NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 356

Pavement Markings — Design and Typical Layout Details

A Synthesis of Highway Practice

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SUBJECT AREAS
Highway Operations, Capacity, and Traffic Control

Research Sponsored by the American Association of State Highway and Transportation Officials
in Cooperation with the Federal Highway Administration

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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FOREWORD

By Staff
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Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis identifies variations in pavement marking designs, practices, and policies, as provided by 48 of 50 state departments of transportation, and transportation agencies from the District of Columbia, Puerto Rico and four cities. This information will be valuable to FHWA and the National Committee on Uniform Traffic Control Devices as they consider the need for revisions to the 2008 edition of Part 3 of the *Manual on Uniform Traffic Control Devices.* In addition, the information will be useful to state and local government agencies as they develop or revise their pavement marking design standards. This synthesis does not specifically address the safety aspects or cost-effectiveness of the pavement marking layout policies and practices of the various agencies.

This synthesis report contains information derived from a survey questionnaire distributed to all 50 state transportation agencies, the District of Columbia, Puerto Rico, and four large cities; a literature review; and interviews.

Bruce E. Friedman, PTOE, Kimley–Horn and Associates, Inc., Raleigh, North Carolina, collected and synthesized the information and wrote the report under the guidance of a panel of experts in the subject field. The members of the oversight panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

CHAPTER ONE

INTRODUCTION

BACKGROUND

Most of the 50 states and many local governments have developed their own designs, detailed layout schemes (typical drawings), and associated practices for pavement markings. These designs, layout details, and practices are usually more specific than the requirements of the national *Manual on Uniform Traffic Control Devices* (*MUTCD*) (2003). The *MUTCD* provides general guidance and/or minimum or maximum dimensions for certain markings, spacing of markings, combinations of markings, and patterns. Among the more detailed designs, layout details, and associated practices that are found in many of the state and local documents are:

- Methods of delineating turn lane channelization,
- Patterns and spacing of lane-use turn arrows and ONLY word markings,
- Patterns and spacing of crosswalk markings and stop lines,
- Patterns and spacing of turn arrows in two-way left-turn lanes,
- Patterns and dimensions of chevrons and diagonal lines,
- Methods of delineating climbing and passing lanes, and
- Methods of delineating entrance ramp and exit ramp gores.

The purpose of this synthesis was to identify variations in pavement marking designs, practices, and policies of each state department of transportation (DOT) and agencies in the District of Columbia, Puerto Rico, and several large cities and counties. From the information contained in this synthesis, common and differing practices and ranges of typical placement dimensions can be identified. This compilation and synthesis of information (which has been unavailable to date) will be highly valuable to FHWA and to the National Committee on Uniform Traffic Control Devices as these organizations consider the need for revisions to Part 3 of the *MUTCD* to add more specificity to the national standards for pavement markings and, where appropriate, to codify the most common policies, practices, and applications of pavement markings. In addition, state and local government agencies can use this information to determine the most common policies and practices in each area of interest as they develop or revise their pavement marking design standards.

Many state DOTs, the District of Columbia, and Puerto Rico provide information on pavement markings, and supplements to the national and state *MUTCDs* on their websites. These websites were accessed and the pertinent pavement marking information for the various areas of interest to this synthesis was obtained and inventoried. The information that was important, but was not provided, was then requested from all 50 states. These requests resulted in additional information being obtained, either by means of hard-copy documents or through the identification of website addresses that had not previously been visited.

Information was also sought from a number of large cities and counties to obtain a sense of the policies and practices that are specific to urban situations. Information was obtained and used in this synthesis from four local governmental agencies:

- City of Charlotte, North Carolina
- City of Los Angeles, California
- City of New York, New York
- City of Tucson/Pima County, Arizona.

Throughout this synthesis, the term "design standards" is used generically to refer to all of the various types of policies and practices regarding pavement marking layouts that are published by the agencies represented herein. As can be seen in the bibliography, these documents have a wide variety of actual titles, including design standards, traffic manuals, standard designs, standard plans, design details, typical drawings, standard construction drawings, design manuals, state *MUTCDs,* and supplement to the *MUTCD.* However, in this synthesis, for clarity and convenience, all of these various publication titles are generically referred to as design standards.

To provide maximum clarity, the terms upstream and downstream are frequently used in this synthesis to describe the pavement marking layout policies and practices. For example, when the phrase "the end of the lane line separating the turn lane from the through lane" is used, the reader could interpret this to be the end of the lane line at the stop line or the end of the lane line in the turn lane taper area. However, if the reader keeps in mind that traffic always flows from upstream to downstream, the phrase "the downstream end of the lane line separating the turn lane from the through lane" can only be interpreted to be the end at the stop line. Figure 1 illustrates the meanings of the terms "upstream" and "downstream" as used in this synthesis.

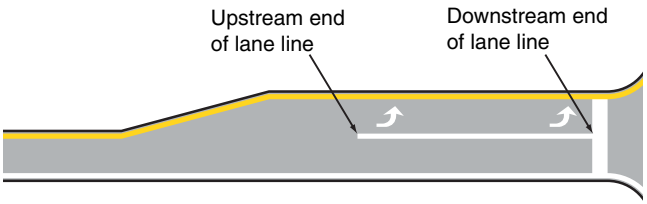


FIGURE 1 Illustration of terms upstream and downstream.

This synthesis is *not* intended to be used by practitioners as a design guideline when they are developing pavement marking plans in the various states. The information in this synthesis is essentially a "snapshot" of current state and local government policies and practices in effect in late 2004 and early 2005. These policies and practices are subject to change, with many agencies indicating that they were in the process of revising their design standards at the time the information in this synthesis was requested. However, practitioners can visit the websites listed in the bibliography to obtain the latest design standards for the various agencies that maintain these websites.

This report addresses only the information that was found in the various policies and practices regarding pavement marking layouts that are published by the agencies represented in this synthesis. Existing pavement markings and the actual implementation of new pavement markings within a particular state might vary from the state's published policies and practices, particularly in small- to medium-sized towns and cities and in the various districts throughout the state. No attempt has been made to discover or document any variations from the published policies and practices within the geographical areas of the agencies represented.

In addition, this synthesis does not specifically address the safety aspects or the cost-effectiveness of the various pavement marking layout policies and practices of the agencies. It also does not provide any value judgments regarding whether certain policies and practices are superior or inferior when compared with the policies and practices of other agencies.

ORGANIZATION

In the following four chapters, information regarding the pavement marking policies and practices of most of the 50 states, the District of Columbia, Puerto Rico, and four local government agencies are presented. In each case, the agencies are identified using the postal service two-letter abbreviations for the 50 states (as identified in the Glossary in this report), with DC used for the District of Columbia, PR for Puerto Rico; CLT for Charlotte, North Carolina; LAN for Los Angeles, California; NYC for New York City, New York; and TUC for Tucson/Pima County, Arizona.

In Chapters two, three, and four, the provisions found in the 2003 *MUTCD* regarding each area of interest are presented first, followed by the policies and practices of each of the 54 government agencies that provided information for the synthesis. Because there was no area of interest in this synthesis for which all 54 agencies had a policy or practice, the number of agencies for which a policy or practice was found in their design standards is shown after each subheading throughout these chapters.

Chapter two details the pavement markings associated with intersections, including lane lines, turn arrows, and ONLY word markings in turn lanes, dual turn lanes, and dropped lanes; dotted lines in turn lane tapers; crosswalks; stop lines; formation of left-turn lanes between the through lanes on two-lane highways; and right-turn channelizing islands.

Chapter three reviews the pavement markings associated with sections of streets and highways between intersections, including midblock crosswalks; passing and no-passing zones; two-way left-turn lanes; climbing and passing lanes; lane reductions; and painted medians, paved shoulders, and approaches to obstructions.

Chapter four details the pavement markings associated with the paved gores for entrance and exit ramps at interchanges.

Chapter five examines miscellaneous arrows and symbols, word markings, and pavement marking treatments that are not specifically addressed in the provisions of the *MUTCD*.

Chapter six presents the conclusions of the synthesis and lists other types of pavement markings that were not included in this synthesis. This chapter also presents suggestions for future research.

Appendix A contains the 16 figures from Chapter 3B of the 2003 *MUTCD* that are referenced throughout this synthesis.

Appendix B is a listing of the Standards from Chapter 3B of the 2003 *MUTCD* that are referenced in this synthesis.

Appendix C is a table that was used during this synthesis to inventory the information that was received from the 54 agencies that supplied information. The numbers in this table will assist the reader in finding the desired information in each agency's design standards.

Appendixes D through R present complete descriptions of each agency's policy or practice for each area of interest. The appendixes are arranged by area of interest and the agency information is presented in alphabetical order within each area of interest. Agencies for which no policies or practices concerning a particular area of interest could be found are identified at the end of each appendix.

CHAPTER TWO

PAVEMENT MARKINGS AT INTERSECTIONS

TURN LANES

Figure 2 illustrates some of the characteristics of turn lanes and their associated pavement markings.

2003 *MUTCD* Provisions

The *MUTCD* does not require or recommend a specific type or width of lane line turn lanes and adjacent through lanes. Figures 3B-7, 3B-11, and 3B-22 show a normal solid lane line between the turn lane and the adjacent through lane. Figures 3B-11 and 3B-22 show the upstream end of the solid lane line to be lined up with the upstream end of the full-width turn lane (see Appendix A for figures).

Paragraphs 3 and 4 of Section 3B.04 contain the following standards: "Where crossing the lane line markings with care is permitted, the lane line markings shall consist of a normal [4- to 6-in.-wide] broken white line. Where crossing the lane line markings is discouraged, the lane line markings shall consist of a normal [4- to 6-in.-wide] solid white line."

Paragraphs 5 and 6 of Section 3B.04 contain the following options: "Solid white lane line markings may be used to separate through traffic lanes from auxiliary lanes, such as uphill truck lanes, left- or right-turn lanes, and preferential lanes. They may also be used to separate traffic lanes approaching an intersection. Wide [8- to 12-in.-wide] solid lane line markings may be used for greater emphasis."

For turn lanes where a through lane becomes a mandatory turn lane, the legends in Figures 3B-11 and 3B-22 note that the use of turn arrows is required, and the legend for Figure 3B-22 states that the use of ONLY word markings is optional. For separate left-turn bays, the legends in Figures 3B-7, 3B-11, and 3B-22 note that the use of turn arrows is optional.

Paragraph 14 of Section 3B.19 contains the following standard: "Where through traffic lanes approaching an intersection become mandatory turn lanes, lane-use arrow markings (see Figure 3B-21) shall be used and shall be accompanied by standard signs." Although this standard is universally followed, no standard is given regarding the use of ONLY word markings or the number or placement of turn arrows.

Paragraphs 17 and 18 of Section 3B.19 contain the following options: "Lane-use arrow markings (see Figure 3B-21) may be used to convey either guidance or mandatory messages. The ONLY word marking (see Figure 3B-20) may be used to supplement lane-use arrow markings (see Figure 3B-22)."

Paragraph 23 of Section 3B.19 contains the following support: "Lane-use arrow markings are often used to provide guidance in turn bays (see Figure 3B-22), where turns may or may not be mandatory, and in two-way left-turn lanes (see Figure 3B-7)."

Paragraph 6 of Section 3B.19 contains the following guidance: "Except for the two opposing arrows of a two-way left-turn lane marking (see Figure 3B-7), the longitudinal space between word or symbol message markings, including arrow markings, should be at least four times the height of the characters for low-speed roads, but not more than ten times the height of the characters under any conditions." Because both the left-turn (or right-turn) arrow symbol and the ONLY word marking typically have a height of 6 to 8 ft, this guidance essentially states that the space between word or symbol message markings should be no less than 24 to 32 ft and no more than 60 to 80 ft.

Type of Lane Line Between a Turn Bay and Adjacent Through Lane (47 agencies)

Except for the five agencies cited here, the design standards consistently show only a solid lane line between a turn bay and the adjacent through lane.

The design standards for South Carolina show a broken lane line (10-ft segments with 30-ft gaps) being used between the turn lane and the adjacent through lane.

The design standards for Maryland state that the solid lane line between the turn lanes and the adjacent through lane starts at the stop line and ends at the halfway point of the full-width turn lanes. A dotted line (3-ft segments with 9-ft gaps) may be used from the halfway point to the upstream end of the full-width turn lanes.

The design standards for New Hampshire show a broken lane line (10-ft segments with 30-ft gaps) being used upstream of the upstream end of the solid lane line between the turn lane and the adjacent through lane, even for turn bays. The length of the broken lane line is based on the posted speed limit.

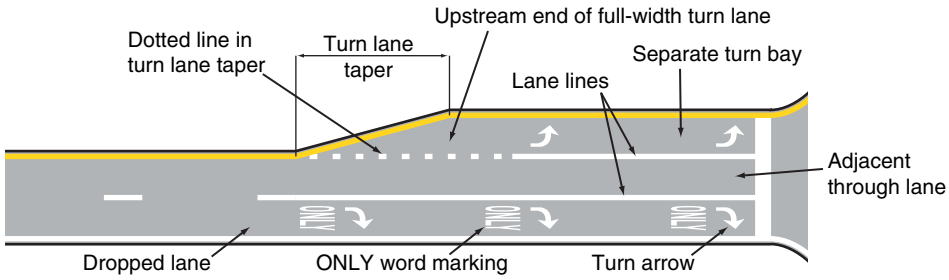


FIGURE 2 Characteristics of turn lanes.

The design standards for North Carolina show that if the length of the full-width turn lane is more than 250 ft, the solid lane line starts at the stop line and ends 250 ft upstream from the stop line. A 4- or 6-in.-wide dotted line (2-ft segments with 13-ft gaps) starts at the upstream end of the solid lane line and ends at the upstream end of the left-turn lane taper.

The design standards for West Virginia show that a solid lane line with a maximum length of 200 ft is used between the turn lane and the adjacent through lane. A broken lane line (10-ft segments with 30-ft gaps) is used between the turn lane and the adjacent through lane upstream of the solid lane line for the remainder of a full-width turn lane that is longer than 200 ft.

Width of Lane Line Between a Turn Bay and Adjacent Through Lane (31 agencies)

The following widths are explicitly specified in the design standards for the lane line between a turn bay and the adjacent through lane:

AR, DE, IN, ME, MI, NE, SD, TN, VT—4 in.
NC, PA—4 or 6 in.
FL, KS—6 in.
WV—6 to 8 in.
AL—6 or 8 in.
AK, CA, CO, ID, LA, MT, NV, ND, OH, OR, TX, UT, WI, WY, DC—8 in.
AZ—12 in.

Length of Lane Line Between a Turn Bay and Adjacent Through Lane (26 agencies)

The following points (measured downstream from the upstream end of the full-width turn lane) are explicitly specified in the design standards for the upstream end of the solid lane line between a turn bay and the adjacent through lane (*L* is the length of the full-width turn lane):

LA—0.5*L*
MD—0.5*L* (an optional dotted line comprised of 3-ft segments with 9-ft gaps may be used from the upstream end of the lane line to the upstream end of the full-width turn lane)
WY (right-turn lanes)—0.5*L* (an optional dotted line comprised of 2-ft segments with 6-ft gaps may be used from the upstream end of the lane line to the upstream end of the right-turn taper)
DE, NV, PA—0.33*L*
MN, WA—50 ft
FL—20 to 120 ft (based on speeds ranging from 35 to 65 mph)
MT—20 ft
ID—10 ft
MI—0 ft for left-turn lanes and 25 ft for right-turn lanes
NC—0 ft for turn lanes that are 250 ft or less in length (for turn lanes longer than 250 ft, the solid lane line ends 250 ft upstream from the stop line)
AK, AZ, NE, OK, SD, TN, VT, VA, WI, WY (left-turn lanes), PR, LAN, TUC—0 ft.

The design standards for Utah state that the solid lane line starts at the stop line and ends at least 100 ft upstream from the stop line.

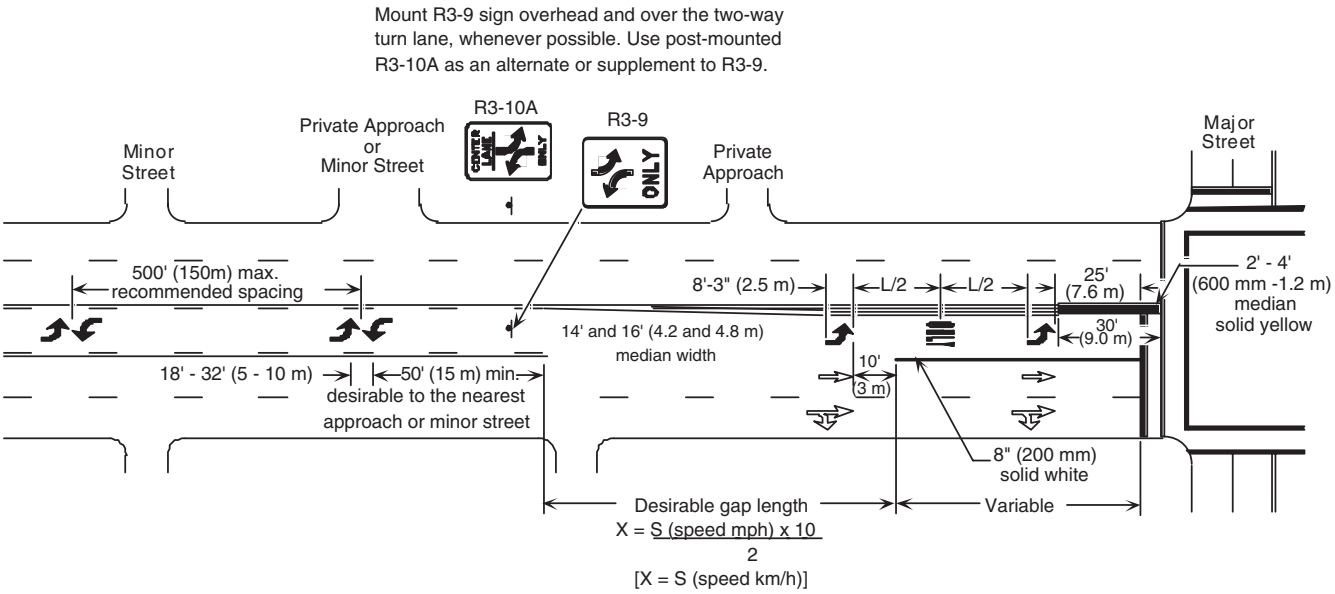
Other Considerations Regarding Lane Lines for Turn Bays (1 agency)

The design standards for Idaho (see Figure 3) show that the centerline on the left-hand side of a turn bay extends beyond the stop line and terminates at the nearest crosswalk line. The last 30 ft of the centerline (including the portion beyond the stop line) is a solid yellow median that is 2 to 4 ft wide (if space is limited, the solid yellow median can be as narrow as 8 in. wide). The double yellow centerline separates into a pair of double yellow centerlines that taper away from each other to connect to the edges of the solid yellow median.

Type of Lane Line Between a Dropped Lane and Adjacent Through Lane (14 agencies)

Except for the four agencies listed here, the design standards consistently show a solid lane line between a dropped lane and the adjacent through lane.

The design standards for California note that an 8-in.-wide solid line preceded by an 8-in.-wide dotted line may be placed in advance of an intersection where the outside lane is dropped as a mandatory turn lane. The dotted line starts



NOTES:
1. Pavement Markings in the through lanes are optional and should be installed only if justified.
2. Two-way left turn lanes should be continuous through "T" intersections, but may be broken for 4-way intersections.
3. Elimination of double yellow reverse curve may be used at the end of two-way left turn lanes at high volume signalized intersections.
4. See Standard Drwg. I-21 for pavement marking details.

FIGURE 3 Solid yellow median used by Idaho DOT (*Source:* 2003 Idaho DOT traffic manual).

where a special RIGHT LANE TURNS RIGHT AHEAD yellow, diamond-shaped warning sign is placed at a distance *D* upstream from the upstream end of the 8-in. solid line. (The distance *D* is the advance placement distance in feet for warning signs per the *MUTCD*.)

The design standards for Maryland state that the normal broken lane line shall become a dotted line (3-ft segments with 9-ft gaps) beginning at the farthest upstream turn arrow, and shall become a solid lane line at the halfway point between the farthest upstream turn arrow and the stop line.

The design standards for Oregon show an 8-in.-wide solid line preceded by an 8-in.-wide dotted line (3-ft segments separated by 9-ft gaps) being placed in advance of an intersection where the outside lane is dropped as a mandatory turn lane.

The design standards for South Carolina show a broken lane line (10-ft segments with 30-ft gaps) being used between a dropped lane and the adjacent through lane.

Width of Lane Line Between a Dropped Lane and Adjacent Through Lane (5 agencies)

The following widths are explicitly specified in the design standards for the solid lane line between a dropped lane and the adjacent through lane:

NC—4 to 6 in.
KS—6 in.
AR, CA, FL—8 in.

Length of Lane Line Between a Dropped Lane and Adjacent Through Lane (2 agencies)

The following lengths are explicitly specified in the design standards for the solid lane line between a dropped lane and the adjacent through lane:

NC—200 ft
KS—561 ft.

Use Versus Non-Use of Turn Arrows in Turn Bays (47 agencies)

Except for the nine agencies listed here, the design standards consistently indicate that the use of turn arrows in turn bays is recommended or required.

The design standards for Tennessee state that turn arrows are typically used in turn bays.

The design standards for five agencies (IA, MD, PA, UT, and WY) state that the use of turn arrows in turn bays is optional.

The design standards for Delaware state that the use of turn arrows in right-turn bays is optional.

The design standards for Colorado show turn bays without turn arrows. However, the design standards also show a curved extension of the lane line partially into the intersection to communicate to drivers when they arrive at the downstream end of the turn bay that they must turn either left or right.

The design standards for South Carolina note that turn arrows are typically not used in turn bays.

Use Versus Non-Use of ONLY Word Markings in Turn Bays (30 agencies)

The design standards for 11 agencies (AK, AZ, AR, MT, NV, NY, ND, VT, WI, DC, and PR) state or show that the use of ONLY word markings in turn bays is required.

The design standards for Tucson/Pima County, Arizona, show that the use of ONLY word markings in turn bays is required for long turn lanes.

The design standards for 12 agencies (AL, ID, IA, ME, MA, OH, OK, OR, PA, UT, WV, and WY) indicate that the use of ONLY word markings in turn bays is optional.

The design standards for six agencies (GA, MD, RI, SC, CLT, and LAN) note that ONLY word markings are not used in turn bays.

Placement of Turn Arrow Nearest to Stop Line in Turn Bays (38 agencies)

The following distances are explicitly specified in the design standards for the distance from the upstream edge of the stop line to the top of the turn arrow nearest to the stop line:

AK, VT—4 ft
NV—8 ft
OH—at least 10 ft from the downstream edge of the stop line in urban areas and at least 30 ft from the downstream edge of the stop line in rural areas
SD—17 ft
ME—20 ft (shown as 6 m) from the downstream edge of the stop line
MA—20 ft (shown as 6 m)
AZ, IN, WI, WY, TUC—20 ft
MT, PA—at least 20 ft
OK—20 ft for turn lanes shorter than 150 ft and 30 ft for longer turn lanes
NY—21 ft (shown as 6.5 m)
GA, ID, CLT—25 ft
MI, KS—at least 25 ft
AL—30 ft
MN—30 to 80 ft for turn lanes longer than 200 ft, and at the midpoint of the full-width turn lane for turn lanes of 200 ft or less in length
TX—typically 32 ft
KY—32 to 80 ft
TN, WA—50 ft
NC—50 ft for long turn lanes
MO—75 ft.

The following distances are explicitly specified in the design standards for the distance from the upstream edge of the stop line to the tip of the arrowhead for the turn arrow nearest to the stop line:

OR—10 ft
FL, IA—25 ft.

The following distances are explicitly specified in the design standards for the distance from the upstream edge of the stop line to the center of the turn arrow nearest to the stop line:

UT—20 ft
MD—50 ft.

The following distances are explicitly specified in the design standards for the distance from the upstream edge of the stop line to the bottom of the turn arrow nearest to the stop line:

NH—40 ft
LA, VA, WV—50 ft.

Placement of Word or Symbol Marking Nearest to Upstream End of Full-Width Turn Lane in Turn Bays (22 agencies)

The following points (measured downstream from the upstream end of the solid lane line between the turn bay and the adjacent through lane) are explicitly specified in the design standards for the bottom (unless otherwise stated) of the word or symbol marking nearest to the upstream end of the full-width turn lane:

CA—near the point of entrance
WA—0 ft (measured to center of arrow)
AL, AK, AZ, DE, ID, KS, SD, VT, VA, PR, LAN, TUC—0 ft
MI, NC—0 ft for long turn lanes
WI—0 or 20 ft depending on the turn lane length
OR—10 ft (measured to tip of arrowhead)
FL—15 ft
MN—20 ft for long turn lanes
TN—25 ft
NY—33 ft (shown as 10 m) for long turn lanes.

Placement of Other Turn Arrows and ONLY Word Markings in Turn Bays (32 agencies)

The term "space between" in this section refers to the unmarked space between the bottom of a word or symbol marking and the top of the next upstream word or symbol marking. The term "interval between" in this section refers to the distance between the top (or center or bottom) of a word or symbol marking and the top (or center or bottom) of the next word or symbol marking.

The following distances are explicitly specified in the design standards for the space between ONLY word markings and the next downstream turn arrow:

VT—4 ft
AK—4 ft for the turn arrow nearest to the stop line and 35 to 80 ft for turn arrows farther upstream based on the speed
NY—5 ft
OR—30 ft
AL, TX, WI, WY—32 ft
MA—32 ft (shown as 9.8 m)
MI—32 ft for 25 mph or less, 48 ft for 30 or 35 mph, 64 ft for 40 or 45 mph, and 80 ft for 50 mph or more
PR—33 ft
ND—typically 44 ft, but no less than 32 ft
IN, PA—four times the character height for low-speed roadways and ten times the character height for high-speed roadways.

The following distances are explicitly specified in the design standards for the interval between ONLY word markings and the next downstream turn arrow:

FL—15 ft
LA—25 ft
UT—30 ft
OK—35 ft for turn lanes shorter than 150 ft and 35 and 55 ft for longer turn lanes
ID, WV—midway between the upstream and downstream turn arrows.

The following minimum spaces between subsequent word or symbol markings are explicitly specified in the design standards:

OH—24 ft in urban areas and 32 ft in rural areas
AZ, KY, NV—32 ft
AL—100 ft.

The following typical spaces between subsequent word or symbol markings are explicitly specified in the design standards:

IL—20 ft in urban areas and 50 ft in rural areas
WY, DC—32 ft
ME—53 ft (shown as 16 m) between turn arrows if ONLY word markings are not used; 33 ft (shown as 10 m) between turn arrows and ONLY word markings if ONLY word markings are used
CLT—50 ft between Turn Arrows 1 and 2 and 3 (where Turn Arrow 1 is the turn arrow nearest to the stop line), and 100 ft between Turn Arrows 3 and 4 and 5 and 6, and 150 ft for any additional upstream turn arrows
WV—72 ft for speeds of 40 mph or less and 168 ft for speeds higher than 40 mph
KS—no less than four times the character height or more than ten times the character height.

The following typical intervals between subsequent word or symbol markings are explicitly specified in the design standards:

UT—30 ft
IA—75 ft between turn arrows (if ONLY word markings are used they are centered in the 75-ft distance between the subsequent arrows)
GA—100 ft (because all turn lanes are required to have at least two turn arrows, a shorter spacing may be used for the second arrow in a short turn lane)
WA—100 ft
LA—125 ft between turn arrows.

The following maximum spaces between subsequent word or symbol markings are explicitly specified in the design standards:

OH—60 ft in urban areas and 80 ft in rural areas
AZ, KY, NV—80 ft
AL—200 ft.

Other Considerations Regarding Arrows and Word Markings in Turn Bays (25 agencies)

The design standards for Arizona state that an ONLY word marking is to be installed midway between the turn arrow nearest the stop line and the turn arrow nearest to the upstream end of the lane line. The turn arrow nearest to the upstream end of the lane line is always required, but the turn arrow nearest to the stop line may be omitted when the length of the turn lane is 150 ft or less.

The design standards for Arkansas show that a 12-in.-wide stop line is used at the end of major street left-turn lanes even if no signals or STOP signs are controlling the approach.

The design standards for California note that an 8-ft-long turn arrow is typically used, but that high approach speeds may justify the use of a 24-ft-long turn arrow.

The design standards for Florida state that for turn lanes where the length of the solid lane line is less than 100 ft, only one turn arrow is used. Two turn arrows are used for turn lanes where the length of the solid lane line is 100 to 150 ft. Three turn arrows are used for turn lanes where the length of the solid lane line is 150 to 200 ft. For turn lanes where the length of the solid lane line is more than 200 ft, an additional turn arrow is added for each additional 100 ft. If more than two turn arrows are used, they are spaced evenly between the first and last turn arrows. ONLY word markings are used in conjunction with lane use arrows where a movement that would otherwise be legal is to be prohibited.

The design standards for Maryland require that for dual turn lanes, turn arrows shall be placed in each lane at the halfway point of the full-width turn lanes. A second set of turn arrows may be placed in each lane halfway between the required arrows and the upstream end of the full-width turn lanes (three-quarters of the distance from the stop line to the upstream end of the full-width turn lanes).

The design standards for Michigan provide a second option for marking turn lanes that consists entirely of word markings. The top of the letters of an ONLY word marking is placed at least 25 ft from the stop line. The top of the letters of a TURN message is placed upstream a distance *D* from the bottom of the letters of the ONLY word marking, and the top of the letters of a LEFT message is placed upstream a distance *D* from the bottom of the letters of the TURN message. The distance *D* is based on the posted speed limit as follows: 32 ft for 25 mph or less, 48 ft for 30 or 35 mph, 64 ft for 40 or 45 mph, and 80 ft for 50 mph or more.

The design standards for Missouri state that two turn arrows are used for the first 200 ft of the turn lane and one additional turn arrow is placed for every additional 400 ft of the turn lane.

The design standards for Montana state that a second turn arrow and ONLY word marking are used if the average annual daily traffic exceeds 5,000 or if the length of the turn lane is more than 150 ft. The distance between turn arrows and ONLY word markings in the turn lane is not specified, but it is clear that each ONLY word marking appears just before the bottom of the turn arrow so that they function as a single message. The spacing between successive sets of turn arrows and ONLY word markings varies with the design speed, and it is suggested that a spacing of approximately four times the character height be used on low-speed facilities (45 mph or less) and up to ten times the character height be used on high-speed facilities (50 mph or more).

The design standards for Nevada note that if the length of the solid lane line is less than 55 ft, a single turn arrow is used and is placed such that the top of the turn arrow is 8 ft from the stop line. If the length of the solid lane line is 55 to 95 ft, an ONLY word marking and a turn arrow are used, with the top of the letters of the ONLY word marking placed 8 ft from the stop line, and the bottom of the turn arrow lined up with the end of the lane line (this is reverse reading with drivers encountering the turn arrow first and the ONLY word marking second). If the length of the solid lane line is more than 95 ft, an alternating series of turn arrows and ONLY word markings are used, with the top of the turn arrow nearest to the stop line placed 8 ft from the stop line and with the spacing between the bottom of subsequent turn arrows or ONLY word markings being 32 to 80 ft from the top of the next turn arrow or ONLY word marking.

The design standards for New Hampshire provide specific layouts of turn arrows and ONLY word markings for the following lengths of solid lane lines between the turn lane and the adjacent through lane: 100, 150, 200, 250, 300, and 350 ft. For a 100-ft lane line, an ONLY word marking and a turn arrow are used, with the bottom of the letters of the ONLY word marking placed 40 ft from the stop line, and the bottom of the turn arrow lined up with the upstream end of the lane line (this is reverse reading, with drivers encountering the turn arrow first and the ONLY word marking second). For 150- and 200-ft lane lines, a turn arrow is placed such that the bottom of the arrow is 40 ft from the stop line, a second turn arrow is placed such that the bottom of the arrow is lined up with the upstream end of the lane line, and an ONLY word marking is placed halfway between the two turn arrows. For 250-, 300-, and 350-ft lane lines, a turn arrow is placed such that the bottom of the arrow is 40 ft from the stop line, a second turn arrow is placed such that the bottom of the arrow is lined up with the upstream end of the lane line, a third turn arrow is placed halfway between the other two turn arrows, and two ONLY word markings are placed at the halfway points between the three turn arrows.

The design standards for New York note that if the length of the full-width turn lane is less than 90 ft, only one turn arrow and ONLY word marking is provided. If the length of the full-width turn lane is between 90 and 135 ft, a second turn arrow and ONLY word marking is provided, with the distance between the top of the second turn arrow 25 to 65 ft (shown as 7.5 to 20 m) from the bottom of the letters of the first ONLY word marking. If the length of the full-width turn lane is between 135 and 250 ft, a second turn arrow and ONLY word marking is provided with the distance between the top of the second turn arrow 65 ft (shown as 20 m) from the bottom of the letters of the first ONLY word marking. If the length of the full-width turn lane is between 250 and 500 ft, a second turn arrow and ONLY word marking is provided, with the distance between the top of the second turn arrow 65 ft (shown as 20 m) from the bottom of the letters of the first ONLY word marking, and a third turn arrow and ONLY word marking is provided, with the bottom of the ONLY word marking being 33 ft (shown as 10 m) downstream from the start of the full-width turn lane.

The design standards for North Carolina state that if the length of the full-width turn lane is less than 125 ft, a single turn arrow is placed halfway between the stop line and the end of the full-width turn lane. If the length of the full-width turn lane is more than 125 ft but less than 250 ft, two turn arrows are placed in the lane with the top of the turn arrow nearest to the stop line placed 50 ft from the stop line and the other turn arrow placed such that the bottom of the arrow is lined up with the upstream end of the full-width turn lane. If the length of the full-width turn lane is more than 250 ft, three turn arrows are placed in the lane with the top of the turn arrow nearest to the stop line placed 50 ft from the stop line, a second turn arrow placed such that the bottom of the arrow is lined up with the upstream end of the full-width turn lane, and a third turn arrow is centered between the other two. Additional arrows may be used if the turn lane is long.

The design standards for Oklahoma state that if the length of the turn lane is less than 100 ft, only one turn arrow is used with the top placed 20 ft from the stop line, and an optional ONLY word marking may be provided with the top of the letters 35 ft upstream from the top of the turn arrow. If the length of the full-width turn lane is 100 to 149 ft, a second

turn arrow is provided with the top of the turn arrow 35 ft upstream from the top of the letters of the ONLY word marking. If the length of the full-width turn lane is 150 to 200 ft, the top of the turn arrow that is nearest the stop line is placed 30 ft from the stop line, an optional ONLY word marking may be provided with the top of the letters 55 ft upstream from the top of the turn arrow, and a second turn arrow is provided with the top of the turn arrow 35 ft upstream from the top of the letters of the ONLY word marking. No information is given for turn lanes that are longer than 200 ft.

The design standards for Oregon state that the tip of the arrowhead for the required turn arrow in a turn lane is 10 ft downstream from the upstream end of the full-width turn lane. A second turn arrow may be used and is placed such that the tip of the arrowhead is 10 ft from the stop line. If an optional ONLY word marking is used, then the second turn arrow 10 ft from the stop line is required.

The design standards for Tennessee note that if the length of the turn lane is less than 150 ft, only one turn arrow is used, with the top placed 50 ft from the stop line. If the length of the full-width turn lane is 150 to 200 ft, a second turn arrow is provided with the bottom of the turn arrow 25 ft downstream from the upstream end of the full-width turn lane. If the length of the full-width turn lane is more than 200 ft, additional turn arrows may be equally spaced between the two required turn arrows.

The design standards for Texas note that two sets of turn arrows and ONLY word markings are used in turn lanes that are 180 ft or more in length. The top of the turn arrow nearest to the stop line is typically 32 ft from the stop line. The top of the letters of the ONLY word marking is placed 32 ft upstream from the bottom of the turn arrow nearest the stop line. A second turn arrow and a second ONLY word marking are placed 32 ft apart at an unspecified distance upstream in the turn lane.

The design standards for Utah and West Virginia require that both turn arrows and ONLY word markings are used where a movement that would otherwise be legal is to be prohibited.

The design standards for Vermont state that if the length of the turn lane is less than 100 ft, only one turn arrow and ONLY word marking is provided with the bottom of the letters of the ONLY word marking lined up with the upstream end of the full-width turn lane and the turn arrow placed such that the bottom of the arrow is 4 ft downstream from the top of the letters of the ONLY word marking. If the length of the full-width turn lane is 100 to 200 ft, a second turn arrow and ONLY word marking is provided with the top of the turn arrow placed 4 ft from the stop line and the ONLY word marking placed such that the top of the letters of the ONLY word marking is 4 ft upstream from the bottom of the arrow. If the length of the full-width turn lane is more than 200 ft, additional sets of turn arrows and ONLY word markings are provided. At unsignalized, non-stopping approaches, the solid lane line between the turn lane and the adjacent through lane is extended and curved into the intersection until the first conflict point is reached.

The design standards for Virginia note that if the length of the turn lane is 300 ft or less, two turn arrows are provided with the bottom of the turn arrow nearest to the stop line located 50 ft from the stop line and the bottom of the other turn arrow lined up with the upstream end of the full-width turn lane. If the length of the full-width turn lane is more than 300 ft, a third turn arrow is placed at the midpoint of the full-width turn lane.

The design standards for Wisconsin state that if the length of the turn lane is less than 108 ft, only one turn arrow and ONLY word marking is provided, with the bottom of the letters of the ONLY word marking typically 20 ft downstream from the upstream end of the full-width turn lane and the turn arrow typically placed such that the top of the turn arrow is 20 ft from the stop line. If the length of the turn lane is 108 to 167 ft, two turn arrows and an ONLY word marking are provided with the top of the turn arrow nearest to the stop line typically placed 20 ft from the stop line, another turn arrow is placed such that the bottom of the arrow is lined up with the upstream end of the full-width turn lane, and the ONLY word marking placed halfway between the turn arrows. If the length of the turn lane is more than 167 ft, two sets of turn arrows and ONLY word markings are provided (with the bottoms of the turn arrows located 32 ft upstream from the top of the letters of the ONLY word marking), with the bottom of the letters of an ONLY word marking placed 20 ft downstream from the upstream end of the full-width turn lane and the turn arrow nearest to the stop line typically placed such that the top of the arrow is 20 ft from the stop line.

The design standards for the District of Columbia state that markings in turn lanes start with a turn arrow, followed by an ONLY word marking, and ending with an arrow near the stop line, all of which fits within the 90-ft distance of the solid lane line between the through lanes. In longer turn lanes, the markings start with a turn arrow, followed by an ONLY word marking, followed by another turn arrow, followed by another ONLY word marking, and ending with an arrow near the stop line.

The design standards for Puerto Rico note that two sets of turn arrows and SOLO messages are provided in the turn lane. The top of the turn arrow nearest to the stop line is placed an unspecified distance from the stop line. The second set is placed such that the bottom of the SOLO message is lined up with the upstream end of the full-width turn lane.

The design standards for the city of Los Angeles state that typically only one turn arrow is used and it is installed such that the bottom of the turn arrow is lined up with the upstream

end of the full-width turn lane. If the turn lane is longer than 250 ft, a second turn arrow is placed at the midpoint of the full-width turn lane. A turn arrow is only placed near the stop line if required by the California DOT (Caltrans) on freeway ramps and other state highway intersections.

The design standards for Tucson/Pima County, Arizona, note that at least two turn arrows are placed in turn lanes. The top of the turn arrow nearest to the stop line is typically placed 20 ft from the stop line. The bottom of the other turn arrow is lined up with the upstream end of the full-width turn lane. If the turn lane is 108 to 200 ft in length, an ONLY word marking is placed halfway between the two turn arrows. If the turn lane is more than 200 ft in length, an ONLY word marking and a third turn arrow are placed at one-third points between the two turn arrows, with the ONLY word marking placed closer to the stop line than the third turn arrow.

Use Versus Non-Use of Turn Arrows in Dropped Lanes (14 agencies)

The design standards consistently are that the use of turn arrows in dropped lanes is required, as stated in Paragraph 14 of Section 3B.19 of the *MUTCD*.

Use Versus Non-Use of ONLY Word Markings in Dropped Lanes (14 agencies)

The design standards for 10 agencies (FL, GA, IA, KS, MD, NC, SC, TN, WY, and CLT) state that the use of ONLY word markings in dropped lanes is required.

The design standards for Idaho and Rhode Island note that the use of ONLY word markings in dropped lanes is recommended.

The design standards for two agencies (Pennsylvania and Oregon) note that the use of ONLY word markings in dropped lanes is optional.

Placement of Turn Arrows and ONLY Word Markings in Dropped Lanes (9 agencies)

The design standards for Georgia state that the top of each ONLY word marking is separated from the top of the next downstream turn arrow by 100 ft and from the top of the next upstream turn arrow by 50 ft.

The design standards for Kansas note that the tip of the arrowhead for the turn arrow nearest to the stop line is at least 25 ft from the stop line. Spacing of alternating turn arrows and ONLY word markings (measured as the blank space between the bottom of one arrow or message to the top of the next arrow or message) is 80 ft. The turn arrow nearest to the upstream end of the lane line is positioned such that the bottom of the arrow is lined up with the start of the lane line.

The design standards for Maryland state that the minimum configuration of turn arrows and ONLY word markings shall be an arrow-ONLY-arrow sequence, with an equal distance of 40 to 90 ft between the center of the ONLY word marking and the center in each direction of the next turn arrows. The center of the turn arrow nearest to the stop line should be approximately 50 ft from the stop line. Section 3B.19 of the Maryland supplement to the *MUTCD* has a chart that specifies (based on a variety of speeds) how to add more turn arrows and ONLY word markings to the lane being dropped such that the first turn arrow encountered ranges from 375 ft from the stop line for a prevailing (not posted) speed of 25 mph to 800 ft from the stop line for a prevailing speed of 55 mph.

The design standards for North Carolina state that two sets of pavement markings (with each set comprised of two turn arrows and one ONLY word marking) are used in all dropped lanes. In each set, the ONLY word marking is placed halfway between the two turn arrows whose tops are placed 150 ft apart. In the first set, the top of the turn arrow nearest to the stop line is placed 50 ft from the stop line. In the second set, the top of the turn arrow nearest to the stop line is placed 350 ft from the stop line if the speed limit is 35 mph or less, 400 ft from the stop line if the speed limit is 40 to 50 mph, or 650 ft from the stop line if the speed limit is 55 mph or more.

The design standards for Oregon specify that two turn arrows are required.

The design standards for South Carolina state that two turn arrows, each accompanied by an ONLY word marking, are required.

The design standards for Wyoming note that two turn arrows and an ONLY word marking are required.

The design standards for the city of Charlotte specify that if the speed limit is 35 mph, a sequence of four turn arrows and two ONLY word markings is used in the downstream direction as follows: a turn arrow, an ONLY word marking, two turn arrows, another ONLY word marking, and a turn arrow. The top of the turn arrow nearest to the stop line is placed 25 ft from the stop line. The next two markings are placed such that the top of the turn arrow or ONLY word marking is 50 ft from the bottom of the next downstream marking. The next three markings are placed such that the top of the turn arrow or ONLY word marking is 100 ft from the bottom of the next downstream marking. If the speed limit is 40 mph or more, the same markings as for a 35 mph speed limit are used, except that an additional turn arrow is placed upstream from the other six markings such that the top of the additional turn arrow is 150 ft from the bottom of the next downstream turn arrow.

The design standards for the city of Tucson/Pima County show that lane-reduction arrows and warning signs are used to move through traffic out of the dropped lane before the turn lane markings are started.

Design of Turn Arrow Symbols (38 agencies)

Drawing "b" in Figure 3B-21 in the 2003 *MUTCD* shows a design for a Turn Lane-Use Arrow that is 8 ft long. This same 8-ft-long and 6-ft 4-in.-wide turn arrow design is shown in greater detail on Page 10-10 of the 2004 *Standard Highway Signs Book.* The pattern for an optional narrow elongated turn arrow is shown on Page 10-11 of the 2004 *Standard Highway Signs Book;* however, exact dimensions are not provided.

The design standards for 36 agencies consistently show turn arrow symbol designs that are similar to the 8-ft-long turn arrow shown in Figure 3B-21 in the 2003 *MUTCD* and on Page 10-10 of the 2004 *Standard Highway Signs Book.* The design standards for 5 of these 36 agencies (CA, HI, OH, OR, and NYC) also show that narrow elongated lane use arrows that are similar to the turn arrow shown on Page 10-11 of the *Standard Highway Signs Book* are available for use. The design standards for one of these 36 agencies (IL) show that a shorter, 6-ft-long turn arrow that is similar to the shape of the turn arrow shown in Figure 3B-21 of the 2003 *MUTCD* is used in urban areas.

The design standards for two agencies (PA and WA) show that the 8-ft-long turn arrow that is similar to the turn arrow shown in Figure 3B-21 of the 2003 *MUTCD* is not used. An elongated 12-ft-long turn arrow that is similar to the turn arrow shown on Page 10-11 of the *Standard Highway Signs Book* is the only style of turn arrow that is available for use.

LANE LINES FOR DUAL TURN LANES

Figure 4 illustrates some of the characteristics of dual turn lanes and their associated pavement markings (see Appendix A for figures).

2003 *MUTCD* Provisions

The *MUTCD* does not require or recommend a specific type or width of lane line for use with dual turn lanes. Both of the figures in Part 3 (Figures 3B-11 and 3B-22) that show dual turn lanes at an intersection show a normal solid lane line between the two turn lanes.

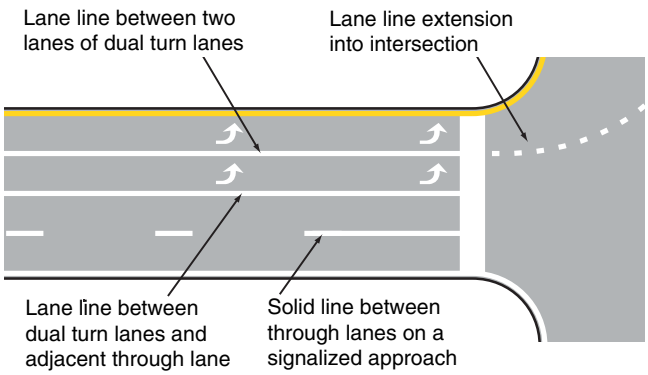


FIGURE 4 Characteristics of dual turn lanes.

Paragraphs 3 and 4 of Section 3B.04 contain the following standards: "Where crossing the lane line markings with care is permitted, the lane line markings shall consist of a normal [4- to 6-in.-wide] broken white line. Where crossing the lane line markings is discouraged, the lane line markings shall consist of a normal [4- to 6-in.-wide] solid white line."

Paragraphs 5 and 6 of Section 3B.04 contain the following options: "Solid white lane line markings may be used to separate through traffic lanes from auxiliary lanes, such as uphill truck lanes, left- or right-turn lanes, and preferential lanes. They may also be used to separate traffic lanes approaching an intersection. Wide [8- to 12-in.-wide] solid lane line markings may be used for greater emphasis."

Type of Lane Line Between the Two Lanes of Dual Turn Lanes (11 agencies)

Except for the three agencies listed here, the design standards consistently show a solid lane line between the two turn lanes.

The design standards for Maryland and Washington State require that the lane line between the two turn lanes is a broken line (10-ft segments with 30-ft gaps) that starts at the stop line and ends at the upstream end of the full-width turn lanes.

The design standards for North Carolina require that the solid lane line starts at the stop line and ends at the midpoint of the full-width turn lanes. From the midpoint to the upstream end of the full-width turn lanes, a broken lane line (10-ft segments with 30-ft gaps) is used.

Width of Lane Line Between the Two Lanes of Dual Turn Lanes (7 agencies)

The following widths are explicitly specified in the design standards for the lane line between the two lanes of dual turn lanes:

MI, TN—4 in.
NC—4 or 6 in.
FL—6 in.
CO, NV, TUC—8 in.

Length of Lane Line Between the Two Lanes of Dual Turn Lanes (7 agencies)

The following lengths are explicitly specified in the design standards for the lane line between the two lanes of dual turn lanes:

CA—at least 100 ft
MD, MI, NV, TN, LAN, TUC—entire length of full-width turn lanes.

Type of Lane Line Between Dual Turn Lanes and Adjacent Through Lane (11 agencies)

Except for one agency, the design standards consistently show a solid lane line between the dual turn lanes and the adjacent through lane.

The design standards for Maryland state that the solid lane line between the turn lanes and the adjacent through lane starts at the stop line and ends at the halfway point of the full-width turn lanes. A dotted line (3-ft segments with 9-ft gaps) is used from the halfway point to the upstream end of the full-width turn lanes.

Width of Lane Line Between Dual Turn Lanes and Adjacent Through Lane (7 agencies)

The following widths are explicitly specified in the design standards for the lane line between dual turn lanes and the adjacent through lane:

MI, TN—4 in.
NC—4 or 6 in.
CO, FL, NV, TUC—8 in.

Length of Lane Line Between Dual Turn Lanes and Adjacent Through Lane (7 agencies)

The following lengths are explicitly specified in the design standards for the lane line between dual turn lanes and the adjacent through lane:

MD, MI, NV, NC, TN, TUC—entire length of full-width turn lanes
LAN—from the stop line to the midpoint between the upstream end of the full-width turn lanes and the upstream end of the turn lane taper.

LANE LINE EXTENSIONS INTO INTERSECTION FOR DUAL TURN LANES

Figure 5 shows an example of a lane line extension into an intersection for dual turn lanes.

2003 *MUTCD* Provisions

The *MUTCD* recommends that dotted or solid line markings be used to extend the lane line between dual turn lanes through an intersection. Figure 3B-11 shows a solid line being used to extend the lane line between dual turn lanes through the intersection. Figure 3B-22 shows a white dotted line being used to extend the lane line between dual turn lanes through the intersection and a single yellow dotted line being used to extend the double yellow centerline to the left of dual left-turn lanes through the intersection. The notes in both of these figures mention that the lane line extensions may be dotted or solid lines (see Appendix A for figures).

Item E in Paragraph 1 of Section 3A.05 contains the following standards: “A dotted line shall consist of noticeably shorter line segments separated by shorter gaps than used for a broken line. The width of a dotted line shall be at least the

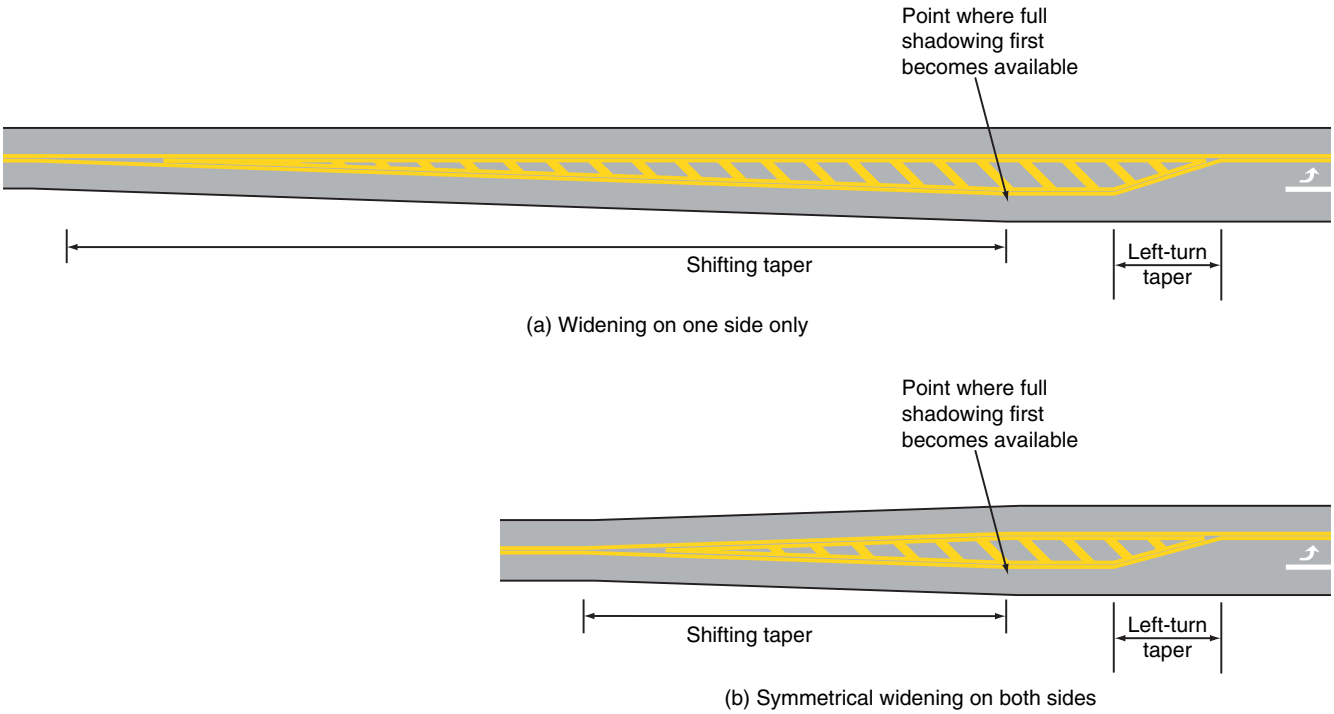


FIGURE 5 Examples of left-turn lanes added between through lanes of two-lane highways.

same as the width of the line it extends." Even though these provisions are classified as requirements, they do not specify the width or the pattern of dotted lines, which varies significantly among the policies of the various agencies.

Paragraph 3 of Section 3A.05 contains the following option: "A dotted line for line extensions may consist of 2 ft line segments and 2 ft to 6 ft gaps."

Paragraphs 1 and 2 of Section 3B.08 contain the following standard and option: "Pavement markings extended into or continued through an intersection or interchange area shall be the same color and at least the same width as the line markings they extend, except that a normal line may be used to extend a wide line through an intersection." This standard specifies the color, but does not specify the use or pattern of pavement marking extensions and gives flexibility as to the width.

Paragraphs 3 and 5 of Section 3B.08 contain the following guidance: "Where highway design or reduced visibility conditions make it desirable to provide control or to guide vehicles through an intersection or interchange, such as at offset, skewed, complex, or multilegged intersections, on curved roadways, or where multiple turn lanes are used, dotted line markings should be used to extend longitudinal line markings through an intersection or interchange area. Where greater restriction is required, solid lane lines or channelizing lines should be extended into or continued through intersections or major driveways."

Paragraph 6 of Section 3B.08 contains the following guidance: "A single line of equal width to one of the lines of the double line should be used to extend a double line through an intersection."

Use Versus Non-Use of Dotted Lines (23 agencies)

The design standards for 13 agencies (CA, IN, MD, MT, NH, NY, OR, PA, SC, WV, DC, CLT, and LAN) state that the use of a dotted line to extend the lane line between the two turn lanes through the intersection is optional.

The design standards for Tennessee and Wyoming note that a dotted line is typically used to extend the lane line between the two turn lanes through the intersection.

The design standards for eight agencies (CO, FL, ID, NC, RI, VA, WA, and TUC) state that the use of a dotted line to extend the lane line between the two turn lanes through the intersection is required.

The design standards for Colorado state that the lane line between the two turn lanes is extended through the intersection using either a dotted or solid line. When dotted lane line extensions are used, the portion of the lane line extension from the stop line to the edge line extended of the cross street is a solid line.

The design standards for Idaho note that when the volume of turning vehicles exceeds 200 per hour, a solid line is used (instead of a dotted line) for the extension through the intersection of the lane line between the two turn lanes.

The design standards for Oregon state that the lane line between the two turn lanes may be extended through the intersection using a dotted or solid line. The dotted or solid line may be continued through a marked crosswalk.

The design standards for Wyoming state that the lane line between the two turn lanes is typically extended through the intersection using a dotted or solid line.

Pattern of Dotted Lines (26 agencies)

The following patterns are used for dotted lines that extend the lane line between the two turn lanes through an intersection:

WV—0.5-ft segments with 2-ft gaps
CA—1-ft segments with 6-ft gaps
LAN—1-ft segments with 8-ft gaps
CO, FL, HI, ID, KS, MI, NY, PA, RI, TN, VA, DC, CLT—2-ft segments with 4-ft gaps
IN—typically 2-ft segments with 4-ft or longer gaps, with a segment-to-gap ratio of no greater than 1 to 4
SC—2-ft segments with 5-ft gaps
NH, OR, WA, WY, TUC—2-ft segments with 6-ft gaps
MT—typically 2-ft segments with 8-ft gaps
NC—2-ft segments with 8- or 13-ft gaps
MD—3-ft segments with 9-ft gaps.

Width of Dotted Lines (7 agencies)

The following widths are explicitly specified in the design standards for dotted lines that extend the lane line between the two turn lanes through an intersection:

CA, HI, NY, WV, DC, TUC—4 in.
TN—8 in.

Other Considerations Regarding Lane Line Extensions for Dual Turn Lanes (4 agencies)

The design standards for Colorado require that the lane line separating the right-most left-turn lane from the adjacent through lane be extended into the intersection just far enough to allow left-turning vehicles in opposite directions to miss each other by at least 4 ft.

The design standards for Florida state that the centerline or edge line on the left-hand side or the lane line on the right-hand

side of the turn lanes may be extended through the intersection using dotted lines if engineering judgment indicates that this would be helpful to drivers.

The design standards for Indiana require that if dual left-turn lanes are provided in opposing directions, the dotted line extensions of the lane lines between the two turn lanes should be separated from each other in the center of the intersection by at least 30 ft.

The design standards for the city of Tucson/Pima County require that if dual left-turn lanes are provided in opposing directions, the dotted line extensions of the lane lines between the two turn lanes should typically be separated from each other in the center of the intersection by at least 26 ft.

USE AND TYPE OF DOTTED LINES IN TURN LANE TAPERS

Figure 2 shows an example of a dotted line in a turn lane taper.

2003 *MUTCD* Provisions

The *MUTCD* does not require or recommend that dotted lines be used in turn lane tapers to discourage through traffic from unintentionally entering the turn lane. None of the figures in Part 3 that show the formation of a turn lane at an intersection (see Figures 3B-2, 3B-7, 3B-11, and 3B-22) show dotted lines in the turn lane tapers. However, the *MUTCD* does not prohibit dotted lines from being used for this purpose (see Appendix A for figures).

Item E in Paragraph 1 of Section 3A.05 contains the following standards: "A dotted line shall consist of noticeably shorter line segments separated by shorter gaps than used for a broken line. The width of a dotted line shall be at least the same as the width of the line it extends." Even though these provisions are classified as requirements they do not specify the width or the pattern of dotted lines, which varies significantly among the policies of the various agencies.

Paragraph 3 of Section 3A.05 contains the following option: "A dotted line for line extensions may consist of 2 ft line segments and 2 ft to 6 ft gaps."

Use Versus Non-Use of Dotted Lines (43 agencies)

The design standards for 30 agencies (AK, AZ, AR, CA, CO, ID, KS, KY, MD, MI, MN, MS, MT, NE, NV, NH, NY, OK, PA, SC, SD, TN, TX, UT, WA, WV, WI, PR, LAN, and TUC) do not show dotted lines in turn lane tapers. The design standards for Colorado specify that dotted lines are not to be used in turn lane tapers. The design standards for Idaho show a dotted line only in the taper of a left-turn lane formed by widening between the through lanes on a two-way highway. (The design standards for Maryland show the upstream end of a dotted line instead of a solid line at the upstream end of the full-width turn lane.)

The design standards for three agencies (OH, OR, and WY) note that dotted lines are optional in turn lane tapers.

The design standards for Florida note that dotted lines are not typically used in turn lane tapers. However, in curves or in other areas where drivers in the through lane might need extra guidance to avoid unintentionally drifting into a turn lane, a broken lane line (6-ft segments with 10-ft gaps) may be used.

The design standards for Virginia note that dotted lines are used if the distance between the upstream end of the turn lane taper and the upstream end of the lane line separating the turn lane from the adjacent through lane is longer than 100 ft. If the distance between the upstream end of the turn lane taper and the upstream end of the lane line separating the turn lane from the adjacent through lane is 100 ft or less, a dotted line is not used.

The design standards for the District of Columbia state that dotted lines are used where a turn lane occurs on a horizontal curve.

The design standards for seven agencies (AL, DE, GA, NC, RI, VT, and CLT) specify that dotted lines are to be used in all turn lane tapers.

Pattern of Dotted Lines (12 agencies)

The following patterns are used for dotted lines in turn lane tapers:

AL, RI, VT, VA, DC—2-ft segments with 4-ft gaps
DE, GA, OR, WY—2-ft segments with 6-ft gaps
CLT—2-ft segments with 10-ft gaps
NC—2-ft segments with 13-ft gaps
FL—6-ft segments with 10-ft gaps.

Width of Dotted Lines (6 agencies)

The following widths are used for dotted lines in turn lane tapers:

AL, VT, WY—4 in.
AL—4 to 6 in.
GA—5 in.
DC—8 in.

LEFT-TURN LANE ADDED BETWEEN THROUGH LANES OF TWO-LANE HIGHWAYS

Figure 5 shows examples of adding a left-turn lane between the through lanes of two-lane highways.

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The MUTCD does not include an illustration of adding a left-turn lane between the through lanes on a two-lane highway, nor does it address the length of left-turn lane tapers. However, the following formulas are recommended in several places in Part 3 (Paragraph 10 of Section 3B.03, Paragraph 2 of Section 3B.09, Paragraph 2 of Section 3B.10, and Figures 3B-12 and 3B-13) for the length (L) in feet of a shifting taper for through traffic: $L = WS$ for speeds of 45 mph or more and $L = WS^2/60$ for speeds of less than 45 mph, where W is the width of the offset distance in feet and S is the speed of traffic in mph (see Appendix A for figures).

Shifting Taper (21 agencies)

The design standards for 15 agencies (AZ, AR, CA, ID, KS, MI, MO, NH, OH, PA, SD, TN, TX, WY, and TUC) use the recommended *MUTCD* formulas for the length of the shifting taper for the through lane as it approaches the left-turn lane location. However, one of these agencies (CA) allows the speed (S) in urban areas to be reduced by 10 to 20 mph.

In the design standards for Oregon the recommended *MUTCD* formulas are used but the threshold between the use of the high-speed formula versus the low-speed formula is 35 mph instead of 45 mph.

In the design standards for Washington State the recommended *MUTCD* high-speed formula ($L = WS$) is used for all speeds, even low speeds.

In the design standards for Utah the recommended *MUTCD* formulas are used to compute L, but only half of L is used for the shifting taper.

In the design standards for Montana the length of the shifting taper is calculated from a taper rate based on design speed and is shown in a chart. The shifting taper rate varies from 10-to-1 for 20 mph (shown as 30 km/h) to 75-to-1 for 70 mph (shown as 120 km/h).

The design standards for Iowa and Louisiana show reverse curves being used to transition from a two-lane section to a three-lane section of roadway. The Iowa design standards specify 12,000 ft for the radii of the reverse curves. The Louisiana design standards do not specify the radii of the reverse curves. (The Louisiana design standards also show a reverse curve being used to transition from a three-lane section back to a two-lane section on the departure side of the intersection.)

Amount of Widening (21 agencies)

The design standards for 17 agencies (AZ, CA, IA, KS, LA, MI, MO, MT, NH, OH, OR, PA, TX, UT, WA, WY, and TUC) use the shifting taper to widen the roadway until the full-width of the turn lane becomes available. These are known as fully shadowed left-turn lanes.

The design standards for four agencies use the shifting taper to widen the roadway until less than the full-width of the turn lane becomes available. These are known as partially shadowed left-turn lanes. In all four cases, the upstream end of the left-turn lane taper begins at the point where the partial width of the turn lane first becomes available. The following are the amounts of partial widening that occur:

ID—half of the width of the left-turn lane
AR, SD—two-thirds of the width of the left-turn lane
TN—three-fourths of the width of the left-turn lane.

Distance from Full Shadowing to Upstream End of Left-Turn Taper (17 agencies)

The design standards for 13 of the 17 agencies that use fully shadowed left-turn lanes (AZ, CA, IA, KS, LA, MI, MO, MT, NH, OR, WA, WY, and TUC) show the upstream end of the left-turn lane taper beginning at the point where the full width of the turn lane first becomes available.

The design standards for four agencies do not show the upstream end of the left-turn lane taper beginning at the point where the full width of the turn lane first becomes available. The following are the distances between the point where the full width of the turn lane first becomes available and the upstream end of the left-turn lane taper for these four agencies:

UT—20 ft
OH—100 ft
PA—half of the shifting taper
TX—unspecified distance.

Length of Left-Turn Taper (21 agencies)

The design standards for 14 agencies show a straight-line left-turn taper. The following lengths are shown for straight-line left-turn tapers:

OH—50 ft
NH—75 ft if the posted speed limit is 40 mph or less and 100 ft if the posted speed limit is 45 mph or more
MO—100 ft
CA—120 ft in high-speed rural areas and 60 or 90 ft in business, residential, or urban areas
WY—150 ft
PA—one-sixth of the shifting taper
AR—one-third of the shifting taper
IA—10-to-1 taper rate
MT—the taper rate, which varies from 8-to-1 for 20 mph (shown as 30 km/h) to 18-to-1 for 70 mph (shown as

120 km/h), is based on design speed and is shown in a table

WA—the length, which varies from 75 ft for a 25 mph speed limit to 180 ft for a 60 mph speed limit, is based on the posted speed limit and is shown in a table

SD, TN, TX, UT—unspecified length.

The design standards for three agencies show a left-turn taper comprised of reverse curves. The following lengths are shown for reverse-curve left-turn tapers:

ID—length in feet is five times the speed limit in mph

KS—unspecified length (reverse curves with a radius of 150 ft for speeds of 40 mph or less and 300 ft for speeds of 45 mph or more are used to form the left-turn lane taper)

LA—unspecified length.

The design standards for three agencies show a gap in the lane line on the left-hand side of the approach through lane instead of a marked taper (see Figure 6). The only longitudinal pavement marking in the gap area is the centerline adjacent to the departure lane in the opposite direction. The following lengths are shown for the gaps in the lane line:

AZ—60 ft if the posted or design speed is less than 40 mph, 90 ft if the posted or design speed is 40 to 50 mph, and 140 ft if the posted or design speed is more than 50 mph

TUC—60 ft if the posted speed limit is 35 mph or less, 90 ft if the posted speed limit is 40 or 45 mph, and 120 ft if the posted speed limit is 50 mph or more

MI—at least 75 ft.

The design standards for Oregon show two options for providing a left-turn taper. One option is to use a set of reverse curves with the length of the reverse curves, which varies from 98 ft for 35 mph to 180 ft for 65 mph, based on design speed and shown in a table. A second option, which uses the same length as the reverse curves, is to extend the double yellow centerline on the left-hand side of the approach through lane for one-eighth of the length and then leave a gap in the lane line on the left-hand side of the approach through lane instead of a marked taper.

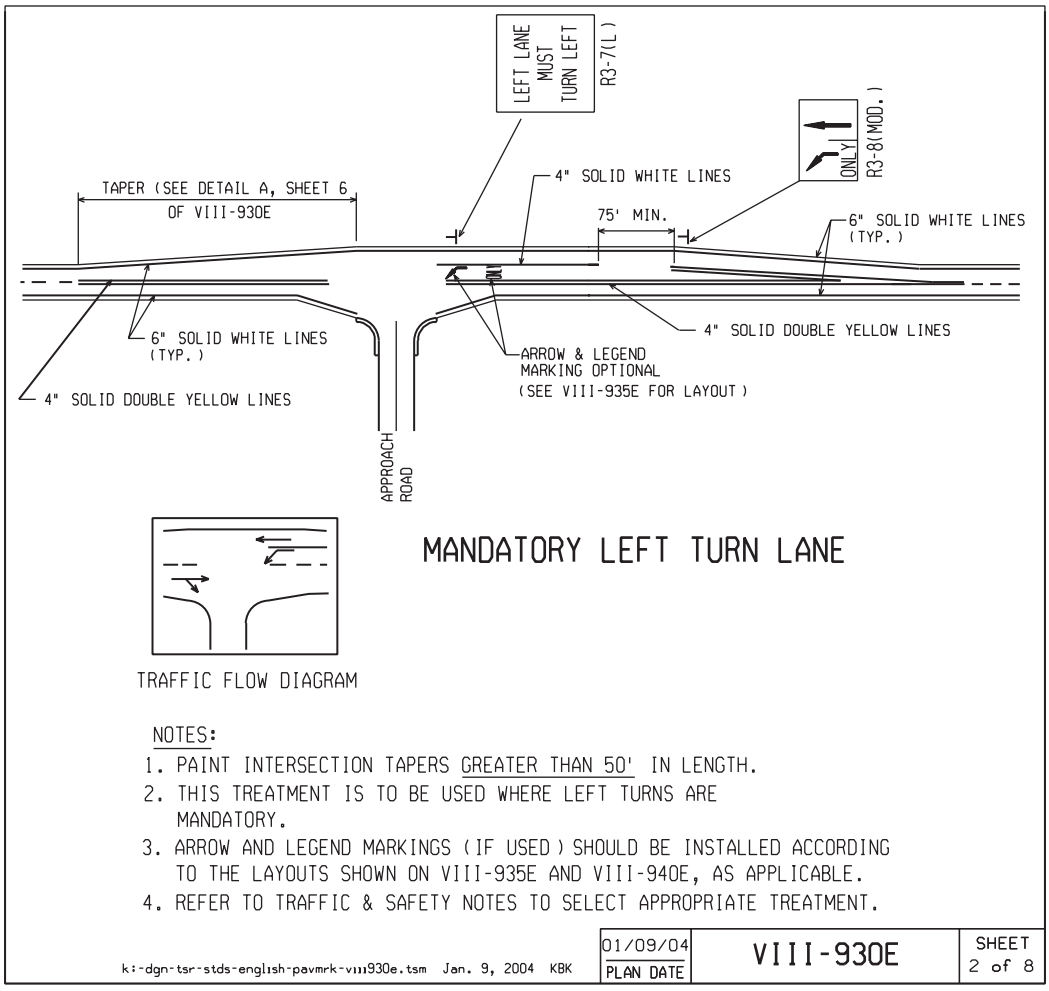

FIGURE 6 Gap in lane line instead of marked taper (*Source:* Michigan DOT pavement markings typical plans).

SOLID LANE LINES BETWEEN THROUGH LANES ON SIGNALIZED APPROACHES

Figure 4 shows an example of a solid lane line between the through lanes on a signalized approach.

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Paragraph 5 of Section 3B.04 contains the following option: "[Solid white lane line markings] may also be used to separate traffic lanes approaching an intersection." Drawing "b" in Figure 3B-11 illustrates the use of solid lane lines between through lanes on the approach to an intersection. Drawings "c" and "d" in Figure 3B-11 illustrate using broken lane lines between through lanes on the approach to an intersection (see Appendix A for figures).

Use Versus Non-Use of Solid Lane Lines Between Through Lanes (42 agencies)

The design standards for 29 agencies (AL, AR, CA, CO, GA, ID, IL, IN, KS, KY, MD, MI, MO, NV, NY, NC, OH, OR, SC, TN, TX, VT, WA, WI, WY, PR, CLT, NYC, and TUC) consistently show the use of broken lane lines between through lanes on the approaches to intersection stop lines. The design standards for Maryland specifically state, "Lane lines between through lanes should not be converted to solid lines on the approaches to intersections, except in critical areas where it is advisable to discourage lane changing."

The design standards for Delaware and Montana show the use of either solid lane lines or broken lane lines between through lanes on the approaches to intersection stop lines.

The design standards for 11 agencies (AK, CT, FL, OK, PA, SD, UT, VA, WV, DC, and LAN) consistently show the use of solid lane lines between through lanes on the approaches to intersection stop lines.

Length of Solid Lane Lines Between Through Lanes (13 agencies)

The following are the lengths of the solid lane lines between through lanes on the approaches to intersection stop lines for the 13 agencies that allow or require them:

UT—27 ft (shown as 8 m)
CT, FL, OK, LAN—50 ft
DC—90 ft
VA, WV—100 ft
PA—150 ft
AK—300 ft in urban areas and 500 ft in rural areas
SD—equal to the length of any full-width turn lanes adjacent to the through lanes
DE, MT—unspecified.

Width of Solid Lane Lines Between Through Lanes (13 agencies)

The following are the widths of the solid lane lines between through lanes on the approaches to intersection stop lines for the 13 agencies that allow or require them:

AK, CT, OK, MT, SD, WV—4 in.
PA—4 or 6 in.
DC—6 in.
DE, FL, UT, VA, LAN—unspecified.

CROSSWALKS

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Paragraph 4 of Section 3B.17 contains the following standard: "When crosswalk lines are used, they shall consist of solid white lines that mark the crosswalk. They shall be not less than 6 in. or greater than 24 in. in width." The color and that the lines must be solid lines are specified, but flexibility is given regarding the width that may be used, and no standards are given regarding the width of the crosswalk or the layout of the lines.

Paragraph 5 of Section 3B.17 contains the following guidance: "If transverse lines are used to mark a crosswalk, the gap between the lines should not be less than 6 ft. If diagonal or longitudinal lines are used without transverse lines to mark a crosswalk, the crosswalk should be not less than 6 ft wide."

Paragraphs 12 through 14 of Section 3B.17 contain the following guidance and options: "For added visibility, the area of the crosswalk may be marked with white diagonal lines at a 45-degree angle to the line of the crosswalk or with white longitudinal lines parallel to traffic flow, as shown in Figure 3B-16. When diagonal or longitudinal lines are used to mark a crosswalk, the transverse crosswalk lines may be omitted. This type of marking may be used at locations where substantial numbers of pedestrians cross without any other traffic control device, at locations where physical conditions are such that added visibility of the crosswalk is desired, or at places where a pedestrian crosswalk might not be expected. If used, the diagonal or longitudinal lines should be 12 to 24 in. wide and spaced 12 to 60 in. apart. The marking design should avoid the wheel paths, and the spacing should not exceed 2.5 times the line width."

Figure 3B-16 shows three examples of crosswalk markings: a standard crosswalk comprised of two parallel transverse lines, a high-visibility crosswalk comprised of longitudinal lines without the transverse lines, and a high-visibility crosswalk comprised of diagonal lines between two transverse lines.

Paragraph 15 of Section 3B.17 contains the following option: "When an exclusive pedestrian phase that permits diagonal

crossing is provided at a traffic control signal, a marking as shown in Figure 3B-17 may be used for the crosswalk."

Figure 3B-17 shows an example of crosswalk markings that allow diagonal crossing of the intersection. The markings are comprised of four standard crosswalks, but the transverse lines closest to the intersection are interrupted at each corner to communicate to pedestrians that a diagonal crossing is permitted. The figure includes a note that mentions that the transverse lines closest to the intersection may be omitted, which would leave only one transverse line across each leg of the intersection (see Appendix A for figures).

Use of Standard and High-Visibility Crosswalks (50 agencies)

For the purposes of this synthesis, the following definitions for standard and high-visibility crosswalks will apply. Standard crosswalks are those crosswalks that are marked by two parallel transverse lines only. High-visibility crosswalks are those crosswalks that are marked by longitudinal or diagonal lines with or without the transverse lines. Figure 7 shows examples of the various crosswalk types.

The design standards for 33 agencies (AL, AK, AZ, AR, CO, DE, FL, ID, IL, IA, KS, MD, MI, MN, MO, MT, NE, NH, NY, NC, OK, OR, PA, RI, TN, TX, UT, WV, DC, PR, LAN, NYC, and TUC) indicate that both standard crosswalks and high-visibility crosswalks are available for use.

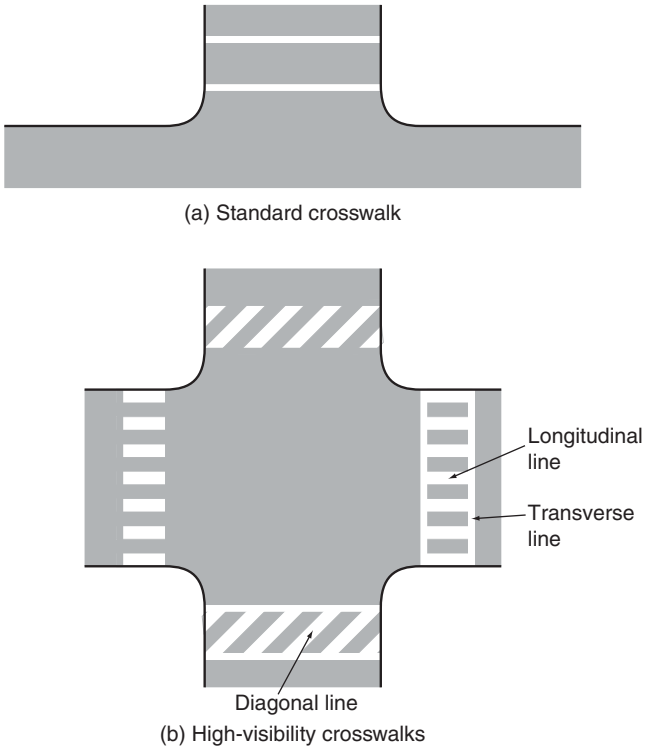

FIGURE 7 Examples of crosswalks.

The design standards for nine agencies (CA, IN, KY, ME, ND, OH, SC, WI, and CLT) show the use of standard crosswalks only.

The design standards for eight agencies (CT, GA, HI, NV, SD, VT, WA, and WY) show the use of high-visibility crosswalks only.

The design standards for Alabama recommend that high-visibility crosswalks be used for school crosswalks.

The design standards for Alaska recommend that standard crosswalks be used at signals and on approaches controlled by STOP signs, and that high-visibility crosswalks be used for all other locations.

The design standards for Colorado recommend that high-visibility crosswalks be used at complicated and/or channelized intersections and at midblock crosswalks.

The design standards for Illinois state that because midblock crosswalks are generally unexpected by the motorist, diagonal or longitudinal lines should be used in marking midblock crosswalks.

The design standards for Maryland note that high-visibility crosswalks may be used across roadways where the speed limit is greater than 35 mph, at midblock locations, at unexpected locations, and at school crosswalks.

The design standards for Rhode Island specify that standard crosswalks are the only type of crosswalk that can be used at intersections, and that high-visibility crosswalks should be used at midblock crosswalks.

The design standards for Utah state that the high-visibility crosswalk with the longitudinal lines is used for school crossings, and that the high-visibility crosswalk with the diagonal lines is used only when permitted by the region traffic engineer.

Minimum Width of Crosswalks (45 agencies)

The design standards for the 45 agencies that specify a minimum crosswalk width use the following minimum widths:

- IA—6 ft (measured to the outside edges of the transverse crosswalk lines)
- NH—6 ft (shown as 2 m, and measured from center to center of the transverse crosswalk lines)
- NY—6 ft (shown as 2 m)
- DE, ID, IN, KY, ME, MD, MN, MO, NE, ND, OH, PA, SC, TX, VT, WI—6 ft
- MI—6 ft, but crosswalks at intersections are the same width as the adjacent sidewalk
- MT—6 ft, but 8 ft is the normal width

FL, OR—6 ft, but 10 ft is desirable
KS—6 ft for standard and 8 ft for high visibility
CO—6 ft for standard and 8 to 10 ft for high visibility
NC, TN—6 ft for standard and 10 ft for high visibility
GA—6 ft 8 in. or the width of the sidewalk, whichever is greater, but the edge of the crosswalk should not be more than 1 ft beyond the edge of the sidewalk
OK, SD, UT, WA—8 ft
CT—8 ft at intersections and 10 ft at midblock locations
NYC—8 to 18 ft
AL, AK, AR, NV, CLT, TUC—10 ft
AZ—10 ft at intersections and 15 ft at midblock locations
HI—typically 10 ft
WY—12 ft
DC—15 ft unless otherwise noted on the plans, and 20 ft in the downtown central business district
LAN—15 ft, but 20 ft in high pedestrian areas and on the receptive leg of dual left turns (to provide a better turning radius).

Width of Transverse Crosswalk Lines (40 agencies)

The design standards for the 40 agencies that specify a transverse line width use the following widths:

IN, ME, MI, MO, NE, NH, ND, WI, DC—6 in.
MN—6 to 12 in.
KY—6 or 12 in.
IA, PA—6 to 24 in.
WV—6 to 24 in., with the 24-in. lines used where no stop line is present, where speeds are more than 35 mph, or where crosswalks are unexpected
MT—8 in. is the normal width, 6 in. is the minimum width, and 24 in. may be used in areas where posted speed limits exceed 35 mph (shown as 60 km/h), where a stop line is not provided, and in areas where crosswalks would not normally be expected
GA, NC, OK, SC, TN, CLT—8 in.
HI—at least 8 in.
AL, AZ, AR, FL, ID, KS, MD, NY, TX, UT, VT, NYC—12 in.
OR—12 in., but 18 in. wide on state highways with posted speed limits of 55 mph or more
CO—12 in., but 24 in. wide if no stop line is provided
TUC—12 in., but 24 in. wide on approaches controlled by STOP signs with speed limits of 45 mph or more
OH—12 in., but 24 in. wide at midblock locations
CA—12 to 24 in.
AK—24 in.

Design of High-Visibility Crosswalks (38 agencies)

Except for 17 agencies, the design standards for those agencies that show high-visibility crosswalks consistently show the use of longitudinal lines only (without transverse lines). The design standards for the following agencies illustrate a different design requirement or option for high-visibility crosswalks:

NY, TX, NYC—transverse lines may be used
AL, AZ, GA, HI, ID, TUC—transverse lines are used
MD—transverse lines are used and 45° diagonal lines may be used
IA, NH—transverse lines may be used and 45° diagonal lines may be used
UT—45° diagonal lines may be used
PA—45° diagonal lines with transverse lines may be used
RI, VT—45° diagonal lines with transverse lines are used
WV—45° diagonal lines are used and transverse lines may be used.

Width of Longitudinal and Diagonal Lines (38 agencies)

The design standards for the 38 agencies that specify the widths of longitudinal or diagonal lines for high-visibility crosswalks use the following widths:

FL, MI, RI, VT, NYC—12 in.
TUC—at least 12 in.
CO, IA, MD, PA, TX, WV—12 to 24 in.
WY—12 to 24 in., but 18 in. is standard
CT—16 in., but 24 in. wide for school, elderly, and handicapped crosswalks
HI—16 in. set of lines (three 4-in.-wide lines separated by gaps of 2 in.)
AL, AZ, ID, KS, MT, NE, NV, NH, NY, NC, OK, SD, TN, UT, DC, LAN, TUC—24 in.
OR—24 in., or a 36-in. set of lines (two 12-in.-wide lines separated by a gap of 12 in.)
WA—24 in., or a 24-in. set of lines (two 8-in.-wide lines separated by a gap of 8 in.)
GA—24 in. set of lines (two 8-in.-wide lines separated by a gap of 8 in.)
AK, MN—24 to 36 in.
MO—30 to 36 in.

Spacing of Longitudinal and Diagonal Lines (37 agencies)

The design standards for the 37 agencies that specify the spaces (the unmarked gap between the nearest edges of the lines) between longitudinal or diagonal lines for high-visibility crosswalks use the following spacings:

MD, TX, WV—12 to 24 in.
IA—12 to 24 in. to avoid wheel paths
PA—12 to 60 in.
CT—16 in., but 24 in. wide for school, elderly, and handicapped crosswalks
AL, AZ, FL, ID, MI, MT, NH, NC, SD, TN, UT, VT, DC, NYC—24 in.

AK—24 to 36 in. to avoid wheel paths
HI—28 in.
RI—30 in.
MO—30 to 36 in. to avoid wheel paths (the widths of the longitudinal lines and the spaces between them are based on the lane width, with 30-in. lines and 30-in. spaces for 10-ft-wide lanes, 33-in. lines and 33-in. spaces for 11-ft-wide lanes, and 36-in. lines and 36-in. spaces for 12-ft wide lanes)
MN—30 to 42 in. to avoid wheel paths (the widths of the longitudinal lines and the spaces between them are specified in a chart that is based on the width of the inside through lane)
OK—36 in.
NY—48 in.
WY—48 to 60 in. to avoid wheel paths
OR—centered on lane lines and centers of approach lanes to avoid wheel paths, with a minimum spacing of 36 in. and a maximum spacing of 48 in.
TUC—centered on lane lines and centers of approach lanes to avoid wheel paths, with an approximate spacing of 48 in.
NE—centered on lane lines and centers of approach lanes to avoid wheel paths, with a maximum spacing of 48 in.
WA—centered on lane lines and centers of approach lanes to avoid wheel paths, with a maximum spacing of 60 in.
CO, GA, KS, LAN—centered on lane lines and centers of approach lanes to avoid wheel paths
NV—centered on lane lines and centers of approach lanes to avoid wheel paths in District 1, and 24 in. in Districts 2 and 3.

Other Considerations Regarding Standard and High-Visibility Crosswalks (6 agencies)

The design standards for Tennessee require that the nearest edge of the crosswalk line be located at least 2 ft from the extended edge line of the street that is parallel to the crosswalk.

The design standards for Arkansas require that crosswalks be located at least 3 ft from the extended edge line of the street that is parallel to the crosswalk.

The design standards for Arizona and California require that crosswalks near schools be yellow, and that the nearest edge of the crosswalk line be located at least 6 ft from the extended edge line of the street that is parallel to the crosswalk.

The design standards for West Virginia require that the outside edges of crosswalks (the edge of the crosswalk farthest from the intersection) be at least 6 ft from the extended edge line of the street that is parallel to the crosswalk.

The design standards for Washington note that when 24-in.-wide longitudinal lines are used for a high-visibility crosswalk, a 12-in.-wide longitudinal line may be placed on paved shoulders that are 4 ft wide or less to extend the crosswalk to the edge of the pavement. A 24-in.-wide longitudinal line may be placed on paved shoulders that are more than 4 ft wide to extend the crosswalk to the edge of the pavement. When two 8-in wide longitudinal lines that are separated by an 8-in. space are substituted for the 24-in.-wide longitudinal lines, an 8-in.-wide longitudinal line may be placed on paved shoulders that are 4 ft wide or less to extend the crosswalk to the edge of the pavement.

Other Types of Crosswalks (3 agencies)

The design standards for Connecticut, Ohio, and Pennsylvania show special crosswalk markings that may be used for an exclusive pedestrian signal phase where all vehicles are stopped and pedestrians can cross all legs of the intersection or can cross diagonally. These markings feature a single line that completely crosses each leg of the intersection. The design standards for Connecticut specify that these lines are 24 in. wide.

STOP LINES

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Paragraph 1 of Section 3B.16 contains the following standard: "If used, stop lines shall consist of solid white lines extending across approach lanes to indicate the point at which the stop is intended or required to be made." The color and that the line must be a solid line are specified, but no standards are given regarding the use or width of the line.

Paragraph 3 of Section 3B.16 contains the following guidance: "Stop lines should be 12 to 24 in. wide."

Use Versus Non-Use of Stop Lines (46 agencies)

Except for four agencies, the design standards consistently require stop lines to be used for all signalized approaches. The design standards for Alaska show that the transverse crosswalk line nearest to the approach lane also serves as the stop line for the approach. The design standards for Oregon state that when standard crosswalks are used, the transverse line nearest to the approach lane is used as the stop line. The design standards for the city of Los Angeles state that where crosswalks are present, the transverse crosswalk line nearest to the approach lane serves as the stop line (the lane lines on the approach and departure end at the transverse crosswalk line nearest to the approach lane, and the centerline crosses through standard crosswalks and ends at the transverse crosswalk line closest to the intersection). The design standards for Nebraska note that stop lines are used if needed.

Width of Stop Lines (43 agencies)

The design standards for the 43 agencies that specify a stop line width use the following widths:

AR, NE, UT, WV, HI—12 in.
CT—at least 12 in.
CA, ME, MN—12 to 18 in. in urban areas and 18 to 24 in. in rural areas
OR, PA—12 to 24 in.
KY—12 or 24 in.
TUC—12 in., but 24 in. wide on approaches controlled by STOP signs with speed limits of 45 mph or more
DE—16 in.
MD—16 in. for approach speed limits of 35 mph or less and 24 in. for approach speed limits more than 35 mph
AZ, NH—18 in.
WI—typically 18 in., but can vary from 12 to 24 in.
NY—18 in., but designer may also specify 12 or 24 in.
AL, CO, FL, ID, IN, IA, KS, LA, MI, MO, MT, NV, NC, ND, OH, OK, SC, SD, TN, TX, VT, VA, WY, NYC—24 in.

Placement of Stop Lines (38 agencies)

The design standards for the 38 agencies that specify a stop line placement use the following distances from the adjacent crosswalk:

MI, MO, NE, NY, OK, PA, SD, WA—4 ft
NH, ND, TX, UT, TUC—typically 4 ft
AZ, AR, CA, CO, CT, FL, ID, IN, IA, KY, LA, ME, MD, MT, NV, NC, SC, TN, VT, VA, WI—at least 4 ft
WY—4 to 30 ft
NYC—5 ft (and STOP messages are placed in approach lanes such that the top of the letters is 10 ft upstream from the stop line)
AL, KS—at least 5 ft.

RIGHT-TURN CHANNELIZING ISLANDS

Figure 8 shows examples of right-turn channelizing islands and their associated pavement markings.

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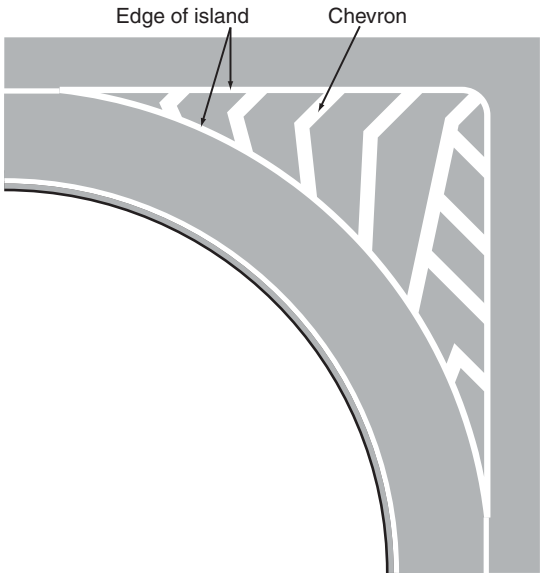
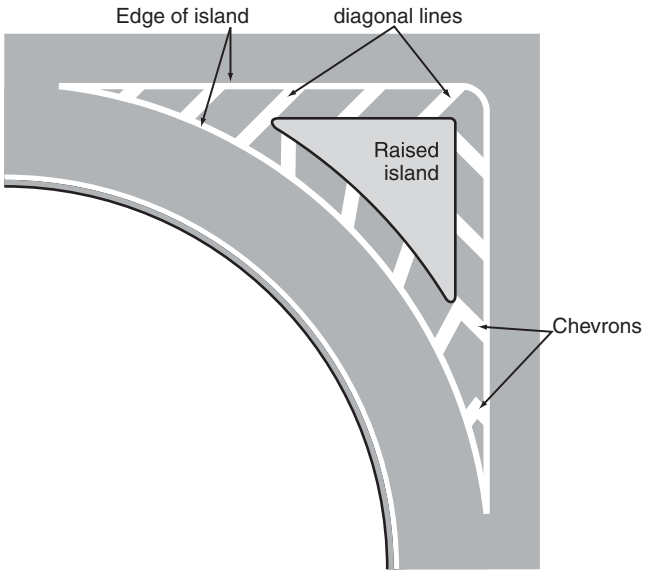
Paragraph 2 of Section 3B.05 contains the following option: "Channelizing lines may be used to form channelizing islands where traffic traveling in the same direction is permitted on both sides of the island."

Paragraph 3 of Section 3B.05 contains the following standard: "Other pavement markings in the channelizing island area shall be white." Thus, the color of the markings in channelizing islands is specified, but not their use, width, or pattern.

Paragraph 9 of Section 3B.10 contains the following option: "If traffic can pass either to the right or left of the obstruction, additional white markings may be placed in the neutral area between the channelizing lines as shown in Figure 3B-13" (see Appendix A for figures).



(a) Right-turn channelizing island using pavement markings only



(b) Right-turn channelizing island using a raised island

FIGURE 8 Examples of right-turn channelizing islands.

Width of Lines That Mark the Edges of Right-Turn Channelizing Islands (18 agencies)

The design standards for the 18 agencies that specify a line width for the channelizing lines that mark the edges of right-turn channelizing islands use the following widths:

PA—4 in.
MI—6 in. for painted islands and 12 in. for approaches to raised islands
WV—6 in. to 8 in.
AK, AR, CO, FL, GA, HI, IN, IA, MT, OK, UT, WY—8 in.

WI—8 in. on approaches to raised islands only (the lines extend only 5 ft beyond the nose of the island)
TN—8 in. if the area of the island is 400 ft^2 or less or if the island is raised, and 24 in. if the area of the painted island is more than 400 ft^2
VT—48 in. if the area of the island is 450 ft^2 or more (if the area of the island is less than 450 ft^2, the island is painted in its entirety).

Width of Lines Within Right-Turn Channelizing Islands (18 agencies)

The design standards for the 18 agencies that specify a line width for the diagonal lines or chevrons within right-turn channelizing islands use the following widths:

MI—6 in. when the speed is 45 mph or less and 12 in. when the speed is more than 45 mph
IA, NC, OK, UT—8 in.
CA, HI, IN, RI, WV, DC, CLT—12 in.
TN—12 in. if area of island is 400 ft^2 or less or if island is raised and more than 6 ft of pavement width exists between the edge line and the raised island, otherwise no markings are used within the island
AK, FL—18 in.
GA, OH, SC—24 in.

Spacing of Lines Within Right-Turn Channelizing Islands (16 agencies)

The design standards for the 16 agencies that specify the spacing (the unmarked gap between the nearest edges of the lines) of the diagonal lines or chevrons within right-turn channelizing islands use the following spacings:

DC—5 ft
SC, WV—6 ft
AK—7 ft
FL, OK, UT—10 ft
TN—10 ft if area of island is 400 ft^2 or less or if island is raised and more than 6 ft of pavement width exists between the edge line and the raised island, otherwise no markings are used within the island
IL—10 ft for speed limits less than 30 mph, 15 ft for speed limits from 30 to 45 mph, and 20 ft for speed limits more than 45 mph (in all of these cases, if the recommended spacing does not provide at least five 12-in.-wide diagonal lines in the area being marked, the spacing from the next lowest speed range should be used)
OH—12 ft
GA—15 ft
HI, IN, IA, MI—20 ft
NC—equal in feet to the posted speed limit in mph.

Other Considerations Regarding Right-Turn Channelizing Islands (9 agencies)

The design standards for Arkansas, Colorado, Vermont, and Wyoming specify that no diagonal lines or chevrons be used within right-turn channelizing islands.

The design standards for Colorado show raised right-turn channelizing islands being marked by 8-in.-wide solid lines on both sides of the gore area leading up to the island, and along the left edge line of the right-turn lane from the point where the island ends to the point where the line intersects the right edge line of the intersecting roadway. The rest of the raised island is surrounded by 4-in.-wide edge lines. There are no markings between the raised island and the 4-in.-wide edge lines or 8-in.-wide solid lines.

The design standards for Montana state that diagonal lines or chevrons are not used on the paved portion between the edge lines and raised islands. The curbs of the raised right-turn channelizing islands are painted yellow.

The design standards for Oklahoma and Pennsylvania note that diagonal lines or chevrons are not used on the paved portion between the edge lines and raised islands.

The design standards for Oregon state that diagonal lines or chevrons are optional in right-turn channelizing islands.

The design standards for Utah show that diagonal lines or chevrons are only placed in the painted island area before the raised portion of the island and in the painted island area after the raised portion of the island.

CHAPTER THREE

PAVEMENT MARKINGS BETWEEN INTERSECTIONS

MIDBLOCK CROSSWALKS

2003 *MUTCD* Provisions

In addition to other *MUTCD* provisions that are normally associated with crosswalks, Paragraphs 8 and 9 of Section 3B.16 contain the following guidance: "If used at an unsignalized midblock crosswalk, yield lines should be placed adjacent to the Yield Here to Pedestrians sign located 20 to 50 ft in advance of the nearest crosswalk line . . . (see Figure 3B-15). Stop lines at midblock signalized locations should be placed at least 40 ft in advance of the nearest signal indication (see Section 4D.15)" (see Appendix A for figures).

Type of Midblock Crosswalk (5 agencies)

The design standards for Arizona and Connecticut require wider crosswalks at midblock locations than at intersections.

The design standards for Colorado and the city of Los Angeles require the use of high-visibility crosswalks at midblock locations.

The design standards for Rhode Island recommend the use of high-visibility crosswalks at midblock locations.

Use and Placement of Stop Lines or Yield Lines at Midblock Crosswalks (6 agencies)

The design standards for Arizona recommend that stop lines at midblock signalized locations be placed at least 40 ft in advance of the far side signal indication.

The design standards for Michigan show a stop line located 4 ft from the nearest edge of a midblock crosswalk.

The design standards for the city of Los Angeles show a stop line located 5 ft from a midblock high-visibility crosswalk.

The design standards for Nevada show a stop line located 30 ft from the nearest edge of a midblock crosswalk.

The design standards for Florida show a stop line located at least 40 ft from the center of a signalized midblock crosswalk.

The design standards for Pennsylvania note that if yield lines are used at unsignalized midblock crosswalks they should be placed 20 to 50 ft in advance of the crosswalk.

Other Considerations at Midblock Crosswalks (1 agency)

The design standards for Idaho state that the use of urban midblock crosswalks, except in special cases, should be discouraged. Midblock crosswalks cause vehicular–pedestrian conflicts, additional vehicle delay, disrupt traffic signal progression, and present an unexpected pedestrian problem to the driver who normally expects these conflicts only at intersections. Midblock crosswalks sometimes have sight distance restrictions because of parked vehicles. Drivers do not respect midblock crosswalks as much as crosswalks at intersections. Pedestrians have a false assumption that marked crosswalks provide them protection, causing an extra problem at midblock locations where both the pedestrian and motorists might not be alert.

MINIMUM LENGTH OF PASSING ZONES

2003 *MUTCD* Provisions

Paragraph 3 of Section 3B.02 contains the following guidance: "Where the distance between successive no-passing zones is less than 400 ft, no-passing markings should connect the lines."

Minimum Length of Passing Zones (22 agencies)

The design standards for Kentucky show 400 ft as the minimum length of a passing zone, but also state that on low-volume roads with low speeds and infrequent passing opportunities this distance may be shortened to 200 ft.

The design standards for 10 agencies (AL, AR, CO, IA, NY, ND, OR, PA, WV, and TUC) show 400 ft as the minimum length of a passing zone.

The design standards for Virginia show 500 ft as the minimum length of a passing zone.

The design standards for Montana show 1,000 ft as the minimum length of a passing zone.

The design standards for Arkansas specify 10 s of travel distance at the 85th percentile or posted speed, whichever is higher, as the minimum length of a passing zone.

The design standards for California specify the minimum length of a passing zone to be the minimum passing sight

distance shown in Table 3B-1 of the *MUTCD* for the prevailing speed.

The design standards for seven agencies (ID, IL, IN, MN, OH, WI, and WY) specified the minimum length of a passing zone to be a range of distances based on the speed of traffic.

The following are the minimum lengths of passing zones for the seven agencies that show a range of distances:

Idaho

400 ft for speed limits of 45 mph or less
450 ft for a speed limit of 50 mph
500 ft for a speed limit of 55 mph
550 ft for a speed limit of 60 mph
600 ft for a speed limit of 65 mph.

Illinois

400 ft for speeds of less than 60 mph and 600 ft for speeds of 60 mph or more
If the gap between consecutive no-passing zones is between 600 and 800 ft, connecting the no-passing zones is optional.

Indiana

420 ft for a speed limit of 30 mph
480 ft for speed limits of 35 or 40 mph
530 ft for a speed limit of 45 mph
580 ft for a speed limit of 50 mph
730 ft for a speed limit of 55 mph
860 ft for a speed limit of 60 mph
1,000 ft for a speed limit of 65 mph
(All of these dimensions are shown in metric units in the design standards.)

Minnesota

500 ft for 85th percentile speeds of 20 to 39 mph
650 ft for 85th percentile speeds of 40 to 54 mph
800 ft for 85th percentile speeds of 55 mph or more.

Ohio

400 ft for speeds of less than 50 mph and 600 ft for speeds of 50 mph or more.

Wisconsin

528 ft for speed limits of 40 mph or less
686 ft for speed limits of 45 or 50 mph
792 ft for a speed limit of 55 mph
(These dimensions are shown as 0.10, 0.13, and 0.15 mi in the design standards.)

Wyoming

280 ft for a speed limit of 25 mph
320 ft for a speed limit of 30 mph
370 ft for a speed limit of 35 mph
410 ft for a speed limit of 40 mph
500 ft for a speed limit of 45 mph
550 ft for a speed limit of 50 mph
650 ft for a speed limit of 55 mph
700 ft for a speed limit of 60 mph
850 ft for speed limits of 65 mph or more.

MINIMUM LENGTH OF NO-PASSING ZONES

2003 *MUTCD* Provisions

The *MUTCD* does not specify the minimum length of a no-passing zone.

Minimum Length of No-Passing Zones (14 agencies)

The design standards for Idaho show 250 ft as the minimum length of a no-passing zone.

The design standards for 12 agencies (AL, AK, IL, IN, IA, NY, MN, MT, OH, OR, WI, and WY) show 500 ft as the minimum length of a no-passing zone.

The design standards for Tucson/Pima County show 550 ft as the minimum length of a no-passing zone.

TWO-WAY LEFT-TURN LANES

2003 *MUTCD* Provisions

Paragraph 3 of Section 3B.03 contains the following standard: "If a two-way left-turn lane [2WLTLS] that is never operated as a reversible lane is used, the lane line pavement markings on each side of the two-way left-turn lane shall consist of a normal broken yellow line and a normal solid yellow line to delineate the edges of a lane that can be used by traffic in either direction as part of a left-turn maneuver. These markings shall be placed with the broken line toward the two-way left-turn lane and the solid line toward the adjacent traffic lane as shown in Figure 3B-7" (see Appendix A for figures). This lane line standard is universally followed, but no standards are given as to the use or placement of turn arrows in the two-way left-turn lane.

Figure 3B-7 shows an example of the pavement markings that are used for 2WLTLs. The lane lines on both sides of the 2WLTL are shown as a solid yellow line adjacent to the through lane and a broken yellow line adjacent to the 2WLTL. The typical spacing between the tips of the arrowheads of the two opposing left-turn arrows that comprise a set of arrows

is shown as 8 to 16 ft. The use of left-turn arrows in the 2WLTL is shown as being optional.

Paragraph 23 of Section 3B.19 contains the following support: "Lane-use arrow markings are often used to provide guidance . . . in two-way left-turn lanes (see Figure 3B-7)."

Lane Lines (37 agencies)

All of the design standards consistently show the lane lines on both sides of the 2WLTL as a solid yellow line adjacent to the through lane and a broken yellow line adjacent to the 2WLTL. None of the design standards show the use of lane lines that are different from those shown in Figure 3B-7 of the *MUTCD*.

Use Versus Non-Use of Left-Turn Arrows (37 agencies)

Except for four agencies, the design standards consistently require the use of left-turn arrows in 2WLTLs. The design standards for four agencies (AZ, CA, TX, and UT) state that the use of the arrows is optional.

Spacing Between Opposing Left-Turn Arrows in a Set of Arrows (36 agencies)

The design standards for 21 agencies specify the spacing between opposing left-turn arrows in a set of arrows as the distance between the tips of the arrowheads. The distances specified for these 21 agencies are as follows:

WA—5 to 10 ft
NH—8 ft
MN, NV, OH, PA—8 to 16 ft
TX—typically 8 to 16 ft
MT—no less than 10 ft and no more than 20 ft
CLT—15 ft
SD—16 ft
ID—18 to 32 ft depending on the prevailing speed
NE—24 to 32 ft in urban areas and 32 to 40 ft in rural areas
MI—32 ft
CO, DE, IN, IA, LA, WY—typically 32 ft
UT—typically 33 ft
CA—generally equal to the left-turn arrow size (the typical left-turn arrow is 8 ft long, but an arrow that is 24 ft long may be used on high-speed roadways).

The design standards for 15 agencies specify the spacing between opposing left-turn arrows in a set of arrows as the distance between the closest points of the arrows. The distances specified for these 15 agencies are as follows:

NY—5 ft
OR—typically 8 to 16 ft
MS, NC—10 ft
FL—12 ft
OK, KS—16 ft
MD—typically 16 ft
GA—25 ft
AR, WI—32 ft
AL, AZ, TN, WV—typically 32 ft.

Minimum Spacing from One Set of Arrows to the Next Set of Arrows (10 agencies)

The design standards for five agencies specify the minimum spacing between sets of arrows as the distance between the center points of the sets. The minimum distances specified for these five agencies are as follows:

CLT—100 ft
TX—150 ft
OR—250 ft
IN—400 ft
AR—500 ft in urban areas and 1,300 ft in rural areas.

The design standards for two agencies specify the minimum spacing between sets of arrows as the distance between the closest points (bottom of the arrows) of each set. The minimum distances specified for these two agencies are as follows:

AL—200 ft
MI—300 ft.

The design standards for one agency specify the minimum spacing between sets of arrows as the distance between the tips of the arrowheads of nearest arrows. The minimum distance specified for this agency is as follows:

UT—100 ft.

The design standards for two agencies specify the minimum spacing between sets of arrows, but do not indicate how the distance is measured. The minimum distances specified for these two agencies are as follows:

IL—200 ft
OH—500 ft for speeds of 40 mph or less and 1,000 ft for speeds of more than 40 mph.

Maximum Spacing from One Set of Arrows to the Next Set of Arrows (14 agencies)

The design standards for six agencies specify the maximum spacing between sets of arrows as the distance between the center points of the sets. The maximum distances specified for these six agencies are as follows:

MN—200 ft
CLT—300 ft

ID—300 ft if the average daily traffic (ADT) is more than 10,000 and 500 ft if the ADT is less than 10,000
WA—500 ft
AR—1,000 ft in urban areas and 1,500 ft in rural areas
TX—1,500 ft.

The design standards for one agency specify the maximum spacing between sets of arrows as the distance between the closest points (bottom of the arrows) of each set. The maximum distance specified for this agency is as follows:

MI—1,000 ft.

The design standards for one agency specify the maximum spacing between sets of arrows as the distance between the tips of the arrowheads of the nearest arrows. The maximum distance specified for this agency is as follows:

UT—300 ft.

The design standards for six agencies specify the maximum spacing between sets of arrows, but do not indicate how the distance is measured. The maximum distances specified for these six agencies are as follows:

FL, IL—300 ft
WI—400 ft
LA—750 ft
OH—1,000 ft for speeds of 40 mph or less and 1,500 ft for speeds of more than 40 mph
TN—2,640 ft (shown as a half-mile).

Spacing from One Set of Arrows to the Next Set of Arrows (12 agencies)

The design standards for seven agencies specify the desired or required spacing between sets of arrows as the distance between the center points of the sets. The desired or required distances specified for these six agencies are as follows:

WV—typically 200 to 500 ft
MS—250 ft
NC, PA—typically 320 ft
OR—placed at even intervals, proportioned within each block, with the approximate interval in feet being ten times the posted speed limit in mph
IA—the interval in feet is typically ten times the speed limit in mph, or one set of arrows located midblock
KS—the interval in feet is ten times the speed limit in mph.

The design standards for four agencies specify the desired or required spacing between sets of arrows as the distance between the closest points (bottom of the arrows) of each set. The desired or required distances specified for these four agencies are as follows:

OK—200 ft
NY—typically 200 ft
AL—400 ft
MD—typically 800 ft.

The design standards for one agency specify the desired or required spacing between sets of arrows, but do not indicate how the distance is measured. The desired or required distances specified for this agency are as follows:

MT—500 ft in urban areas and 1,320 ft in rural areas.

Other Considerations Regarding the Spacing of Sets of Arrows (15 agencies)

The design standards for New York recommend that a set of arrows be placed 21 ft (shown as 6.5 m) from the end of a single-direction turn lane (this distance is measured from the bottom of the nearest arrow to the end of the 2WLTL).

The design standards for the city of Charlotte show that a set of arrows is placed 25 ft from the end of a single-direction turn lane (this distance is measured from the center point between a pair of arrows to the end of the 2WLTL).

The design standards for Oklahoma show that a set of arrows is placed 30 ft from the ends of the 2WLTLs, including when they are interrupted for intersecting streets.

The design standards for Idaho show that a set of arrows should be placed such that the tip of the nearest arrowhead is no closer than 50 ft to the nearest edge of an intersecting street.

The design standards for Maryland require that a set of arrows be placed on each approach to all intersecting streets at a distance of 50 ft from the resumption of the centerline markings.

The design standards for Minnesota recommend that a set of arrows be placed such that the center point between a set of arrows is 50 ft from the resumption of the centerline markings if they are interrupted for an intersecting street.

The design standards for Montana require that a set of arrows be placed 50 ft from intersections or the ends of single-direction turn lanes.

The design standards for Mississippi require that each segment of continuous 2WLTL be considered separately. If the segment is shorter than 350 ft, one set of arrows is placed in the center of the segment. If the segment is longer than 350 ft, the first set of arrows is placed 50 to 100 ft from the beginning or end of the segment.

The design standards for New Hampshire recommend that a set of arrows be placed no less than 50 ft and no more than 100 ft from the end of a single-direction turn lane (this distance is measured from the tip of the nearest arrowhead to the end of the 2WLTL).

The design standards for Arkansas show that a set of arrows is placed 100 ft (measured to the center point between the pair of arrows) from the beginning or end of the 2WLTL, including where the 2WLTL is interrupted for a one-direction left-turn lane at an intersection. A set of arrows is placed 100 ft (measured to the center point between the pair of arrows) from side streets if the 2WLTL centerline markings are interrupted for an intersecting street.

The design standards for Washington State show that a set of arrows is placed approximately 100 ft from the ends of the 2WLTLs.

The design standards for Ohio recommend that a set of arrows be placed 100 to 200 ft from the near edge of intersecting streets or from the ends of the 2WLTLs.

The design standards for Wisconsin recommend that a set of arrows be placed near intersections or driveways with turning traffic.

The design standards for Illinois require that at least two sets of arrows be used.

The design standards for Louisiana require that at least one set of arrows be used per block.

The design standards for Montana require that at least two sets of arrows be used per block.

CLIMBING OR PASSING LANES

2003 *MUTCD* Provisions

The *MUTCD* does not specifically address climbing or passing lanes.

Figure 3B-3 illustrates the typical pavement markings that are used on roadways that have two lanes in one direction and a single lane in the other direction. This figure shows a broken lane line being used to separate the two lanes traveling in the same direction. Drawing "a" in Figure 3B-3 shows that passing can be permitted in the single-lane direction.

Figure 3B-12 shows examples of the pavement markings that are used where a lane is ending. This figure shows the broken lane line ending 0.75*D* upstream from the downstream end of the full-width section, where *D* is the distance (based on Section 2C.05) that a Lane Ends (W4-2) sign is placed upstream from the downstream end of the full-width section. This is consistent with Paragraph 5 of Section 3B.09, which says that, "Lane line markings should be discontinued one-quarter of the distance between the Lane Ends sign (see Section 2C.33) and the point where the transition taper begins." Lane-reduction arrows are not shown in Figure 3B-12.

Paragraph 19 of Section 3B.19 contains the following option: "In situations where a lane reduction transition occurs, the lane reduction arrow markings shown in Figure 3B-21 may be used" (see Appendix A for figures).

Type of Lane Line (22 agencies)

Except for the three agencies listed here, the design standards consistently show a broken lane line being used to separate the two lanes in the same direction.

The design standards for California show a broken lane line being used to separate the two lanes in the same direction, but state that when a climbing lane is provided and it is necessary to prohibit trucks from passing slower moving vehicles, an 8-in.-wide solid line shall be used in place of the broken lane line and a TRUCKS RIGHT LANE ONLY sign shall be placed at the beginning of the restriction and at approximately quarter-mile intervals.

The design standards for Connecticut show a double broken line (10-ft segments with 30-ft gaps) starting at the upstream end of the full-width climbing lane and ending 1,150 ft upstream from the downstream end of the full-width climbing lane. For the next 500 ft, a double line comprised of a solid line next to the permanent (left) lane and a broken line (10-ft segments with 30-ft gaps) next to the climbing (right) lane is used. For the last 650 ft of the full-width climbing lane, no lane line is used. (The treatments of climbing lanes through portions of roadways where entrance or exit ramps enter or exit the roadway are also shown, as is the treatment of a climbing lane that is on an entrance ramp.)

The design standards for Massachusetts show a broken line comprised of 100-ft segments with 10-ft gaps.

Start (Upstream End) of Lane Line (22 agencies)

Except for the four agencies listed here, the design standards consistently show the lane line starting at the upstream end of the full-width climbing or passing lane.

The design standards for California and climbing lanes in Minnesota show the lane line starting 50 ft downstream from the upstream end of the full-width climbing or passing lane.

The design standards for Iowa show the lane line starting 250 ft downstream from the upstream end of the full-width climbing or passing lane.

The design standards for Wyoming show the lane line starting an unspecified distance downstream from the upstream end of the full-width climbing or passing lane.

Other Markings at Start (Upstream End) of Lane Line (6 agencies)

The design standards for Georgia show that drivers are always directed into the right lane when they are approaching a

passing lane area regardless of which side or sides of the roadway are widened. This is done by providing a painted median for the upstream two-thirds of the transition taper. The painted median, which includes 24-in.-wide diagonal stripes between two sets of double yellow centerlines, goes from no width to a width of 8 ft during this distance. After the painted median has become 8 ft wide, a 100-ft taper is used to open up the left lane for faster traffic.

The design standards for Idaho and Kansas show a dotted line (2-ft segments with 4-ft gaps) connecting the double yellow centerline at the upstream end of the shifting taper with the upstream end of the broken lane line to encourage drivers to move into the right lane at the beginning of the passing lane area.

The design standards for Minnesota show that when a passing lane section is provided, passing lanes are constructed for both directions of traffic. A painted median marked with diagonal stripes is provided to move all traffic into the newly formed right lane by means of a shifting taper. A no-passing zone that is at least 500 ft in length is provided upstream of the painted median. At the downstream end of the painted median, a broken lane line begins and the painted median abruptly ends with a line that is perpendicular to the centerline.

The design standards for New York show a partial barrier line (a 4-in.-wide solid line on the left-hand side and a 4-in.-wide broken line with 10-ft segments and 30-ft gaps on the right-hand side) connecting the centerline at the upstream end of the shifting taper with the upstream end of the broken lane line to encourage drivers to move into the right lane at the beginning of the passing lane area.

The design standards for Wisconsin show that if the length of the shifting taper is at least 700 ft, a 4-in.-wide dotted line (3-ft segments with 12-ft gaps) connects the centerline at the upstream end of the shifting taper with the upstream end of the broken lane line to encourage drivers to move into the right lane at the beginning of the climbing or passing lane area.

End (Downstream End) of Lane Line (18 agencies)

The design standards for seven agencies (AK, AZ, CA, KS, KY, MT, and UT) show the lane line ending at a distance 0.75*D* upstream from the downstream end of the full-width climbing or passing lane. The design standards for Wyoming show the lane line ending at a distance 0.5*D* upstream from the downstream end of the full-width climbing or passing lane. For each of these eight agencies, the distance *D* is the advance distance (based on Condition A in Table 2C-4 of the *MUTCD*) in feet that a Lane Ends warning sign is placed upstream from the downstream end of the full-width section.

The design standards for 10 agencies show the lane line ending at a specific distance upstream from the downstream end of the full-width climbing or passing lane. The distances are as follows:

MA—0 ft
NY—100 ft
MN—passing lanes at 150 ft, climbing lanes at 200 ft
ID—200 ft
OR—at least 200 ft, but typically 375 ft (which is 0.75*D,* where *D* is the 500-ft distance to the advance warning sign)
GA—200 ft for 35 mph, 275 ft for 45 mph, 350 ft for 55 mph
WI—350 ft
IN—375 ft
IA—550 ft
CT—650 ft.

Use of Lane-Reduction Arrows (18 agencies)

The design standards for 14 agencies (AZ, CT, GA, IN, IA, KS, KY, MA, MN, MT, NY, UT, WI, and WY) do not show the use of lane-reduction arrows in the climbing or passing lane.

The design standards for Idaho and Oregon state that the use of lane-reduction arrows in the climbing or passing lane is optional.

The design standards for Arkansas and California require the use of lane-reduction arrows in the climbing or passing lane.

Number and Placement of Lane-Reduction Arrows (4 agencies)

The four agencies that use lane-reduction arrows in the climbing or passing lane use the following number of arrows:

OR—at least 2
AK, CA, ID—3.

The four agencies that use lane-reduction arrows in the climbing or passing lane place the top of the arrows at the following distances upstream from the downstream end of the full-width climbing or passing lane:

CA, ID—0 ft, 200 ft, and 400 ft
AK—0 ft, 0.375*D,* and 0.75*D*
OR—500 ft to the first arrow and then additional lane-reduction arrows are placed upstream with the spacing between the bottom of the downstream arrow and the top of the upstream arrow being 200 ft.

Passing Permitted or Prohibited in Opposing (Single-Lane) Direction (21 agencies)

The design standards for 17 agencies (AK, GA, ID, IN, IA, KS, KY, MA, MN, NY, ND, OR, UT, WI, WY, PR, and

LAN) show that passing may be permitted in the single-lane direction. The design standards for Massachusetts also show that passing can be permitted in the climbing lane direction if sight distance allows, thus creating a third available lane when there is a sufficient gap in opposing traffic.

The design standards for three agencies (AZ, MT, and WV) require that passing be prohibited in the single-lane direction. The design standards for Arizona also state that when uphill passing lanes are provided, the centerline for downhill traffic "shall be solid from 500 ft in advance of the initial taper to 200 ft past the end of the terminal taper."

The design standards for California require that passing be prohibited in the single-lane direction if the ADT exceeds 3,000. When the ADT is 3,000 or less, passing can be permitted in the single-lane direction provided that one or more YIELD TO UPHILL TRAFFIC signs are installed.

LANE REDUCTIONS

2003 *MUTCD* Provisions

Figure 3B-12 shows examples of the pavement markings that are used where a lane is ending. Figure 3B-12 shows the broken lane line ending 0.75*D* upstream from the downstream end of the full-width section, where *D* is the distance (based on Section 2C.05) that a Lane Ends (W4-2) sign is placed upstream from the downstream end of the full-width section. This is consistent with Paragraph 5 of Section 3B.09, which says that, "Lane line markings should be discontinued one-quarter of the distance between the Lane Ends sign (see Section 2C.33) and the point where the transition taper begins." Lane-reduction arrows are not shown in Figure 3B-12 (see Appendix A for figures).

Paragraph 19 of Section 3B.19 contains the following option: "In situations where a lane reduction transition occurs, the lane reduction arrow markings shown in Figure 3B-21 may be used."

Downstream End of Broken Lane Line (31 agencies)

The design standards for 11 agencies (AZ, CA, CO, DE, KY, LA, NV, ND, TN, UT, and PR) show the broken lane line ending at a distance 0.75*D* upstream from the upstream end of the transition taper. The design standards for Wyoming show the broken lane line ending 0.5*D* upstream from the upstream end of the transition taper. The design standards for Pennsylvania show the broken lane line ending at a distance *D* upstream from the upstream end of the transition taper. For each of these 13 agencies, the distance *D* is the advance distance (based on Condition A in Table 2C-4 of the *MUTCD*) in feet that a Lane Ends warning sign is placed upstream from the upstream end of the transition taper.

The design standards for three other agencies show the broken lane line ending at a distance 0.75*D* upstream from the upstream end of the transition taper, but with a different means of determining the distance *D*. The means of determining the distance *D* for these three agencies are as follows:

FL—the values of *D* are 325 ft for 30 mph, 475 ft for 40 mph, 550 ft for 45 mph, 625 ft for 50 mph, and 700 ft for 55 mph
NC, OR—the values of *D,* which range from 175 ft for 20 mph to 850 ft for 65 mph, are shown in a table.

The design standards for 12 agencies show the broken lane line ending at a specific distance upstream from the upstream end of the transition taper. The distances for these 12 agencies are as follows:

CLT, LAN—0 ft
NY—100 ft
ID—200 ft
IA—190 ft for 25 mph, 300 ft for 35 mph, 415 ft for 45 mph, 565 ft for 55 mph
MN—200 ft
GA—200 ft for 35 mph, 275 ft for 45 mph, 350 ft for 55 mph
TUC—245 ft for 30 mph, 300 ft for 35 mph, 350 ft for 40 mph, 415 ft for 45 mph, 475 ft for 50 mph
IN—375 ft
AR—525 ft
VT—550 ft
MA—565 ft (shown as 170 m).

The design standards for Michigan show the broken lane line ending at a specified distance upstream from the upstream end of the transition taper. The distance in feet is calculated using the formula $15(S - 10) + 25$, where S is the higher of the posted or 85th percentile speed.

The design standards for Maryland show the broken lane line ending at a specified distance upstream from the upstream end of the transition taper based on speed (1,275 ft for 65 mph, 1,165 ft for 60 mph, 1,050 ft for 55 mph, 940 ft for 50 mph, and 825 ft for 45 mph). A 10-in.-wide dotted line (3-ft segments with 9-ft gaps) is provided from the downstream end of the broken lane line to the upstream end of the transition taper.

The design standards for Mississippi show the broken lane line ending at an unspecified distance upstream from the upstream end of the transition taper. A 6-in.-wide dotted line (2-ft segments with 12-ft gaps) is provided from the downstream end of the broken lane line to the upstream end of the transition taper.

Dotted Lane Line in Transition Area (1 agency)

The design standards for North Carolina show a 4- to 6-in.-wide dotted line (2-ft segments with 13-ft gaps) from the end

of the broken lane line to the downstream end of the transition taper.

Use of Lane-Reduction Arrows (31 agencies)

The design standards for 17 agencies (AZ, AR, CO, DE, GA, IN, IA, LA, MA, MN, NY, ND, TN, UT, VT, WY, and PR) do not show the use of lane-reduction arrows in the lane that is ending.

The design standards for three agencies (ID, MI, and OR) state that the use of lane-reduction arrows in the lane that is ending is optional. The design standards for Michigan also require a MERGE message to be placed just upstream of each lane-reduction arrow if lane-reduction arrows are used. The design standards for Oregon note that lane-reduction arrows are optional for speeds higher than 45 mph, but are generally not used for speeds of 45 mph or less.

The design standards for 11 agencies (CA, FL, KY, MD, MS, NV, NC, PA, CLT, LAN, and TUC) require the use of lane-reduction arrows in the lane that is ending. The design standards for Florida also require a MERGE message to be placed just upstream of each lane-reduction arrow.

Number and Placement of Lane-Reduction Arrows (14 agencies)

The 14 agencies that use lane-reduction arrows in the lane that is ending use the following number of arrows:

FL, MI, MS—2
OR—at least 2
CA, ID, KY, MD, NV, LAN, TUC—3
PA—at least 3
CLT—4
NC—5.

The design standards for Maryland show a lane-reduction arrow positioned such that the bottom of the arrow is lined up with the downstream end of the broken lane line. Two additional lane-reduction arrows are placed in the lane, one in either direction from the lane-reduction arrow that is lined up with the downstream end of the broken lane line. These additional arrows are placed at a distance (measured from the bottom of one arrow to the bottom of the next arrow) that is based on speed (850 ft for 65 mph, 775 ft for 60 mph, 700 ft for 55 mph, 625 ft for 50 mph, and 550 ft for 45 mph).

The design standards for Mississippi show a lane-reduction arrow placed at the halfway point of the 6-in.-wide dotted line and the other placed 100 ft upstream of the downstream end of the broken lane line. The lane-reduction arrows are the same shape as the lane use arrows used in straight-through lanes and are positioned at a 30° angle from the lane line.

The design standards for Pennsylvania show the center of the lane-reduction arrow nearest to the downstream end of the lane placed at a distance D upstream from the upstream end of the transition taper. At least two additional lane-reduction arrows are placed upstream of the arrow nearest to the downstream end of the lane. The distance from the center of one arrow to the center of the next arrow is 300 ft on conventional roadways and 600 ft on expressways and freeways.

The design standards for the city of Charlotte show the tops of the lane-reduction arrows positioned as follows: 25 ft downstream from the upstream end of the transition taper, at the upstream end of the transition taper, at 50 ft upstream from the upstream end of the transition taper, and at 100 ft upstream from the upstream end of the transition taper.

The design standards for the city of Tucson/Pima County show the lane-reduction arrow farthest upstream positioned with its top a distance in feet upstream from the upstream end of the transition taper that is calculated using the formula $15(S - 25) + 250$, where S is the posted speed in mph. Two additional lane-reduction arrows are placed downstream from this arrow at 40-ft intervals for speed limits of 30 mph or less, 80-ft intervals for 35 or 40 mph speed limits, and 120-ft intervals for speed limits of 45 mph or more.

The other nine agencies that use lane-reduction arrows in the lane that is ending place the top of the arrows at the following distances upstream from the upstream end of the transition taper:

CA, ID, LAN—0 ft, 200 ft, and 400 ft
NC—0 ft, 100 ft, 200 ft, 500 ft, and 800 ft
NV—0, 0.25D, and 0.5D
KY—0.75D, D, and D + 250 ft
MI—D and 2D
FL—just before the downstream end of the full-width lane where a painted taper begins (the edge of pavement taper begins 120 to 910 ft farther downstream based on the speed and lateral offset, and at the downstream end of the broken lane line
OR—typically 500 ft to the first arrow and then additional lane-reduction arrows are placed upstream with the spacing between the bottom of the downstream arrow and the top of the upstream arrow being 200 ft.

PAINTED MEDIANS, PAVED SHOULDERS, AND APPROACHES TO OBSTRUCTIONS

Figure 9 shows examples of diagonal lines in painted medians and on paved shoulders. Figure 3B-13 (see Appendix A) shows examples of diagonal lines and chevrons on approaches to obstructions.

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Paragraph 6 of Section 3B.03 contains the following standard that makes it clear that painted medians do not have to include

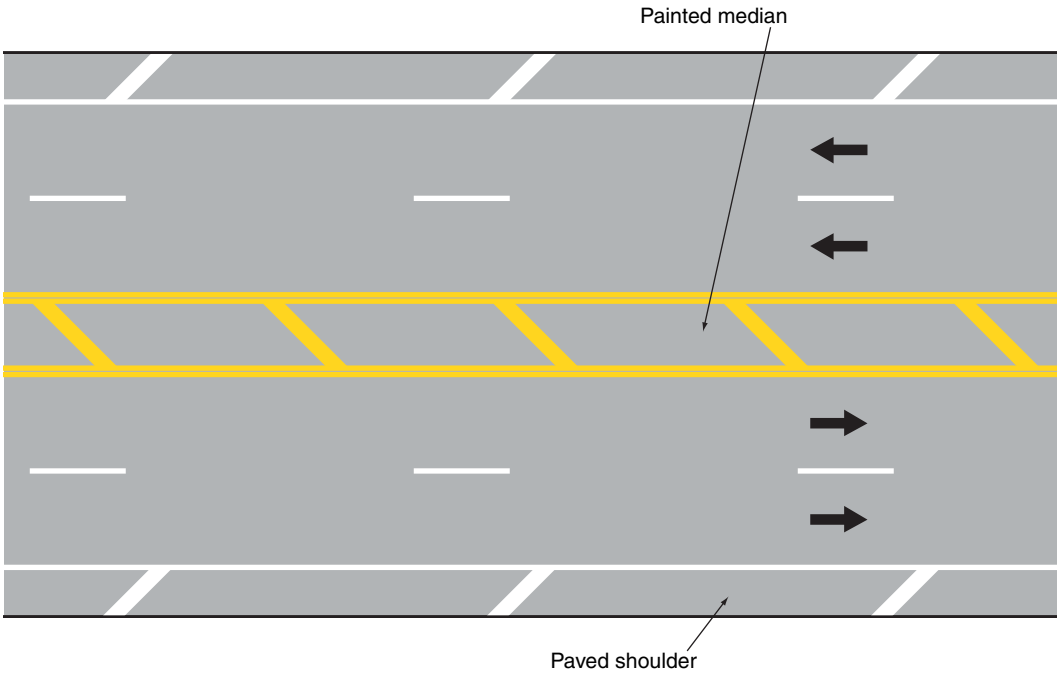

FIGURE 9 Examples of diagonal lines in painted medians and on paved shoulders.

diagonal lines, but that yellow pavement markings (such as diagonal lines) may be used: "If a continuous median island formed by pavement markings separating travel in opposite directions is used, two sets of double solid yellow lines shall be used to form the island as shown in Figures 3B-2 and 3B-4. Other markings in the median island area shall also be yellow, except crosswalk markings which shall be white (see Section 3B.17)." Although the type of lane line has been made a standard, no standards are provided for the use, width, or placement of diagonal lines in the painted median area.

Paragraph 7 of Section 3B.10 contains the following option: "If traffic is required to pass only to the right of the obstruction, yellow diagonal approach markings may be placed in the neutral area between the no-passing zone markings as shown in Figure 3B-13" (see Appendix A for figures).

Paragraph 9 of Section 3B.10 contains the following option: "If traffic can pass either to the right or left of the obstruction, additional white markings may be placed in the neutral area between the channelizing lines as shown in Figure 3B-13."

Use Versus Non-Use of Diagonal Lines Within Painted Medians (39 agencies)

Except for the 12 agencies listed here, the design standards consistently show the use of diagonal lines within painted medians.

The design standards for three agencies (AK, AZ, PR) indicate that diagonal lines are not used within painted medians. The design standards for Tennessee indicate that diagonal lines are not used within painted medians that are less than 6 ft wide.

The design standards for six agencies (CA, CO, MI, NH, OR, UT) indicate that diagonal lines are optional within painted medians. The design standards for Ohio indicate that diagonal lines are optional, but typically not used within painted medians that are less than 6 ft wide.

The design standards for Idaho state that diagonal lines should not be placed as a standard practice because of the questionable benefits and high exposure of paint crews to traffic. Exceptions should be limited to those locations where the additional emphasis is clearly needed and then only for medians with widths of 10 ft or more.

The design standards for Pennsylvania note that diagonal lines are used only when required to provide emphasis if the visibility or sight distance is restricted.

The design standards for Iowa state that if the width of the painted median becomes less than 2 ft the median is painted solid yellow.

Width of Diagonal Lines Within Painted Medians (34 agencies)

The design standards for the 34 agencies that specify a line width for the diagonal lines (at a forward angle of 45° unless otherwise stated) within painted medians use the following widths:

MI—6 in. for posted speed limits of 45 mph or less and 12 in. for posted speed limits of more than 45 mph
CO, IA, NC, OK, UT, VT—8 in.

CA, HI, IL, NE, RI, TN, WV, WI, DC—12 in.
OR—12 in. at a 36° angle (the diagonal lines are rectangular in shape and do not connect to the lane lines—the nearest points of the diagonal lines are placed 4 in. from the centerline)
KS, CLT—12 in. at a 30° angle
IN—12 in. for posted speed limits of 45 mph or less and 24 in. for posted speed limits of more than 45 mph
TUC—12 in. for posted speed limits of 40 mph or less and 24 in. for posted speed limits of more than 40 mph
FL, MS—18 in.
GA, LA, NH, OH, PA, SC, SD—24 in.
NY—24 in. at a 45° angle, 12 in. at a 20° angle, or 8 in. at a 15° angle
MT—24 in. at a 30° angle
MN—24 in., but may be reduced to 12 in. for speeds less than 40 mph
TX—typically 24 in., but no less than 12 in.

Spacing of Diagonal Lines Within Painted Medians (33 agencies)

The design standards for the 33 agencies that specify the spacing (measured along the centerline unless otherwise stated) for the diagonal lines within painted medians use the following spacings:

DC—5 ft
SC—6 ft for the first five diagonal lines, 12 ft for the next four diagonal lines, and 18 ft for the remaining diagonal lines (the diagonal lines start when the median width reaches 2 ft and end when the median width reaches 8 ft; however, the length of median with diagonal lines spaced at 18-ft intervals is not less than 72 ft or more than 500 ft)
VT—7 ft where speeds are low, sight distance is less than 200 ft, and the length of the painted median is 75 ft or less; 14 ft where speeds are high, sight distance is 200 ft or more, and where the length of the painted median is more than 75 ft
PA—8 ft for posted speed limits of 35 mph or less and 16 ft for posted speed limits of more than 35 mph
RI, UT—10 ft
FL, MI—10 to 40 ft based on posted speed limit
NY—11 ft (shown as 3.3 m) for 45° angle lines, 12 ft (shown as 3.6 m) for 20° angle lines, or 10 ft (shown as 3.0 m) for 15° angle lines
WV—12 ft
NE—12 ft in urban areas and 20 ft in rural areas
OH—12 ft for the first 48 ft, 24 ft for the next 48 ft, and 48 ft thereafter (the 12-ft spacing starts on both ends of the painted median)
GA, OK—15 ft
IL—15 ft for speed limits less than 30 mph, 20 ft for speed limits from 30 to 45 mph, and 30 ft for speed limits of more than 45 mph near intersections and in pavement width transition areas; and 50 ft for speed limits less than 30 mph, 75 ft for speed limits from 30 to 45 mph, and 150 ft for speed limits of more than 45 mph between intersections (if the recommended spacing does not provide at least five diagonal lines in the area being marked, the spacing from the next lowest speed range should be used)
MN—20 ft, but may be increased to 30 ft for speeds of more than 40 mph (measured perpendicular to the diagonal lines)
HI, IA, MS, NH, TX—20 ft
OR—20 ft, but may be increased to 40 ft if the distance between left-turn lanes exceeds 200 ft
IN—20 ft for posted speed limits of 45 mph or less and 40 ft for posted speed limits of more than 45 mph
TUC—20 ft for posted speed limits of 40 mph or less and 80 ft for posted speed limits of more than 40 mph
LA—24 ft
CO—25 ft
MT—25 ft (shown as 7.5 m)
WI—25 ft starting when the painted median becomes 3 ft wide
SD—25 ft, but 20 ft for two-lane to four-lane transition areas
CLT—30 ft
TN—50 ft for posted speed limits of 40 mph or less and 100 ft for posted speed limits of more than 40 mph (where a left-turn lane is formed by roadway widening at an intersection, diagonal lines are spaced at 10-ft intervals and start when the width of the median becomes 6 ft)
NC—the distance in feet is equal to the posted speed limit in mph
KS—the distance in feet is equal to the speed in mph.

Longitudinal Lines Surrounding Painted Medians (39 agencies)

Except for the two agencies listed here, the design standards consistently show double yellow centerlines on both sides of painted medians.

The design standards for Iowa show 8-in.-wide solid lines surrounding painted medians.

The design standards for Mississippi show 12-in.-wide solid lines surrounding painted medians.

Use Versus Non-Use of Diagonal Lines on Paved Shoulders (20 agencies)

Except for the two agencies cited here, the design standards consistently show that the use of diagonal lines on paved shoulders is optional.

The design standards for Arkansas indicate that diagonal lines are not used on paved shoulders.

The design standards for Idaho note that diagonal lines should not be placed as a standard practice because of the questionable benefits and high exposure of paint crews to traffic. Exceptions should be limited to those locations where the additional emphasis is clearly needed and then only for paved shoulders with widths of 10 ft or more.

Width of Diagonal Lines on Paved Shoulders (20 agencies)

The design standards for the 20 agencies that specify a line width for the diagonal lines (at a forward angle of 45° unless otherwise stated) on paved shoulders use the following widths:

MI—6 in. for posted speed limits of 45 mph or less and 12 in. for posted speed limits of more than 45 mph
CO, NC—8 in.
CA, HI, IL, RI, TN, DC, PR—12 in.
KS, CLT—12 in. at a 30° angle
NYC—16 in.
FL, MS—18 in.
GA, NH, OH, PA—24 in.
NY—24 in. at a 45° angle, 12 in. at a 20° angle, or 8 in. at a 15° angle.

Spacing of Diagonal Lines on Paved Shoulders (17 agencies)

The design standards for the 17 agencies that specify the spacing (measured along the centerline) for the diagonal lines (at a forward angle of 45° unless otherwise stated) on paved shoulders use the following spacings:

DC—5 ft
FL, MI—10 to 40 ft based on posted speed limit
OH—12 ft for the first 48 ft, 24 ft for the next 48 ft, and 48 ft thereafter
GA—15 to 50 ft
MS, NH—20 ft
CO—20 to 100 ft
CLT—30 ft
PR—33 ft
HI—40 ft
TN—50 ft for posted speed limits of 40 mph or less and 100 ft for posted speed limits of more than 40 mph
IL—50 ft for speed limits less than 30 mph, 75 ft for speed limits from 30 to 45 mph, and 150 ft for speed limits of more than 45 mph (if the recommended spacing does not provide at least five diagonal lines in the area being marked, the spacing from the next lowest speed range should be used)
NY—up to 100 ft for 45° angle lines or 12 ft (shown as 3.6 m) for 20° angle lines or 10 ft (shown as 3.0 m) for 15° angle lines
NC, PA—the distance in feet is equal to the posted speed limit in mph, but can be increased to 200 ft or more on Interstate highways
KS—the distance in meters is equal to the speed in kilometers/hour divided by five.

Width of Diagonal Lines or Chevrons on Approaches to Obstructions (8 agencies)

The design standards for the eight agencies that specify a line width for the diagonal lines or chevrons (both at a forward angle of 45° unless otherwise stated) on approaches to obstructions use the following widths:

CO—8 in.
CA, GA, IL, TN, DC—12 in.
KS—12 in. at a 30° angle
AK—18 in.

Spacing of Diagonal Lines or Chevrons on Approaches to Obstructions (6 agencies)

The design standards for the six agencies that specify the spacing (measured along the centerline or lane line) for the diagonal lines or chevrons on approaches to obstructions use the following spacings:

GA, DC—5 ft
IL—10 ft for speed limits less than 30 mph, 15 ft for speed limits from 30 to 45 mph, and 20 ft for speed limits of more than 45 mph (if the recommended spacing does not provide at least five diagonal lines in the area being marked, the spacing from the next lowest speed range should be used)
TN—10 ft for posted speed limits of 40 mph or less and 20 ft for posted speed limits of more than 40 mph
AK—12 ft
CO—25 ft.

CHAPTER FOUR

PAVEMENT MARKINGS AT INTERCHANGES

Figures 3B-8 and 3B-9 (see Appendix A) show examples of the pavement markings that are used in the gore areas of entrance and exit ramps, including channelizing lines and optional chevron markings. Figure 10 shows an example of the use of diagonal lines within the paved gore of an exit ramp.

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Paragraph 1 of Section 3B.05 contains the following standard: "A channelizing line shall be a wide or double solid white line." A wide line is 8 to 12 in. wide. A double line consists of two parallel lines separated by a discernible space.

Paragraph 6 of Section 3B.05 contains the following support: "Channelizing lines at entrance ramps as shown in Figure 3B-9 promote reasonably safe and efficient merging with the through traffic."

Paragraph 9 of Section 3B.05 contains the following guidance: "For entrance ramps, a channelizing line should be placed along the side of the neutral area adjacent to the ramp lane."

Paragraph 11 of Section 3B.05 contains the following option: "For entrance ramps with a tapered acceleration lane, lane line markings may be placed to extend the channelizing line, but not beyond a point where the tapered lane meets the near side of the through traffic lane as shown in Figure 3B-9."

Paragraph 5 of Section 3B.05 contains the following support: "Channelizing lines at exit ramps as shown in Figure 3B-8 define the neutral area, direct exiting traffic at the proper angle for smooth divergence from the main lanes into the ramp, and reduce the probability of colliding with objects adjacent to the roadway."

Paragraph 7 of Section 3B.05 contains the following standard: "For exit ramps, channelizing lines shall be placed along the sides of the neutral area adjacent to the through traffic lane and the ramp lane." This standard is universally followed.

Paragraph 8 of Section 3B.05 contains the following option: "White chevron markings may be placed in the neutral area for special emphasis as shown in Figure 3B-8." Although this paragraph immediately follows a paragraph regarding exit ramps and although Figure 3B-9 does not mention the option of using chevrons in the paved gores for entrance ramps, there are no provisions in the *MUTCD* that specifically prohibit the use of chevrons in the paved gores for entrance ramps.

Figure 3B-9 provides examples of entrance ramps with parallel and tapered acceleration lanes. Chevrons are not shown in the paved gores. Wide channelizing lines that begin at the upstream end of the paved gore are shown on both sides of the paved gore for the parallel acceleration lane example. In the example with the tapered acceleration lane, a wide channelizing line that begins at the upstream end of the paved gore is shown only on the ramp side of the paved gore. The wide channelizing line ends before the downstream end of the gore and a broken lane line is used to define the remainder of the ramp side of the paved gore.

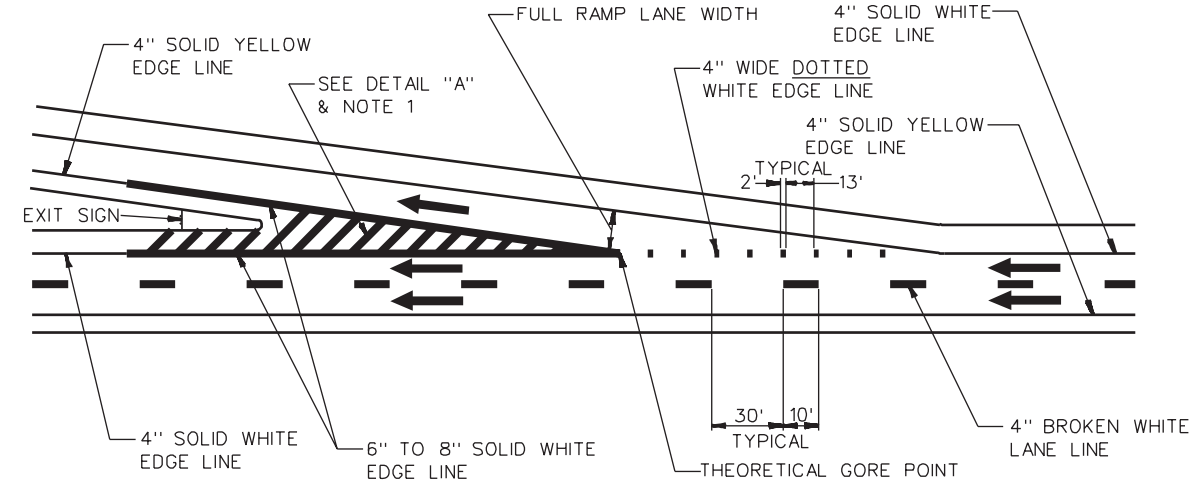
Figure 3B-8 provides examples of exit ramps with parallel and tapered deceleration lanes. Chevrons are shown in the paved gores, but a note indicates that they are optional. The note for Drawing "c" indicates that the markings within the paved gore may also be diagonal lines rather than chevrons. Wide channelizing lines that end at the downstream end of the paved gore are shown on both sides of the paved gores. In the example with the tapered deceleration lane, an optional dotted extension of the right edge line is shown upstream from the upstream end of the paved gore. Figure 3B-10 provides an example of an exit ramp where chevrons are not shown in the paved gore (see Appendix A for figures).

ENTRANCE RAMP GORES

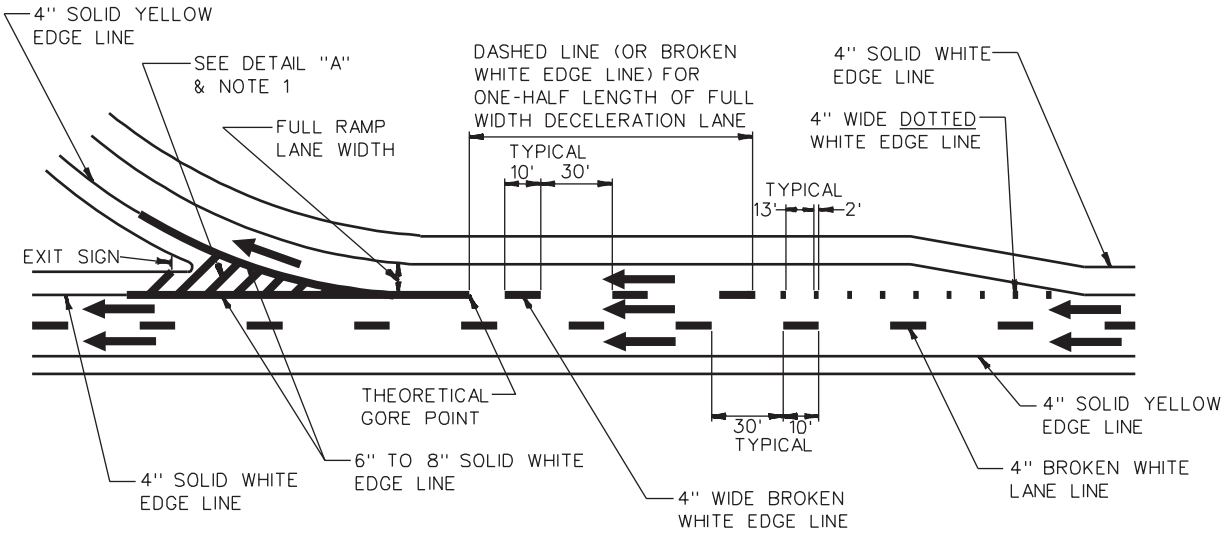
Width of Channelizing Lines (43 agencies)

The following widths are explicitly specified in the design standards for the channelizing lines associated with entrance ramps:

- UT—4 in. for parallel acceleration lanes and 8 in. for tapered acceleration lanes
- WV—6 to 8 in.
- CA, CO, CT, FL, HI, IL, IN, IA, KS, LA, MA, MN, MO, MT, ND, OK, OR, PA, TN, TX, VA, WA, WI, WY, PR, NYC—8 in.
- AL, NC, OH—8 in. or 12 in.
- SC—8 in. for primary and secondary highways and 12 in. for expressways and freeways
- GA, MD—10 in.
- AZ, DE, MI, MS, NE, NH, NY, RI, VT—12 in.



EXIT RAMP: STRAIGHT TAPERED DECELERATION LANE



EXIT RAMP: PARALLEL DECELERATION LANE

FIGURE 10 Examples of use of diagonal lines in paved gores (*Source:* West Virginia DOT 1994 *Standard Details Book,* Sheet TEM-1).

Upstream End of Channelizing Line on Left-Hand Side of Entrance Ramp (42 agencies)

The following points (measured upstream from the upstream end of the paved gore) are explicitly specified in the design standards for the upstream end of the channelizing line on the left-hand side of the entrance ramp:

AL, CA, FL, GA, IN, IA, KS, LA, MA, MI, MN, MS, MO, MT, NY, ND, OH, OR, TX, UT, VT, VA, WA, WY, PR—0 ft
CO—just upstream
NH—5 ft
CT—20 ft
WV—25 ft
HI—40 ft
AZ, DE, IL, MD, PA, TN, WI—50 ft
NC—where the paved shoulders portion of the gore starts
OK—downstream end of the paved shoulder on the ramp
NE, SC, NYC—unspecified distance upstream.

Downstream End of Channelizing Line on Left-Hand Side of Entrance Ramp (26 agencies)

The design standards consistently show the channelizing line on the left-hand side of an entrance ramp extending to the downstream end of the paved gore (where the ramp and the mainline roadway become adjacent to one another) when a parallel acceleration lane is used.

The following points are explicitly specified in the design standards for the downstream end of the channelizing line

on the left-hand side of an entrance ramp when a tapered acceleration lane is used:

NC—upstream end of the paved gore
ND—195 ft downstream from the upstream end of the paved gore
WV—midpoint of the paved gore
WY—point where ramp and mainline roadway are the same distance apart as the width of the mainline shoulder
CA, CO, GA, HI, IL, MN, MT, NY, OH, TN, WA—point where ramp and mainline roadway are 6 ft apart
AZ, NH—point where ramp and mainline roadway are 5 ft apart
UT—point where ramp and mainline roadway are 3 ft apart
IA—point where ramp and left edge line of a 2-lane mainline roadway are 28 ft apart
IN, OK, PA, VT, WI, PR—downstream end of the paved gore.

Extension of Channelizing Line on Left-Hand Side of Entrance Ramp (26 agencies)

The design standards consistently show the channelizing line extension on the left-hand side of an entrance ramp extending to the downstream end of the paved gore (where the left-hand side of the ramp reaches the edge of the mainline roadway) when a tapered acceleration lane is used.

The following widths are used for the channelizing line extensions on the left-hand side of entrance ramps when a tapered acceleration lane is used:

CA, CO, IA, MT, NC, ND, WY—4 in.
GA—5 in.
AZ, NH—6 in.

The following patterns are used for the channelizing line extensions on the left-hand side of entrance ramps when a tapered acceleration lane is used:

CA—7-ft segments with 17-ft gaps
AZ, CO, GA, HI, IL, IA, MT, NH, NC, ND, OH, TN, UT, WV, WY—10-ft segments with 30-ft gaps.

The design standards for New York show a partial barrier line (a 6-in.-wide solid line on the gore side and a 6-in.-wide broken line with 10-ft segments and 30-ft gaps on the ramp side) being used to extend the channelizing line on the left-hand side of the entrance ramp.

Use Versus Non-Use of Channelizing Line on Right-Hand Side of Mainline Roadway (42 agencies)

The design standards for 26 agencies (AL, AZ, DE, FL, HI, IN, KS, LA, MD, MA, MI, MS, MO, MT, NE, NH, NC, OK, OR, PA, TN, TX, VT, VA, PR, and NYC) show that the use of a channelizing line on the right-hand side of the mainline roadway is required.

The design standards for seven agencies (CA, CO, CT, OH, SC, UT, and WA) state that channelizing lines are not used on the right-hand side of the mainline roadway.

The design standards for nine agencies (GA, IL, IA, MN, NY, ND, WV, WI, and WY) state that channelizing lines are not used on the right-hand side of the mainline roadway when a tapered acceleration lane is used, but are used on the right-hand side of the mainline roadway when a parallel acceleration lane is used.

Upstream End of Channelizing Line on Right-Hand Side of Mainline Roadway (34 agencies)

The following points (measured upstream from the upstream end of the paved gore) are explicitly specified in the design standards for the upstream end of the channelizing line on the right-hand side of the mainline roadway:

AL, FL, GA, IL, IN, IA, KS, LA, MA, MI, MN, MS, MO, MT, NY, ND, OK, OR, TX, VT, VA, WY, PR—0 ft
NH—5 ft
WV—25 ft
HI—40 ft
DE—less than 50 ft (the point on the right edge line where a perpendicular line would line up with the upstream end of the gore striping on the ramp)
AZ, MD, PA, TN—50 ft
NC—where the paved shoulders portion of the gore starts
NE, NYC—unspecified distance prior.

Use Versus Non-Use of Chevrons Within Paved Gore (44 agencies)

The design standards for four agencies (FL, OK, TN, and PR) show that the use of chevrons within the paved gores of entrance ramps is required. The design standards for Tennessee note that if the gore area is so short that at least five chevrons cannot be placed within the gore, the chevrons are omitted from the gore area.

The design standards for three agencies (KY, MD, and VA) show that the use of chevrons within the paved gores of entrance ramps is optional.

The design standards for 36 agencies (AL, AZ, CA, CO, CT, DE, GA, HI, IL, IA, KS, LA, MA, MI, MN, MS, MO, MT, NE, NH, NY, NC, ND, OH, OR, PA, RI, SC, TX, UT, VT, WA, WV, WI, WY, and NYC) state or show that chevrons are not used within the paved gores of entrance ramps.

The design standards for Indiana state that chevrons are not used within the paved gores of entrance ramps when a parallel

acceleration lane is used, but are used within the paved gores of entrance ramps when a tapered acceleration lane is used.

Width of Chevrons Within Paved Gore (7 agencies)

The design standards for the seven agencies that specify a width for the chevrons (at a forward angle of 45°) that are placed within the paved gores of entrance ramps use the following widths:

OK—8 in.
IN—12 in. when the posted speed limit is 45 mph or less and 24 in. when the posted speed limit is more than 45 mph
TN, PR—12 in.
MD—16 in.
FL—18 in.
VA—24 in.

Spacing of Chevrons Within Paved Gore (7 agencies)

The design standards for the seven agencies that specify the spacing (measured along the edge line of the mainline roadway) for the chevrons that are placed within the paved gores of entrance ramps use the following spacings:

PR—7 ft (shown as 2.0 m)
VA—8 ft
OK—10 ft
IN—20 ft when the posted speed limit is 45 mph or less and 40 ft when the posted speed limit is more than 45 mph
FL—20 ft
TN—20 ft (until the width of the gore becomes 6 ft)
MD—50 ft for blunt angle gores and up to 100 ft for sharp angle gores.

Other Considerations for Entrance Ramps (6 agencies)

The design standards for Maryland show that the last chevron stripe is placed 50 ft upstream from the point where the gore width becomes 1 ft wide.

The design standards for Massachusetts do not show pavement markings within the paved portion of the gore, but "rubble block" is shown as an option in this area unless travel is sometimes permitted in the breakdown lane (shoulder) of the mainline roadway.

The design standards for Michigan show that at the downstream end of the gore the two 12-in.-wide channelizing lines are side-by-side, thus resulting in a 24-in.-wide line.

The design standards for North Carolina show a 4- to 6-in.-wide dotted line (2-ft segments with 13-ft gaps) being placed along the right-hand side of the adjacent mainline lane from the downstream end of the gore to the downstream end of the taper for the acceleration lane. Three through arrows at a 45° angle are placed at 100-ft intervals ending at the downstream end of the acceleration lane.

The design standards for Tennessee show that for tapered acceleration lanes a 6-in.-wide dotted line (2-ft segments with 4-ft gaps) is placed along the right-hand side of the adjacent mainline lane from the downstream end of the gore to the downstream end of the entrance ramp.

The design standards for West Virginia show for tapered acceleration lanes a 4-in.-wide dotted line (2-ft segments with 13-ft gaps) being placed along the right-hand side of the adjacent mainline lane from the downstream end of the gore to the downstream end of the taper for the acceleration lane.

EXIT RAMP GORES

Width of Channelizing Lines (44 agencies)

The following widths are explicitly specified in the design standards for the channelizing lines associated with exit ramps:

WV—6 to 8 in.
CA, CO, CT, FL, HI, IL, IN, IA, KS, LA, MA, MN, MO, MT, ND, OK, OR, PA, TN, TX, UT, VA, WA, WI, WY, PR, NYC—8 in.
AL, NC, OH—8 in. or 12 in.
SC—8 in. for primary and secondary highways and 12 in. for expressways and freeways
GA, MD—10 in.
AZ, DE, MI, MS, NE, NV, NH, NY, RI, VT—12 in.

Use Versus Non-Use of Channelizing Line on Right-Hand Side of Mainline Roadway (44 agencies)

The design standards consistently show that the use of a channelizing line on the right-hand side of the mainline roadway is required for exit ramps.

Upstream End of Channelizing Lines for Exit Ramps with Tapered Deceleration Lanes (44 agencies)

The design standards consistently show that the upstream end of channelizing lines for exit ramps with tapered deceleration lanes to be the point where the full width of the exit ramp first becomes available.

Downstream End of Channelizing Line on Left-Hand Side of Exit Ramp (43 agencies)

The following points (measured downstream from the downstream end of the paved gore) are explicitly specified in the

design standards for the downstream end of the channelizing line on the left-hand side of the entrance ramp:

AL, CA, FL, GA, IN, IA, MA, MI, MN, MO, MT, NV, NY, NC, OH, OR, PA, SC, UT, VT, VA, WA, WY, PR—0 ft
KS—0 ft for parallel deceleration lanes and an unspecified distance downstream for tapered deceleration lanes
NH—5 ft
CT—20 ft
HI—40 ft
ND—40 ft for parallel deceleration lanes and 240 ft from the upstream end of the paved gore for tapered deceleration lanes
AZ, DE, IL, MD, TN, WI—50 ft
TX—at the downstream end of the paved shoulder portion of the gore
CO—at the location of the Exit Gore sign
WV—25 ft downstream from the location of the Exit Gore sign
LA—at the point where the shoulder returns to normal width
OK—at the point where the paved shoulder begins
MS—at the point where the curvature on the ramp changes
NE, NYC—unspecified distance downstream.

Downstream End of Channelizing Line on Right-Hand Side of Mainline Roadway (43 agencies)

The following points (measured downstream from the downstream end of the paved gore) are explicitly specified in the design standards for the downstream end of the channelizing line on the right-hand side of the mainline roadway:

AL, CA, FL, GA, IN, IA, MA, MI, MN, MO, MT, NV, NY, NC, OK, OR, UT, VT, WA, WY, PR—0 ft
ND—0 ft for parallel deceleration lanes and 200 ft from the upstream end of the paved gore for tapered deceleration lanes
NH—5 ft
CT—20 ft
HI—40 ft
DE—less than 50 ft (the point on the right edge line where a perpendicular line would line up with the downstream end of the gore striping on the ramp)
AZ, IL, MD, PA, TN, WI—50 ft
VA—150 ft
TX—at the downstream end of the paved shoulder portion of the gore
CO—at the location of the Exit Gore sign
WV—25 ft downstream from the location of the Exit Gore sign
OH—at the point where the paved shoulder ends
LA—at the point where the shoulder returns to normal width
KS—at the point where the extra roadway paving on the right of the right edge line of the mainline roadway ends (diagonal lines that are 12 in. wide at a 30° angle at 40-ft spacing are placed in the extra roadway paving)
MS—at the point well beyond the downstream end of the gore where the portion of the shoulder that is paved with mainline roadway paving (as opposed to shoulder thickness paving) becomes only 6 ft wide
NE, SC, NYC—unspecified distance downstream.

Use Versus Non-Use of Chevrons or Diagonal Lines Within the Paved Gore (45 agencies)

The design standards for 11 agencies (AZ, FL, HI, IN, KS, LA, OK, RI, TN, PR, and NYC) show that the use of chevrons within the paved gores of exit ramps is required. The design standards for Indiana state that when ramp volumes are low, diagonal lines may be used instead of chevrons. The design standards for Tennessee note that if the gore area is so short that at least five chevrons cannot be placed within the gore the chevrons are omitted from the gore area.

The design standards for New York State show that the use of chevrons is required within the paved gores of exit ramps at major exits, and the use of diagonal lines is required within the paved gores of exit ramps at minor exits.

The design standards for Texas and West Virginia show that the use of diagonal lines within the paved gores of exit ramps is required.

The design standards for Massachusetts show that the use of diagonal lines within the paved gores of exit ramps is required unless travel is sometimes permitted in the breakdown lane (shoulder) of the mainline roadway.

The design standards for five agencies (CO, CT, KY, MD, and VA) state or show that the use of chevrons within the paved gores of exit ramps is optional.

The design standards for four agencies (IL, OH, VT, and WI) state or show that the use of diagonal lines within the paved gores of exit ramps is optional.

The design standards for Pennsylvania state or show that the use of chevrons or diagonal lines within the paved gores of exit ramps is optional.

The design standards for Oregon state or show that chevrons or diagonal lines are not used within the paved gores of exit ramps with parallel deceleration lanes, but the use of chevrons or diagonal lines within the paved gores of exit ramps with tapered deceleration lanes is optional.

The design standards for 18 agencies (CA, DE, GA, IA, MI, MN, MS, MO, MT, NE, NV, NH, NC, ND, SC, UT,

WA, and WY) state or show that chevrons or diagonal lines are not used within the paved gores of exit ramps.

The design standards for Alabama show that chevrons are not used within the paved gores of exit ramps unless a recovery area or a parallel recovery lane is provided.

Width of Chevrons or Diagonal Lines Within the Paved Gore (25 agencies)

The design standards for the 25 agencies that specify a width for the chevrons (at a forward angle of 45°) or diagonal lines (at a forward angle of 45° from the right edge line of the mainline lane unless otherwise stated—they do not intersect the left edge line of the ramp at a 45° forward angle) that are placed within the paved gores of exit ramps use the following widths:

CO, OK—8 in.
AZ, HI, IL, KS, OR, RI, TN, VT, PR—12 in.
MA—12 in. at a 3-to-1 slope forward angle from the right edge line of the mainline lane (they do not intersect the left edge line of the ramp at a forward angle)
IN—12 in. when the posted speed limit is 45 mph or less and 24 in. when the posted speed limit is more than 45 mph
MD, NYC—16 in.
FL—18 in.
TX—typically 24 in., but no less than 12 in.
AL, LA, NY, OH, PA, VA, WV, WI—24 in.

Spacing of Chevrons or Diagonal Lines Within Paved Gore (23 agencies)

The design standards for the 23 agencies that specify the spacing (measured along the edge line of the mainline roadway) for the chevrons or diagonal lines that are placed within the paved gores of exit ramps use the following spacings:

VT—7 ft
PR—7 ft (shown as 2.0 m)
VA—8 ft
WV—8 to 12 ft
WI—8 to 25 ft
OK—10 ft
IL—10 to 20 ft
NY—11 ft (shown as 3.3 m)
LA—12 ft for posted mainline speed limits of 45 mph or less, 18 ft for 50 or 55 mph, and 24 ft for 65 mph
OH—12 ft for the first 48 ft, 24 ft for the next 48 ft, and 48 ft thereafter
AL—15 ft in urban areas and 25 ft in rural areas
PA—16 ft
MA—16 ft (shown as 5 m)
FL, HI, RI, TX—20 ft
TN—20 ft (starting at the point where the gore becomes 6 ft wide)
IN—20 ft when the posted speed limit is 45 mph or less and 40 ft when the posted speed limit is more than 45 mph
CO—25 ft (starting at the point where the gore becomes 6 ft wide)
AZ, KS—40 ft
MD—50 ft for blunt angle gores and up to 100 ft for sharp angle gores.

Use Versus Non-Use of Dotted Line in Departure Area of Tapered Deceleration Lane (41 agencies)

The design standards for 20 agencies (AL, CO, CT, GA, HI, IN, IA, KS, MI, NH, NC, ND, OH, OK, TN, TX, UT, VT, WV, and WI) show that the use of a dotted line to extend the right edge line of the mainline roadway to the upstream end of the paved gore of exit ramps with tapered deceleration lanes is required.

The design standards for New York City show that the use of a dotted line to extend the right edge line of the mainline roadway to the upstream end of the paved gore of exit ramps with tapered deceleration lanes is typically used.

The design standards for nine agencies (AZ, IL, MS, MT, NY, OR, PA, WY, and PR) show that the use of a dotted line to extend the right edge line of the mainline roadway to the upstream end of the paved gore of exit ramps with tapered deceleration lanes is optional.

The design standards for 11 agencies (CA, FL, LA, MD, MN, MO, NE, NV, SC, VA, and WA) state or show that dotted lines are not used to extend the right edge line of the mainline roadway to the upstream end of the paved gore of exit ramps with tapered deceleration lanes.

Width of Dotted Line in Departure Area of Tapered Deceleration Lane (28 agencies)

The following widths are used for the dotted line in the departure area of exit ramps with tapered deceleration lanes:

AL, CO, HI, IL, IN, IA, MT, ND, OK, TX, UT, VT, WV, WI, WY—4 in.
NC, OH—4 to 6 in.
GA—5 in.
AZ, CT, KS, MI, MS, NH, NY, TN—6 in.
PA, NYC—8 in.

Type of Dotted Line in Departure Area of Tapered Deceleration Lane (28 agencies)

The following patterns are used for the dotted line in the departure area of exit ramps with tapered deceleration lanes:

AL, AZ, CO, IA, KS, MT, OH, PA, TN, TX, VT, NYC—2-ft segments with 4-ft gaps

GA, ND, OR, UT, WY—2-ft segments with 6-ft gaps
HI, IN—2-ft segments with 8-ft gaps
CT, NH, NY—2-ft segments with 10-ft gaps
MS—2-ft segments with 12-ft gaps
NC, WV—2-ft segments with 13-ft gaps
OK, WI—3-ft segments with 12-ft gaps
MI—5-ft segments with 20-ft gaps.

The design standards for Ohio show that a 4- to 6-in.-wide broken lane line (10-ft segments with 30-ft gaps) is placed from the point where a full lane width first becomes available to the upstream end of the gore. An optional 4- to 6-in.-wide dotted line (2-ft segments with 4-ft gaps) may be placed along the right-hand side of the adjacent mainline lane from the upstream end of the ramp to the upstream end of the broken lane line.

The design standards for Oklahoma show that a 4-in.-wide dotted line (3-ft segments with 12-ft gaps) followed by a 4-in.-wide broken lane line is placed along the right-hand side of the adjacent mainline lane from the upstream end of the exit ramp to the upstream end of the gore.

Other Considerations for Exit Ramps (5 agencies)

The design standards for Alabama show that for exit ramps with a tapered deceleration lane and a parallel recovery lane, diagonal 12-in.-wide lines at 20-ft intervals in urban areas and 30- to 40-ft intervals in rural areas are used within the right shoulder of the parallel recovery lane for the recovery lane's entire length and within the left shoulder of the ramp for a distance of 80 ft beyond the point where the paved portion of the gore ends. For exit ramps with a recovery area, diagonal 12-in.-wide lines at 20-ft intervals in urban areas and 30- to 40-ft intervals in rural areas are used within the right shoulder of the mainline roadway for a distance of at least 320 ft beyond the point where the paved portion of the gore ends and within the left shoulder of the ramp for a distance of 80 ft beyond the point where the paved portion of the gore ends.

The design standards for Florida show that diagonal 18-in.-wide cross-hatching is placed beyond the gore on the right shoulder of the mainline roadway until the shoulder width returns to its normal width.

The design standards for Maryland show that the first chevron stripe is placed 50 ft downstream from the point where the gore width becomes 1 ft.

The design standards for Michigan show that at the upstream end of the gore, the two 12-in.-wide channelizing lines are side-by-side, thus resulting in a 24-in.-wide line.

The design standards for Washington State show that raised pavement markers forming diagonal lines that point at a 45° forward angle from the right edge line of the mainline lane (they do not intersect the left edge line of the ramp at a 45° forward angle) may be placed within the paved portion of the gore to increase visibility.

CHAPTER FIVE

PAVEMENT MARKINGS NOT SPECIFICALLY ADDRESSED IN THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

ARROWS AND SYMBOLS

The design standards for California show that wrong-way arrows (one in each direction) are used at locations near intersections and at a maximum of one-mile spacing where motorists could perceive that they are on a one-way roadway when, actually, they are on a two-lane, two-way highway. The following are some typical situations:

- Construction sites where a two-lane highway is being converted to a freeway or an expressway.
- Two-lane, two-way highways where ultimate freeway or expressway right-of-way has been purchased and grading for the full width has been completed.
- Two-lane, two-way highways following long sections of multi-lane freeway or expressway.

The design standards for Georgia show that a different spacing pattern is specified for lane-use arrows and ONLY messages on intersection approaches at the end of exit ramps.

The design standards for Georgia also show that U-turn arrows and combination U-turn/left-turn arrows are available for use.

The design standards for New York state show that a diverge arrow (see Figure 11) is available for use.

WORD MESSAGES

The design standards for California show that a STOP word marking is placed such that the tops of the letters are 8 ft from the stop line in advance of all stop lines at STOP sign controlled intersections.

The design standards for California also state that the SLOW SCHOOL XING word marking shall be used in advance of all yellow school crosswalks that are not controlled by STOP signs, YIELD signs, or traffic signals. The words shall be yellow with the final word in the sequence, XING, at least 100 ft in advance of the crosswalk. The SCHOOL XING word marking shall be used in advance of all white school crosswalks. The SCHOOL word marking shall be restricted to a single lane.

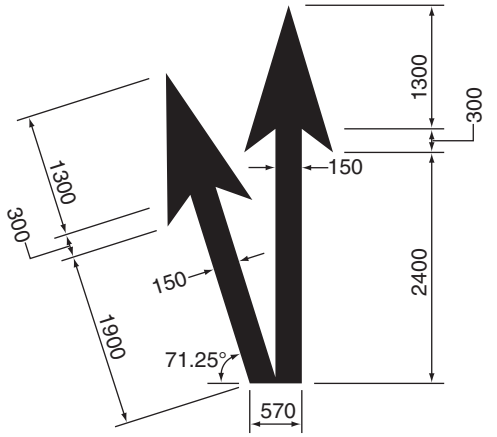


FIGURE 11 Diverge arrow used by New York State DOT (*Source:* New York DOT pavement marking details, October 22, 2001, Drawing M685-5R1, Sheet 5 of 5).

MISCELLANEOUS TREATMENTS

The design standards for Alaska show that overhead snow poles (delineators cantilevered to the edge line suspended from a steel pipe that is mounted 12 ft from the edge line) are available.

The design standards for Colorado show that solid 8-in.-wide lane lines separating mandatory left-turn lanes from adjacent through lanes are extended beyond the stop line and may be curved slightly to the left just before they terminate. Lane lines separating mandatory right-turn lanes from adjacent through lanes are extended beyond the stop line to the extension of the edge line of the cross street and are curved slightly to the right just before they terminate.

The design standards for Georgia show a design for a combination left-turn/U-turn pavement marking arrow.

The design standards for Montana show that designs for historical marker turnouts, mailbox turnouts, and chain-up areas are included in the Montana *Traffic Engineering Manual.*

The design standards for New York show that when a climbing lane is provided on a one-way roadway, a double

broken line (10-ft segments with 30-ft gaps) starts at the upstream end of the full-width lane and ends 600 ft from the downstream end of the full-width lane. A partial barrier line (a 4-in.-wide solid line on the left-hand side and a 4-in.-wide broken line with 10-ft segments and 30-ft gaps on the right-hand side) starts at the downstream end of the double broken line and ends 100 ft from the downstream end of the full-width lane. Lane-reduction arrows are not shown.

The design standards for Virginia include a design for the transition from a left-turn lane in one direction to a left-turn lane in the other direction in a paved center median area.

The design standards for the District of Columbia note that on Pennsylvania Avenue between 3rd Street and 15th Street all pavement markings are white, including the centerline, because this is a special historic street and does not follow the *MUTCD.*

The design standards for the city of Los Angeles state that pavement markings associated with pedestrians and schools, such as crosswalks and school word markings, may be yellow.

CHAPTER SIX

CONCLUSIONS AND FUTURE RESEARCH NEEDS

Although Part 3 of the *Manual on Uniform Traffic Control Devices* contains provisions for pavement markings on streets and highways across the United States, it does not require or recommend uniformity for many of the aspects of pavement marking layout that were studied in this synthesis. This flexibility and latitude given to the states and local governments has resulted in a wide variety of policies and practices among the various agencies as documented in this report. Tables 1, 2, and 3 show the range of values and the most common practices found in the design standards for the various agencies for pavement markings at intersections, pavement markings between intersections, and pavement markings at interchanges, respectively.

In some cases, such as the width of a line, road users who travel from one state to another might be unaware of the difference. In other cases, road users might experience confusion about pavement markings that are unfamiliar to them.

States and local government agencies most likely appreciate some degree of flexibility and latitude as they develop and implement their various pavement marking policies and practices. Variations in line widths and sizes of gaps between line segments in broken or dotted lines may be attributable to the economics of construction and maintenance. States with tight budgets might specify narrower lines and longer gaps to save money, whereas states that have larger proportions of older drivers might favor wider lines and shorter gaps.

It is hoped that this synthesis will be used by FHWA and the National Committee on Uniform Traffic Control Devices in the development of the 2008 edition of Part 3 of the *Manual on Uniform Traffic Control Devices* to develop new standards, upgrade existing guidance to standards, and upgrade existing options to guidance. In addition, it is hoped that state and local governmental agencies will use the information in this synthesis to determine the most common policies and practices in each area of interest as they develop or revise their pavement marking design standards.

Because this synthesis was limited to a finite number of areas of interest, there remains a need to research and synthesize other aspects of pavement marking layouts. Among the pavement markings not included in this synthesis were:

- Types and patterns of longitudinal lines,
- Use of black contrast markings on concrete surfaces,
- Centerline markings on two-lane roads approaching signals and STOP signs,
- No-passing zones on two-lane roads approaching intersections and grade crossings,
- Railroad–highway grade crossings,
- Transitions between divided and undivided highways,
- Dotted guidelines and lane line extensions through intersections,
- Edge line extensions through medians and intersections,
- Yield lines and yield ahead symbols,
- Markings on acceleration lanes downstream from the gore area,
- Markings on deceleration lanes upstream from the gore area,
- Exit ramps with through lane drops,
- Exit ramps with through lane drop and option lane,
- Reversible lanes,
- Curb markings,
- Parking spaces,
- Accessible parking for persons with disabilities,
- Bypass lanes,
- Passing flare or auxiliary bypass lanes at the top of T intersections,
- Paved turnouts,
- Bus turnouts,
- Truck and bus turnouts at non-exempt railroad crossings,
- Runaway truck ramps,
- Speed measurement markings,
- High-occupancy vehicle and other preferential lane markings,
- Approaches to narrow bridges,
- Bike lanes,
- Speed humps and speed tables,
- Roundabouts,
- Toll plazas,
- Rest areas,
- Raised pavement markers,
- Rumble strips,
- Delineators,
- Object markers,
- Cattle guards,
- Temporary traffic control, and
- Markings that are presently in the experimental stage.

TABLE 1
SUMMARY OF RANGES AND MOST COMMON PRACTICES IN CHAPTER TWO—PAVEMENT MARKINGS AT INTERSECTIONS

Area of Interest	Range		Most Common Practice	
	Low End	High End	Practice	No. of Agencies
Turn Lanes				
Type of lane line between a turn bay and the adjacent through lane	Broken lane line	Solid lane line	Solid lane line	42 of 47
Width of lane line between a turn bay and the adjacent through lane	4 in.	12 in.	8 in.	15 of 31
Length of lane line between a turn bay and the adjacent through lane	Half the length of the full-width turn lane	Entire length of the full-width turn lane	Entire length of the full-width turn lane	13 of 26
Type of lane line between a dropped lane and the adjacent through lane	Broken lane line	Solid lane line	Solid lane line	10 of 14
Width of lane line between a dropped lane and the adjacent through lane	4 in.	8 in.	8 in.	3 of 5
Use versus non-use of turn arrows in turn bays	Typically not used	Required	Required	38 of 47
Use versus non-use of only word markings in turn bays	Not used	Required	Optional	12 of 30
Placement of turn arrow nearest to the stop line in turn bays	4 ft upstream	75 ft upstream	20 ft upstream	7 of 38
Placement of word or symbol marking nearest to the upstream end of the full-width turn lane in turn bays	0 ft downstream	33 ft downstream	0 ft downstream	15 of 22
Use versus non-use of turn arrows in dropped lanes	Required	Required	Required	14 of 14
Use versus non-use of only word markings in dropped lanes	Optional	Required	Required	10 of 14
Lane Lines for Dual Turn Lanes				
Type of lane line between the two lanes of dual turn lanes	Broken lane line	Solid lane line	Solid lane line	8 of 11
Width of lane line between the two lanes of dual turn lanes	4 in.	8 in.	8 in.	3 of 7
Length of lane line between the two lanes of dual turn lanes	At least 100 ft	Entire length of the full-width turn lanes	Entire length of the full-width turn lanes	6 of 7
Type of lane line between dual turn lanes and the adjacent through lane	Combination solid and dotted lane line	Solid lane line	Solid lane line	10 of 11
Width of lane line between dual turn lanes and the adjacent through lane	4 in.	8 in.	8 in.	4 of 7
Length of lane line between dual turn lanes and the adjacent through lane	Entire length of the full-width turn lanes	Entire length of the full-width turn lanes plus half of taper	Entire length of the full-width turn lanes	6 of 7
Lane Line Extensions into Intersection for Dual Turn Lanes				
Use versus non-use of dotted lines	Optional	Required	Optional	13 of 23
Pattern of dotted lines	0.5-ft segments with 2-ft gaps	3-ft segments with 9-ft gaps	2-ft segments with 4-ft gaps	13 of 26
Width of dotted lines	4 in.	8 in.	4 in.	6 of 7
Use and Type of Dotted Lines in Turn Lane Tapers				
Use versus non-use of dotted lines	Not used	Required	Not used	30 of 43
Pattern of dotted lines	2-ft segments with 4-ft gaps	6-ft segments with 10-ft gaps	2-ft segments with 4-ft gaps	5 of 12

TABLE 1
SUMMARY OF RANGES AND MOST COMMON PRACTICES IN CHAPTER TWO—PAVEMENT MARKINGS AT INTERSECTIONS (*Continued*)

Area of Interest	Range		Most Common Practice	
	Low End	High End	Practice	No. of Agencies
Width of dotted lines	4 in.	8 in.	4 in.	3 of 6
Left-Turn Lanes Added Between Through Lanes of Two-Lane Highways				
Amount of widening	Half of left-turn lane width	Full width of left-turn lane	Full width of left-turn lane	17 of 21
Distance from full shadowing to upstream end of left-turn taper	0 ft	Half of shifting taper	0 ft	13 of 17
Length of left-turn taper	50 ft	180 ft	No two alike	1 of 21
Solid Lane Lines Between Through Lanes on Signalized Approaches				
Use versus non-use of solid lane lines between through lanes	Broken lane line	Solid lane line	Broken lane line	29 of 42
Length of solid lane line between through lanes	27 ft	500 ft	50 ft	4 of 13
Width of solid lane line between through lanes	4 in.	6 in.	4 in.	6 of 13
Crosswalks				
Use of standard and high-visibility crosswalks	Standard crosswalks only	High-visibility crosswalks only	Standard or high-visibility crosswalks may be used	33 of 50
Minimum width of crosswalks	6 ft (measured to outside edges of transverse lines)	20 ft	6 ft (measured to inside edges of transverse lines)	17 of 44
Width of transverse crosswalk lines	6 in.	24 in.	12 in.	12 of 40
Design of high-visibility crosswalks	Longitudinal lines only	Longitudinal (or diagonal) lines and transverse lines	Longitudinal lines only	21 of 38
Width of longitudinal and diagonal lines	12 in.	36 in.	24 in.	17 of 38
Spacing of longitudinal and diagonal lines	12 in.	60 in.	24 in.	14 of 37
Use of standard and high-visibility crosswalks	Standard crosswalks only	High-visibility crosswalks only	Standard or high-visibility crosswalks may be used	33 of 50
Stop Lines				
Use versus non-use of stop lines	Not used if crosswalks are present	Required on signalized approaches	Required on signalized approaches	42 of 46
Width of stop lines	12 in.	24 in.	24 in.	24 of 43
Placement of stop lines	4 ft	At least 5 ft	At least 4 ft	21 of 38
Right-Turn Channelizing Islands				
Width of lines that mark the edges of right-turn channelizing islands	4 in.	48 in.	8 in.	12 of 18
Width of lines within right-turn channelizing islands	6 in.	24 in.	12 in.	8 of 18
Spacing of lines within right-turn channelizing islands	5 ft	Number of feet equals posted speed limit in mph	Tie between 10 ft and 20 ft	4 of 16

TABLE 2
SUMMARY OF RANGES AND MOST COMMON PRACTICES IN CHAPTER THREE—PAVEMENT MARKINGS BETWEEN INTERSECTIONS

Area of Interest	Range		Most Common Practice	
	Low End	High End	Practice	No. of Agencies
Minimum Length of Passing Zones				
Minimum length of passing zones	200 ft	1,000 ft	400 ft	10 of 22
Minimum Length of No-Passing Zones				
Minimum length of no-passing zones	250 ft	550 ft	500 ft	12 of 14
Two-Way Left-Turn Lanes (2WLTLs)				
Use versus non-use of left-turn arrows	Optional	Required	Required	33 of 37
Spacing between opposing left-turn arrows in a set of arrows	5 ft	33 ft	32 ft	13 of 36
Minimum spacing from one set of arrows to the next set of arrows	100 ft	1,300 ft	Tie between 100 ft and 200 ft	2 of 10
Maximum spacing from one set of arrows to the next set of arrows	200 ft	2,640 ft	300 ft	4 of 14
Spacing from one set of arrows to the next set of arrows	200 ft	1,320 ft	No two alike	1 of 12
Climbing or Passing Lanes				
Type of lane line	Broken lane line	Double broken lane line	Broken lane line	19 of 22
Start (upstream end) of lane line (measured from upstream end of full-width climbing or passing lane)	0 ft	250 ft downstream	0 ft	18 of 22
End (downstream end) of lane line (measured from downstream end of full-width climbing or passing lane)	0 ft	650 ft upstream	0.75*D* (where *D* is the advance placement distance for a Lane Ends sign)	7 of 18
Use of lane-reduction arrows	Not used	Required	Not used	14 of 18
Number of lane-reduction arrows	At least 2	3	3	3 of 4
Passing permitted or prohibited in opposing (single-lane) direction	Permitted	Prohibited	Permitted	17 of 21
Lane Reductions				
Downstream end of broken lane line (measured from upstream end transition taper)	0 ft	565 ft upstream	0.75*D* (where *D* is the advance placement distance for a Lane Ends sign)	11 of 31
Use of lane-reduction arrows	Not used	Required	Not used	17 of 31
Number of lane-reduction arrows	2	5	3	7 of 14
Painted Medians, Paved Shoulders, and Approaches to Obstructions				
Use versus non-use of diagonal lines within painted medians	Not used	Used	Used	27 of 39
Width of diagonal lines within painted medians	6 in.	24 in.	12 in.	12 of 34
Spacing of diagonal lines within painted medians	5 ft	100 ft	20 ft	5 of 33
Lane lines surrounding painted medians	Double yellow centerlines	12-in.-wide solid lines	Double yellow centerlines	37 of 39
Use versus non-use of diagonal lines on paved shoulders	Not used	Optional	Optional	18 of 20
Width of diagonal lines on paved shoulders	6 in.	24 in.	12 in.	9 of 20
Spacing of diagonal lines on paved shoulders	5 ft	100 ft	20 ft	2 of 17
Width of diagonal lines or chevrons on approaches to obstructions	8 in.	18 in.	12 in.	6 of 8
Spacing of diagonal lines or chevrons on approaches to obstructions	5 ft	25 ft	5 ft	2 of 6

TABLE 3
SUMMARY OF RANGES AND MOST COMMON PRACTICES IN CHAPTER FOUR—PAVEMENT MARKINGS AT INTERCHANGES

Area of Interest	Range		Most Common Practice	
	Low End	High End	Practice	No. of Agencies
Entrance Ramp Gores				
Width of channelizing lines	4 in.	12 in.	8 in.	26 of 43
Upstream end of the channelizing line on the left-hand side of the entrance ramp (measured from the upstream end of the paved gore)	0 ft	50 ft	0 ft	25 of 42
Downstream end of the channelizing line on the left-hand side of an entrance ramp with a tapered acceleration lane	At upstream end of paved gore	At downstream end of paved gore	At point where ramp and mainline lane are 6 ft apart	11 of 26
Use versus non-use of a channelizing line on the right-hand side of the mainline roadway	Not used	Required	Required	26 of 42
Upstream end of the channelizing line on the right-hand side of the mainline roadway (measured from the upstream end of the paved gore)	0 ft	50 ft	0 ft	23 of 34
Use versus non-use of chevrons within the paved gore	Not used	Required	Not used	36 of 44
Width of chevrons within the paved gore	8 in.	24 in.	12 in.	2 of 7
Spacing of chevrons within the paved gore	7 ft	100 ft	20 ft	2 of 7
Exit Ramp Gores				
Width of channelizing lines	6 in.	12 in.	8 in.	27 of 44
Use versus non-use of channelizing line on right-hand side of mainline roadway	Required	Required	Required	44 of 44
Upstream end of channelizing lines for exit ramps with tapered deceleration lanes	At point where full width of exit ramp becomes available	At point where full width of exit ramp becomes available	At point where full width of exit ramp becomes available	44 of 44
Downstream end of channelizing line on left-hand side of exit ramp (measured from the downstream end of the paved gore)	0 ft	50 ft	0 ft	24 of 43
Downstream end of channelizing line on right-hand side of mainline roadway (measured from the downstream end of the paved gore)	0 ft	150 ft	0 ft	21 of 43
Use versus non-use of chevrons or diagonal lines within the paved gore	Not used	Required	Not used	18 of 44
Width of chevrons or diagonal lines within the paved gore	8 in.	24 in.	12 in.	11 of 25
Spacing of chevrons or diagonal lines within the paved gore	7 ft	100 ft	20 ft	5 of 23
Use versus non-use of dotted line in the departure area of a tapered deceleration lane	Not used	Required	Required	20 of 41
Width of dotted line in the departure area of a tapered deceleration lane	4 in.	8 in.	4 in.	15 of 28
Type of dotted line in the departure area of a tapered deceleration lane	2-ft segments with 4-ft gaps	5-ft segments with 20-ft gaps	2-ft segments with 4-ft gaps	12 of 28

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

GLOSSARY

The following two-and three-letter codes are used to identify the 54 agencies that supplied information for this synthesis:

Alabama	AL	Nevada	NV
Alaska	AK	New Hampshire	NH
Arizona	AZ	New York	NY
Arkansas	AR	North Carolina	NC
California	CA	North Dakota	ND
Colorado	CO	Ohio	OH
Connecticut	CT	Oklahoma	OK
Delaware	DE	Oregon	OR
Florida	FL	Pennsylvania	PA
Georgia	GA	Rhode Island	RI
Hawaii	HI	South Carolina	SC
Idaho	ID	South Dakota	SD
Illinois	IL	Tennessee	TN
Indiana	IN	Texas	TX
Iowa	IA	Utah	UT
Kansas	KS	Vermont	VT
Kentucky	KY	Virginia	VA
Louisiana	LA	Washington	WA
Maine	ME	West Virginia	WV
Maryland	MD	Wisconsin	WI
Massachusetts	MA	Wyoming	WY
Michigan	MI	District of Columbia	DC
Minnesota	MN	Puerto Rico	PR
Mississippi	MS	Charlotte, NC	CLT
Missouri	MO	Los Angeles, CA	LAN
Montana	MT	New York, NY	NYC
Nebraska	NE	Tucson/Pima County, AZ	TUC

PAVEMENT MARKINGS—DESIGN AND TYPICAL LAYOUT DETAILS

SUMMARY

States and many local governments have developed their own designs, detailed layout schemes (typical drawings), and associated practices for pavement markings. These designs, layout details, and practices are usually more specific than the requirements of the national *Manual on Uniform Traffic Control Devices* (*MUTCD*). Among the more detailed designs, layout details, and associated practices that are found in many of the state and local documents are the following:

- Methods of delineating turn lane channelization,
- Patterns and spacing of lane-use turn arrows and ONLY word markings,
- Patterns and spacing of crosswalk markings and stop lines,
- Patterns and spacing of turn arrows in two-way left-turn lanes,
- Patterns and dimensions of chevrons and diagonal lines,
- Methods of delineating climbing and passing lanes, and
- Methods of delineating entrance ramp and exit ramp gores.

This synthesis identifies variations in pavement marking designs, practices, and policies of 48 of the 50 state departments of transportation, the District of Columbia, Puerto Rico, and four large cities. From the information contained in this synthesis, common and differing practices and ranges of typical placement dimensions can be identified. This compilation of information (which has been unavailable to date) will be highly valuable to FHWA and to the National Committee on Uniform Traffic Control Devices as they consider the need for future revisions to Part 3 of the *MUTCD* to add more specificity to the national standards for pavement markings and, where appropriate, to codify the most common policies, practices, and applications of pavement markings. In addition, state and local government agencies can use the information in this synthesis to determine the most common policies and practices in each area of interest as they develop or revise their pavement marking design standards.

This synthesis is not intended to be used by practitioners in the various states as a design guideline when developing pavement marking plans. The information in this synthesis is essentially a "snapshot" of current state and local government policies and practices in the late 2004/early 2005 time frame. Such policies and practices are subject to change and many agencies reported that they were in the process of revising their design standards at the time the information in this synthesis was requested. However, practitioners can visit the websites listed in the bibliography of this synthesis to obtain the latest design standards for the various agencies that maintain these websites.

This synthesis addresses only the information that was found in the various policies and practices regarding pavement marking layouts that are published by the agencies represented herein. Existing pavement markings and the actual implementation of new pavement markings within a particular state might vary from the state's published policies and practices. No attempt has been made to discover or document any variations from the published policies and practices within the geographical areas of the agencies represented in this synthesis.

This synthesis does not specifically address the safety aspects or the cost-effectiveness of the agency's various pavement marking layout policies and practices. The report also does not

provide any value judgments regarding whether certain policies and practices of one agency are superior or inferior when compared with the policies and practices of other agencies.

Although Part 3 of the *MUTCD* contains provisions for pavement markings on streets and highways across the United States, it does not require or recommend uniformity for many of the aspects of pavement marking layout that were studied in this synthesis. This flexibility and latitude given to the states and local governments has resulted in a wide variety of policies and practices among the various agencies as documented in this synthesis. Tables 1–3 in chapter six (Conclusions, pages 46–49) show the range of values and the most common pavement marking practices found in the design standards for the various agencies.

Table 1 contains information regarding pavement markings at intersections including:

- Turn lanes,
- Lane lines for dual turn lanes,
- Lane line extensions into intersections for dual turn lanes,
- Use and type of dotted lines in turn lane tapers,
- Left-turn lanes added between through lanes of two-lane highways,
- Solid lane lines between through lanes on signalized approaches,
- Crosswalks,
- Stop lines, and
- Right-turn channelizing islands.

Table 2 contains information regarding pavement markings between intersections including:

- Minimum length of passing zones;
- Minimum length of no-passing zones;
- Two-way left-turn lanes;
- Climbing or passing lanes;
- Lane reductions; and
- Painted medians, paved shoulders, and approaches to obstructions.

Table 3 contains information regarding pavement markings at interchanges including:

- Entrance ramp gores and
- Exit ramp gores.

In some cases, such as the width of a line, road users who travel from one state to another might be unaware of any differences; whereas, in other instances, road users might experience confusion about unfamiliar pavement markings. There is little doubt that states and local government agencies appreciate some degree of flexibility and latitude as they develop and implement their various pavement marking policies and practices. Variations in line widths and sizes of gaps between line segments in broken or dotted lines may be attributable to the economics of construction and maintenance. States with tight budgets might specify narrower lines and longer gaps to save money, whereas states that have larger proportions of older drivers might be inclined to favor wider lines and shorter gaps.

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APPENDIX A

Figures from Chapter 3B of the 2003 *MUTCD* That Are Referenced in this Synthesis

Sixteen figures from Chapter 3B of the 2003 *MUTCD* are referenced in this synthesis. These figures (Figures 3B-2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 20, 21, and 22) are shown in numerical order in Appendix A.

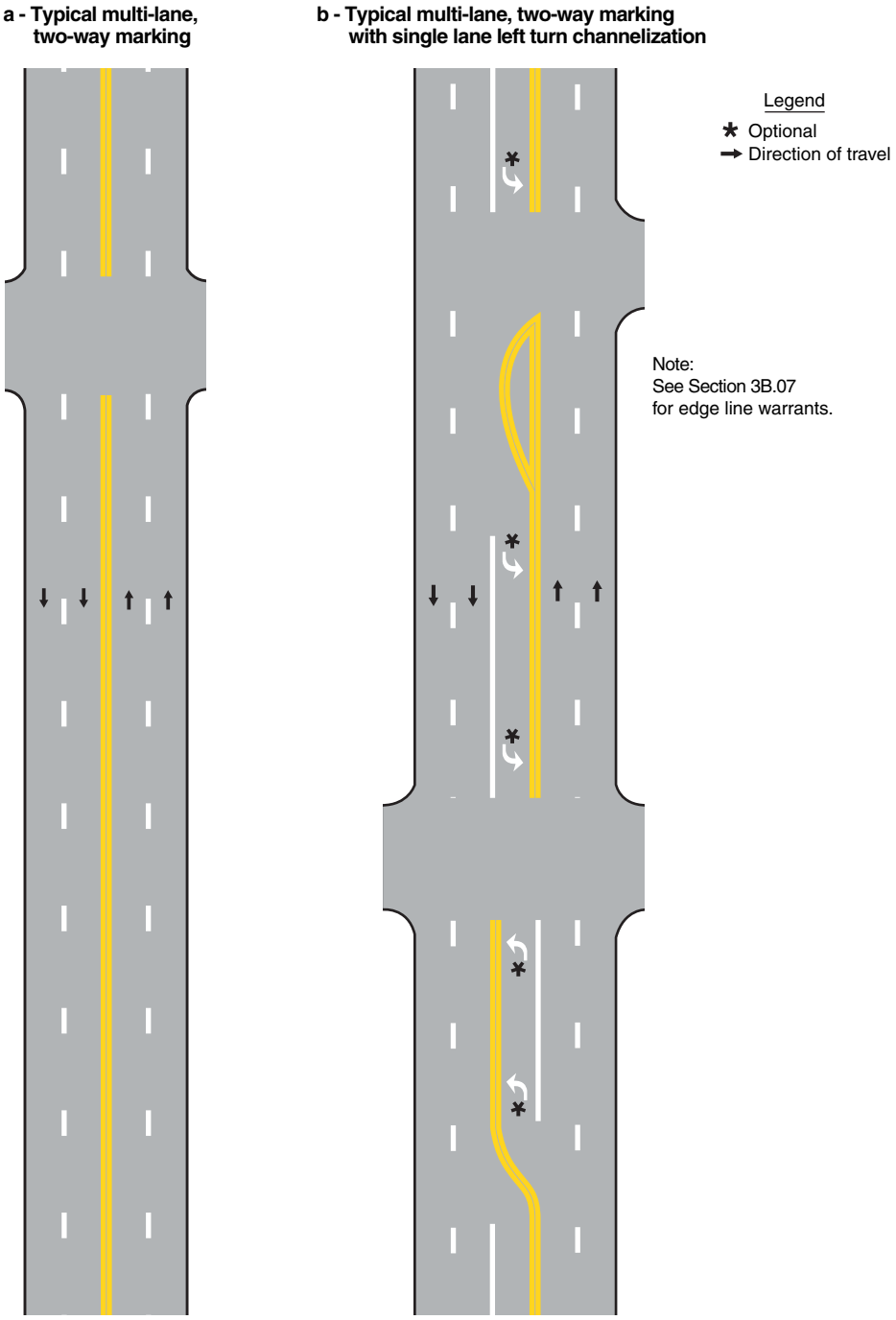


FIGURE 3B-2 Examples of Four-or-More Lane, Two-Way Marking Applications

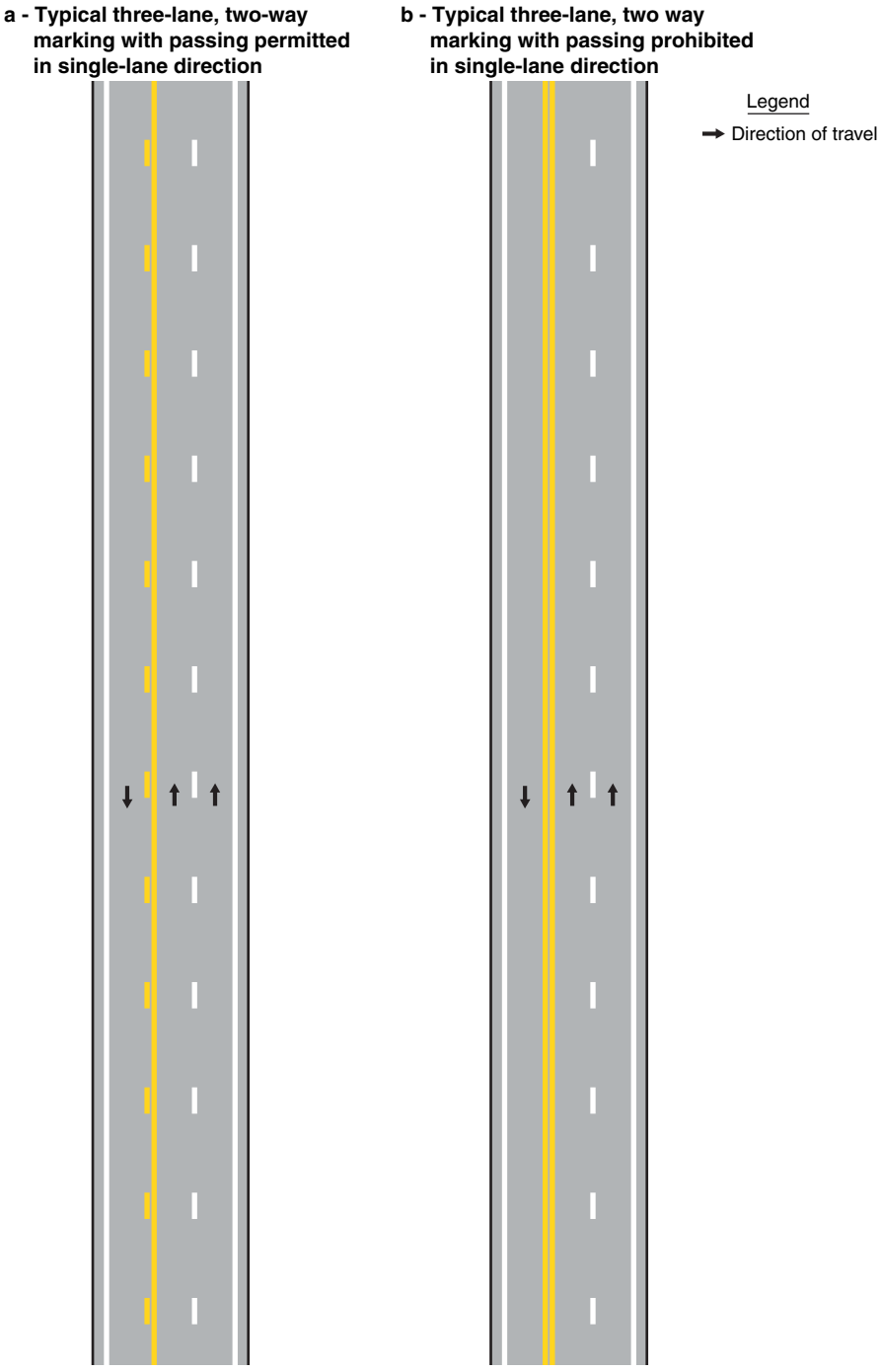


FIGURE 3B-3 Examples of Three-Lane, Two-Way Marking Applications

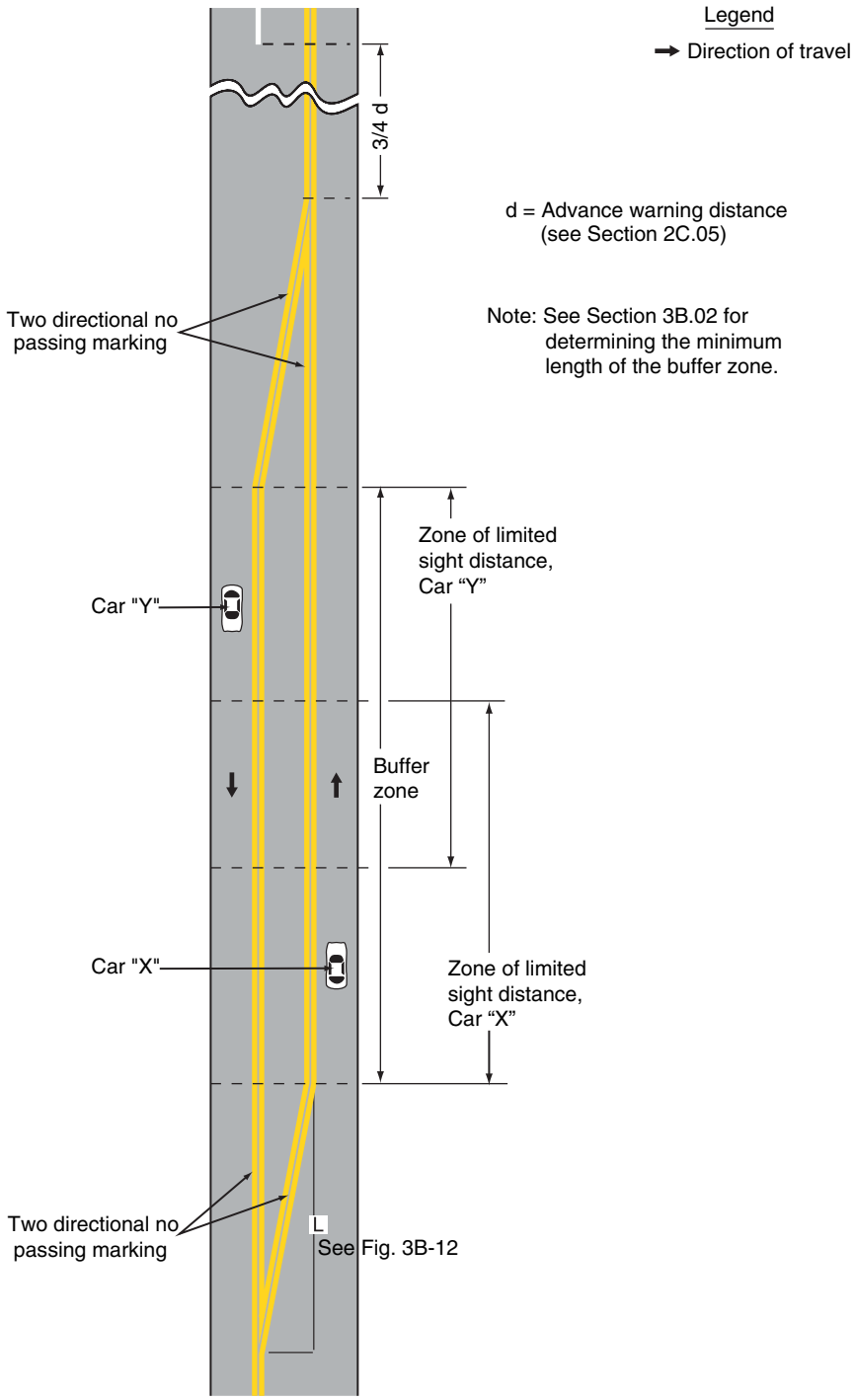


FIGURE 3B-4 Example of Three-Lane, Two-Way Marking for Changing Direction of the Center Lane

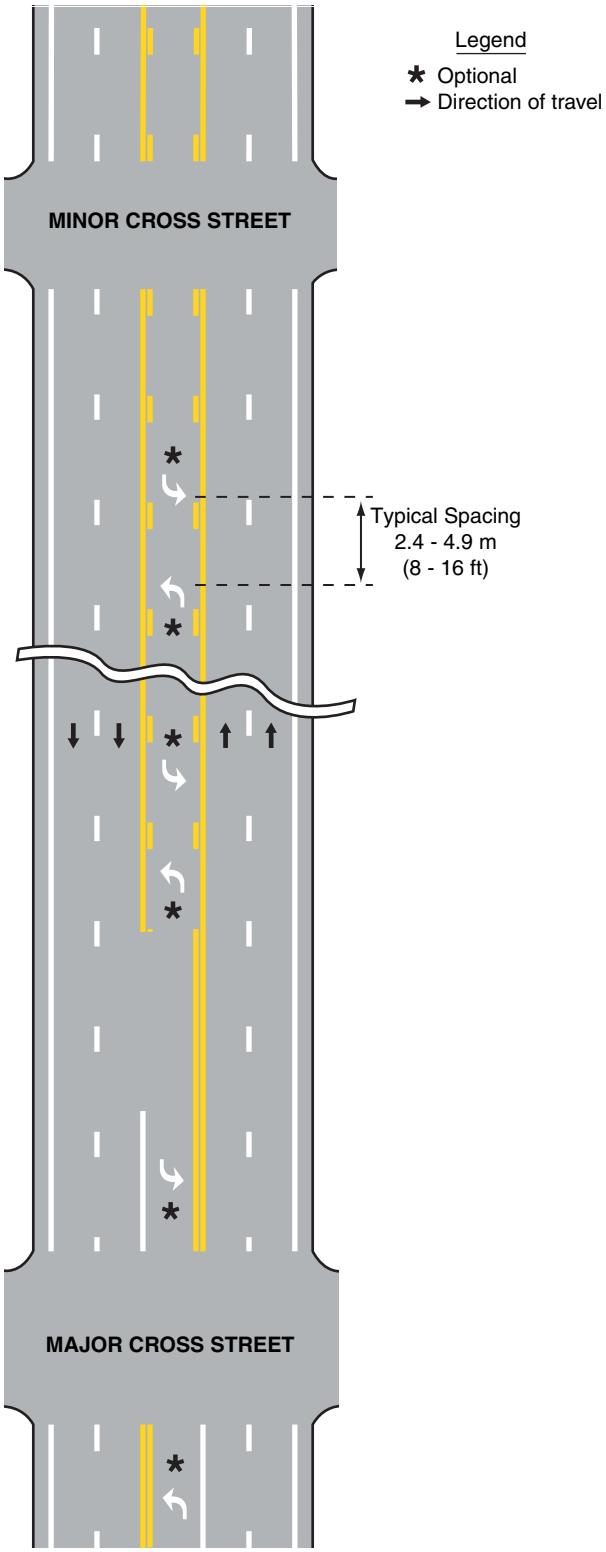


FIGURE 3B-7 Example of Two-Way Left-Turn Lane Marking Applications

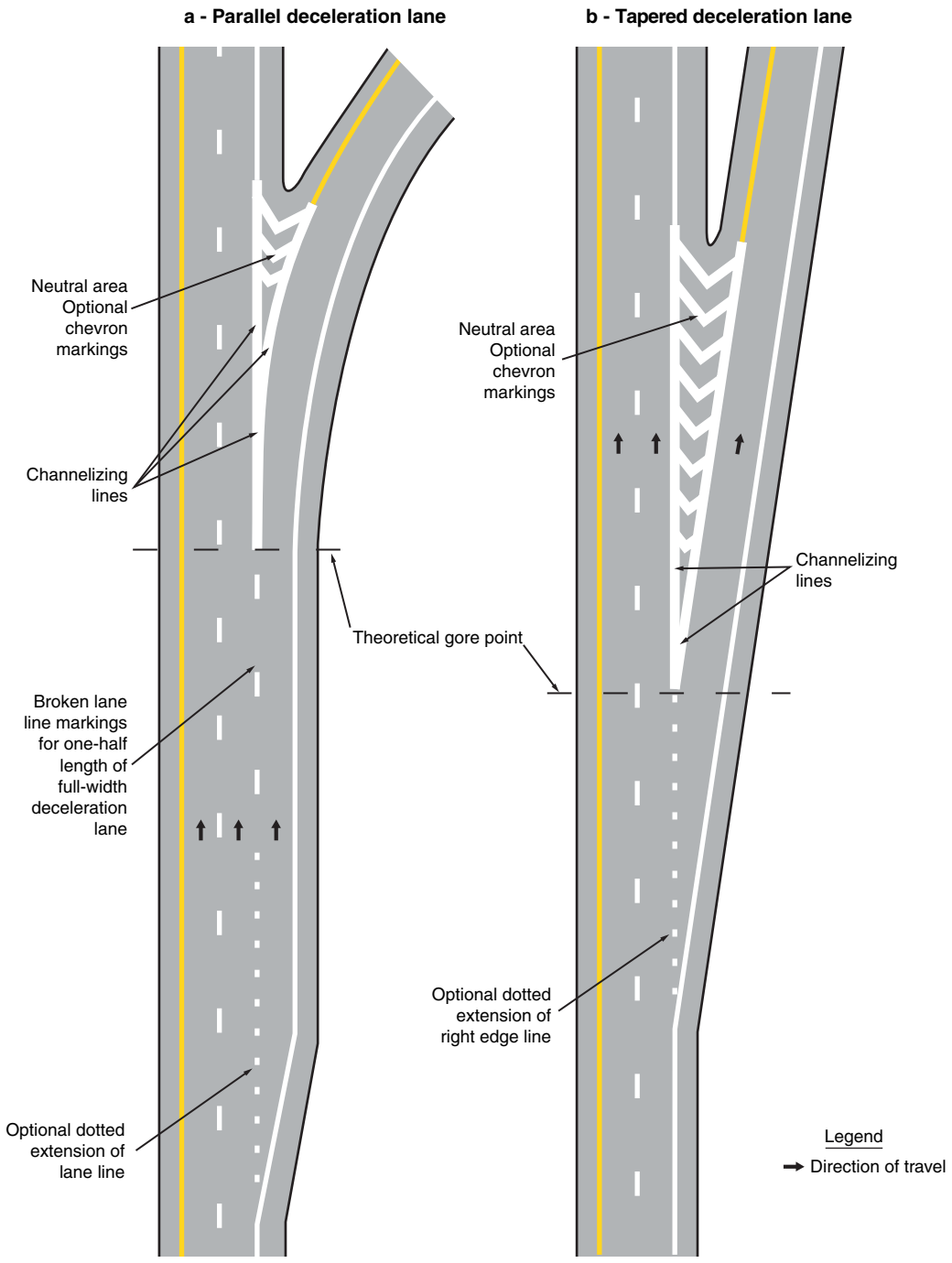


FIGURE 3B-8 Examples of Channelizing Line Applications for Exit Ramp Markings *(Sheet 1 of 2)*

c - Auxiliary lane, such as at cloverleaf interchange

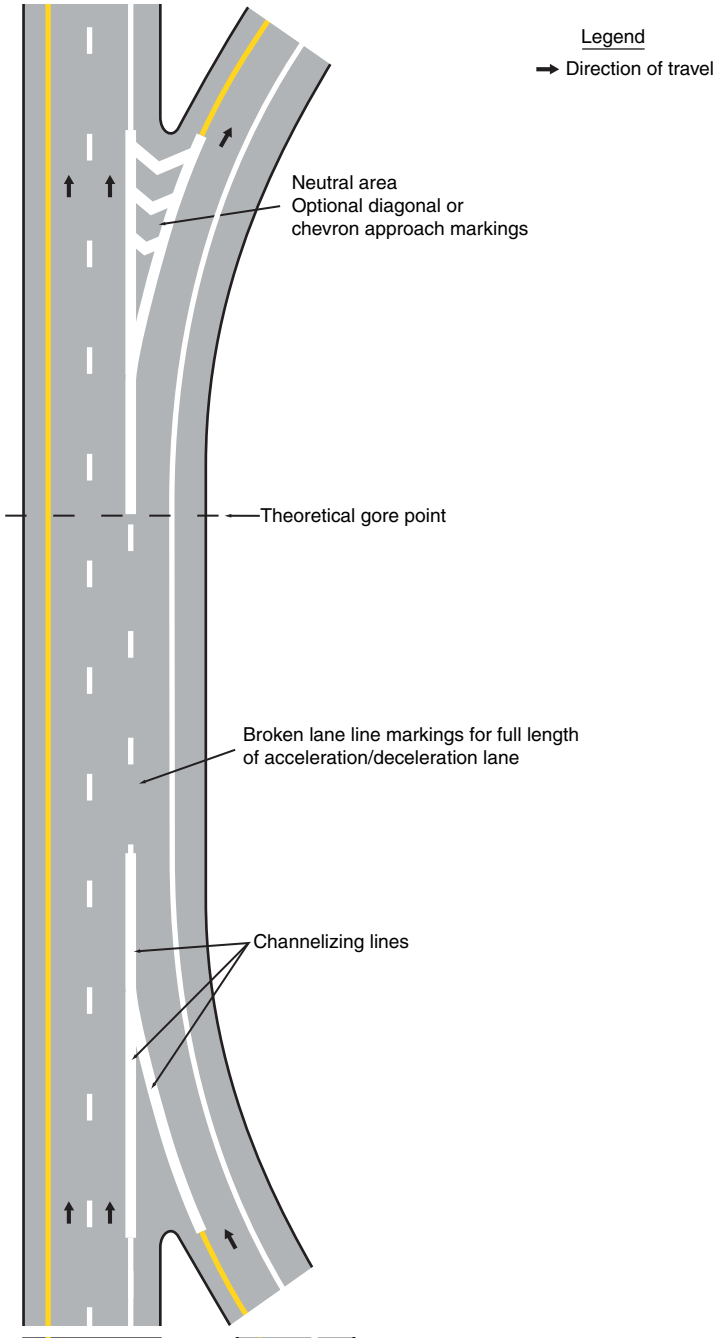


FIGURE 3B-8 Examples of Channelizing Line Applications for Exit Ramp Markings *(Sheet 2 of 2)*

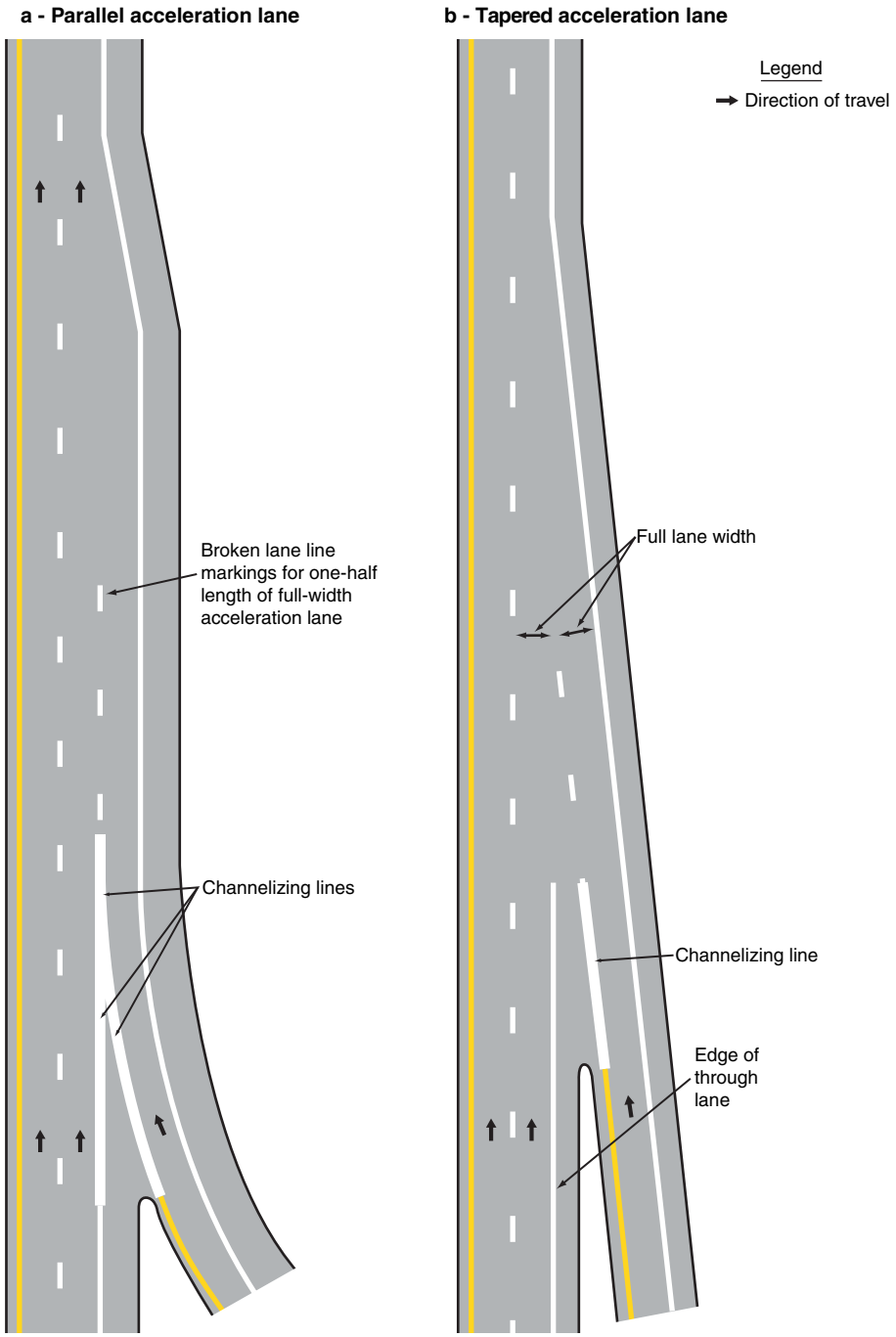


FIGURE 3B-9 Examples of Channelizing Line Applications for Entrance Ramp Markings

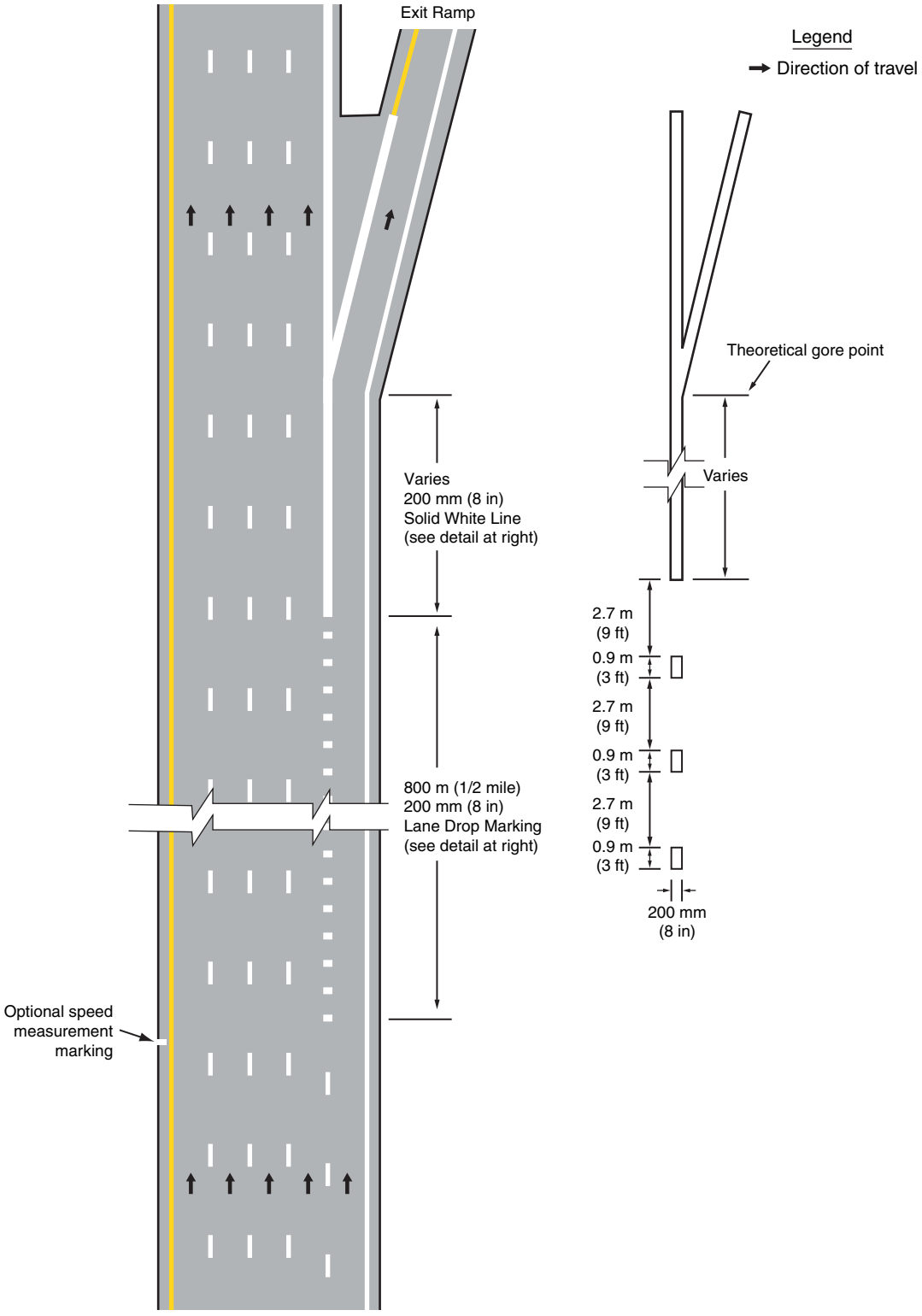
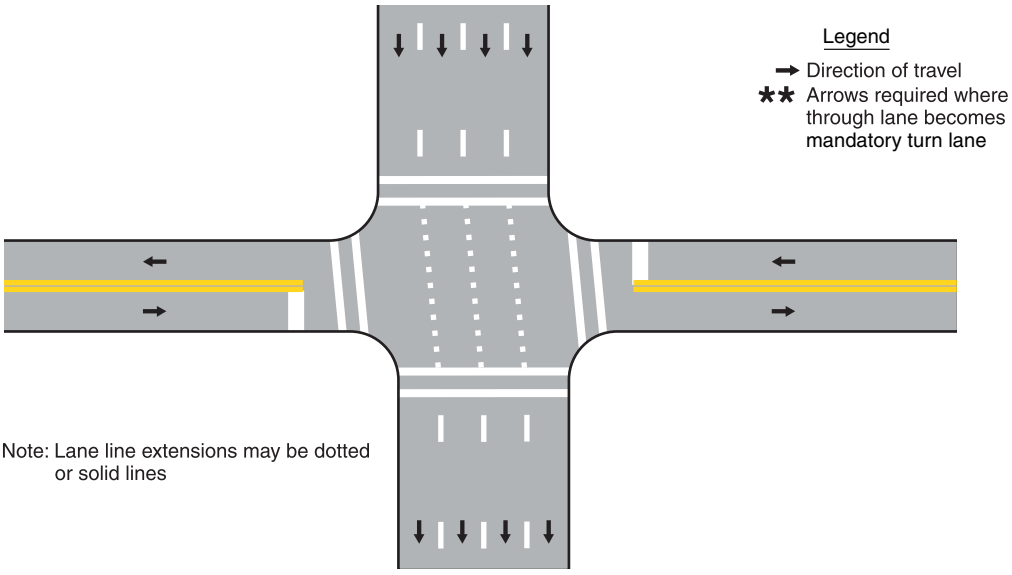


FIGURE 3B-10 Example of Lane Drop Markings at Exit Ramps

a - Typical pavement markings with offset lane lines continued through the intersection and optional crosswalk lines and stop lines



b - Typical pavement markings with optional double-turn lane lines, lane-use turn arrows, crosswalk lines, and stop lines

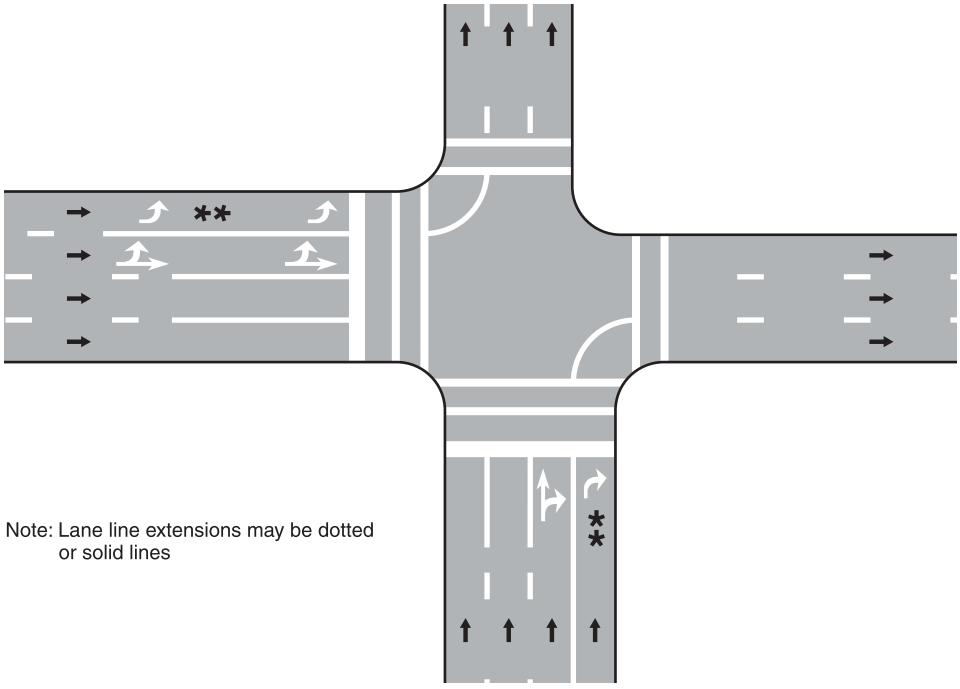
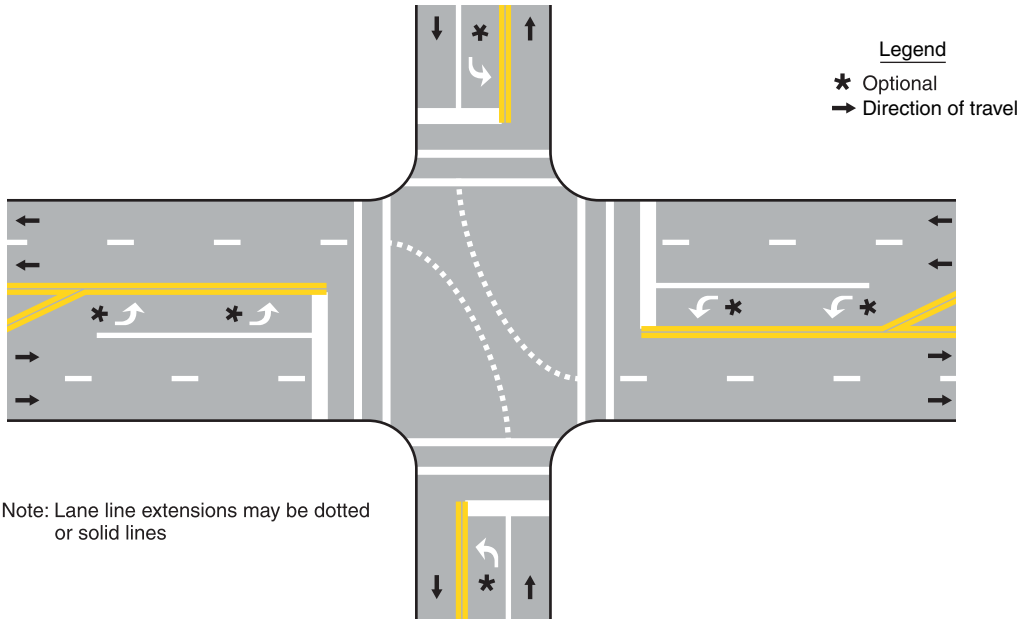


FIGURE 3B-11 Examples of Extensions through Intersections *(Sheet 1 of 2)*

c - Typical dotted line markings to extend longitudinal lane line markings



d - Typical dotted line markings to extend longitudinal centerline markings

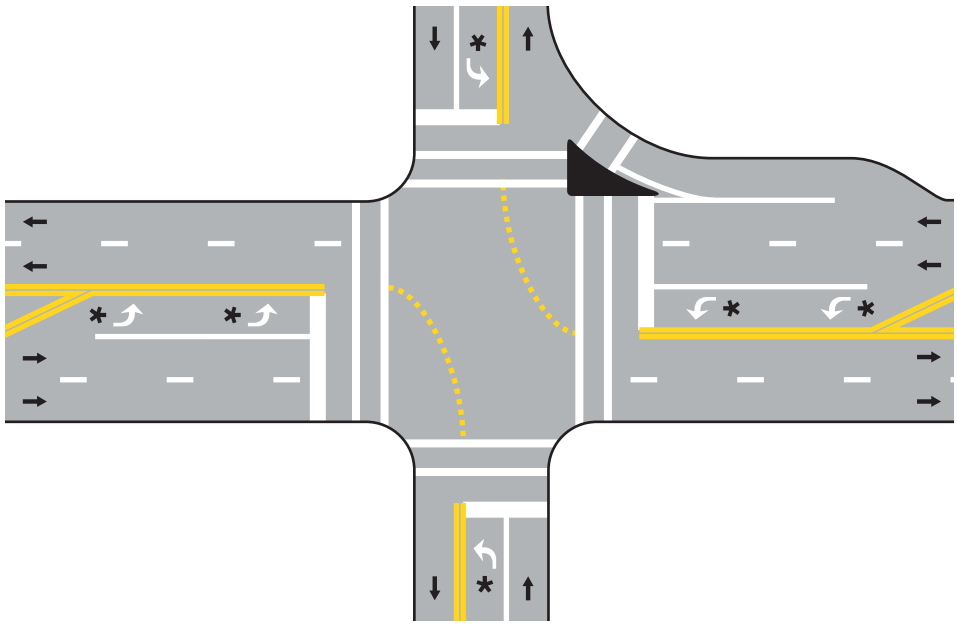
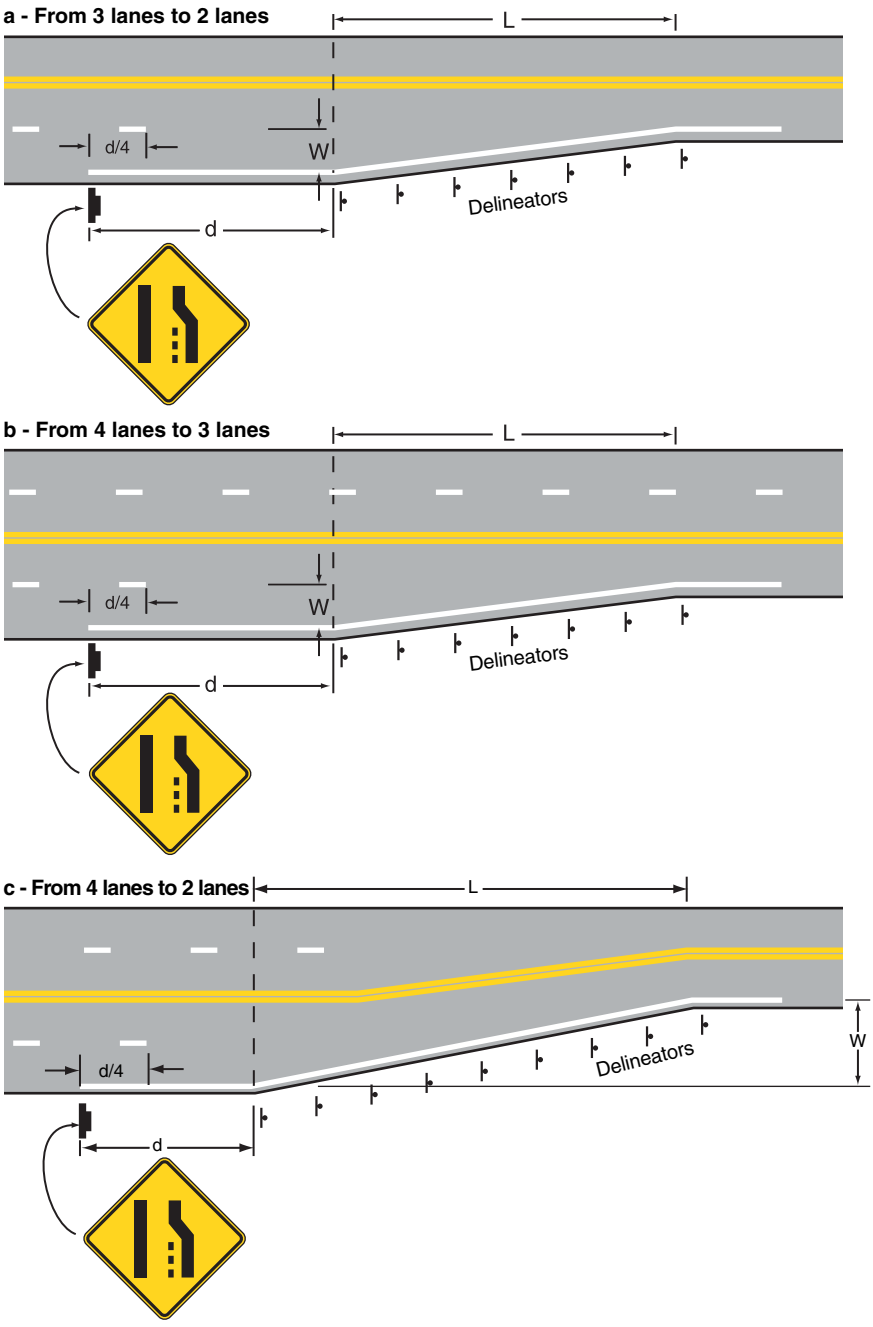


FIGURE 3B-11 Examples of Extensions through Intersections *(Sheet 2 of 2)*



L = Length in meters (feet)
S = Posted, 85th-percentile, or statutory speed in km/h (mph)
W = Offset in meters (feet)
d = Advance warning distance (see Section 2C.05)

See Section 3D.04 for delineator spacing.

For speeds 70 km/h (45 mph) or more:
$L = 0.62\ WS$ (L=WS)

For speeds less than 70 km/h (45 mph):
$L = \frac{WS^2}{155}$ $\left(L = \frac{WS^2}{60}\right)$

FIGURE 3B-12 Examples of Lane Reduction Markings

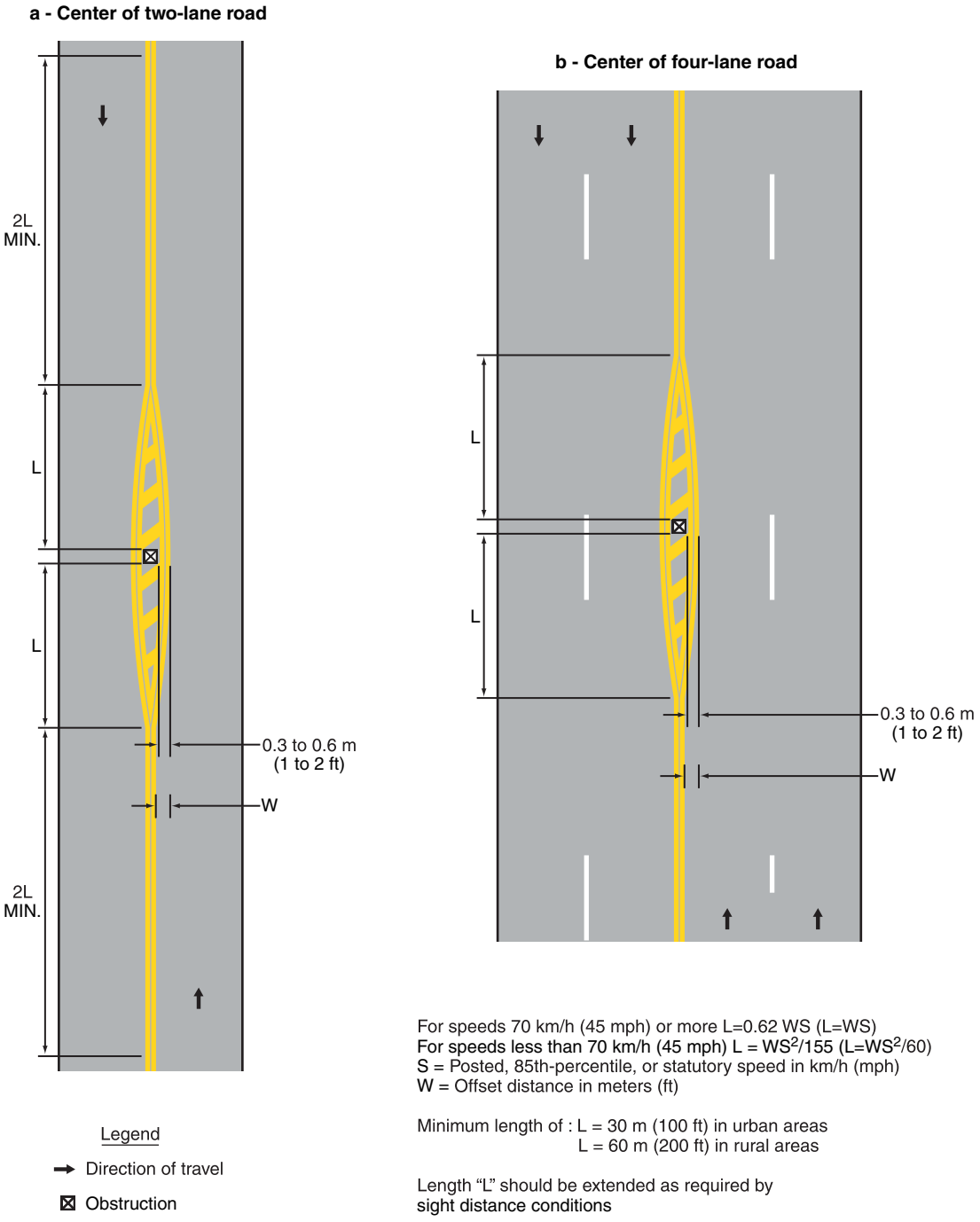
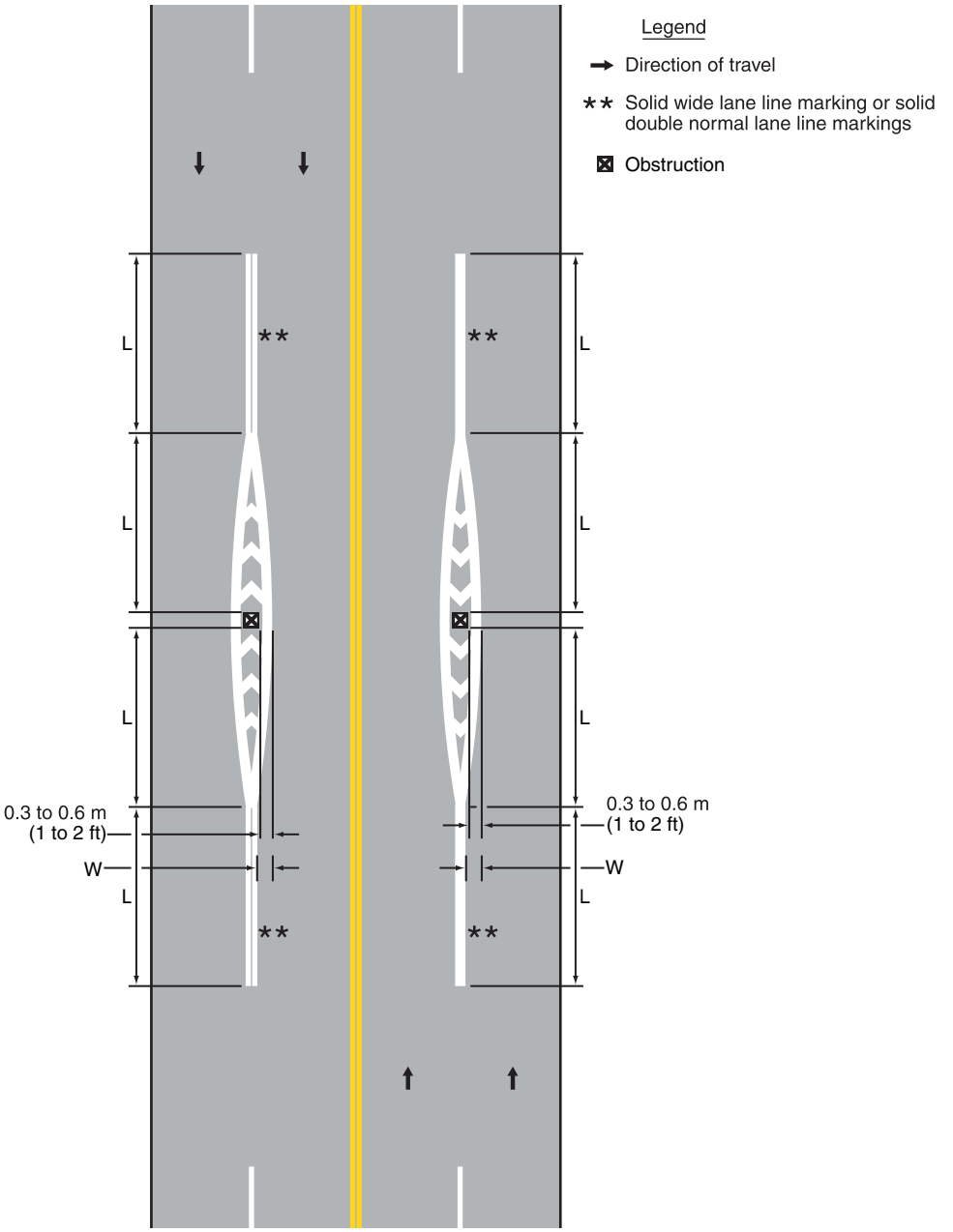


FIGURE 3B-13 Examples of Markings for Obstructions in the Roadway *(Sheet 1 of 2)*

c - Traffic passing both sides of obstruction



For speeds 70 km/h (45 mph) or more L=0.62 WS (L=WS)
For speeds less than 70 km/h (45 mph) $L = WS^2/155$ ($L=WS^2/60$)
S = Posted, 85th-percentile, or statutory speed in km/h (mph)
W = Offset distance in meters (ft)

Minimum length of : L = 30 m (100 ft) in urban areas
L = 60 m (200 ft) in rural areas

Length "L" should be extended as required by sight distance conditions

FIGURE 3B-13 Examples of Markings for Obstructions in the Roadway *(Sheet 2 of 2)*

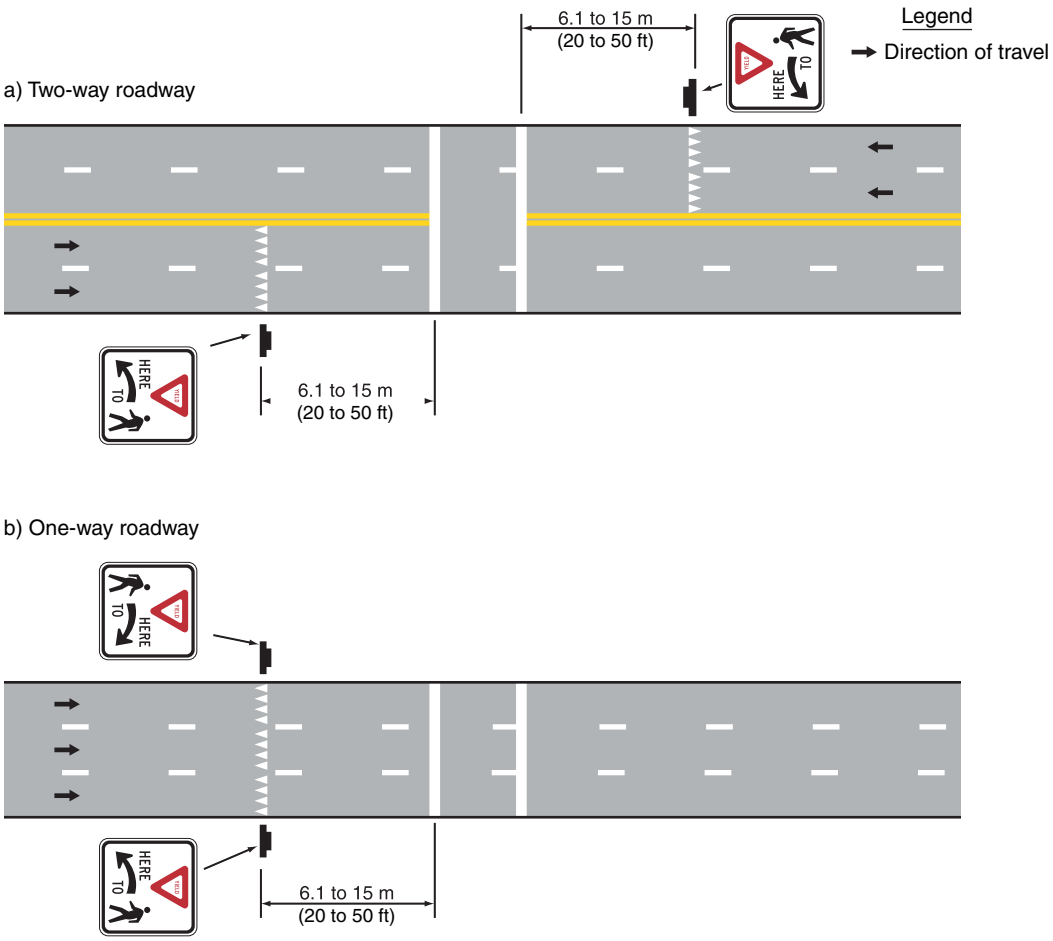


FIGURE 3B-15 Examples of Yield Lines at Unsignalized Midblock Crosswalks

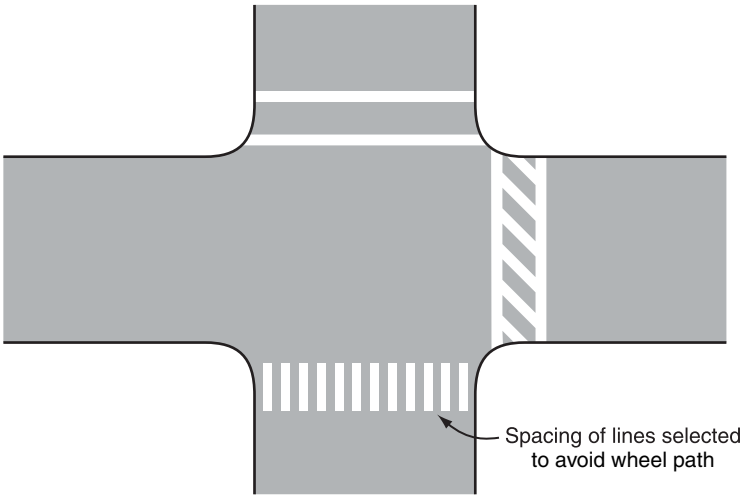


FIGURE 3B-16 Examples of Crosswalk Markings

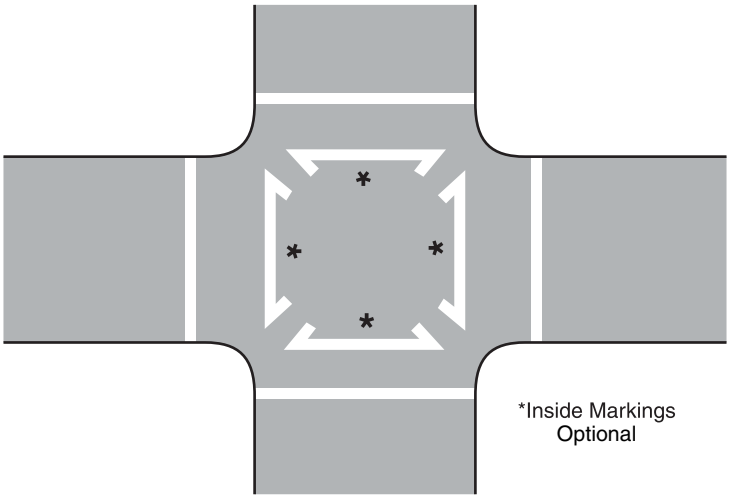
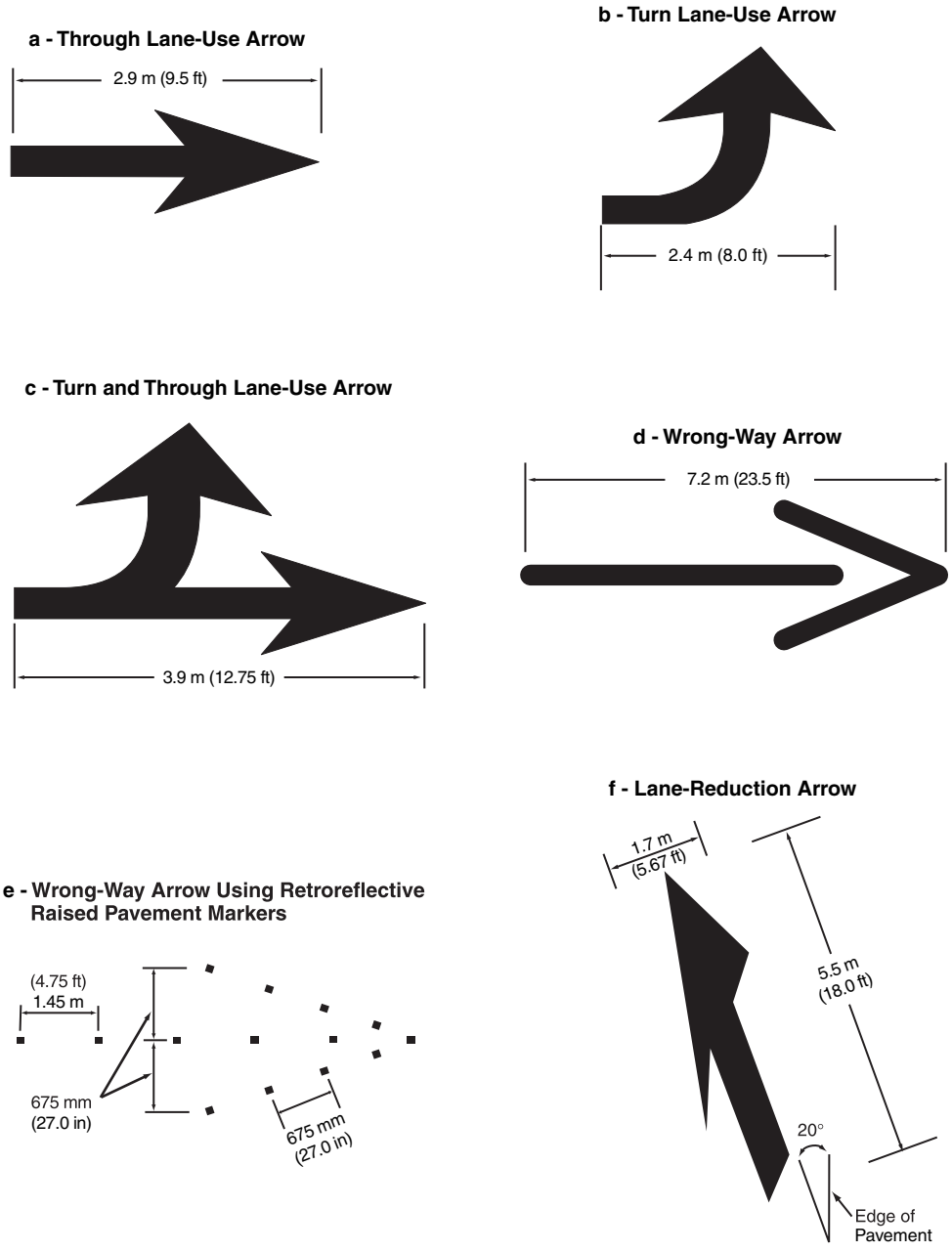


FIGURE 3B-17 Example of Crosswalk Markings for Exclusive Pedestrian Phase That Permits Diagonal Crossing

FIGURE 3B-20 Example of Elongated Letters for Word Pavement Markings



Typical sizes for normal installation; sizes may be reduced approximately one-third for low-speed urban conditions; larger sizes may be needed for freeways, above average speeds, and other critical locations. A narrow elongated arrow design is optional. For proper proportion, see the Pavement Markings chapter of the "Standard Highway Signs" book (see Section 1A.11).

FIGURE 3B-21 Examples of Standard Arrows for Pavement Markings

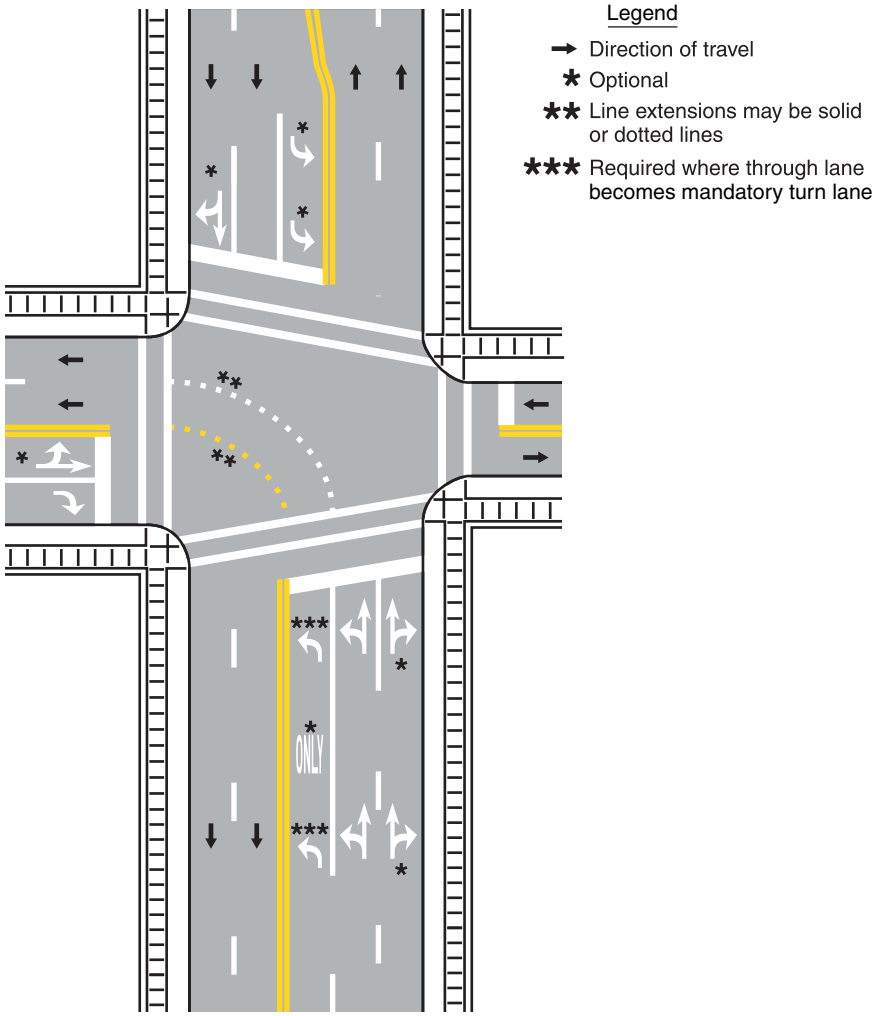


FIGURE 3B-22 Examples of Lane Use Control Word and Symbol Markings