway Accommodation Policy, Bridge Policy, Bicycle Policy, and Pedestrian Policy

RECOMMENDATION #22: For each of these documents, when NCDOT updates or revises these plans and policies, they will review for opportunities to include policy support and planning guidance for improving pedestrian safety, with the intent of reducing pedestrian injuries and fatalities. Additionally, there are dozens of MPO, community and county bicycle and pedestrian plans that should be reviewed for opportunities to incorporate pedestrian safety measures. The DBPT within NCDOT will be responsible for leading this effort.

NCDOT Design and Traffic Manuals

In addition to FHWA, AASHTO and MUTCD guidance, NCDOT has developed design and traffic manuals. These manuals are the most used resources for engineers within the Department and incorporating countermeasure considerations into these manuals is one of the key steps to making their use routine. NCDOT provides design guidance and standards that addresses the design of roadway crossings at

uncontrolled locations to maximize pedestrian safety and access. These include:

- » NCDOT Complete Streets Guidance
- » Standard Practices (Mid-block standard practice)– Traffic Engineering, Mobility and Safety Group/Team
- » Pedestrian Crossing Guide
- » Highway Design Manual
- » Traffic Engineering Policies, Practices, and Legal Authority (TEPPL)

NCDOT Design and Traffic Manuals provide design guidance and standards that ensure roadway crossings at uncontrolled locations are designed to maximize pedestrian safety and access.

RECOMMENDATION #23: NCDOT will update manuals where needed to reflect national best practices. More specifically, the Pedestrian Crossing Guide is an excellent resource and could be selectively updated to consider the STEP recommendations made in this plan –adapting STEP recommendations to fit into the existing NCDOT approach. Additionally, recommendations made earlier in this plan called for the preparation of a complete crosswalk policy statement and procedure which can be completed by mainly putting existing and disparate parts together into one policy statement and procedure. The DBPT within NCDOT will be responsible for leading this effort.

Annual Resurfacing Programs, Reconstruction, and HSIP

Integrating pedestrian facilities into routine reconstruction and resurfacing projects as part of the North Carolina highway improvement program, and in some case using Road Diets, is a cost-effective way to institutionalize pedestrian facilities into projects.

NCDOT has not routinely reviewed projects for opportunities to include pedestrian improvements at marked crosswalks at uncontrolled locations; however, the DBPT has been invited to take part in roadway scoping meetings.

RECOMMENDATIONS #24: NCDOT will improve its consideration of STEP measures as part of its project development process for highway projects. Of the five countermeasures, enhancing crosswalks are the most universally viable option for projects because of the low cost and ease of implementation. However, if certain state highway projects are considered for road diets or involve reconstruction, additional small to moderate-scale STEP measures (pedestrian refuge islands and corner bump-outs) may become feasible.

Also, NCDOT will consider including minor STEP treatments as part of resurfacing projects since they add only a small fraction of the overall cost of the project and folding in countermeasures can allow DOTs to take advantage of lower unit costs. NCDOT will review its project development process to consider the following:

- » Inclusion of Complete Streets and STEP (pedestrian crossings) checkbox in roadway scoping project documents; and,
- » Revisit discussions on cost contributions for Complete Streets and pedestrian-focused crossing treatments; and,
- » Conduct annual quality control evaluation of projects to examine how these projects have been considered for bicycle and pedestrian accommodations in general, and more specifically for STEP countermeasures; and,
- » Make better use of HSIP funds to implement STEP countermeasures as part identified high priority intersections.

The DBPT within NCDOT will be responsible for leading this effort.

American Disabilities Act (ADA) Transition Plan

The NCDOT ADA Transition Plan ensure that all pedestrian facilities will become accessible over time. Implementation of the ADA Transition Plan also provides an opportunity to make safety improvements that benefit all pedestrians. According to ADA requirements, whenever streets are resurfaced, ramps and other accessibility improvements must be made; this activity opens opportunities for crosswalk countermeasures. The NCDOT Transition Plan was updated in 2015.

RECOMMENDATION #25: NCDOT will consider recommending STEP countermeasures as part of its ADA review of projects. This is especially true for low-cost countermeasures such as crosswalk enhancements (high visibility crosswalk markings, crosswalk signage, etc.). Crosswalks are the extension of curb ramps so there is a strong and logical tie between those two facilities. The DBPT within NCDOT will be responsible for leading this effort.

Public Involvement as an Implementation Strategy

NCDOT recognizes that public involvement is another excellent tool to get a better product. It also builds public support for programs and policies to reduce pedestrian crashes. To be effective, stakeholders must feel they are heard.

The NCDOT routinely solicits public comment on upcoming projects. The Walk/Bike NC plan has a robust outreach effort as it has reached an extraordinary high number of people.

RECOMMENDATION #26: No changes recommended other than to involve pedestrian stakeholders in all planning and safety programming efforts.

Request for Proposals (or Qualifications) – RFPs (or RFQs)

Including experts in pedestrian transportation planning on consulting teams for major public works ensures that opportunities for making pedestrian improvements are maximized. This can be accomplished by making sure the requests for proposals or qualifications (RFPs or RFQs) that are issued by NCDOT include a requirement for pedestrian transportation expertise.

RECOMMENDATION #27: NCDOT will examine its standardized RFP solicitation process to ensure that RFPs and RFQs include appropriate requests for pedestrian design expertise. The DBPT within NCDOT will be responsible for leading this effort.

Ongoing Training

NCDOT recognizes that the field of pedestrian transportation planning and design is changing rapidly as new research is completed and innovative approaches are implemented. To take advantage of these changes and state-of-the-art practices, NCDOT needs to support training. Currently, NCDOT uses ITRE as key resource for training materials and for delivering training. The followed have been developed or delivered by NCDOT or ITRE:

- » Pedestrian Crossing Assessments
- » Non-motorized data monitoring program development
- » Pedestrian safety crosswalk enforcement operations
- » Developing a Pedestrian Safety Action Plan
- » Designing for Pedestrian Safety
- » Pedestrian Planning and Design
- » Designing Facilities for Pedestrian Accessibility

RECOMMENDATION #28: NCDOT will review their current trainings to make sure they include STEP

countermeasures. NCDOT will increase the frequency of trainings, conduct more shorter length webinar trainings, and host the ActiveTrans Priority Tool (APT)¹ webinar. Additionally, as FHWA continues to develop and update training materials on how to improve pedestrian safety (presentations at conferences, virtual and in-person workshops, and written materials), NCDOT will continue to assess its own training materials to keep its training program current. The DBPT within NCDOT will be responsible for leading this effort either as part of the Complete Streets training, webinars, or separate workshops.

Ongoing Research

NCDOT has a history of conducting research on a variety of safety issues and applying that research to enhance the safety of all modes of transportation including pedestrians. Throughout this plan, there have been numerous examples showcasing the importance and application of research, including but limited to crash reporting and analysis, pedestrian crash analysis, non-motorized counting research, and the development of the Pedestrian Crossing Guidance, etc. Research is often paramount to implementation, but will also follow implementation to gauge performance. This plan will rely on research to further implement and develop tools to support the plan's recommendations.

RECOMMENDATION #29: NCDOT will continue to support research activities internally and within the research units of the state's university system. This research will not be just limited to traditional research and the development of pedestrian safety tools, but will include the critical analyses that underpins the support and justification for new or updated policy, procedures, or directives.

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¹ Pedestrian and Bicycle Information Center. ActiveTrans Priority Tool: A Model Methodology for Prioritizing Pedestrian and Bicycle Improvements on Existing Roads. 2014. Retrieved from http://www.pedbikeinfo.org/training/webinars_PBIC_LC_120414.cfm

Glossary

AVERAGE ANNUAL DAILY TRAFFIC (AADT)

The total volume of traffic passing a point or segment of a highway facility in both directions for one year divided by the number of days in the year.

AVERAGE DAILY TRAFFIC (ADT)

The average 24-hour volume of traffic passing a point or segment of a highway in both directions.

COMPLETE STREETS

Complete Streets are designed and operated to enable safe access for all users, including pedestrians, bicyclists, motorists, and transit riders of all ages and abilities. (Smart Growth America, National Complete Streets Coalition).

CONTROLLED PEDESTRIAN CROSSING

A pedestrian crossing where motorists are required to stop by either a STOP sign, traffic signal, or other traffic control device.

CRASH MODIFICATION FACTOR (CMF)

A multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure. If available, calibrated or locally developed State estimates may provide a better estimate of effects for the State. (Crash Modification Factors Clearinghouse).

CRASH REDUCTION FACTOR (CRF)

The percentage crash reduction that might be expected after implementing a given countermeasure at a specific site.

CURB EXTENSIONS

A roadway edge treatment where a curb line is bulbed out toward the middle of the roadway to narrow the width of the street. Curb extensions are sometimes called “neckdowns.”

HIGHWAY SAFETY IMPROVEMENT PROGRAM (HSIP)

A Federal-aid program with the purpose to achieve a significant reduction in traffic fatalities and serious injuries on all public roads, including non-State-owned roads and roads on tribal land. The HSIP requires a data-driven, strategic approach to improving highway safety on all public roads with a focus on performance. (FHWA).

HIGH VISIBILITY CROSSWALK

A pedestrian crossing location marked by patterns such as zebra, ladder, or continental markings as described by the MUTCD.

MARKED CROSSWALK

A pedestrian crossing that is delineated by white crosswalk pavement markings.

PARKING RESTRICTION

Parking restriction can include the removal of parking space markings, installation of new “parking prohibition” pavement markings or curb paint, and signs.

PEDESTRIAN HYBRID BEACON (PHB)

A traffic control device with a face that consists of two red lenses above a single yellow lens. Unlike a traffic signal, the PHB rests in dark until a pedestrian activates it via pushbutton or other form of detection.

RAISED CROSSWALK

Raised crosswalks are ramped speed tables spanning the entire width of the roadway, often placed at midblock crossing locations.

REFUGE ISLAND

A median with a refuge area that is intended to help protect pedestrians who are crossing the road. This countermeasure is sometimes referred to as a crossing island or pedestrian island.

ROAD DIET

A roadway reconfiguration resulting in a reduction in the number of travel lanes. The space gained by eliminating lanes is typically used for other uses and travel modes (FHWA).

ROAD SAFETY AUDIT (RSA)

A formal examination of an existing or future road or intersection by a multidisciplinary team. It qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users (FHWA).

TOWARD ZERO DEATHS (TZD)

TZD is a traffic safety framework that seeks to eliminate highway fatalities by engaging diverse safety partners and technology to address traffic safety culture (also see Vision Zero).

UNCONTROLLED PEDESTRIAN CROSSING

An established pedestrian crossing that does not include a traffic signal, beacon, or STOP sign to require that motor vehicles stop before entering the crosswalk.

VEHICLE QUEUE

A line of stopped vehicles in a single travel lane, commonly caused by traffic control at an intersection.

VISION ZERO (VZ)

Similar to TZD, Vision Zero is a vision to eliminate traffic fatalities and serious injuries within the transportation system. VZ employs comprehensive strategies to address roadway design, traffic behavior, and law enforcement.

Appendix: CRF and CMF Summary Table

Table 3. CRFs and CMFs by countermeasure.

Countermeasure	CRF	CMF	Basis	Reference
Crosswalk visibility enhancement ¹	—	—	—	—
Advance STOP/YIELD signs and markings	25%	0.75	Pedestrian crashes ²	Zegeer, et. al. 2017
Add overhead lighting	23%	0.77	Total injury crashes	Harkey, et. al. 2008
High-visibility marking ³	48%	0.52	Pedestrian crashes	Chen, et. al., 2012
High-visibility markings (school zone) ³	37%	0.63	Pedestrian crashes	Feldman, et. al. 2010
Parking restriction on crosswalk approach	30%	0.70	Pedestrian crashes	Gan, et. al., 2005
In-street Pedestrian Crossing sign	UNK	UNK	N/A	N/A
Curb extension	UNK	UNK	N/A	N/A
Raised crosswalk (speed tables)	45%	0.55	Pedestrian crashes	Elvik, et. al., 2004
	30%	0.70	Vehicle crashes	
Pedestrian refuge island	32%	0.68	Pedestrian crashes	Zegeer, et. al., 2017
PHB	55%	0.45	Pedestrian crashes	Zegeer, et. al., 2017
Road Diet – Urban area	19%	0.81	Total crashes	Pawlovich, et. al., 2006
Road Diet – Suburban area	47%	0.53	Total crashes	Persaud, et. al., 2010
RRFB	47%	0.53	Pedestrian crashes	Zegeer, et. al., 2017

¹This category of countermeasure includes treatments which may improve the visibility between the motorist and the crossing pedestrian.

²Refers to pedestrian street crossing crashes, and does not include pedestrians walking along the road crashes or “unusual” crash types.

³The effects of high-visibility pavement markings (e.g., ladder, continental crosswalk markings) in the “after” period is compared to pedestrian crashes with parallel line markings in the “before” period.

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3. R. Srinivasan, B. Lan, D. Carter, S. Smith, C. Sundstrom, N.J. Thirsk, J. Zegeer, C. Lyon, E. Ferguson, and R. Van Houten. NCHRP Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. NCHRP, Transportation Research Board, Washington, DC, 2017.

Resources

[EDC Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations \(2018\)](#)

This guide assists State or local transportation or traffic safety departments that are considering developing a policy or guide to support the installation of countermeasures at uncontrolled pedestrian crossing locations. This document provides guidance to agencies, including best practices for each step involved in selecting countermeasures. By focusing on uncontrolled crossing locations, agencies can address a significant national safety problem and improve quality of life for pedestrians of all ages and abilities. Agencies may use this guide to develop a customized policy or to supplement existing local decision-making guidelines

[FHWA How to Develop a Pedestrian and Bicycle Safety Action Plan \(2017\)](#)

The purpose of this guide is to assist agencies in developing and implementing a safety action plan to improve conditions for bicycling and walking. The plan lays out a vision for improving safety, examining existing conditions, and using a data-driven approach to match safety programs and improvements with demonstrated safety concerns. This guide will help agencies enhance their existing safety programs and activities, including identifying safety concerns and selecting optimal solutions. It will also serve as a reference for improving pedestrian and bicycle safety through a multidisciplinary and collaborative approach to safety, including street designs and countermeasures, policies, and behavioral programs.

[NCHRP Report 803: Pedestrian and Bicycle Transportation Along Existing Roads—ActiveTrans Priority Tool Guidebook \(2015\)](#)

This resource includes an interactive tool and guidance to help agencies prioritize pedestrian and bicycle improvements, including safety projects, either as standalone or incidental to a roadway project.

[FHWA Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts \(2016\)](#)

This resource focuses on flexibility and options for the design of pedestrian and bicycle networks designed to minimize crash conflicts, including case studies to illustrate various design treatments.

[FHWA State SHSP Resources](#)

The FHWA Office of Safety posts a link to each State's current SHSP. This website also lists noteworthy practices. Many SHSP plans provide an emphasis on pedestrians and contain goals for reducing traffic fatalities and injuries.

[FHWA HSIP Resources](#)

The HSIP includes the projects selected for implementation, an evaluation of past projects, and an annual status report. Projects can include pedestrian safety improvement programs and projects. For example, the 2016 Oregon HSIP Annual Report details how the its All Roads Transportation Safety Program sets aside funding to address systemic pedestrian crash locations.

[State HSP Documents](#)

NHTSA posts the States' current HSP outlining non-infrastructure strategies for improving roadway safety. A State HSP is likely to contain a pedestrian fatality and injury reduction goal, an associated performance measure, and describe non-infrastructure initiatives like enforcement and education programs. For example, Colorado DOT's 2017 HSP (called the 2017 Integrated Safety Plan) supports the Denver Police Department's "Decoy Pedestrian Program" to enforce driver yielding compliance at high-crash pedestrian crossings.

[Manual on Uniform Traffic Control Devices \(MUTCD\)](#)

This manual provides transportation engineers and planners with detailed guidance for the design and application of traffic control devices, including signage, roadway markings, and intersection controls. Refer to the specific sections of the MUTCD listed in the countermeasure descriptions and consult State-level supplements for additional information.

[PEDSAFE: Pedestrian Crash Typing](#)

PEDSAFE provides definitions for 12 key pedestrian crash types identified by the software package, the Pedestrian and Bicycle Crash Analysis Tool (PBCAT). PBCAT is still used by many agencies but may not be compatible with some current operating systems.

[NHTSA Pedestrian Safety Information](#)

NHTSA publishes annual reports summarizing the latest pedestrian fatality statistics. These statistics are based on FARS and the reports describe pedestrian fatality trends per different socioeconomic groups and for each State.

[Walkability Checklist](#)

This tool can be used by community leaders during a walkability audit to evaluate pedestrian infrastructure and traffic behavior.

[FHWA Model Road Safety Audit Policy \(2014\)](#)

This resource outlines the steps typically taken to conduct an RSA and the roles of the stakeholders. Identifying safety issues is an element of the RSA that is accompanied by suggestions on how to enhance the specific road's safety.

[Vision Zero Network](#)

This collaborative website posts case studies and tracks cities who are implementing Vision Zero plans or goals. The Vision Zero Network website also notes best practices by agencies who are working to eliminate traffic fatalities and serious injuries. Vision Zero goals are accompanied by policies, strategies, and target

dates. For example, Columbia, Missouri's Vision Zero Action Plan contains an outreach campaign to educate pedestrians and drivers on new and potentially confusing infrastructure improvements like pedestrian hybrid beacons and enhanced pedestrian crosswalks.

[Countermeasure Selection System](#)

This online tool includes links to research studies, crash reduction statistics, and case studies for nearly 70 pedestrian safety countermeasures. Its Countermeasure Selection Tool provides countermeasure recommendations for uncontrolled crossing locations based upon variables such as AADT, vehicle speed, and number of lanes.

[Highway Safety Manual](#)

This manual provides detailed guidance for the collection, analysis, and evaluation of roadway crash data, as well as related CMFs and treatment selection guidance.

[FHWA Road Diet Desk Reference \(2015\)](#)

This resource includes sample policy, case studies, and design guidance for agencies and decision-makers considering Road Diets. The benefits of Road Diets include reducing vehicle speeds, reducing number of lanes to cross, and allocating space for pedestrian refuge island.

[FHWA Design Resource Index](#)

This resource directs practitioners to the specific location of information about pedestrian and bicycle treatments or countermeasures, across various design guidelines published by organizations such as AASHTO, the Institute of Transportation Engineers, and National Association of City Transportation Officials.

[TCRP REPORT 112/NCHRP REPORT 562: Improving Pedestrian Safety at Unsignalized Crossings \(2006\)](#)

This document recommends treatments to improve safety for pedestrians crossing high-volume, high-speed roadways at unsignalized intersections, with

particular focus on roadways served by public transportation.

[AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, 1st Edition \(2004\)](#)

This guide provides recommendations for the planning, design, and operation of accommodations for pedestrians on public rights-of-way. This guide also discusses the impact of land use and site design on pedestrian safety and connectivity

[FHWA Federal-aid Program Administration](#)

This website includes links to guidance for local and State governments administering federally-funded projects, such as those funded by HSIP or STBG.

[Pedestrian RSA Guidelines and Prompt Lists \(2007\)](#)

This resource complements practices for RSAs with additional guidance and a field manual for a pedestrian-focused RSA. An RSA team will use the knowledge of a diverse team, analysis of crash data, and a site visit to identify pedestrian safety issues.

[Pedestrian RSA Case Studies \(2009\)](#)

This website provides links to several examples of RSAs focused on identifying pedestrian safety risks and improvement strategies. For example, the City of Tucson, Arizona conducted an RSA of roadways with PHBs to improve the countermeasures' visibility and usability.

[FHWA Pedestrian and Bicycle Funding Opportunities Summary \(2016\)](#)

This resource includes a matrix comparing eligibility of various federal transportation funding programs for different types of bicycle and pedestrian projects.

[FHWA Guidebook for Developing Pedestrian and Bicycle Performance Measures \(2016\)](#)

This resource identifies a wide variety of potential metrics for setting goals, prioritizing projects and evaluating outcomes of bicycle and pedestrian plans, including plans for pedestrian safety improvements. Performance measures may include pedestrian levels of service or pedestrian fatality rates.

[NCHRP Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments \(2017\)](#)

This report describes the safety benefits and CMFs for four types of pedestrian crossing treatments—rectangular rapid flashing beacons, PHBs, pedestrian refuge islands, and advance crosswalk signs and pavement markings.

[NCHRP Synthesis 498: Application of Pedestrian Crossing Treatments for Streets and Highways \(2016\)](#)

This is a compilation of existing practices regarding the selection and implementation of pedestrian crossing improvements, as well as a literature review of research on more than 25 pedestrian crossing treatments.

[NHTSA "A Primer for Highway Safety Professionals" \(2016\)](#)

This resource outlines a comprehensive approach to improving safety for bicyclists and pedestrians and offers a summary of the most frequently used engineering, enforcement, and education safety measures. The resource identifies how certain treatments may be placed in relation to other treatments, such as the coordinated installation of a pedestrian refuge island and lighting.



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