

Chapter 7

MARKINGS AND DELINEATION

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7-1.00 INTRODUCTION

7-1.01 Purpose

It is MN/DOT's mission to:

Provide an appropriate pavement marking on all highways, 365 days per year.

This chapter gives specific guidelines for the use of pavement markings. The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), Part III, sets forth general standards, while this manual outlines preferred practices within the MN MUTCD standards.

7-1.02 Scope

Standards for the application of markings and delineation are set forth in the MN MUTCD, and those basic principles must be followed by the engineers, technicians, and maintenance personnel responsible for the design, selection, placement, and documentation of these devices. This Manual does not duplicate the standards established in the MN MUTCD. Rather, this chapter presents the preferred practice in the application of pavement markings, object markers, and delineators. Information presented in this chapter includes: (1) types and use of materials, (2) general principles to be followed, (3) design details, including standards and specifications, and (4) the specific use of markings and delineation. The major source document for this chapter is the MN MUTCD, and users of the Traffic Engineering Manual should be completely familiar with the MN MUTCD requirements before attempting to apply the guidelines established in this chapter.

7-1.03 Chapter Organization

As indicated above, this chapter supplements the MN MUTCD by presenting the preferred practices related to the use of markings and delineation. Important terms used in the chapter are defined in the Glossary of the TEM. The remaining sections of the chapter discuss: (1) legality, (2) pavement markings, (3) special markings, (4) object markings, (5) delineation.

7-2.00 GLOSSARY

Appropriate Pavement Marking - One that meets or exceeds the standards defined in the MN MUTCD including any minimum levels of retroreflectivity, when weather permits. During winter operations, pavement markings should provide presence after bare pavements are attained.

Centerline - A line indicating the division of the roadway between traffic traveling in opposite directions.

Channelizing Line - A line which directs traffic and indicates that traffic should not cross the line.

Delineator - A light-reflecting device mounted at the side of the roadway, in a series with others, to indicate the alignment of the roadway.

Durable Markings - Marking materials, other than conventional paints, that last at least two years providing year round presence and retroreflectivity.

Edge Line - A line which indicates the edge of the roadway.

Hazardous Waste - With respect to removal of pavement markings, waste debris created may be toxic (see Toxicity in Specified Products) and require handling and disposal procedures prescribed by waste management laws, rules, and regulations. The toxicity level is determined by sending debris samples to a qualified laboratory for Toxicity Content Leaching Procedures (TCLP) testing. The waste debris is considered a hazardous waste if the toxic content is equal or greater than 5.0 mg/L (**5.0 parts per million**).

Lane Line - A line separating two lanes of traffic traveling in the same direction.

Non-Hazardous Waste - With respect to the removal of pavement markings, waste debris may be disposed of using less stringent criteria. This would make it acceptable at some in-state waste facilities as designated by the Office of Environmental Services.

Object Markers - Markings intended for use on obstructions within or adjacent to the roadway.

Pavement Markings - All lines, symbols, words, colors, or other devices, except signs and power-operated traffic control devices, set into the surface of, applied upon, or attached to the roadway.

Roadway - That portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the berm or shoulder. In the event a highway includes two or more separate roadways, the term 'roadway' refers to any such roadway separately.

Stop Line - A line which indicates where vehicles should stop when directed by a traffic officer or traffic control device.

Toxics in Specified Products - Minnesota Statute 115A.9651 prohibits the use of toxic heavy metals in any ink, dye, pigment, paint, or fungicide after September 1, 1994. The prohibited toxic heavy metals are lead, cadmium, mercury, and hexavalent chromium. They may be found in older pavement markings, particularly lead and chromium in yellow markings. Consequently, non-toxic pavement markings must be specified in contracts and purchases.

Waste Debris - With respect to pavement marking materials, white or yellow-colored paint/bituminous or concrete mixtures generated by the removal of pavement markings. It is collected and stored separately by color and pavement type unless otherwise specified in contracts or by an appropriate supervisor.

CHAPTER 7 - MARKINGS AND DELINEATION

7-3.00 LEGALITY

7-3.01 Legal Authority

Minnesota Statutes 169.06 (Subdivisions 1-4) and 169.07 establishes the legal authority for the Department and local units of government to: (1) place and maintain markings, (2) require obedience to official markings, (3) prohibit the display of unauthorized markings, and (4) prohibit interference with official markings. Markings shall be placed only by the authority of the public body having jurisdiction over the highway, road, or street for the purpose of regulating, warning, or guiding traffic. Pavement and curb markings, object markers, and delineators are all normally within highway, road, or street rights-of-way and, therefore, should never be installed except under public authority.

Two 1990 Session Laws, Chapters 482 and 497, modified handicapped parking requirements for the disabled.

7-3.02 Responsibility for Placement and Removal

Permanent pavement markings are the responsibility of the governing road authority. These markings may be placed whether by maintenance personnel or by contract with a private company. Removals are generally done by contract.

7-3.03 Legal Effect

Minnesota Statutes, Section 169.18, refers to specific distinctive pavement markings which prohibit the driver from making specified maneuvers or guide the driver in certain paths.

Since markings have specific meanings defined in the law, the use of inappropriate markings and delineators could lead to legal claims of negligence. It is extremely important, therefore, that the correct types of markings are used for each specific situation.

7-4.00 PAVEMENT MARKINGS

7-4.01 Materials

The basic requirements for pavement marking materials are: (1) the specified colors must be identifiable during both daylight and nighttime hours and (2) the required visibility must be maintained throughout the material's lifetime. While pavement, curb, and object markings may be created through the use of a variety of materials, factors to be considered in selecting a marking are durability, workability, drying time or non-track time, accommodation of heavy traffic volumes and replacement of material, including environmental concerns.

7-4.01.01 Durable Markings

Durable pavement markings, such as epoxies and polymer tapes, are being used per application guidelines. A multi-discipline task force was instrumental in developing MN/DOT's use and evaluation of pavement marking materials.

Guidelines

- All marking materials shall be installed according to the manufacturer's specifications.
- All applications should be reviewed to determine the compatibility with adjacent roadway sections (i.e., does the roadway fall within the limits of a district's overall striping plan; will the remaining section(s) be under construction, re-striped, or otherwise enhanced in the near future).
- District maintenance and traffic personnel should be consulted by design prior to the selection of the designer's marking material. Product Material Sheets should be reviewed for specific information regarding each product, application windows, surface preparation, and cost.
- Individual consideration should be given to messages and special markings. Durable materials (i.e., epoxy, tape, thermoplastic, etc.) should be utilized whenever possible. When durable materials are not practical, messages and special markings should use the same material as called for on center lines.
- Part VI of the MN MUTCD should be consulted for interim pavement marking requirements.

7-4.01.02 Permanent Markings

Permanent pavement markings are desirable in almost all situations except where a temporary traffic control situation of short duration exists and engineering judgment justifies the use of temporary markings. Permanent markings must comply with all standards and specifications set forth in the MN MUTCD and this Manual. The types of permanent pavement markings which are used in Minnesota and their respective characteristics are described in Chart 7.1. General construction requirements for various products are listed in Chart 7.2.

7-4.01.03 Temporary Markings

There is a definite need for temporary markings in construction areas and at locations where a temporary hazard must be properly marked until the necessary repairs or improvements can be made.

The types of temporary pavement markings which are used in Minnesota and their respective characteristics are described in Section 8-4.02.03 of Chapter 8.

7-4.01.04 Retroreflectivity

Pavement markings which must be visible at night shall be reflectorized unless ambient illumination assures adequate visibility. Since most roadways do not have ambient light, most pavement markings are reflectorized with the exceptions of curb and parking lines.

Retroreflectorization of pavement markings is increasingly important to the older driver. In 1991, the national transportation bill, ISTEA, charged the Federal Highway Administration to develop standards for maintaining retroreflectivity. MN/DOT was selected to participate in FHWA's development efforts to determine the minimum maintained levels. This permits MN/DOT to provide information on the impact of snow plowing and other wintertime conditions on the retroreflectivity component.

Retroreflectorization, i.e., the return of light from a vehicle head lamp to the driver's eye, is accomplished by glass spheres (beads) imbedded into the marking material slightly greater than half the bead diameter. Road grime, salt, dirt, plow-shaved surface of the beads or runoff of rainfall that covers the bead reduces or negates the retroreflectivity capability. Snow plowing, particularly by the under-body plow blade type, can destroy retroreflectivity by shaving or removing the glass beads. Snowbelt states such as Minnesota are experimenting with durable markings using larger beads and adhesion enhancement coatings to improve the retention of retroreflectivity.

Retroreflectivity of in place pavement markings is determined with hand held reflectometers or MN/DOT's mobile LASERLUX® van. The latter is preferred as large quantities of data are readily and safely obtained at highway speeds.

LASERLUX® has three major components:

1. laser scan outputs and sensing of retroreflected waves,
2. distance measuring device, and
3. on-board computer that merges location and retroreflectivity measurements into report formats as elected by the operator.

The automated LASERLUX® is playing a major role in determining loss of retroreflectivity over time resulting from traffic wear and snowplowing. The data collected will be used in the development of a pavement marking management system.

7-4.01.05 Removal of Markings

Permanent or temporary pavement markings required by road conditions or restrictions or deemed a special need should be removed or obliterated when those conditions, restrictions or special needs cease to exist. Failure to remove conflicting markings may create confusion in the minds of the motorists. Additionally, care must be exercised during removal to avoid scarring the

pavement surface in such a way that drivers are not misled during nighttime and wet weather conditions.

Nighttime inspections are needed to verify that the appropriate markings exist once obliteration work has been completed.

Typically, sandblasting, grinding, burning, chemical treatment, and high pressure water jet have been used to remove markings, but the results at times have been less than desirable. For larger projects, truck-mounted, hydraulically controlled, dual scarifying drums with a built-in vacuum system could be considered. A trailing sweeper/vacuum unit recovers the coarser paint/surface waste mixture.

For temporary situations, a wide, black polymer tape may be used to cover unwanted 100 mm (**4-inch**) wide lines.

7-4.02 Standards and Specifications

The cycle length for pavement marking is 15 m (**50 feet**). This consists of a 3 m (**10 foot**) stripe and a 12 m (**40 foot**) gap.

Implementation

These guidelines shall be followed on all MN/DOT striping operations:

1. All new surfaces/overlays shall be striped with the 15 m (**50 foot**) cycle.
2. All striping done on existing surfaces shall match the cycle currently in place. If the cycle is to be changed from a 10 m (**40 foot**) to a 15 m (**50 foot**) cycle, the existing pavement markings shall be removed.

7-4.02.01 Centerlines in Rural Areas

On two-lane, two-way, rural roadways the standard centerline shall be a broken yellow line with 3 m (**10 foot**) line segments and 12 m (**40 foot**) gap lengths. See Figure 7.1.

On multilane, undivided, rural roadway (four or more lanes) the centerline shall be marked with double yellow solid lines to indicate that vehicles may not drive to the left of such centerlines to execute a passing maneuver. See Figure 7.2 and Figure 7.12.

7-4.02.02 Centerlines on Urban Streets

On a two lane, two-way urban street, the standard centerline shall be a broken yellow line with 3 m (**10 foot**) line segments and 12 m (**40 foot**) gap lengths.

On a two-way urban street with four lanes of moving traffic, the center shall be marked with double yellow solid lines to indicate that vehicles must stay to the right of such centerlines, except when making a left turn.

On two-way urban streets with three or five lanes, with a two way center left turn lane, a double line consisting

of a broken yellow line with 3 m (**10 foot**) line segments and 12 m (**40 foot**) gap lengths on the inside and a solid yellow line on the outside shall be used to delineate the turn lane from the through lanes. See Figure 7.3.

7-4.02.03 Lane Lines

Lane lines shall be broken white lines with 3 m (**10 foot**) line segments and 12 m (**40 foot**) gap lengths, except that a channelizing line (solid white) may be used to distinguish a turning lane or other special lane from the adjacent through lane.

7-4.02.04 No-Passing Line

No-passing lines shall be solid yellow lines placed to the right of, and at a distance of 100 mm (**4 inches**) from, the adjacent centerline. The "NO PASSING ZONE" sign must also be erected on the left side of the roadway at the beginning of the no-passing zone.

7-4.02.05 Channelizing Traffic Lines

Channelizing traffic lines shall be either solid lines 100 mm to 300 mm (**4 inches to 12 inches**) in width or double solid lines. For example, turning lane lines should be 100 mm (**4 inches**) wide, while channelizing lines for entrance-exit ramps should be 200 mm (**8 inches**) wide. In general, the width of the line should indicate the degree of emphasis required.

7-4.02.06 Pavement Edge Lines

Pavement edge lines shall be solid white lines, broken only at intersections with public roads and at private entrances if they are controlled by a yield sign, stop sign or traffic signal. The break point is to be at the start of the radius for the intersection or at marked stop lines or crosswalks. On divided highways and one-way roadways, the edge line on the left side of each roadway shall be a solid yellow line.

When edge lines are provided on a trunk highway they should be located as follows:

- On pavements that are 6 m (**20 feet**) wide and have no shoulders or unpaved shoulders the edge line should be on the pavement surface, within 50 mm $\pm$ 25 mm (**2 inches $\pm$ 1 inch**) from the edge of pavement.
- On pavements that are 6 m (**20 feet**) wide and have paved shoulders the edge line should be on the shoulder, within 50 mm $\pm$ 25 mm (**2 inches $\pm$ 1 inch**) from the edge of pavement.
- On pavements that are 6.6 or 7.2 m (**22 or 24 feet**) wide the edge line should be on the pavement surface within 50 mm $\pm$ 25 mm (**2 inches $\pm$ 1 inch**) from the edge of pavement.
- On pavements that are 8.2 m (**27 feet**) wide the edge line should be placed at a maximum of 3.6 m (**12 feet**) from centerline.

Because it is impractical to control the exact location of pavement markings all dimensions shown are approximate. The dimensions shown are the desired, not exact, location of the pavement markings and actual conditions may vary.

The above guidelines do not address all pavement designs or cover all situations encountered. If a 6 to 6.6 m (**20 to 22 foot**) wide pavement has structurally adequate shoulders, the shoulders may be considered part of the pavement surface and the edge line may be placed accordingly. Regardless of pavement width, edge lines should generally be placed on the pavement surface 50 mm $\pm$ 25 mm (**2 inches $\pm$ 1 inch**) from the edge of pavement but no further than 3.6 m (**12 feet**) from the center joint or nearest lane joint to the outside edge of the edge line.

For pavement maintenance purposes, it is important that longitudinal striping be offset 50 mm (**2 inches $\pm$ 1"**) from:

- underlying longitudinal joints
- centerline, lane and edge line joints
- bituminous seams in the wearing course.

7-4.03 Application Guidelines

Where used, pavement striping shall conform to the Highway Striping Plan, Standard Plan Nos. 5-297.341, 5-297.342 and Figure 7.4 as follows:

7-4.03.01 Two-Lane, Two-Way Roadways and Passing Lane Sections

1. Two-lane, Two-way roadways shall have:

- Broken yellow centerlines
- Pavement edge lines wherever there is not good color contrast between pavement and shoulders, especially at night, also where fog conditions or the unusual hazards may exist or on approaches to piers, abutments, and retaining walls. Edge lines are used extensively by MN/DOT.
- Solid yellow lines to restrict passing where required, in accordance with the warrants and criteria for such markings. (See Section 7-4.04 of this chapter).

2. Passing Lane Sections

Pavement markings are needed as follows:

a. At the Lane Addition

Figure 7.4 shows the recommended pavement markings at the lane addition. It is further recommended that both the pavement edge marking and the diagonal gore marking be installed immediately prior to the beginning of the left lane line.

b. In the Passing Lane

A solid double yellow centerline pavement marking should be used to separate the lanes that carry opposing traffic. A broken white skip pavement marking is used to separate traffic moving in the same direction. Pavement edge markings are recommended for both directions of opposing traffic in the passing lane sections.

c. At the Lane Drop

Pavement markings in the lane drop transition area should be provided in accordance with the MN MUTCD, Section 3B-9 and Figure 3.12. Pavement edge markings are important in the lane drop transition area.

7-4.03.02 Multilane, Two-Way Roadways

Multilane, two-way roadways (four or more lanes) shall have the following:

- Double yellow solid line as centerline markings
- Lane lines to provide for better use of each lane
- Pavement edge lines.

7-4.03.03 Roadways with Two-Way Left Turn Lanes

Pavement markings shall conform to Figure 7.3.

7-4.03.04 One-Way Roadways

One-way roadways shall have the following:

- Lane lines to provide for better use of each lane
- Pavement edge lines on right side or both sides where needed for night visibility or where fog conditions or other unusual hazards may be encountered. Edge lines are used extensively by MN/DOT.

7-4.03.05 Narrow Bridges

Bridge decks on two-lane, two-way bridges may have double yellow barrier lines depending on bridge width and length. No-passing zones shall begin 300 m (**1000 feet**) in advance of a narrow bridge.

7-4.03.06 Intersections

Supplementary pavement markings at intersections, where used, shall conform to the standards shown in Figure 7.5.

7-4.03.07 Interchange Exit and Entrance Ramps

Pavement markings for interchange ramps, where applied, shall conform to the standards shown in the Highway Striping Plan (see Figures 7.6 & 7.7).

7-4.03.08 Auxiliary Lanes and Lane Drops

The purpose of this section is to clarify the use of these markings. Figures 7.8A and 7.8B display the size, spacing of these markings and typical applications for lane drops and auxiliary lanes.

7-4.03.09 Turn Lanes

The mere existence of a turn lane does not mandate the use of a turn lane message. Where evaluation by the district traffic engineer is affirmative, the message may be placed similar to Figure 7.9. Messages are required to supplement appropriate signing where a normal through lane is designated for turn option--through and/or turn only operation.

7-4.03.10 Bypass Lanes at Intersections

Bypass lanes at intersections should be marked as illustrated in Figure 7.10.

7-4.03.11 Obstructions in Traveled Way

See the MN MUTCD, Section 3B-10 and Figure 3B.13.

7-4.03.12 Transitions

Approaches to median islands in roadways shall be marked as illustrated in Figure 7.11. Markings for two-lane to four-lane undivided pavements shall be as shown in Figure 7.12.

7-4.03.13 Special Climbing Lanes

Pavement markings for special climbing lanes shall conform to the standards shown in Figure 7.13.

7-4.03.14 Truck Stopping Lane

Pavement markings for truck stopping lanes at railroad crossings shall be as shown in Figure 7.14.

7-4.03.15 Free Right Conditions

Pavement Markings for free right conditions shall conform to the standards shown in Figure 7.15.

7-4.04 No-Passing Zone Surveys**7-4.04.01 Warrants**

A no-passing zone is warranted when the minimum sight distance is less than the distances shown in Chart 7-3 for various design speeds. No-passing zone surveys shall be run at an eye height of 1070 mm (**3.5 feet**) to an object height of 1070 mm (**3.5 feet**) at the sight distance required in Chart 7-3 based upon the 85 percentile speed. The beginning of a no-passing zone shall be the point at which the sight distance first becomes less than that specified in Chart 7-3.

The end of the marking shall be that point at which the sight distance becomes greater than the minimum specified in Chart 7-3. In no case shall a no-passing line be less than 150 m (**500 feet**) in length. If the end of a no-passing line is less than that specified in Chart 7-4 from the beginning of the line for the next no-passing zone, the two no-passing lines should be connected to provide a continuous restriction through both zones.

7-4.04.02 Survey Procedures

The first and most vitally important step in any surveying operation is work zone traffic control. All work zone traffic control shall be installed according to MN MUTCD, Section 6K, (*the Field Manual*).

There are two methods for surveying no-passing zones: (1) the hand signal method and (2) a method utilizing distance-measuring instruments and two-way radios.

1. Hand Signal Methods

Survey crews must be trained in the field before using the hand signal survey method.

Example:

Using the 60 mph (100 km/h) criterion of 305 m (**1000 feet**) of sight distance for discussion purposes, the hand signal survey procedure shall consist of the following steps:

Using two vehicles, the survey chief should follow his assistant over the section of highway being surveyed, maintaining a distance between the vehicles slightly in excess of the sight distance criteria (i.e., greater than 305 m (**1000 feet**) in this case). The survey chief should record his odometer reading at the crest of each vertical curve or at the center of each horizontal curve where the lead vehicle approaches the disappearing point, indicating a probable sight distance restriction.

All probable sight restrictions locations are surveyed as follows. The survey assistant should stand at a point A1 in the northbound traffic lane approximately 305 m (**1000 feet**) preceding the location where the odometer reading was taken. (See Figure 7.16 for a vertical curve and Figure 7.17 for a horizontal curve). The survey chief should then drive the survey vehicle to point B1 305 m (**1000 feet**) ahead of his assistant. The distance is measured by means of the survey odometer or other distance measuring instrument on the survey vehicle. The chief should stand at point B1 in the southbound traffic lane near the center line. The chief should then sight with the 1070 mm (**3.5 foot**) height-sighting device at the 1070 mm (**3.5 foot**) target held by his assistant in the northbound traffic lane at point A1. If the target is completely visible, the chief should then signal his assistant to move toward him 5 or 10 paces, depending upon the percent of grade or degree of curvature.

The chief should also move an equal number of paces in the same direction to maintain the 305 m (**1000 foot**) distance between them. A second sighting should then be taken from point B2 to point A2. Assuming that at B2 the target at A2 is just visible, points A2 and B2 should be marked. These points, A2 and B2, establish the beginning of the northbound no-passing stripe and the end of the southbound no-passing stripe.

For vertical curves, the end of the southbound line should be extended to point B3 as a safety factor to offset any tendency of the driver to anticipate the end of the no-passing zone and pass too soon. To locate this point, B3, the chief should move toward point A2 until his line of sight extends from 1070 mm (**3.5 feet**) above the roadway surface at point B3 to approximately 150 mm (**6 inches**) at point A2. The chief should then mark point B3, which should be the end of the southbound stripe. This extension should not be used for horizontal curves.

The survey chief should then move to the northbound lane, picking a potential ending point D1 from the northbound stripe (see Figures 7.16 and 7.17). His assistant should move 305 m (**1000 feet**) north from point D1 to point C1. The end of the northbound stripe, point D2 on Figure 7.17 and point D3 on Figure 7.16 and the beginning of the southbound stripe, point C2, should then be determined in the same manner as outlined for points B2, B3, and A2 in the previous paragraph.

The termini of the no-passing zones should be marked by the chief and his assistant with yellow lines normally placed on the edge of the pavement. These marks serve as a guide to the operator of the striping machine (see Standard Spotting Procedure in Section 7-4.05 of this chapter).

Next, the survey chief should record the length of the northbound and the southbound no-passing lines. If the no-passing distance in either direction is less than 150 m (**500 feet**) in length, additional length shall be added at the beginning of the zone to make a total of 150 m (**500 feet**). If the distance between two zones in the same direction is less than the minimum distance listed in Chart 7-4, they shall be added together to form one continuous zone. The length of the overlap or gap between the ends of the northbound no-passing zone and the southbound no-passing zone should also be recorded. Figure 7.16 shows an overlap of the northbound and southbound zones and Figure 7.17 shows a gap between zones. Each no-passing restriction consisting of a northbound and a southbound zone should be referenced by a distance from the beginning of the section to the beginning of the first no-passing line in each zone.

In this manner, all no-passing zones on a roadway section are recorded in order beginning from one end of the section and progressing to the other end of the section.

Often only a single vehicle is available. This being the case the survey chief would let the assistant off in advance of the anticipated start of the zone and then drive up 305 m (**1000 feet**). With this interval established the same procedure as described above would be used to determine the exact line location. When the line termini are established in one direction, the survey chief would then drive down to pick up the assistant and the procedure repeated in the opposite direction.

2. Distance-Measurement Instrument (DMI) and Two-Way Radio Method

Hand held two-way radios provide the best and most reliable means of communication between the survey chief and the assistant. Hand held signals can confuse motorists and may be missed by the assistant. Using a two-man crew and two vehicles equipped with two-way radios and DMI's, the survey procedure is as follows:

a. Vertical Curve

Beginning at a common point, the lead operator should proceed a distance of 305 m (**1000 feet**) (60 mph - 305 m [**1000 feet**] sight distance). The operator should then reset his DMI to read the same as the trailing vehicle which is still 305 m (**1000 feet**) behind him at the point of beginning. After resetting the DMI, the lead operator should proceed at a predetermined speed with the trailing vehicle following, until the lead operator comes to a sight restriction. Assuming the leader (lead operator) is traveling east and has come to a vertical curve, the leader should stop on the crest and radio his DMI reading to the trailer (trailing operator). The trailer should stop at the same reading (305 m [**1000 feet**] behind the leader).

The two vehicles, maintaining the 305 m (**1000 feet**) interval, should move forward or backward to locate the point of beginning for the eastbound no-passing zone. This should occur when the leader has passed over the crest of the hill and the target on the back of his vehicle appears to be just visible above the surface of the roadway, maintaining the 305 m (**1000 feet**) interval. The trailing operator should mark the pavement and record the reading. The leader should back up until he reaches a point where he can see a full car silhouette (150 mm [**6 inches**] above the pavement surface) down the hill. He should then locate the point ending the westbound line and mark the pavement. The trailer should record his reading when he passes this mark on the pavement.

The beginning point of the eastbound line and ending point of the westbound line have now been located. The next step is to locate the end of the eastbound line and the beginning of the westbound line. To do this, both vehicles should proceed at a pre-arranged speed (**5-10 mph** [10 km/h]) at a distance of 305 m (**1000 feet**) apart in an easterly direction over the crest. The target on the leader should disappear. The point at which it comes back into view at 1070 mm (**3.5 feet**) height of eye is the location of the beginning of the westbound line. At that point, the trailer should radio the leader to stop and the leader should mark the pavement.

The trailer should move ahead until he reaches a point where he can see a full car silhouette (150 mm [**6 inches**] above the pavement surface) down the hill. This point is the end of the eastbound line. The trailer should mark the point on the pavement and record the reading. As the trailer passes the beginning terminal for the westbound line, he should record this reading, thus tying in all beginning and ending terminals for the zone.

b. Horizontal Curve

The leader should stop at a point where he thinks he will go out of sight of the trailer and should radio his location to the trailer. The trailer should stop at that same reading (vehicles 305 m [**1000 feet**] apart) and both vehicles should move ahead or back until the point is established. The trailer should mark the pavement and record the reading. This is the beginning of the eastbound line. The leader should then mark the end of the westbound terminal or adjust it slightly to a point where he can see the full road ahead (west). The trailer should record the reading when he gets to that point. To establish the other ends of the zone, the two vehicles should move easterly at a pre-arranged speed, 305 m (**1000 feet**) apart, until the trailer can see the leader again. The leader should mark the pavement for the beginning of the westbound line. The trailer should then mark the end of the eastbound terminal, adjusting it slightly if necessary to a point when he can see the full road ahead. This is the end of the eastbound line. The trailer should record the readings at these termini to complete the establishment of the zone. Where the distance between successive no-passing zones is less than 150 m (**500 feet**), the zones should be connected together to make a long, continuous zone. The operators must use discretion in establishing horizontal zones because crops maturing in the late summer may create temporary sight restriction.

7-4.05 Standard Spotting Procedure

A standard practice of the department is to "spot" or mark guidelines for pavement markings and striping.

Usually a traffic technician or survey crew does this spotting with a small spray paint can after the proper location of the marking has been determined. To ensure that the proper markings are placed, a standard means of spotting has been adopted. The spotting system shown in Figure 7.18, and described below, should be used for all striping.

All spotting should be the color of the stripe to be painted.

Generally spot as necessary.

On tangents, control points "spots" should be placed as necessary to maintain a straight accurate line. Control points on curves should be located at intervals which assure the accurate placement of the line.

7-4.06 Special Markings

7-4.06.01 Pedestrian Crossings

Pedestrian lanes or crosswalk markings may be placed at intersections and represent extensions of the sidewalk lanes. Pedestrian crosswalk markings should be used at signalized intersections in urban areas. Pedestrian crosswalk markings are used in rural areas to encourage pedestrian crossings at definite points.

Pedestrian crosswalk lines should be placed as shown in Figure 7.19. The words PED XING in white may be placed on the approaching pavement lane or lanes for the benefit of approaching traffic. This pavement message should be placed near the PEDESTRIAN CROSSING (W11-2) sign. The optional "zebra" design (see Figure 7.20) may be used where additional visibility is required, such as with midblock crosswalks.

In municipalities, crosswalks and pavement markings for school and pedestrian crossings are usually provided by local authorities. The district traffic engineer may provide expertise in the initial efforts by the municipality. The department usually does not provide crosswalks or pedestrian markings in unincorporated areas. However, if a definite need exists, the department may install crosswalk and pavement markings.

7-4.06.02 School Crossings

School and pedestrian crosswalks and pavement markings should be provided by local authorities within incorporated areas. The department has found that school crosswalks or messages in unincorporated areas are not generally required.

However, if a definite need exists in an unincorporated location, the markings may be installed by the department (see Figure 7.21). The following guidelines govern the provision of school markings:

1. School Adjacent to Highway

When a school building or its grounds are adjacent to a trunk highway, School Advance Warning signs should be erected. If no crosswalk is provided, the word "SCHOOL" may be applied in white on the approaching traffic lane or lanes near the School Warning signs (S1-1). "School" warning signs and "SCHOOL" pavement messages should not be used if the highway right-of-way is fenced and no access is provided directly to the highway.

2. Crosswalks

When a crosswalk is provided within a school zone, SCHOOL CROSSING signs may be installed on each approach. The crosswalks may also be painted and the words SCHOOL XING may be applied in white near the SCHOOL CROSSING signs.

3. Roadway Messages

Crosswalks, when used, shall be placed by MN/DOT where need is determined by the district traffic engineer. If a signal face sight restriction exists, the advance warning message SCHOOL XING shall be applied along with appropriate advance warning signs required by the MN MUTCD, Section 4D-15.

7-4.06.03 Railroad Crossings

All approaches to railroad grade crossings in rural areas, except minor spurs, shall be marked as shown in Figure 7.14. See MN MUTCD Section 8B-16. The local road authority is responsible for marking all railroad crossings on their roadways.

7-4.06.04 Stop Lines

Stop lines should be used in both rural and urban areas where it is important to indicate the point behind which vehicles are required to stop. Stop lines shall extend across all approach lanes. See Figure 7.22. Guidelines for the placement of stop lines are described as follows.

1. Stop Sign

If a stop line is used in conjunction with a STOP sign, it should ordinarily be placed in line with the STOP sign. However, if the sign cannot be located exactly where vehicles are expected to stop, the stop line should be placed at the desired stopping point.

2. Rural Areas

Stop lines in rural locations shall be placed only where a study by the district traffic engineer has determined a need for such control. A traffic control order shall be used.

3. Urban Areas

Stop lines in urban areas should be placed 1.2 m (**4 feet**) in advance of and parallel to the nearest crosswalk line. In the absence of a marked crosswalk, the stop line should be placed at the desired stopping point. In no case shall a stop line be placed more than 9 m (**30 feet**) or less than 1.2 m (**4 feet**) from the nearest edge of the intersecting curbline or edge of shoulder.

7-4.06.05 Stop Ahead or Signal Ahead

The STOP AHEAD or SIGNAL AHEAD messages shall be placed where a study by the district traffic engineer has determined a need for this type of warning. A pavement message is usually placed at or shortly beyond the sign giving the same message and may be repeated wherever approach speeds are high or unusual alignment exists. A solid yellow no-passing line shall be used with the STOP AHEAD or SIGNAL AHEAD pavement message (see Figure 7.22).

7-4.06.06 Parking Space Markings

Parallel parking spaces, where used, are to be marked with white lines with desirable dimensions of 2.4 m by 6.7 m to 7.9 m (**8 feet by 22 to 26 feet**) (see MN MUTCD, Section 3B-18). Parking spaces in state rest areas should be striped as shown in Figure 7.23. Municipal parking spaces are marked by local authorities.

7-4.06.07 Curb Markings

Curb markings are recommended only to show that parking is prohibited at all times. Other restrictions should be shown by standard parking signs. Local authorities may paint curbs yellow under the conditions described in Minnesota Statutes Section 169.34. Local authorities may also prohibit parking at other locations. However, if the restriction is on a trunk highway, permission must be obtained from the appropriate district office. The district traffic engineer reviews requests for local parking prohibitions on trunk highways.

7-4.06.09 Markings for Speed Enforcement (Airplane Markings)

In determining the appropriate application pavement markings for State Patrol airplanes, each district traffic engineer should confer annually with the patrol captain and chief pilot to review each existing zone. This review should identify zones which can be eliminated because of nonuse and zones which will be marked the next year.

The markings shall be white stripes, with dimensions of

1.2 m by 600 mm (**4 feet by 2 feet**) where the markings are placed in the traffic lane or on the centerline. Shoulder markings shall be 1.8 m by 600 mm (**6 feet by 2 feet**). Figure 7.24 illustrates typical applications of airplane markings.

A zone should consist of a set of 5 markers and be placed on a straight roadway if possible. Zones should be separated by 800 to 1600 m (**1/2 to 1 mile**).

7-4.06.10 Preferential Lane Markings

1. Bus and Car Pool

The increasing importance of preferential treatment for high-occupancy vehicles has created a need for a unique pavement marking symbol to guide and regulate approaching vehicles. Figure 7.25 shows an example of the application of "restricted lane" markers at a freeway on-ramp. The use of "restricted lane" markings shall be documented by a Traffic Control Order and approved by the State Traffic Engineer.

7-5.00 OBJECT MARKINGS

7-5.01 Purpose

Object markings are used to identify physical features located within or adjacent to the roadway. Included are objects constructed for the control of traffic such as traffic islands, road or street termination and, in the case of freeways, the gore area between an exit ramp or loop and the nearest through traffic lane. Obstacles such as bridge piers and abutments that are close to a traveled lane generally require additional warning techniques.

7-5.02 Types of Object Markers

For object marker types, color, and uses, consult the Minnesota Standard Signs Manual and the MN MUTCD. Additionally, Mn/DOT uses a Snowplow Marker (X4-5) which is not referenced in the MN MUTCD.

Information pertaining to materials, sheeting, and sign substrates can be found in the Minnesota Standard Specifications for Construction, sections 2564 and 3352.

7-5.02.01 Snowplow Marker (X4-5)

In the winter, this marker indicates to a snowplow operator the beginning and end of a guardrail installation. The snowplow marker is shown in Chart 7-5 and Figure 7.26.

7-5.03 Applications and Guidelines

7-5.03.01 Bridges Abutments, Piers, and Rails

Bridge abutments, piers, and rails within the width of the approaching shoulders shall be delineated by Type 3 Object Markers (Clearance Marker X4-4). A typical application can be found in Figure 7.26.

7-5.03.02 Narrow Bridges/One Lane Bridges

A narrow bridge shall be defined as any of the following:

- A bridge with a minimum driving surface width greater than 5.5 m (**18 feet**) and less than the roadway approach width (not including shoulders).
- A bridge where engineering judgment of approach grades, curvatures, number of trucks or other considerations justifies a narrow bridge classification.

Narrow bridges should be marked and delineated as shown in Figure 7.27.

A one-lane bridge is defined as any bridge having a clear opening width of 5.5 m (**18 feet**) or less. One-lane bridges shall be marked and delineated as shown in Figure 7.28.

7-5.03.03 Cattle passes/Large Culverts

Cattle passes and larger culverts that meet one of the following descriptions are subject to the provisions of this subsection:

- headwalls are present and are not protected by guardrail, subject to engineering judgement
- minimum width of 1 m (**42 inches**) and a maximum width of 6 m (20 feet). Large culverts (6 m [**20 feet**] or wider) may be treated as a bridge, subject to engineering judgement.
- any culvert with an end or opening that is within 2.5 m (**8 feet**) of the shoulder P.I. This 2.5 m (**8 foot**) distance was selected because it may allow a motorist to pull off of a narrow shouldered roadway if other conditions permit.
- other structures as determined by the district traffic engineer.

All drainage structures and cattle passes meeting the above criteria should be marked with Type 2 object markers as described in Section 3C-3 of the MN MUTCD and the following:

- The Type 2 Marker used shall be a 150 x 300 mm (**6" x 12"**) marker constructed of 1.6 mm (**0.062"**) aluminum or other lightweight material such as fiberglass or flexible urethane sheeting. The marker shall use Yellow Diamond Grade VIP Retroreflective Sheeting of a type compatible with the base material.

- On special flexible post designs that cannot accommodate the 150 x 300 mm (**6" x 12"**) marker, a 75 x 300 mm (**3" x 12"**) marker may be used.
- Two markers shall be mounted back-to-back on a flexible post or 3.0 kg/m (**2-pound**) steel post. A flexible post is preferred due to its resistance to being knocked down by snowplows and farm equipment. Additionally, it provides better daytime visibility.
- The two-way marker assembly shall be installed on the near right side immediately in front of the structure as shown in Figure 7.29.

The typical marking of cattle passes and large culverts not protected by guardrail are shown in Figure 7.29.

7-5.03.04 Guardrail

The approach end of plate beam guardrail installations should be marked with a striped object marker sized to fit the end terminal of the guardrail. The alternating black and reflective yellow stripes shall slope downward at a 45 degree angle toward the side on which traffic is to pass. The marker shall be made of wide angle prismatic retroreflective sheeting.

On guardrail installations with flat end treatments, the object marker shall fit within the recessed area. On those installations with round end treatments, the object marker shall wrap around the circular end treatment and shall be mounted so that the top of the marker is even with the top of the circular end treatment.

Both ends of all guardrails shall be delineated with the Snowplow Marker (X4-5) A typical application of these object markers can be found in Figure 7.26.

7-5.03.05 Islands and Interchange Gores

A typical application of the placement of object markers on Islands or Interchange gores can be found in Chart 7-5 and Figure 7.26.

7-5.03.06 End of Roadway

A typical placement of markings for a roadway that ends with no alternative vehicular path is shown in Figure 7.26.

7-5.03.07 Driveway Reflectors

A property owner may mark each side of a driveway entrance with reflectors. Blue colored reflectors are preferred although white (colorless) may be used. Each reflector should be placed on its own structure (not to exceed a 0.45 kg/m [**1.0#**] post), no more than 1.5 m (**5 feet**) above the ground, and at least 3.7 m (**12 feet**) from the outside edge of the shoulder. This will help reduce the chances of the reflector being covered by snow and damage by snowplow operations.

Red or yellow reflectors should not be used because they can be easily confused with motor vehicle tail lights. Mn/DOT forces may remove existing reflectors if they obstruct or interfere with the effectiveness of any traffic control device. (Reference: MS169.07)

7-5.03.08 *Other Objects*

Objects located within the clear zone should be marked with the proper object marker. The clear zone should be determined as stated in Chapter 4 of Road Design Manual, Part I.

7-6.00 DELINEATION

7-6.01 Types and Materials

For delineator types and colors, consult the Minnesota Standard Signs Manual, the MN MUTCD, and Figure 7.30 of this manual.

Information pertaining to materials, sheeting, and sign substrates can be found in the Minnesota Standard Specifications for Construction, sections 2564 and 3352.

7-6.02 Delineator Location

The details of height and location of delineators are shown in Figure 7.30 and stated below.

7-6.02.01 *Delineator Height and Lateral Placement*

Delineators, if used, should normally be installed so that the mounting height to the bottom of the delineator is 1.3 m (**4 feet**) above the surface of the nearest traffic lane. They shall be no more than 2.5 m (**8 feet**), nor less than 0.6 m (**2 feet**), outside the roadway or pavement edge. On roadways with shoulders, delineators should be installed 1.9 m (**6 feet**) outside the shoulder break. Along curbed sections of roadways, delineators shall be placed not less than 0.6 m (**2 feet**), nor more than 1.5 m (**5 feet**), from the curb face.

7-6.02.02 *Delineator Spacing*

Delineators should be placed at a constant distance from the edge of the roadway except where a guardrail or other obstruction intrudes into the space between the pavement edge and the extension of the line of delineators. The delineators should then be in line with or inside the innermost edge of the obstruction. A typical delineator installation is shown in the MN MUTCD, Section 3D-4, and Figure 7-30 of this manual.

A simple method for field personnel to determine the degree of curve or the radius of a curve is shown in Figure 7.31.

1. Along Horizontal Curves

When applied on the approaches to and throughout horizontal curves, spacing should permit several delineators to always be visible along the curve ahead of the driver. Figure 3D-1 and Table 3D-1 of the MN MUTCD show the recommended spacing for delineators along horizontal curves. A typical layout for delineator spacing on horizontal curves is shown in Chart 7-8.

2. Along Vertical Curves

When applied on crest vertical curves, the spacing should permit a minimum of three delineators to be visible from all points along the centerline of the curve at an eye level of 1.3 m (**4 feet**) above the pavement.

3. Along Tangent

When applied delineators should be spaced 160 m (**0.1 mile**) apart along the through roadway, except along acceleration and deceleration lanes where the spacing should be as indicated in section 3D-4 of the MN MUTCD.

7-6.02.03 *Divided-Highway Crossovers*

Delineation of divided-highway crossovers is shown in Figure 7.32.

7-6.02.04 *Interchanges*

Delineations of cloverleaf and diamond interchanges are shown in Figures 7.33 through 7.36.

7-6.02.05 *Guardrail*

Three cable guardrail shall be delineated as shown in Standard Plate Nos. 8330 F and 8331 B. The color of the reflective sheeting shall match the color of the adjacent edge line.

Platebeam guardrail delineation is under investigation.

7-6.03 Deer Reflectors

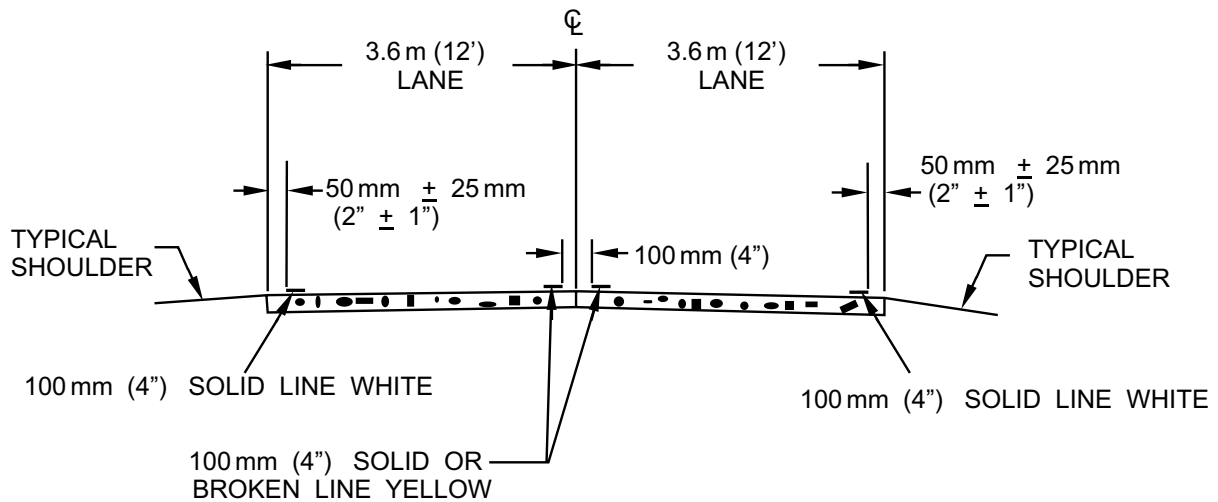
Each district may make the decision to remove existing deer reflectors based on any of the following conditions:

1. The existing installations are more than six years old and there is no intent of maintaining them due to replacement costs (lack of maintenance funds), complicated installation procedures, and a lack of staff.
2. The existing installations are a problem for maintenance activities (their lateral placement causes mowing and snow removal problems).

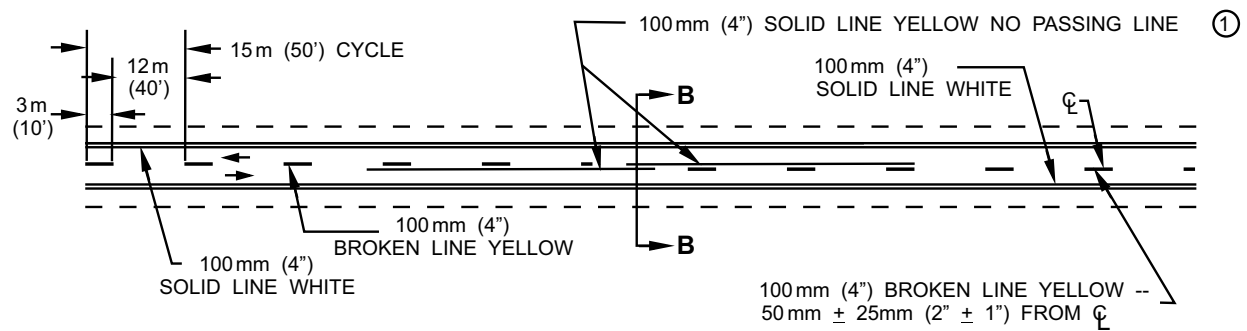
3. Written documentation indicates that either the number of deer kills has not been significantly deer reduced or the number of deer kills has actually increased.

7-7.00 REFERENCES

1. Minnesota Department of Transportation, Minnesota, **Manual on Uniform Traffic Control Devices**, 1991.
2. American Association of State Highway Officials, **A Policy on Geometric Design of Rural Highways**, 1990.
3. State of Minnesota, **Minnesota Statutes**.
4. Minnesota Department of Transportation, **Standard Signs Summary**, 1997.
5. Minnesota Department of Transportation, **Road Design Manual**, 1982.
6. Minnesota Department of Transportation, **Bicycle Transportation, Planning and Design Guidelines**, June, 1996.
7. American Association of State Highway and Transportation Officials (AASHTO), **Guide for the Development of Bicycle Facilities**, 1991.



SECTION B-B



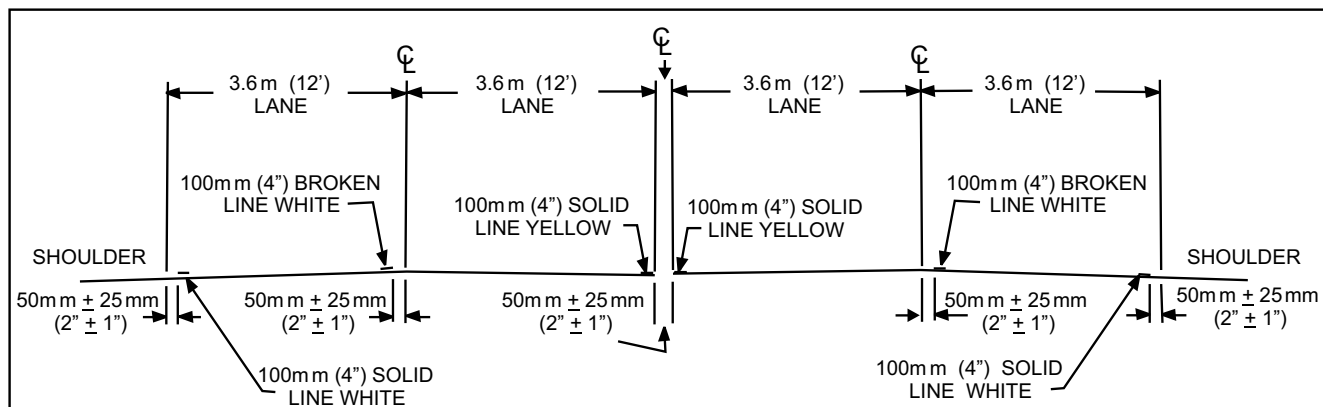
① CONTACT TRAFFIC ENGINEER FOR NO PASSING SURVEY.

Text Ref.: 7-4.04.01

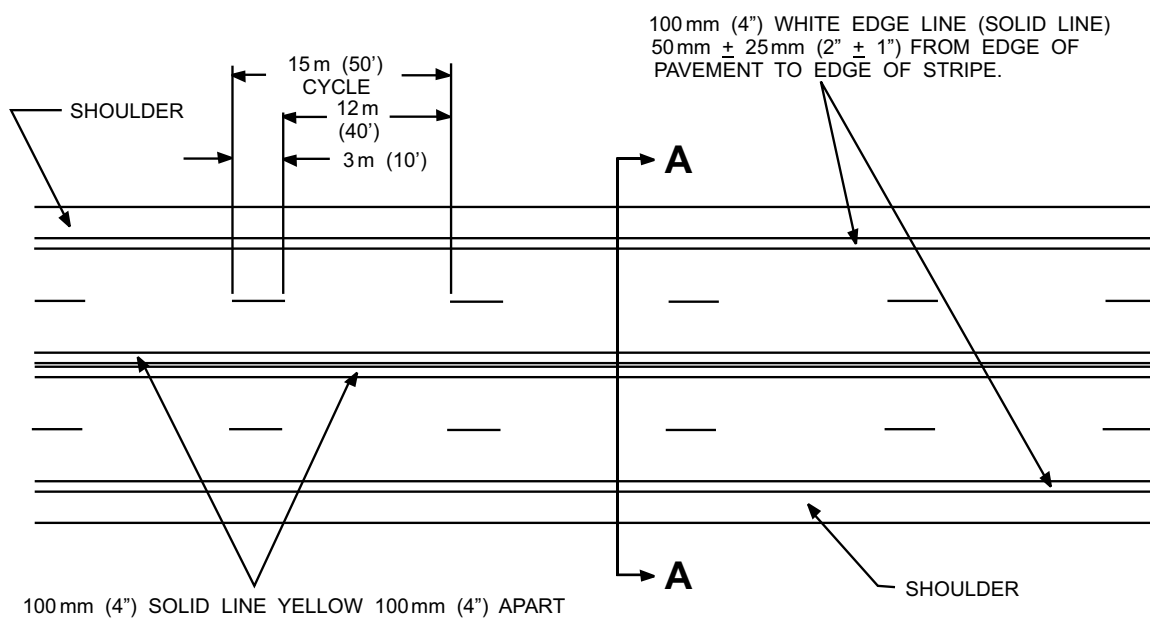
January 1, 1996

**TWO-LANE, TWO-WAY ROADWAY
PAVEMENT MARKING DETAILS**

**FIGURE
7.1**



SECTION A-A

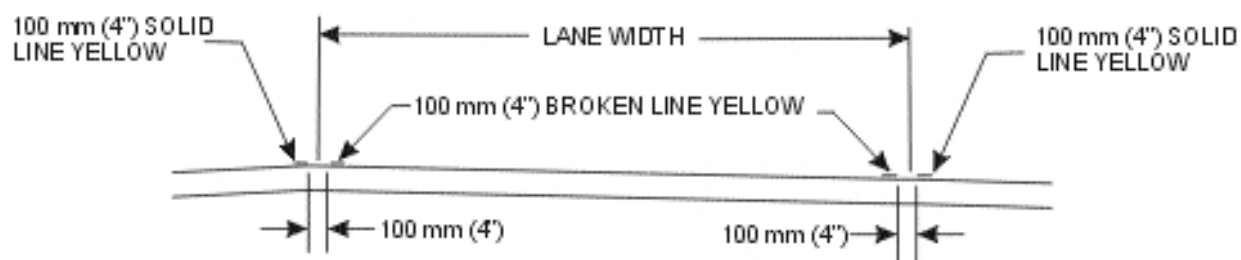


Text Ref.: 7-4.04.01

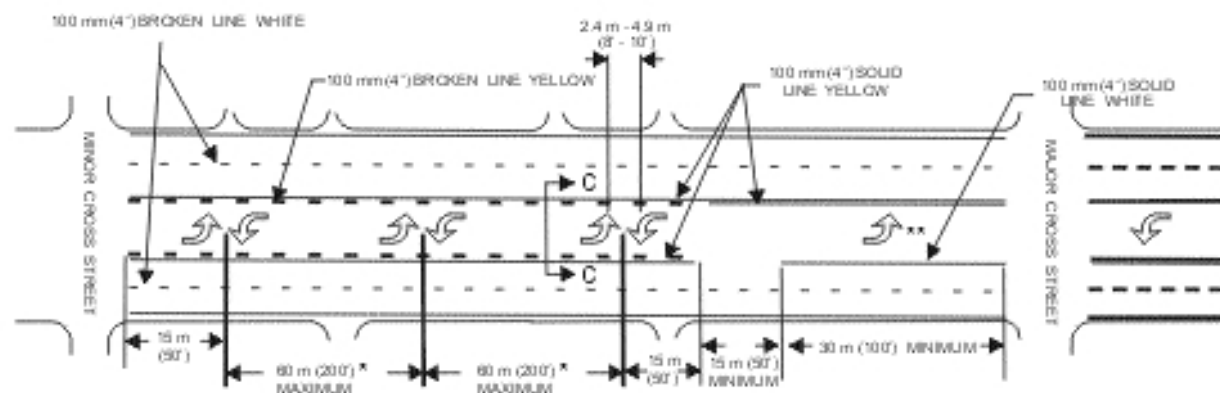
July 1, 1998

MULTI-LANE UNDIVIDED ROADWAY PAVEMENT MARKING DETAILS

FIGURE
7.2



SECTION C-C



* THESE DISTANCES SHOULD BE EQUAL.
THE PAVEMENT ARROWS ARE PLACED TO SHOW
THE OPERATION AND DO NOT HAVE TO LINE
UP WITH ANY OF THE DRIVEWAYS.

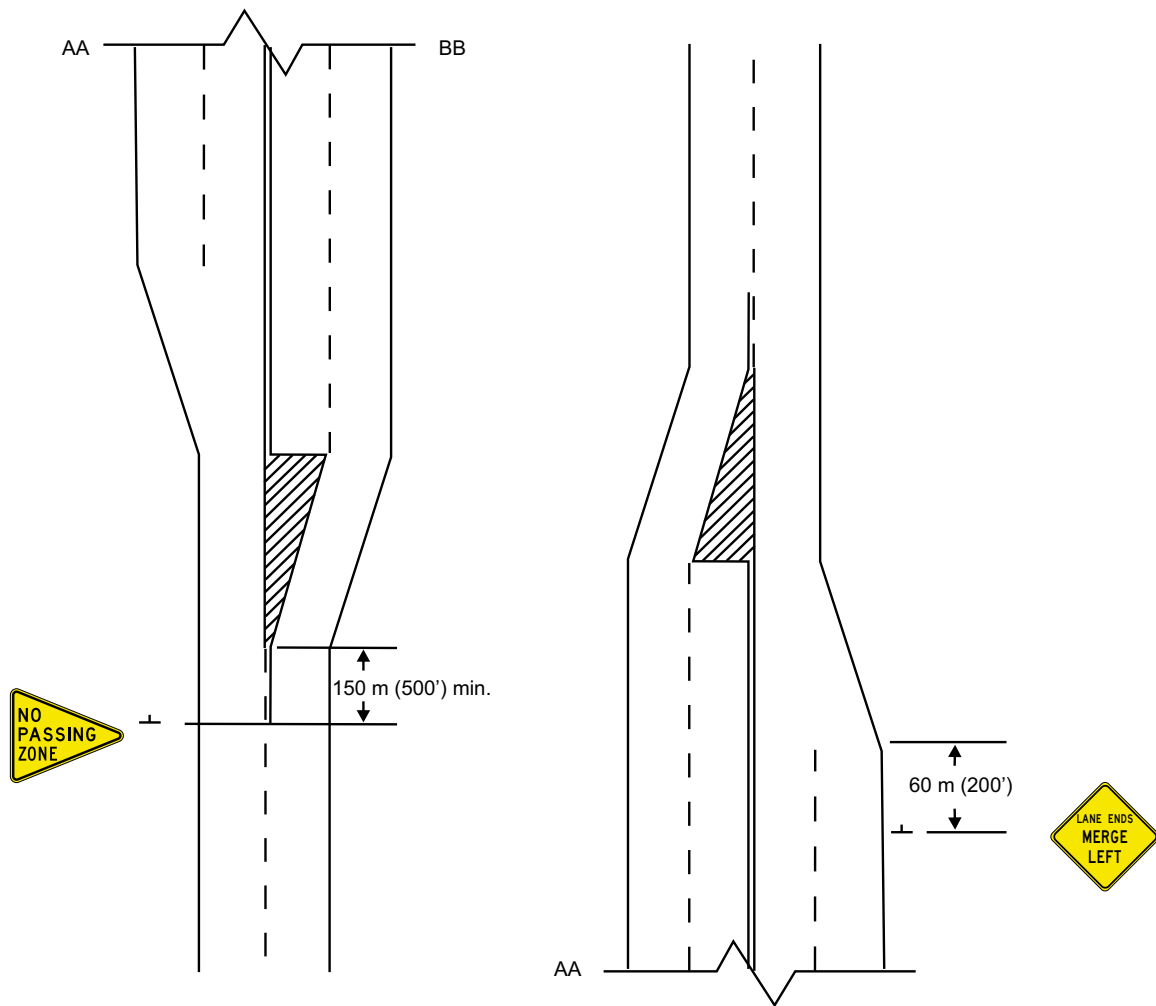
** SEE "TYPICAL MESSAGE PLACEMENT FOR TURN LANES" FOR NUMBER AND PLACEMENT OF TURN ARROWS - Figure 7.9

Text Ref.: 7-4.02.02

July 1, 1991

TWO-WAY LEFT TURN LANE PAVEMENT MARKING DETAILS

FIGURE 7.3



NOTE:

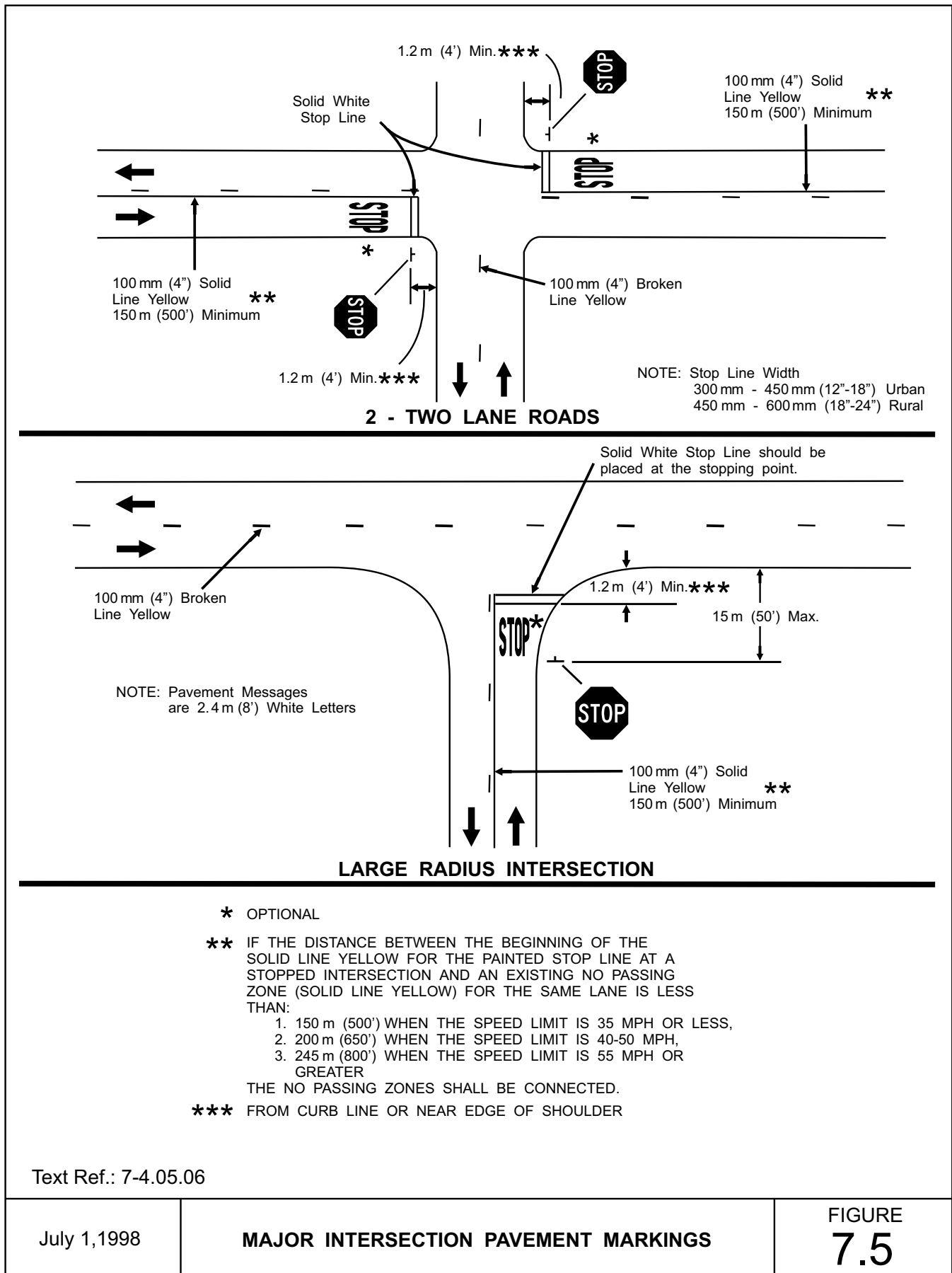
1. The same treatment is used for both approaches. Only one direction is shown here.
2. The lane skip striping shall end approximately 15 m (50 feet) beyond the Lane Reduction sign.
3. More details on signing can be found in Chapter 6.

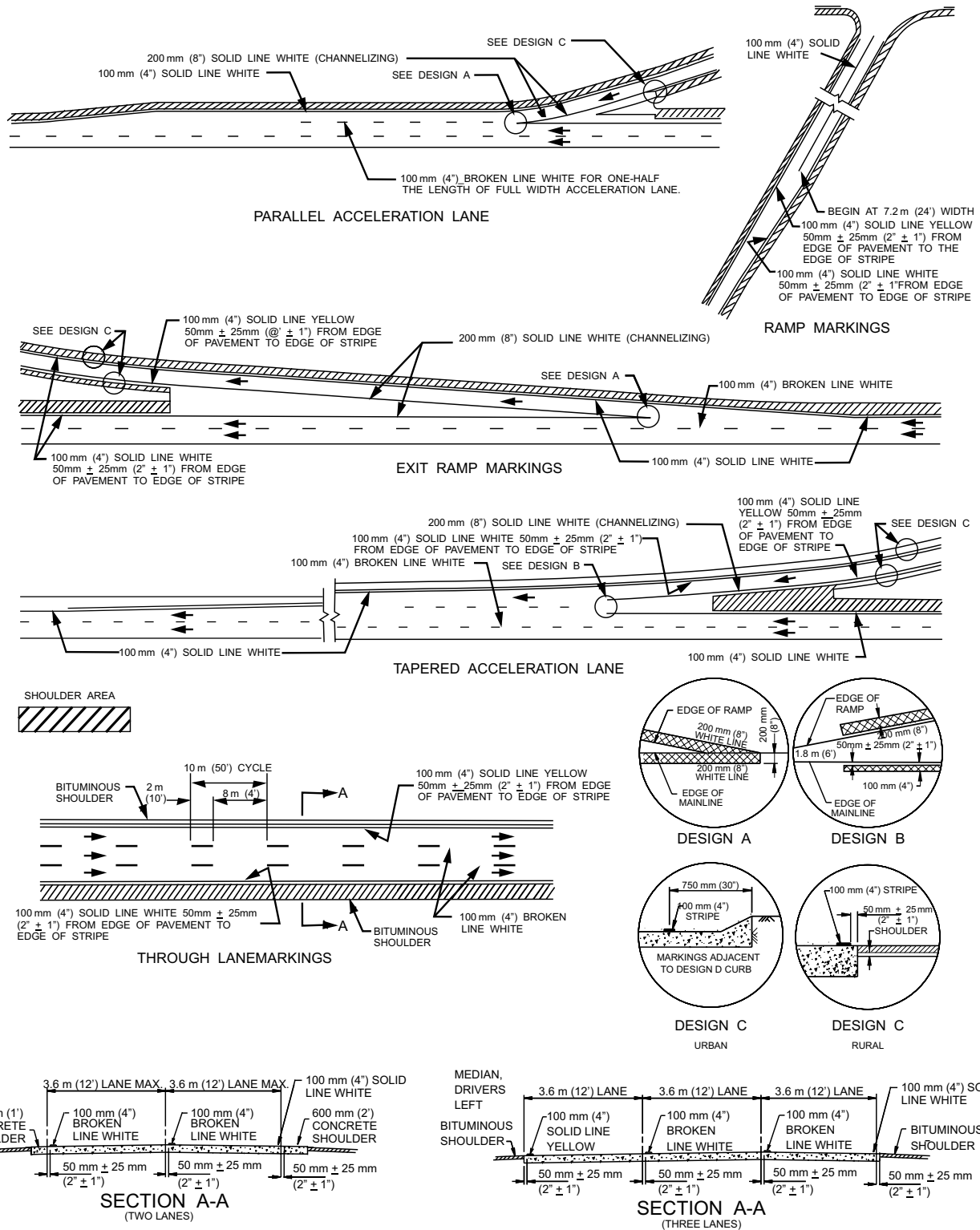
Text Ref.: 7-4.05.01

July 1, 1991

PASSING LANE SECTION PAVEMENT MARKINGS

FIGURE
7.4



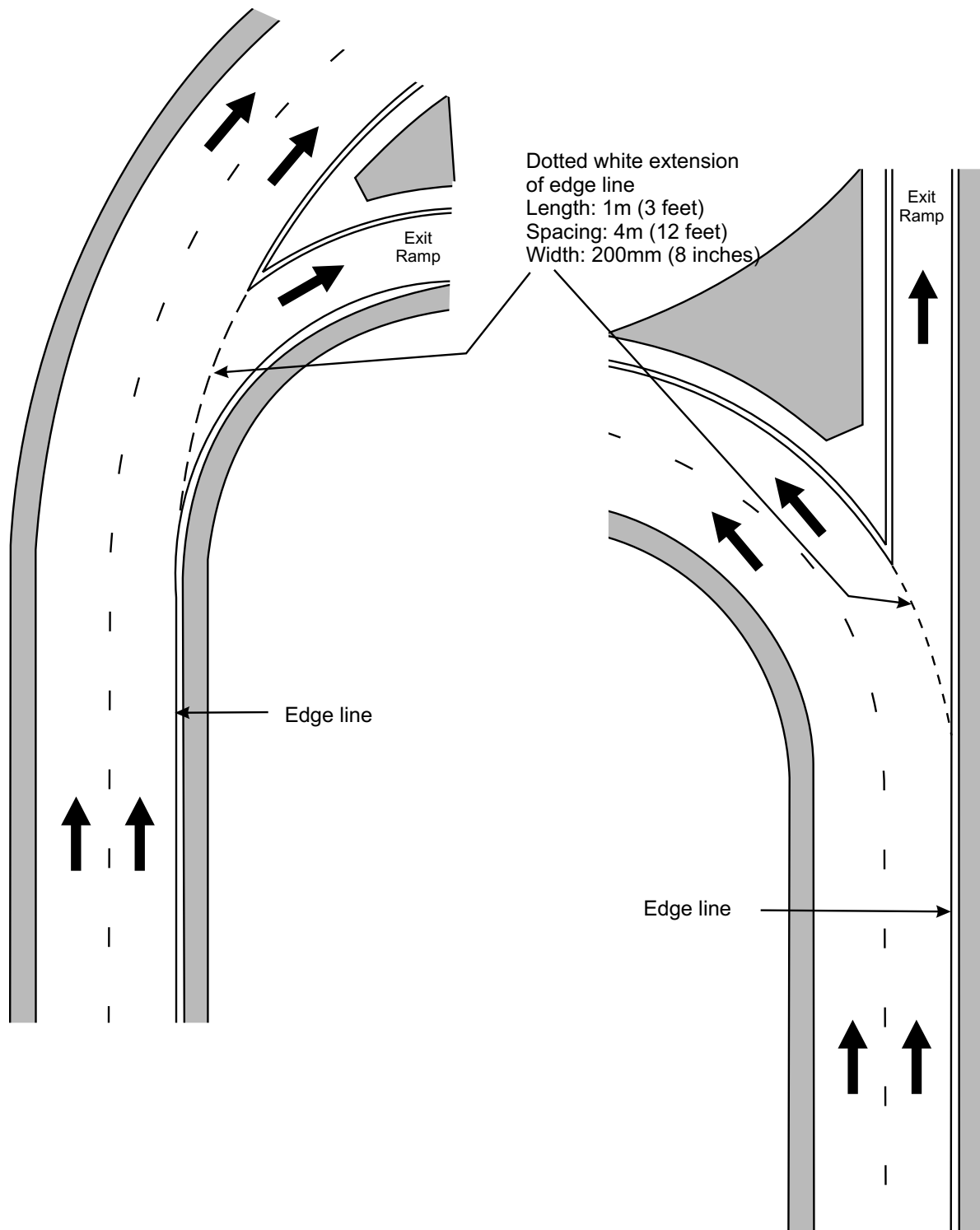


Text Ref.: 7-4.05.07

July 1, 1998

RAMP AND THROUGH LANE PAVEMENT MARKINGS

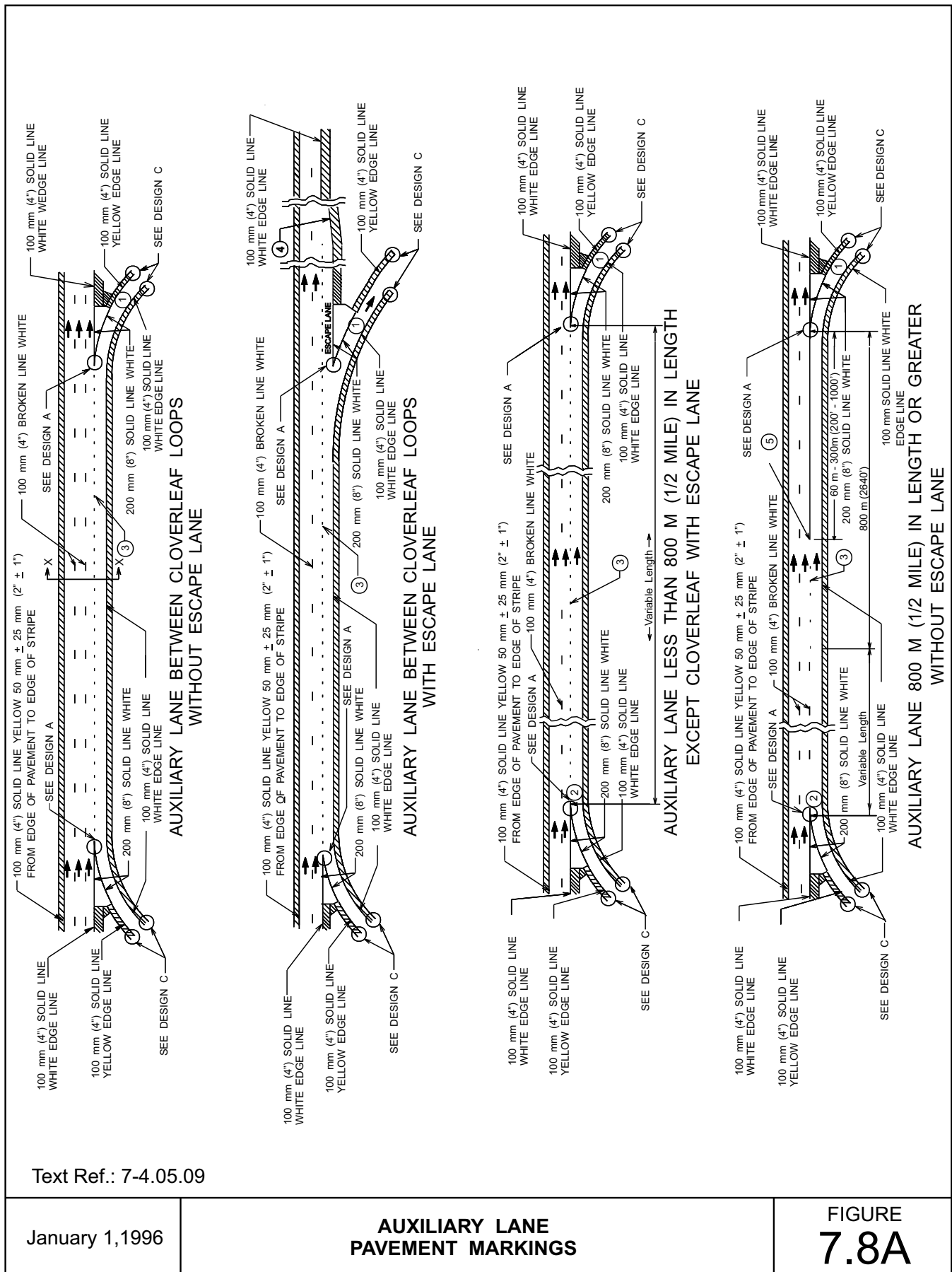
FIGURE
7.6



Text Ref.: 7-4.05.07

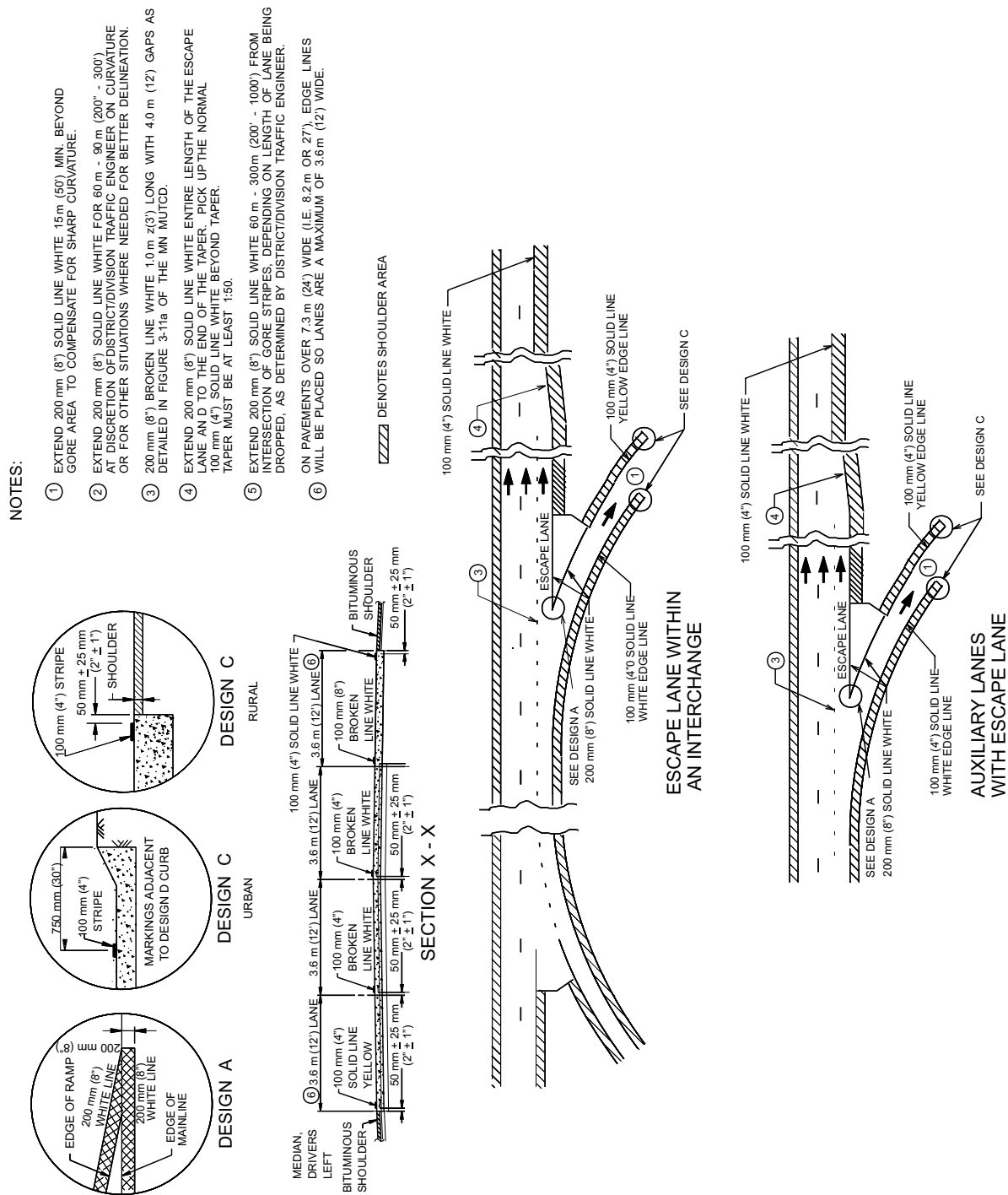
January 1, 1996

**EXIT RAMP ON CURVED ROADWAY
PAVEMENT MARKINGS****FIGURE
7.7**



January 1, 1996

AUXILIARY LANE
PAVEMENT MARKINGSFIGURE
7.8A

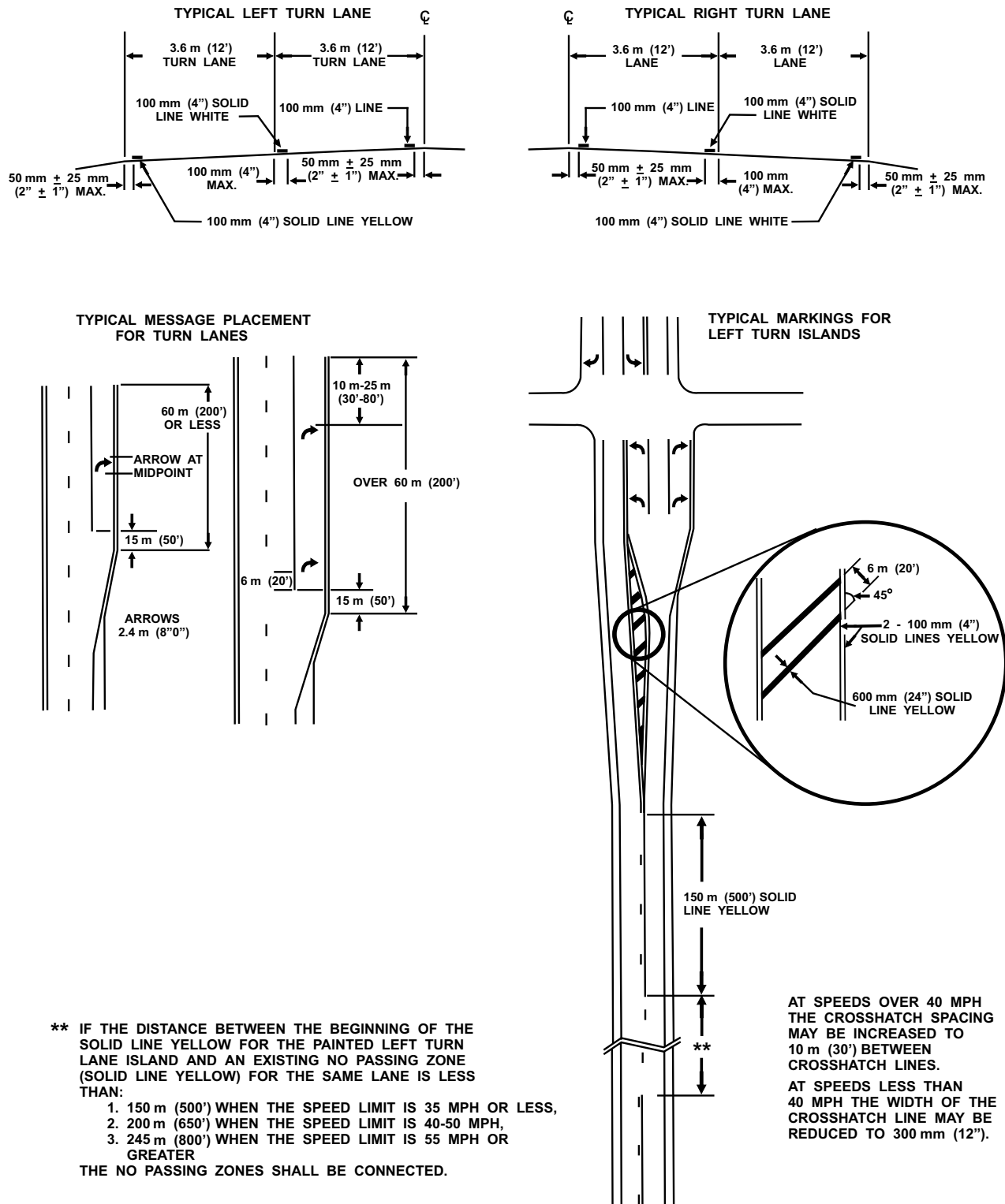


Text Ref.: 7-4.05.08

July 1, 1997

AUXILIARY LANE PAVEMENT MARKINGS

FIGURE
7.8B

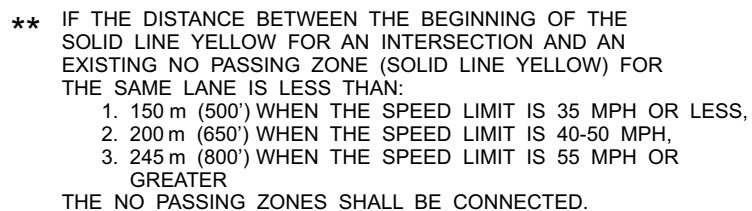


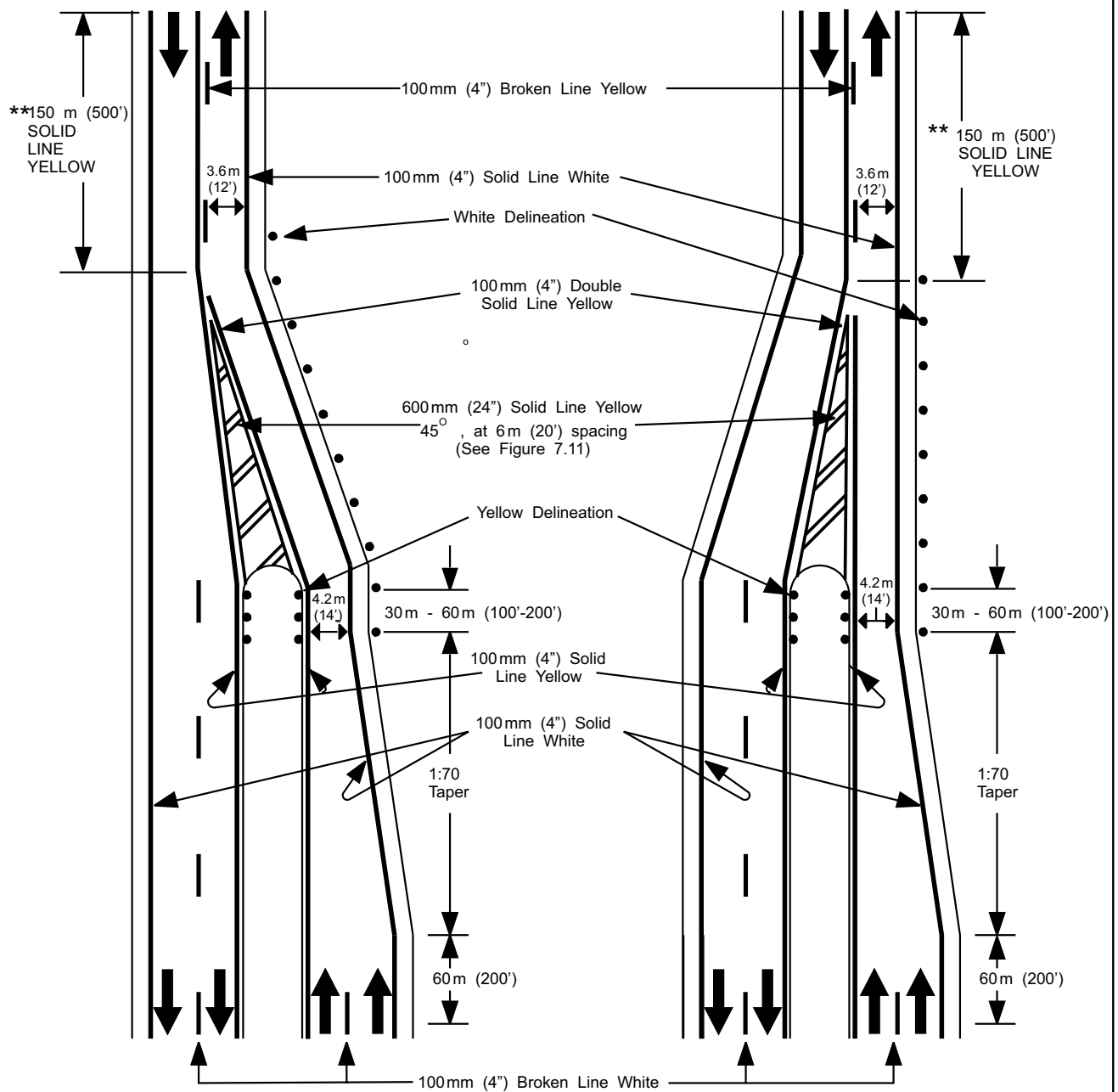
Text Ref.: 7-4.05.09

July 1, 1999

TURN LANE AND LEFT TURN ISLAND PAVEMENT MARKINGS

FIGURE
7.9

FIGURE
7.10

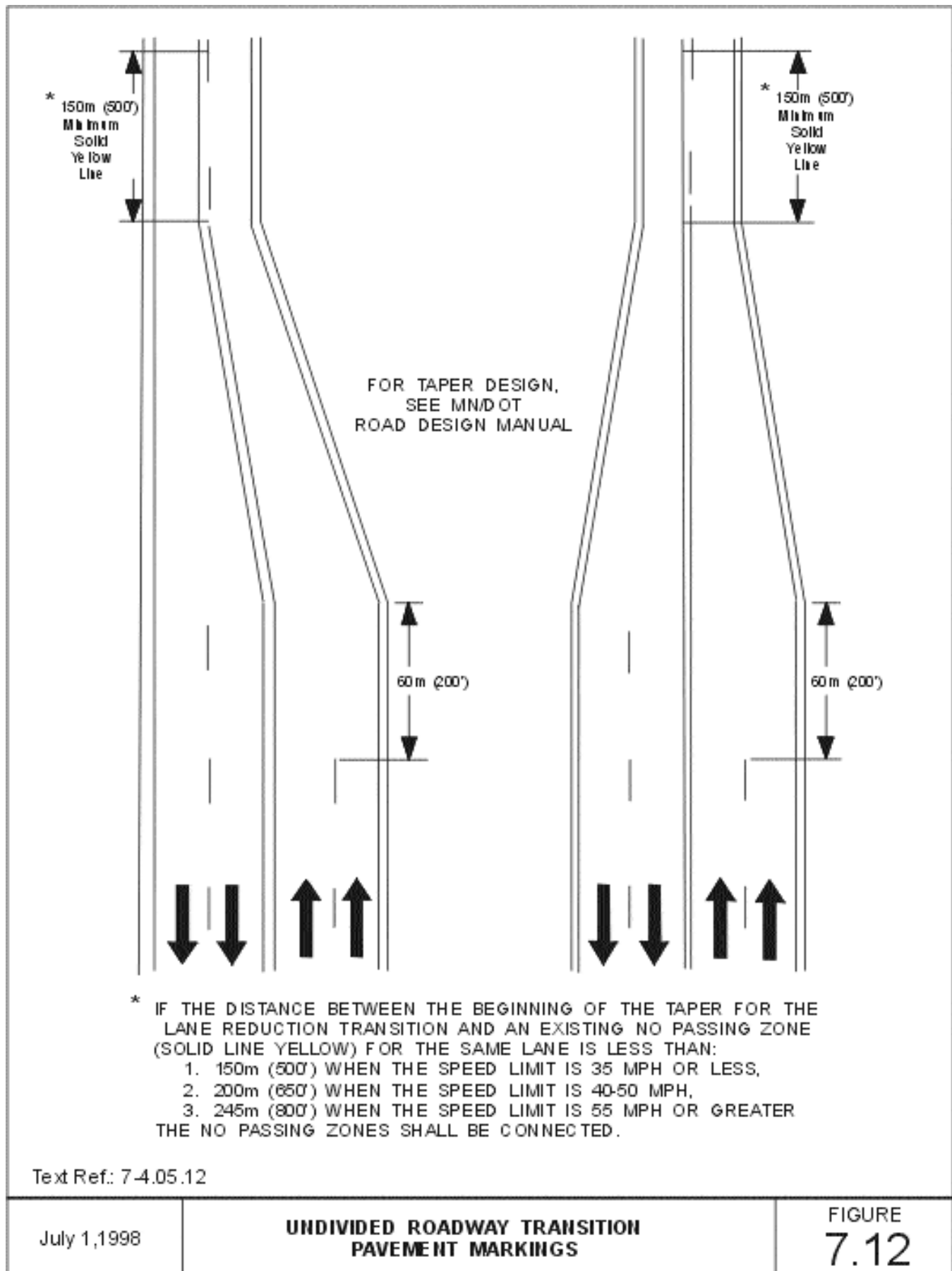


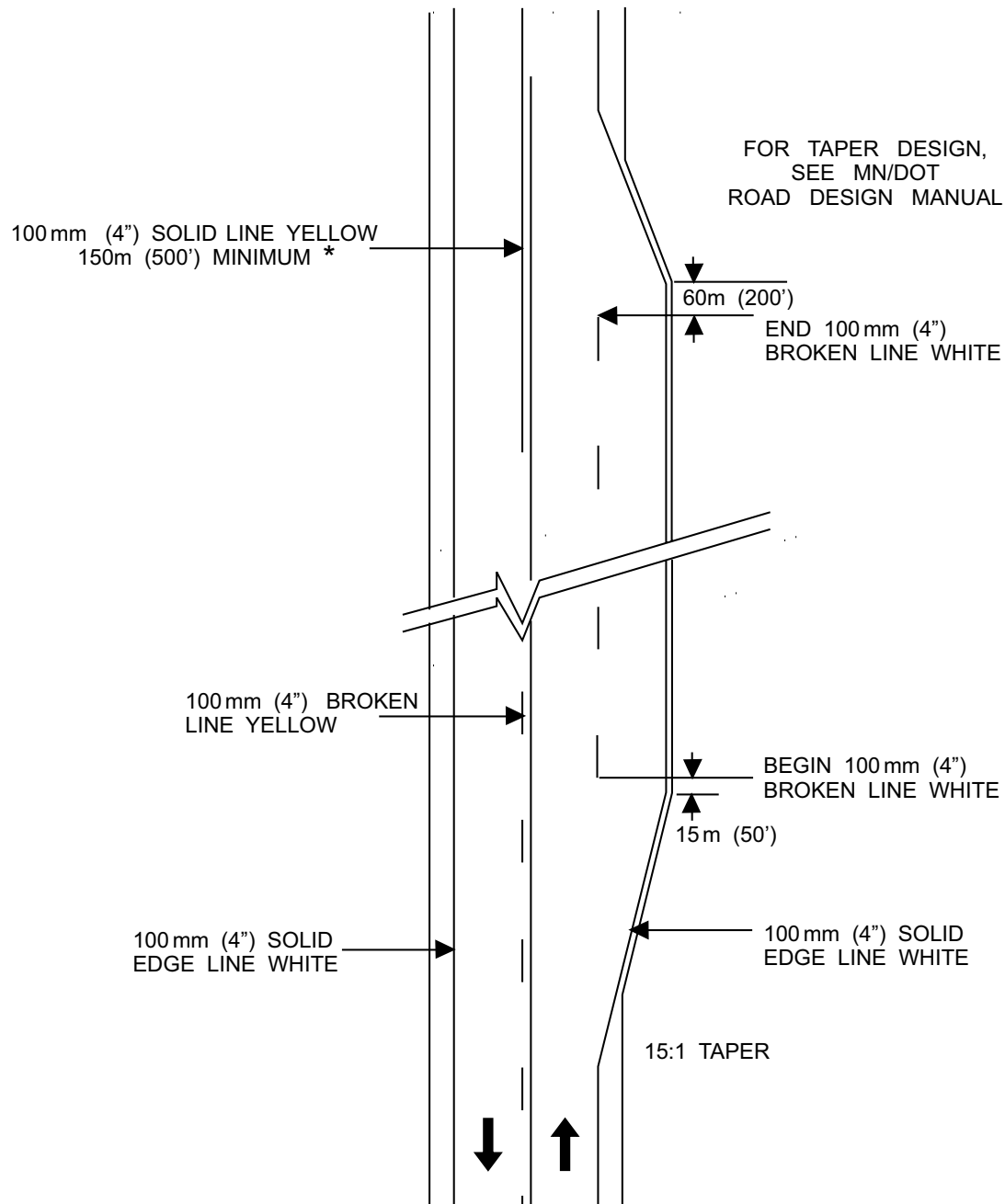
Text Ref.: 7-4.05.12

July 1, 1998

DIVIDED ROADWAY TRANSITION PAVEMENT MARKINGS

FIGURE
7.11





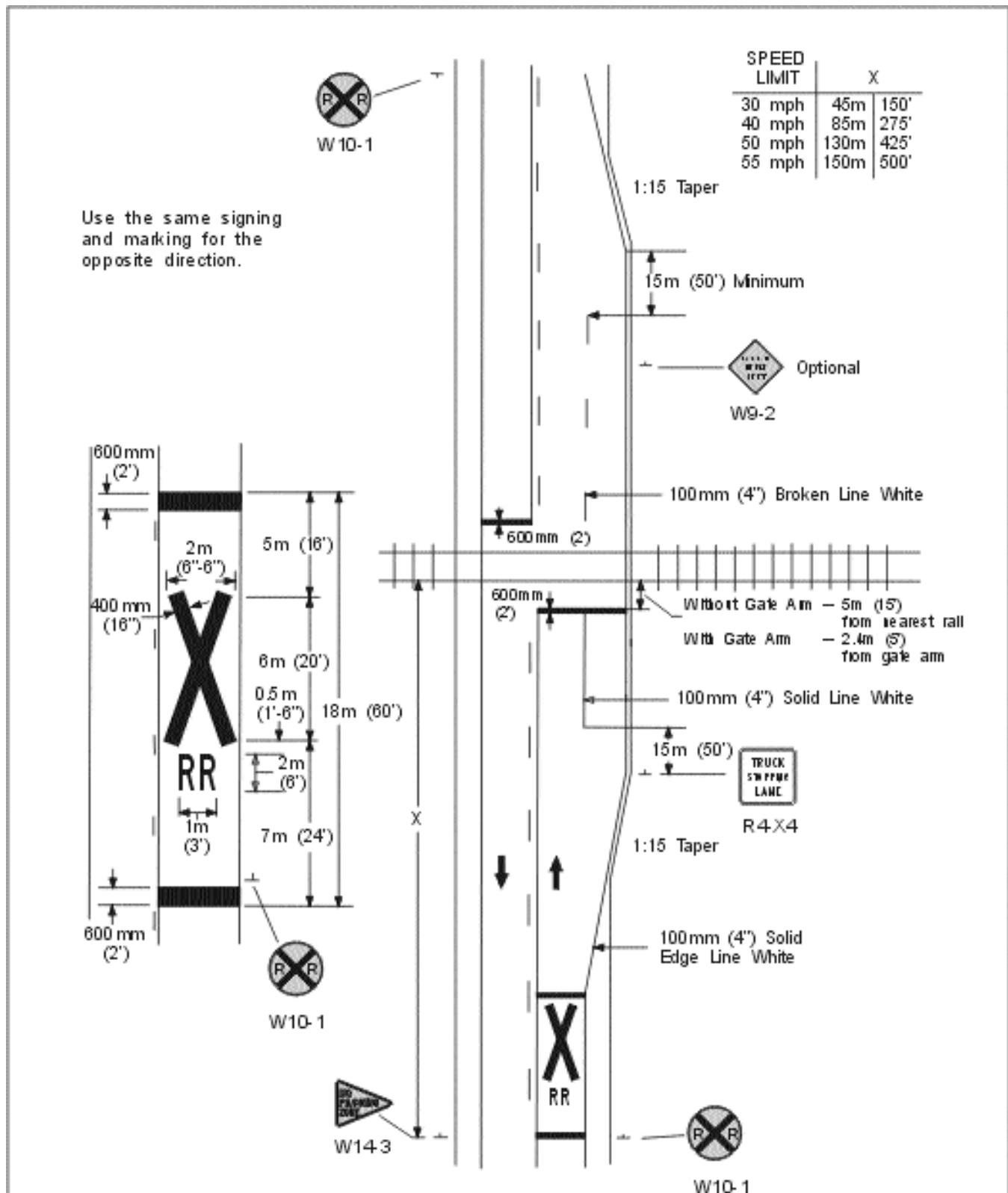
* IF THE DISTANCE BETWEEN THE END/BEGINNING OF A TRUCK CLIMBING LANE AND AN EXISTING NO PASSING ZONE (SOLID LINE YELLOW) FOR THE SAME LANE IS LESS THAN:

1. 150 m (500') WHEN THE SPEED LIMIT IS 35 MPH OR LESS,
2. 200 m (650') WHEN THE SPEED LIMIT IS 40-50 MPH,
3. 245 m (800') WHEN THE SPEED LIMIT IS 55 MPH OR GREATER

THE NO PASSING ZONES SHALL BE CONNECTED.

Text Ref.: 7-4.05.13

July 1,1998	TRUCK CLIMBING LANE PAVEMENT MARKINGS	FIGURE 7.13
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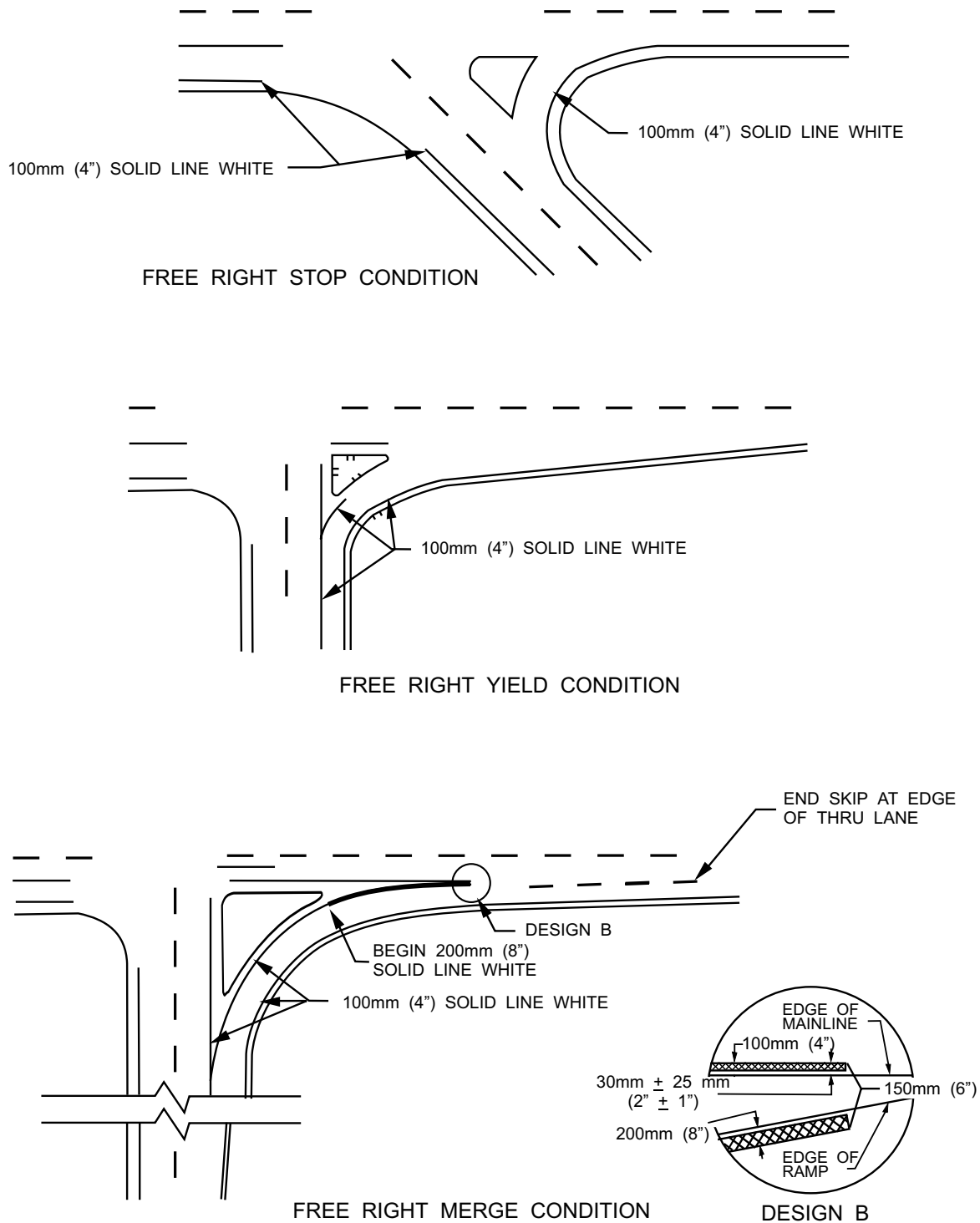


Text Ref.: 7-4.05.14

July 1, 1998

**RAILROAD CROSSINGS WITH TRUCK STOPPING LANE
PAVEMENT MARKINGS**

FIGURE
7.14

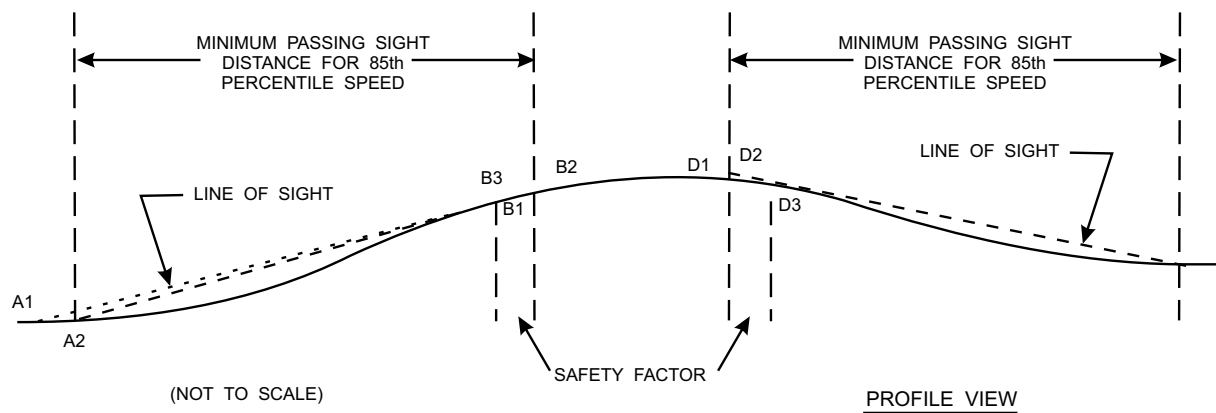
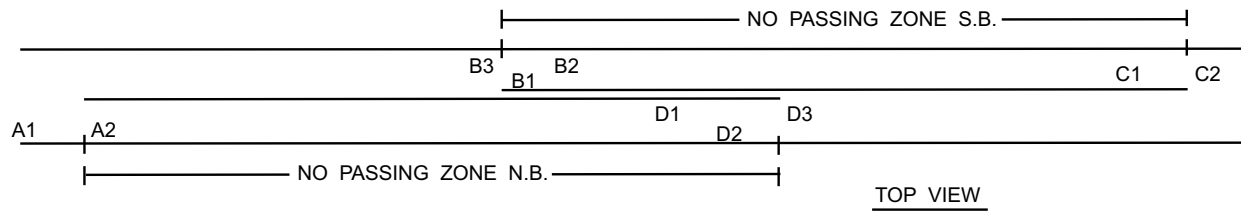


Text Ref.: 7-4.05.15

January 1, 1996

FREE RIGHT TURN LANE PAVEMENT MARKINGS

FIGURE
7.15

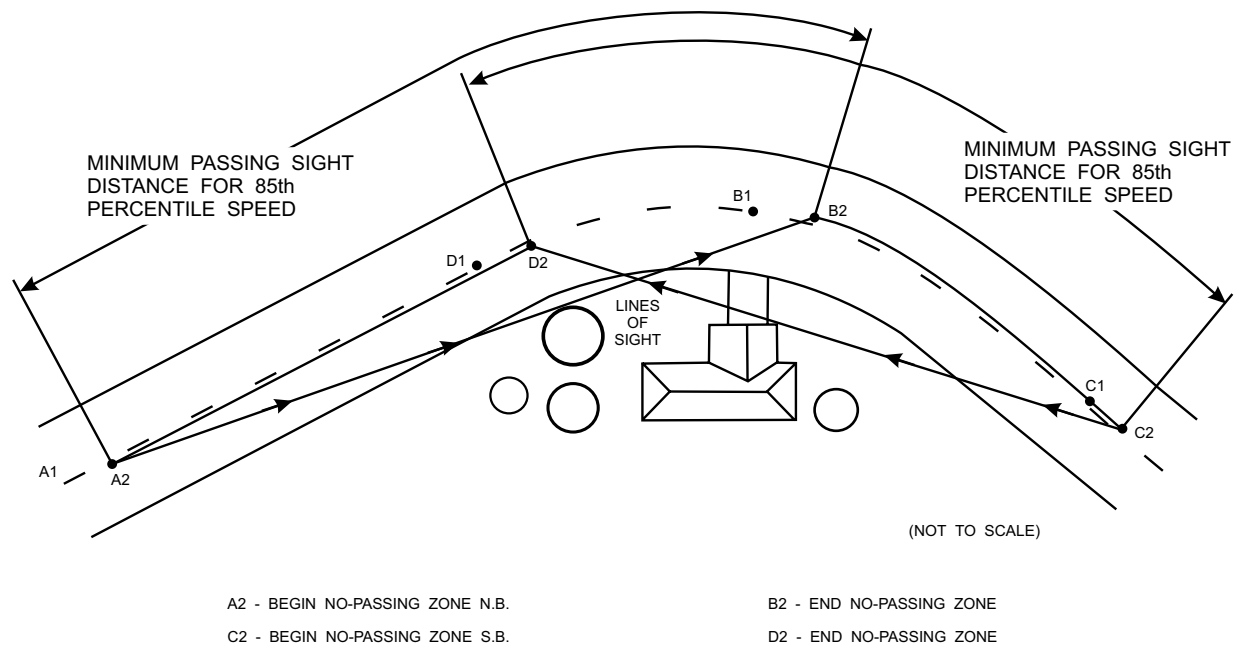


Text Ref.: 7-4.06.02

July 1, 1991

**NO PASSING ZONE -
SURVEY PROCEDURE FOR A VERTICAL CURVE**

**FIGURE
7.16**

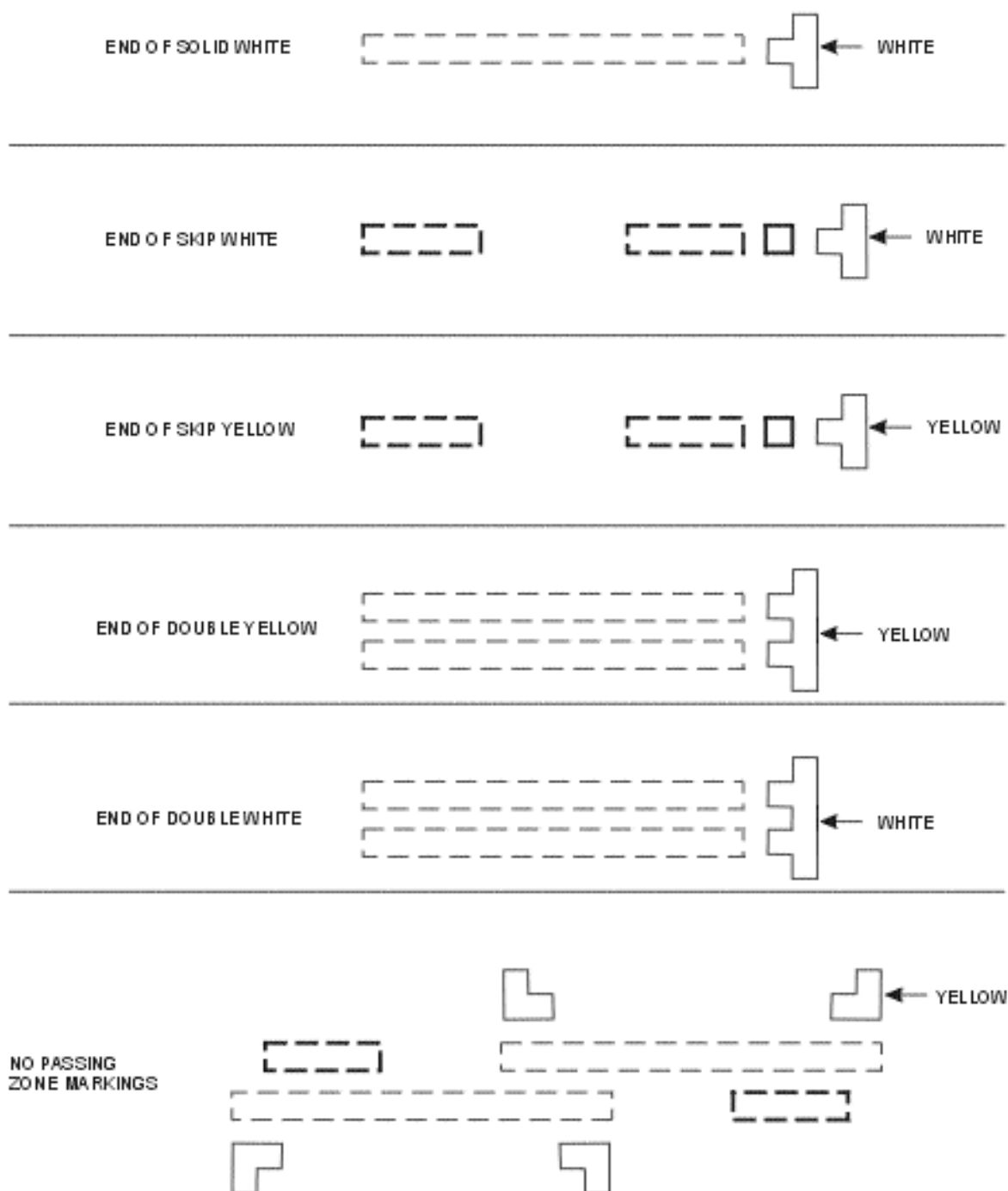


Text Ref.: 7-4.06.02

January 1, 1996

**NO PASSING ZONE -
SURVEY PROCEDURE FOR A HORIZONTAL CURVE**

FIGURE
7.17

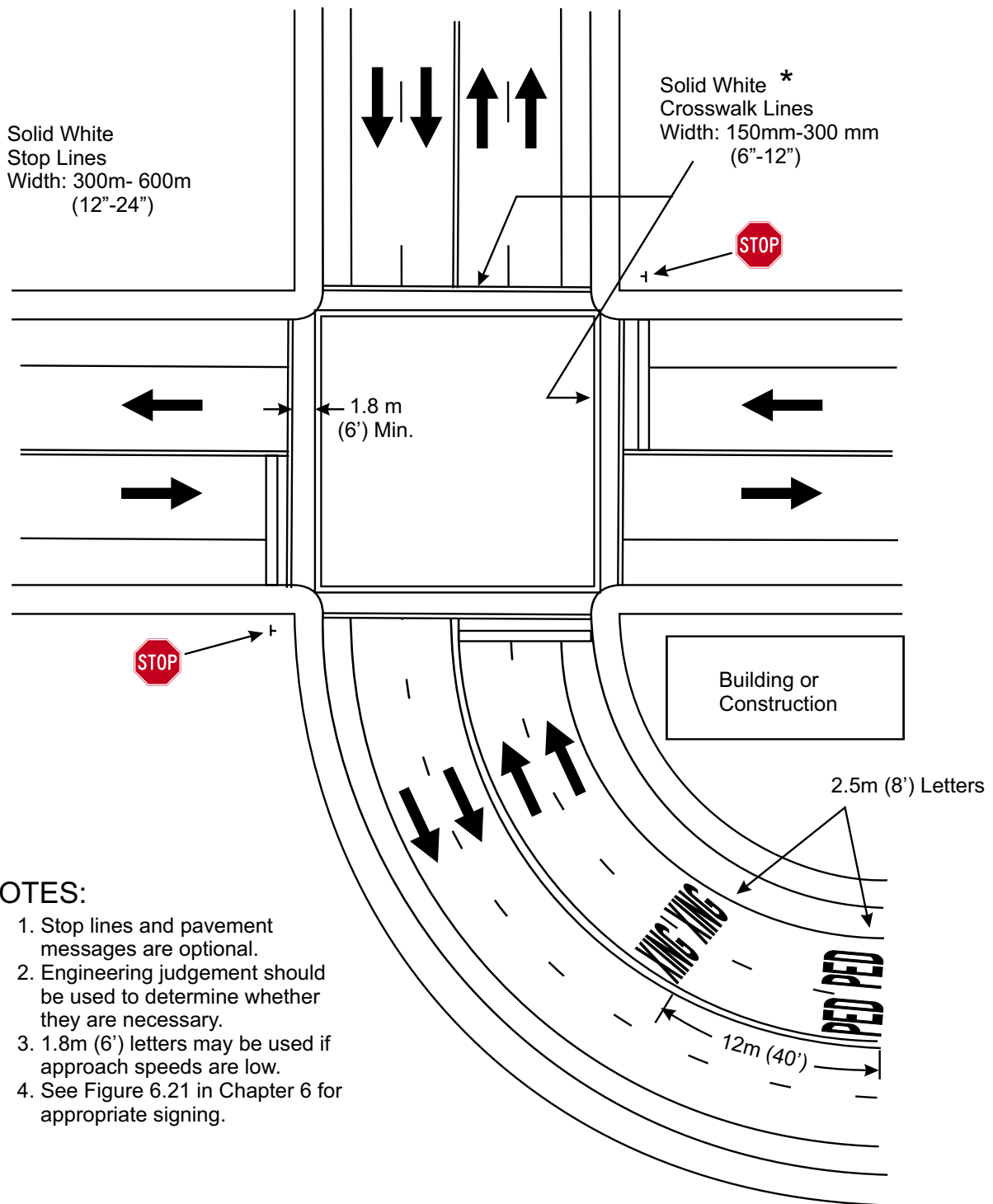


Text Ref.: 7-4.07

January 1, 1996

SPOTTING SYMBOLS FOR PAVEMENT STRIPING

**FIGURE
7.18**



NOTES:

1. Stop lines and pavement messages are optional.
2. Engineering judgement should be used to determine whether they are necessary.
3. 1.8m (6') letters may be used if approach speeds are low.
4. See Figure 6.21 in Chapter 6 for appropriate signing.

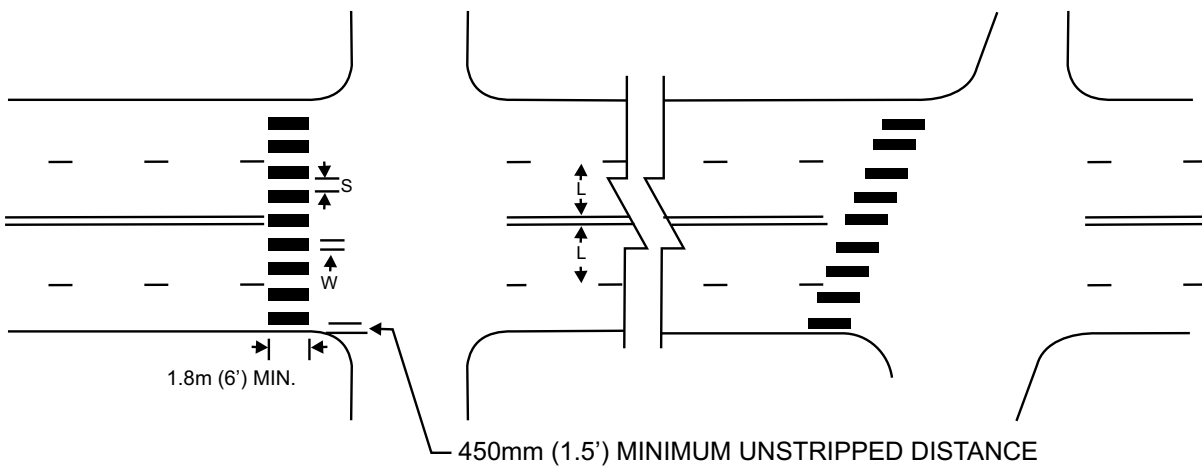
Text Ref.: 7-4.08.01

July 1, 1997

PEDESTRIAN CROSSWALK MARKINGS

FIGURE
7.19

(L) WIDTH OF INSIDE LANE	(W) WIDTH OF PAINTED AREA	(S) WIDTH OF SPACE
2.7m (9')	600mm (2.0')	750mm (2.5')
3.0m (10')	750mm (2.5')	750mm (2.5')
3.3m (11')	750mm (2.5')	900mm (3.0')
3.6m (12')	900mm (3.0')	900mm (3.0')
4.0m (13')	900mm (3.0')	1100mm (3.5')



NOTES:

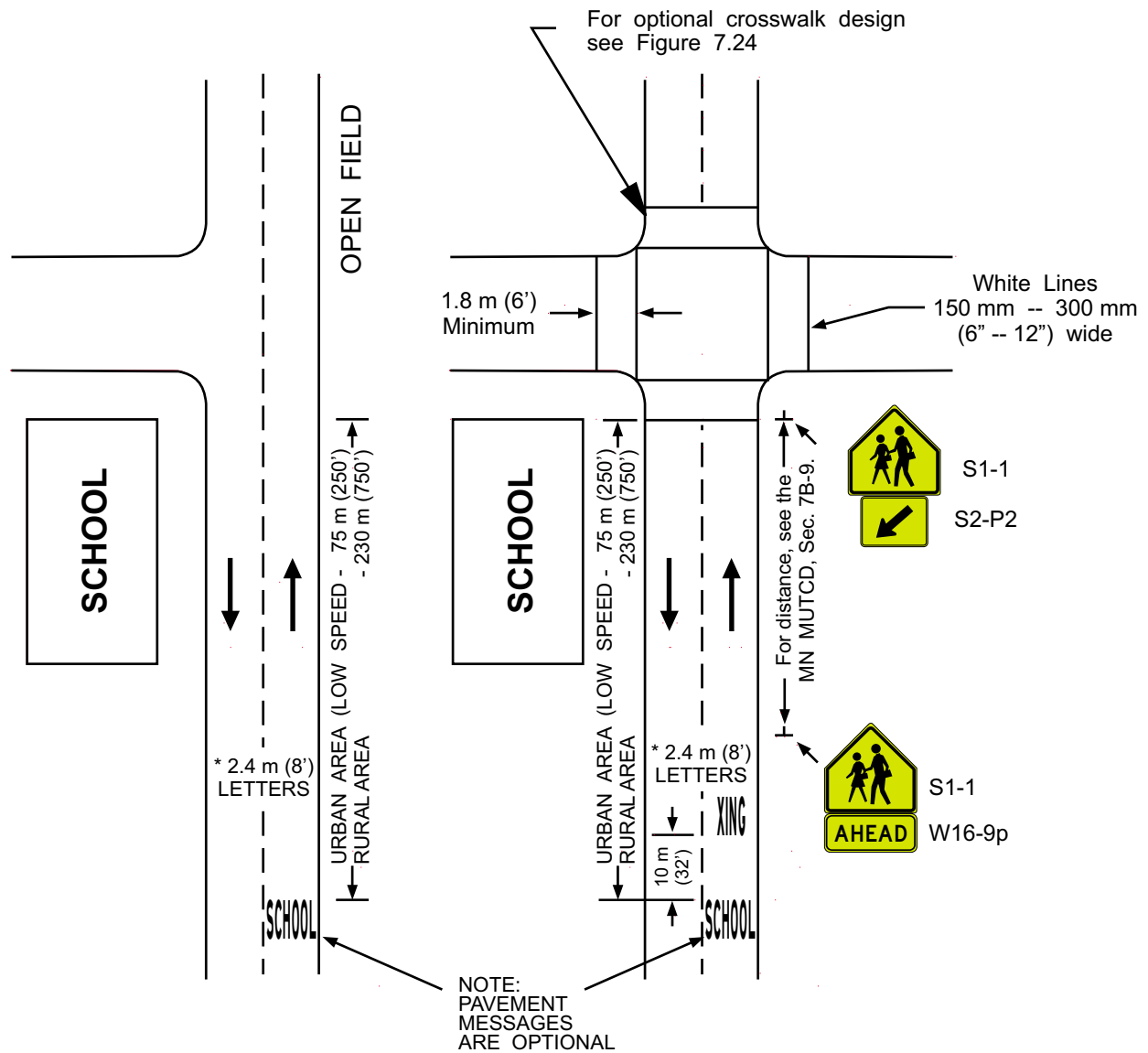
1. Painted areas to be centered on centerline and lane lines.
2. A minimum of 450 mm (1.5 feet) clear distance shall be left adjacent to the curb. If the last painted area falls into this distance, it must be omitted.
3. On two-lane, two-way streets, use the spacing shown for a 3.3 m (11 foot) inside lane.
4. For divided roadways, adjustments in spacing of the blocks should be made in the median so that the blocks are maintained in their proper location across the traveled portion of the roadway.
5. At skewed crosswalks, the blocks are to remain parallel to the lane lines as shown.

Text Ref.: 7-4.08.01

January 1, 1996

**PEDESTRIAN CROSSWALK MARKINGS -
ZEBRA DESIGN**

FIGURE
7.20

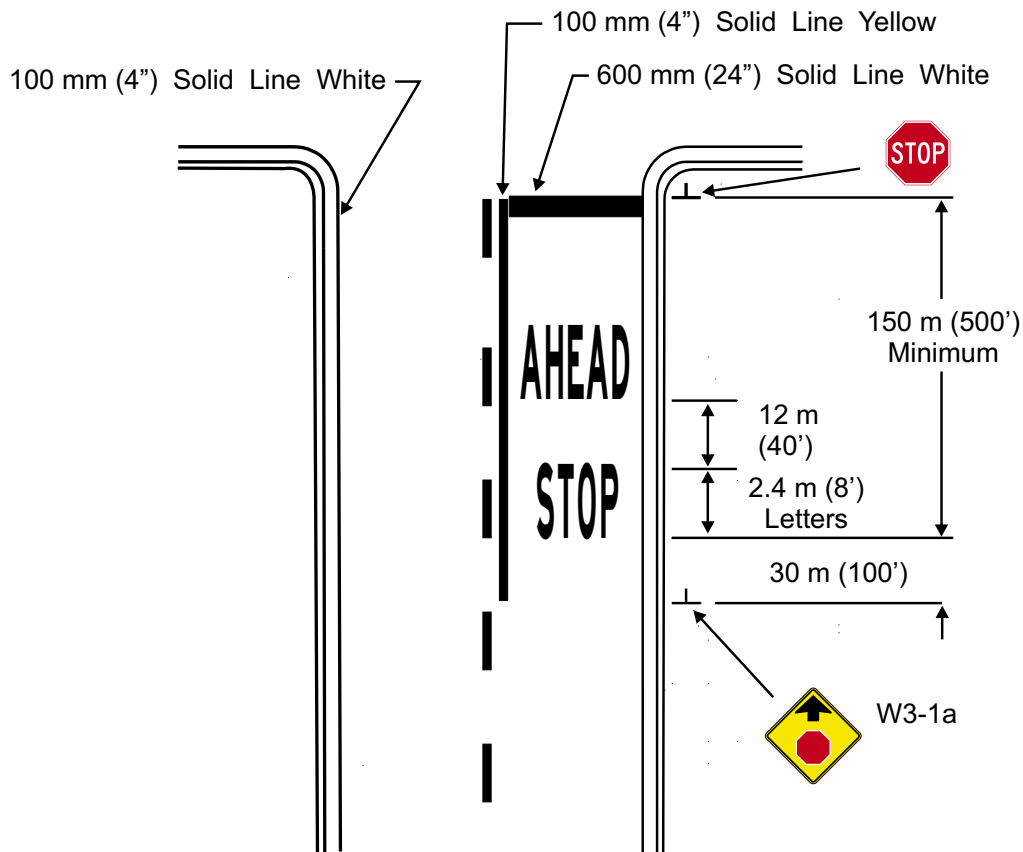


Text Ref.: 7-4.08.02

January 1, 1996

SCHOOL ZONE MARKINGS - UNSIGNALIZED INTERSECTIONS

FIGURE
7.21



NOTES:

1. Double pavement messages should be installed whenever the Stop Ahead sign is placed a minimum of 336 m (1100') in advance of the STOP sign.
2. If the distance between the beginning of the solid line yellow is less than the distances in the chart below from the end of a preceding solid line yellow in the same lane, the solid line shall be extended between them.

35 mph speed limit or less	150 m (500')
40-45 mph speed limit	200 m (650')
55 mph speed limit	245 m (800')

3. The stop line should ordinarily be placed 1.2 m (4 feet) in advance of a parallel to the nearest crosswalk line. In the absence of a marked crosswalk, the stop line should be placed at the desired stopping point, and in no case no more than 9 m (30 feet) or less than 1 m (4 feet) from the nearest edge of the intersecting curb line or the near edge of the shoulder.

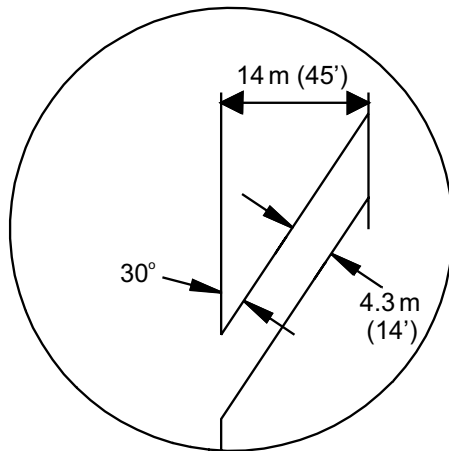
If a stop line is used in conjunction with a stop sign, it should ordinarily be placed in line with the stop sign. However, if the sign cannot be located exactly where vehicles are expected to stop, the stop line should be placed at the stopping point.

Text Ref.: 7-4.08.04

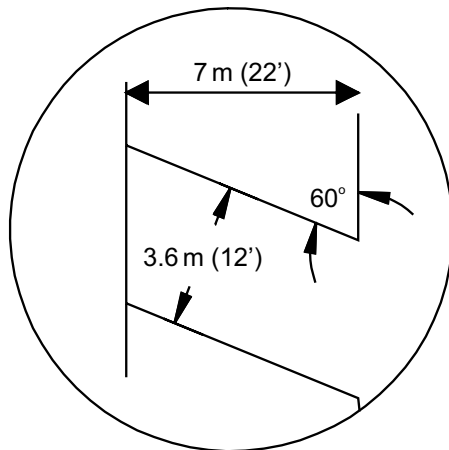
July 1, 1999

STOP AHEAD & STOP LINE PAVEMENT MARKINGS

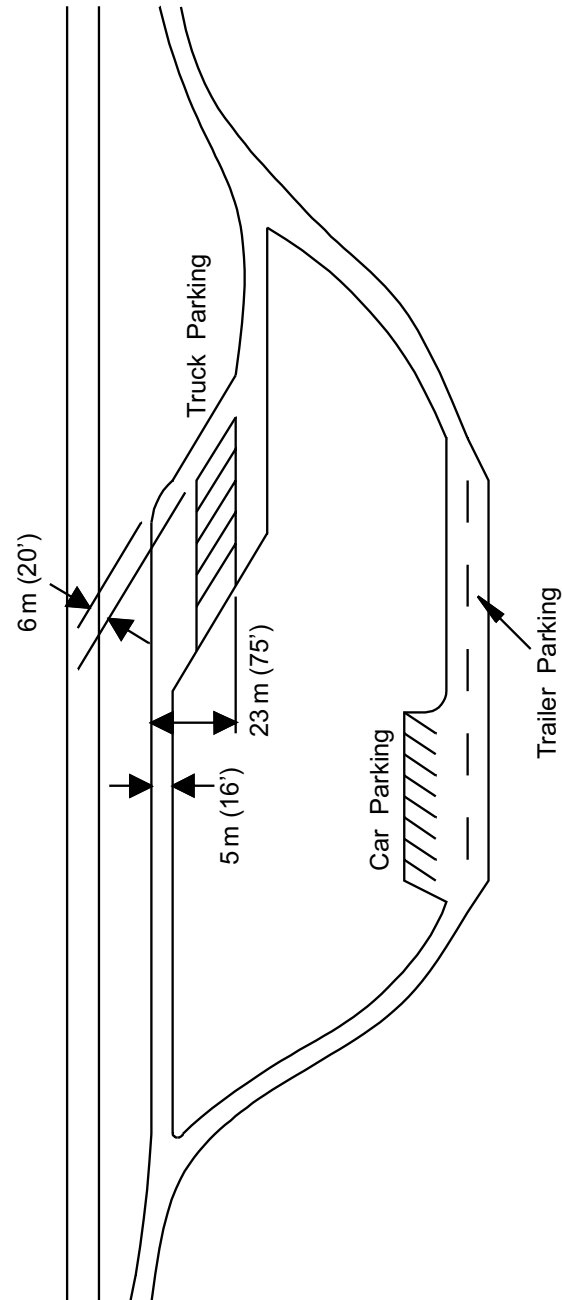
FIGURE
7.22



**TRUCK STALL
DETAIL**



**CAR STALL
DETAIL**



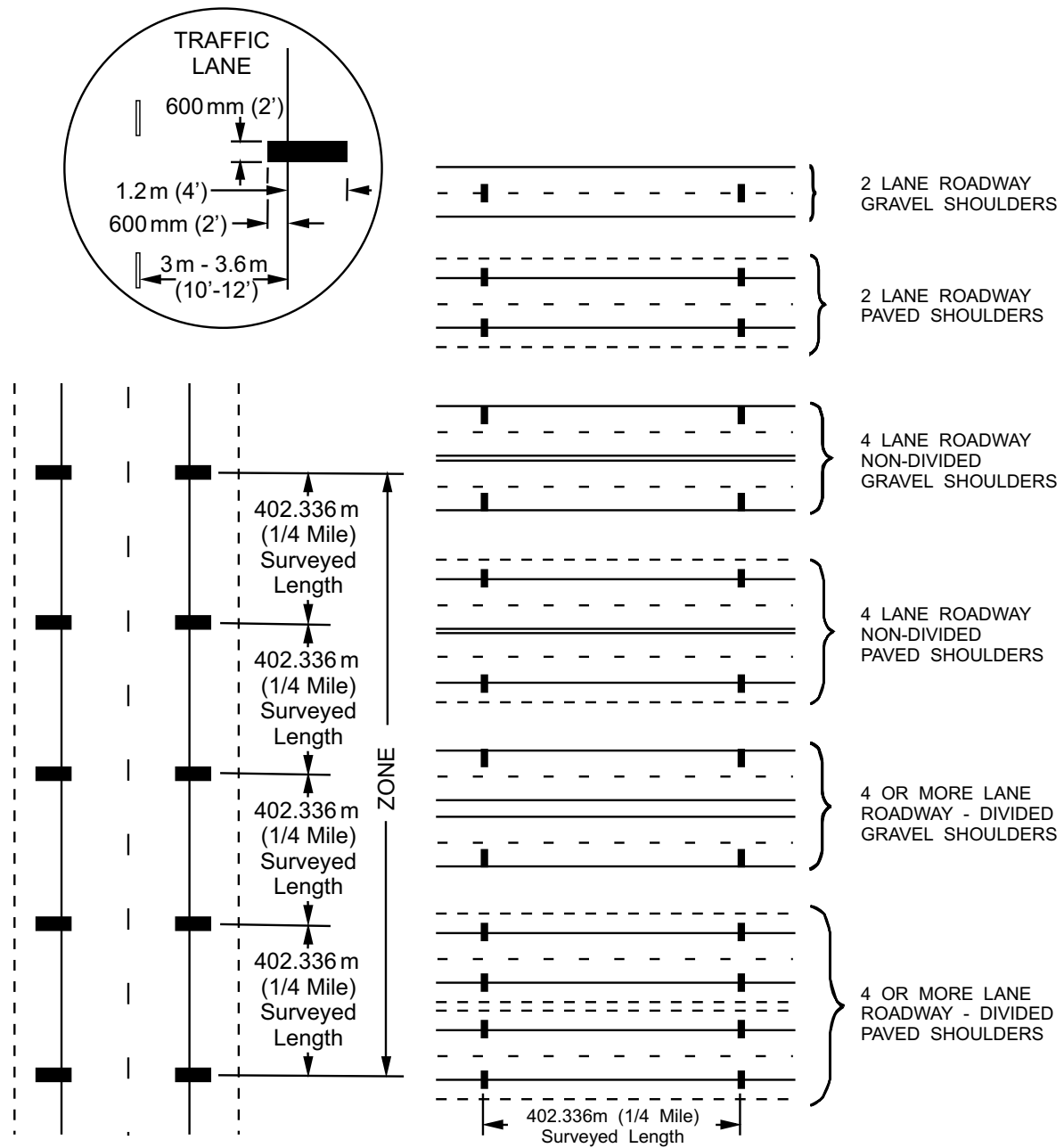
NOTE: Details are available for various angles of parking in the Road Design Manual. See RDM Figures 11.201 C, D, and E.

Text Ref.: 7-4.08.06

January 1, 1996

REST AREA PAVEMENT MARKINGS

**FIGURE
7.23**

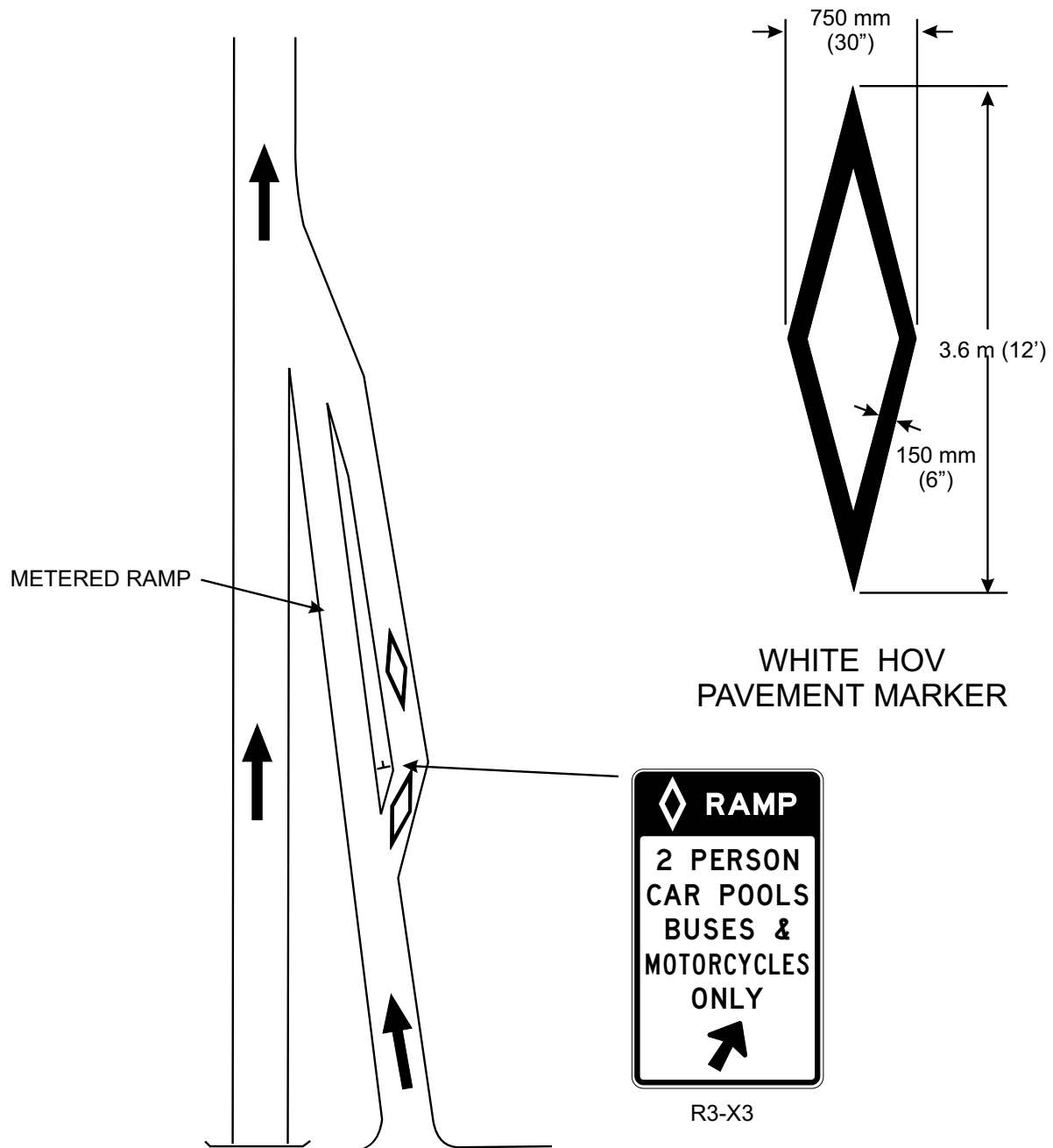


Text Ref.: 7-4.08.09

July 1, 1998

AIRPLANE PAVEMENT MARKINGS

FIGURE
7.24

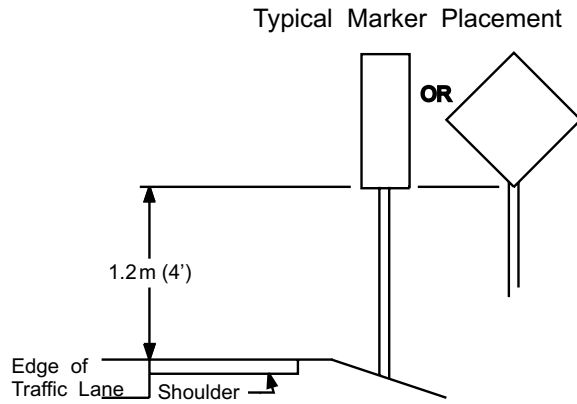


Text Ref.: 7-4.08.10

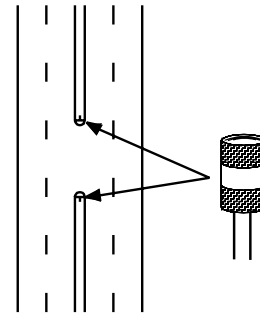
July 1, 1997

**HIGH OCCUPANCY VEHICLE (HOV)
PAVEMENT MARKINGS**

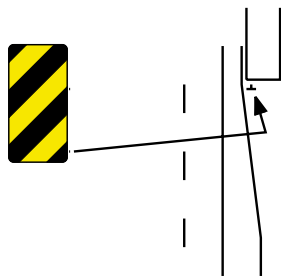
**FIGURE
7.25**



Cylinder Style Delineator

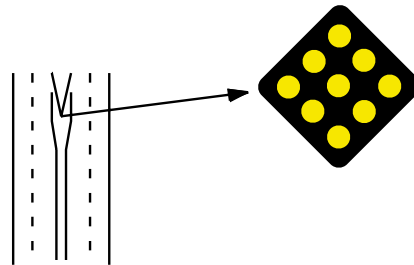


Clearance Marker X4-4 (R)



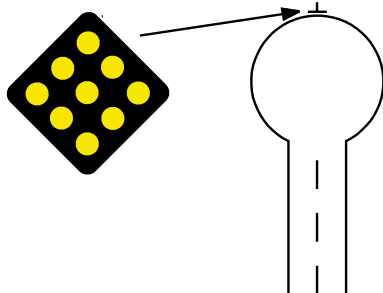
Use clearance marker to mark hazards adjacent to the roadway.

Hazard Marker Plate X4-2



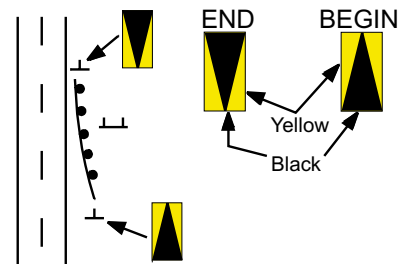
Use clearance marker to mark hazards within the roadway. See Figures 7.39 through 7.42 for typical application in gore areas of interchanges.

End of Roadway Marker X4-11



Use end of roadway marker to mark the end of the roadway.

Snowplow Marker X4-5



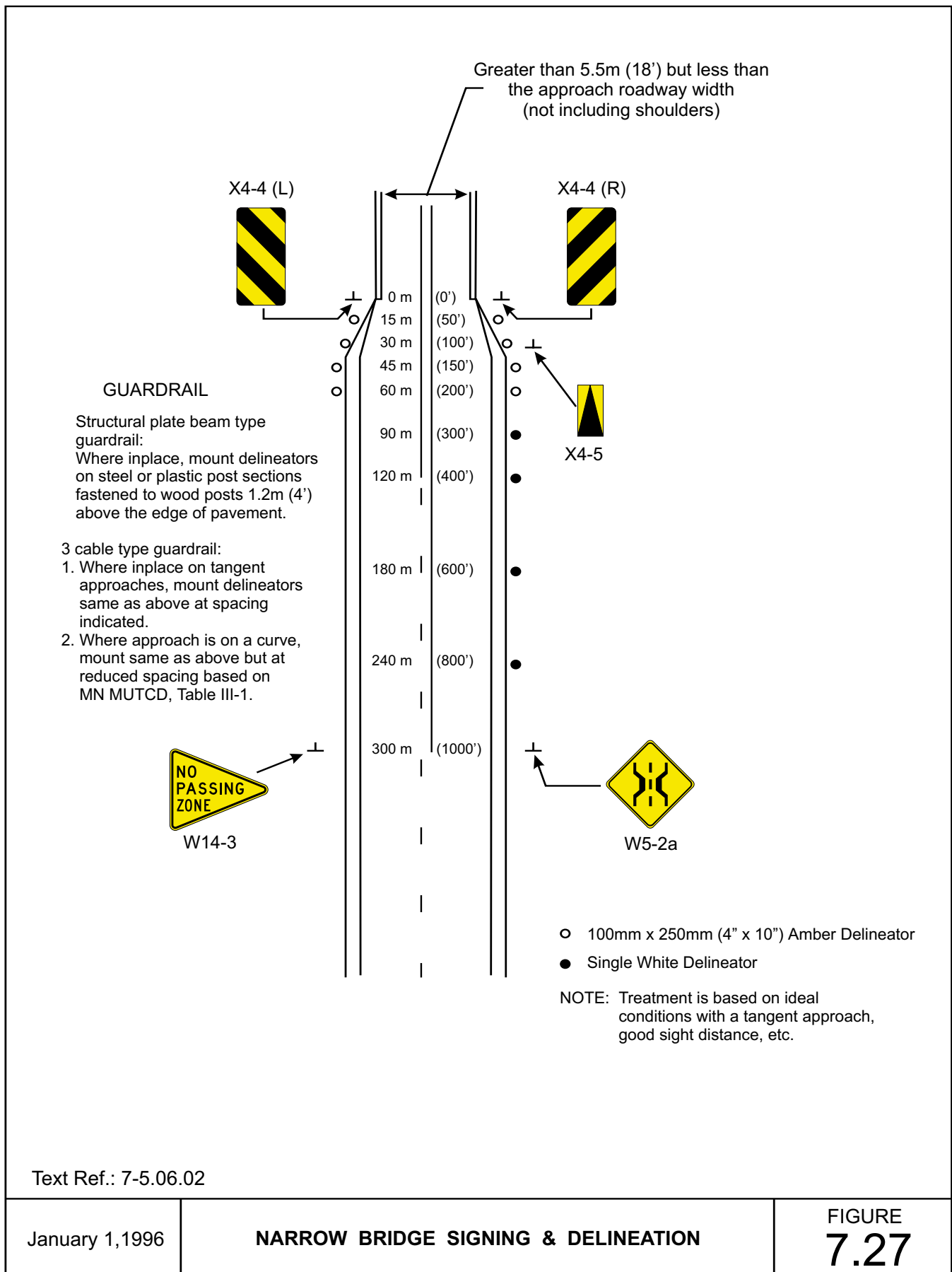
Use snowplow marker to delineate guardrail for snowplowing operations.

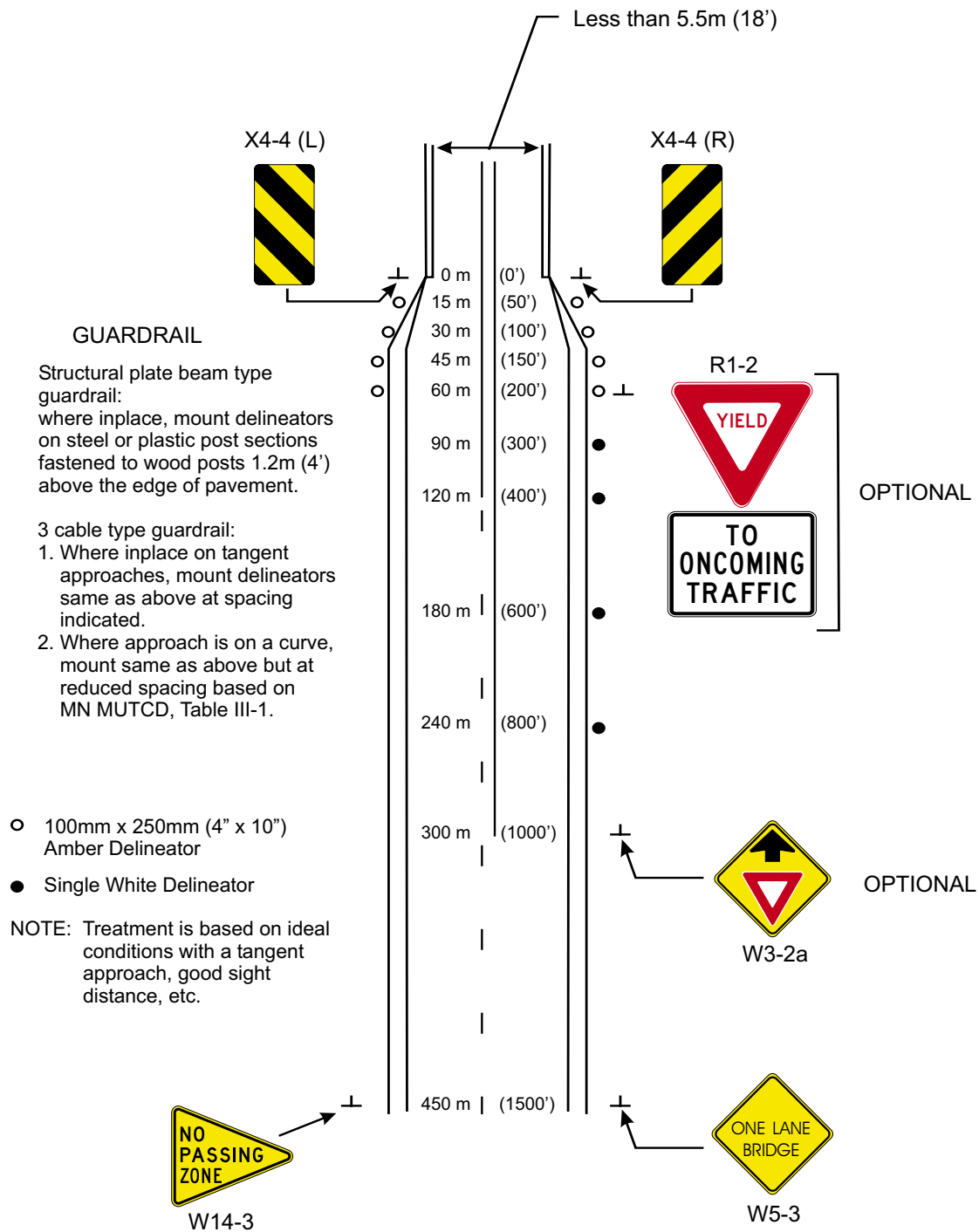
Text Ref.: 7-5.04

July 1,1997

COMMONLY USED OBJECT MARKERS

FIGURE
7.26



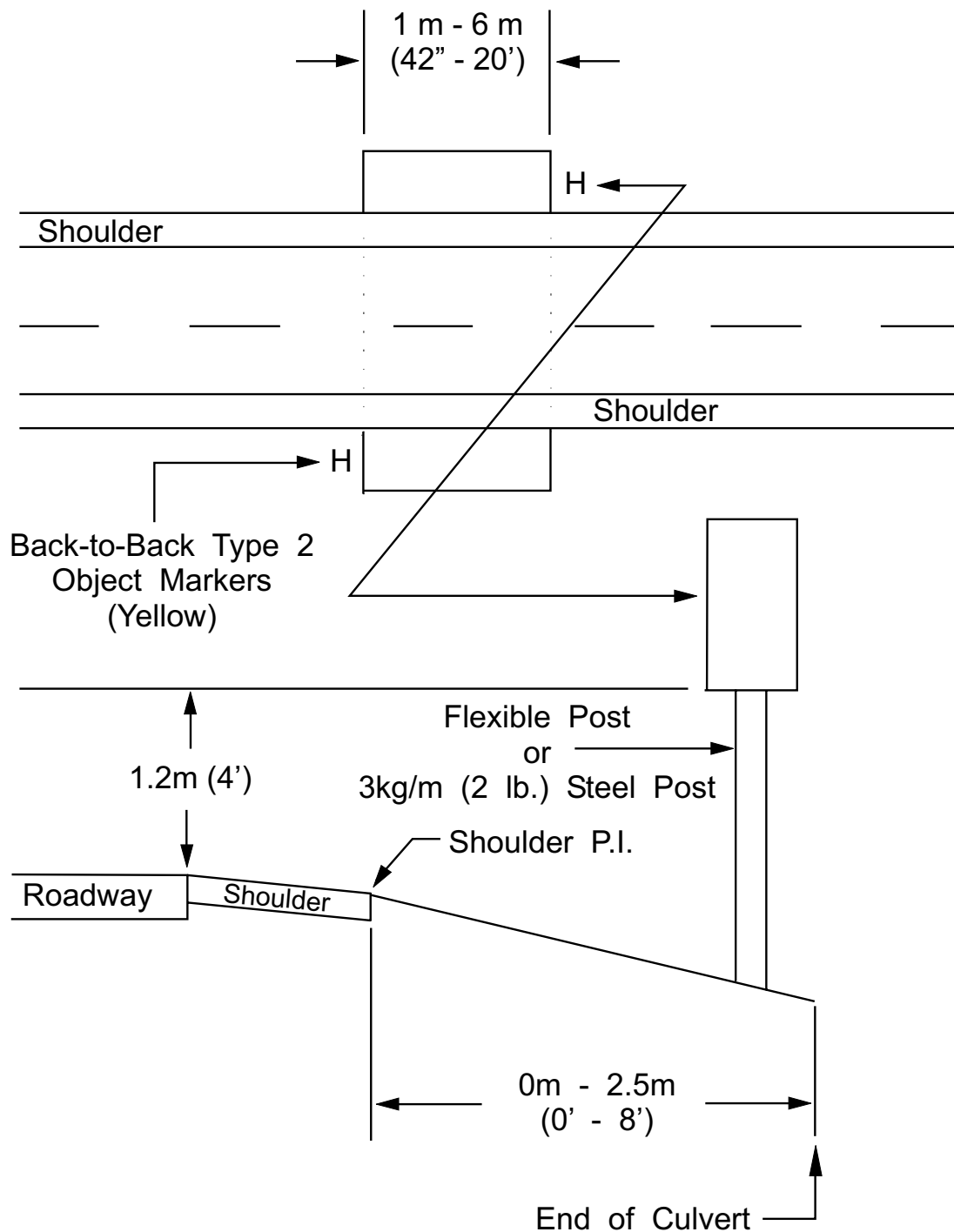


Text Ref.: 7-5.06.02

January 1, 1996

ONE LANE BRIDGE SIGNING & DELINEATION

FIGURE
7.28

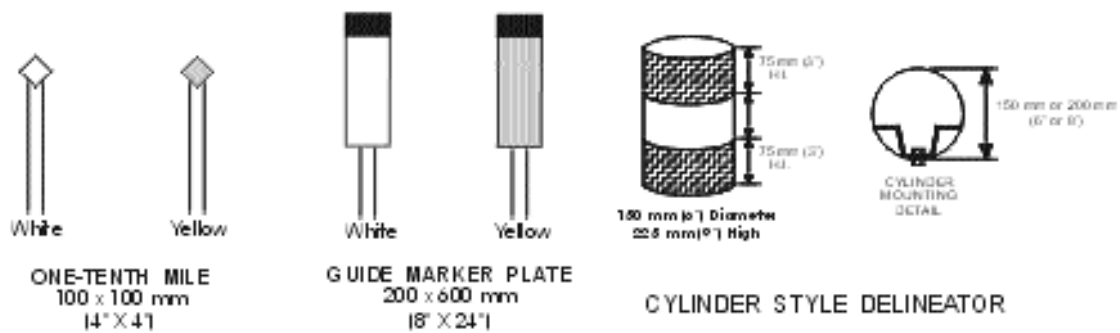


Text Ref.: 7-5.06.03

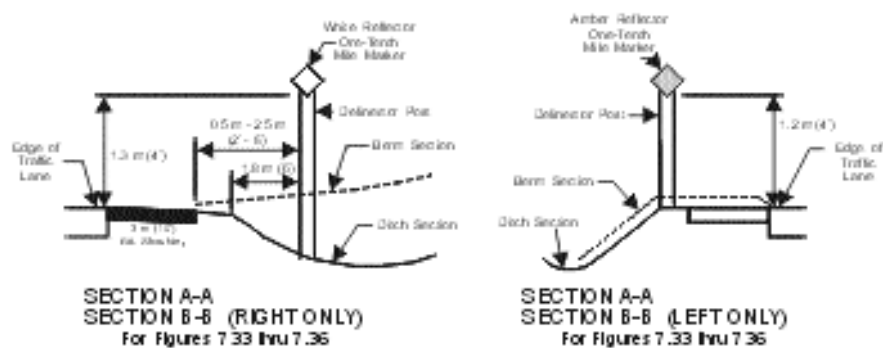
July 1, 1998

**UNPROTECTED LARGE CULVERT &
CATTLEPASS DELINEATION**

FIGURE
7.29



TYPES OF DELINEATORS



TYPICAL DELINEATOR PLACEMENT



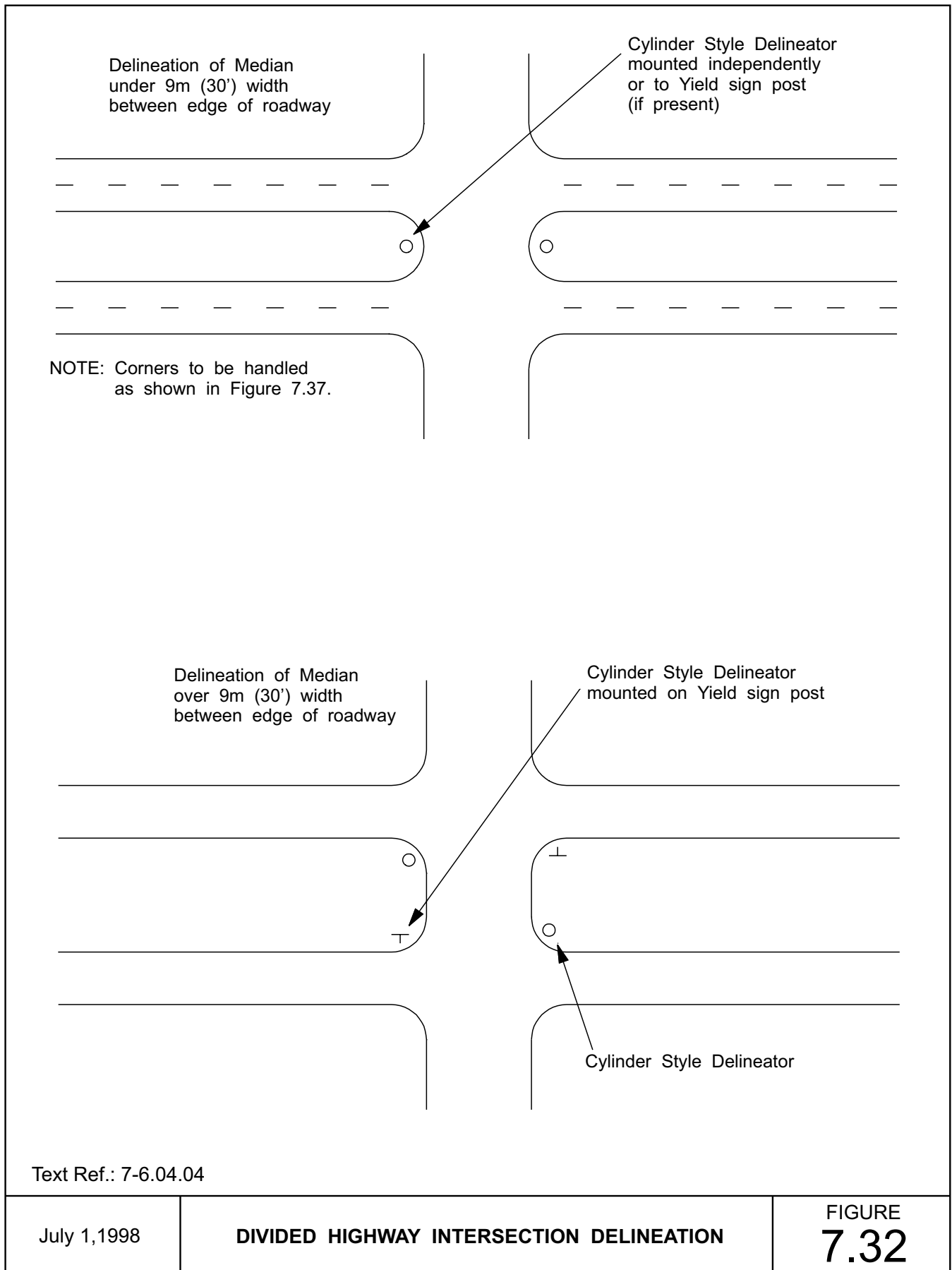
HAZARD PLATE MARKER AT EXIT GORE

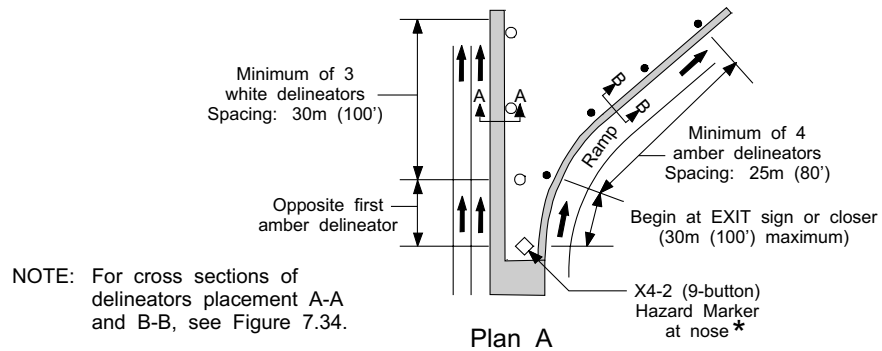
Text Ref.: 7-6.01

July 1, 1999

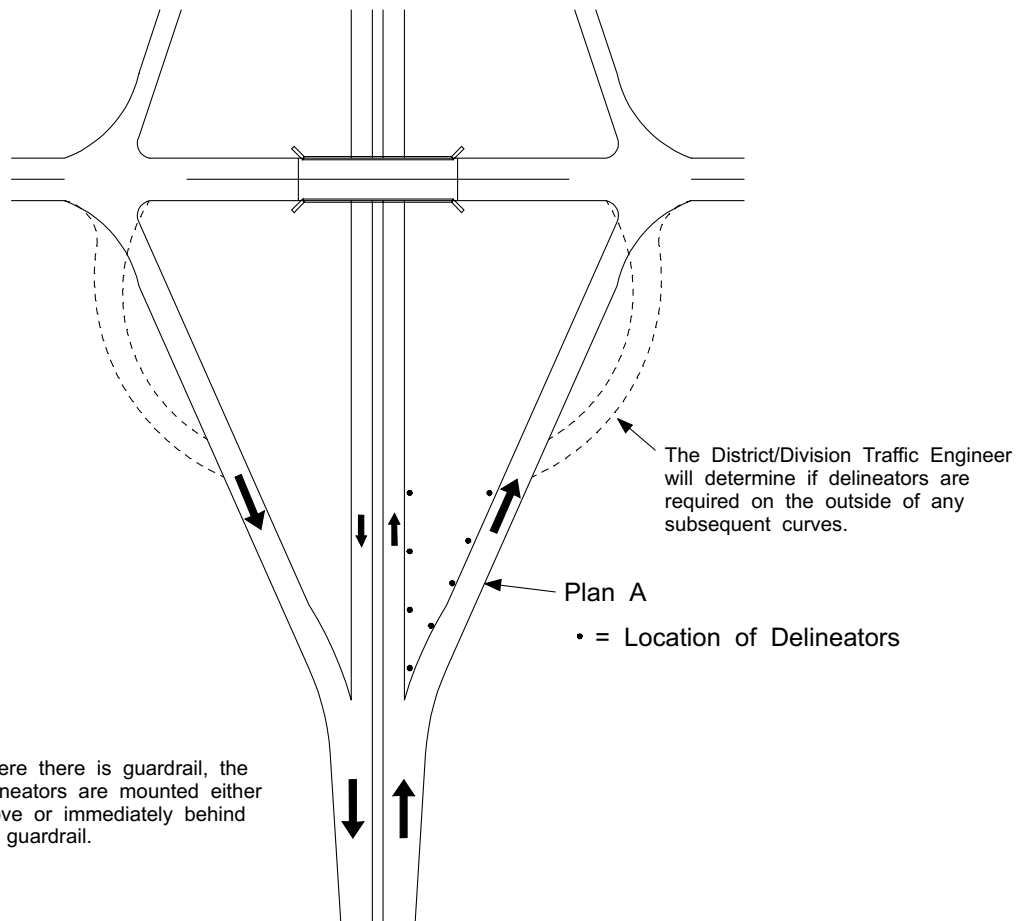
DELINEATOR TYPES & INSTALLATION

FIGURE
7.30





* Optional if no hazard exists

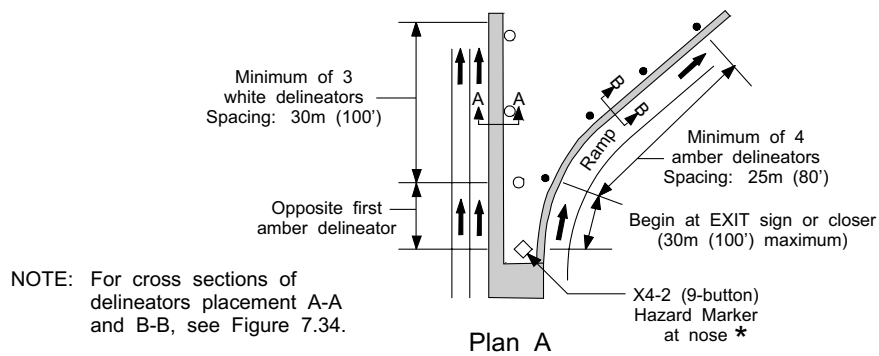


Text Ref.: 7-6.04.05

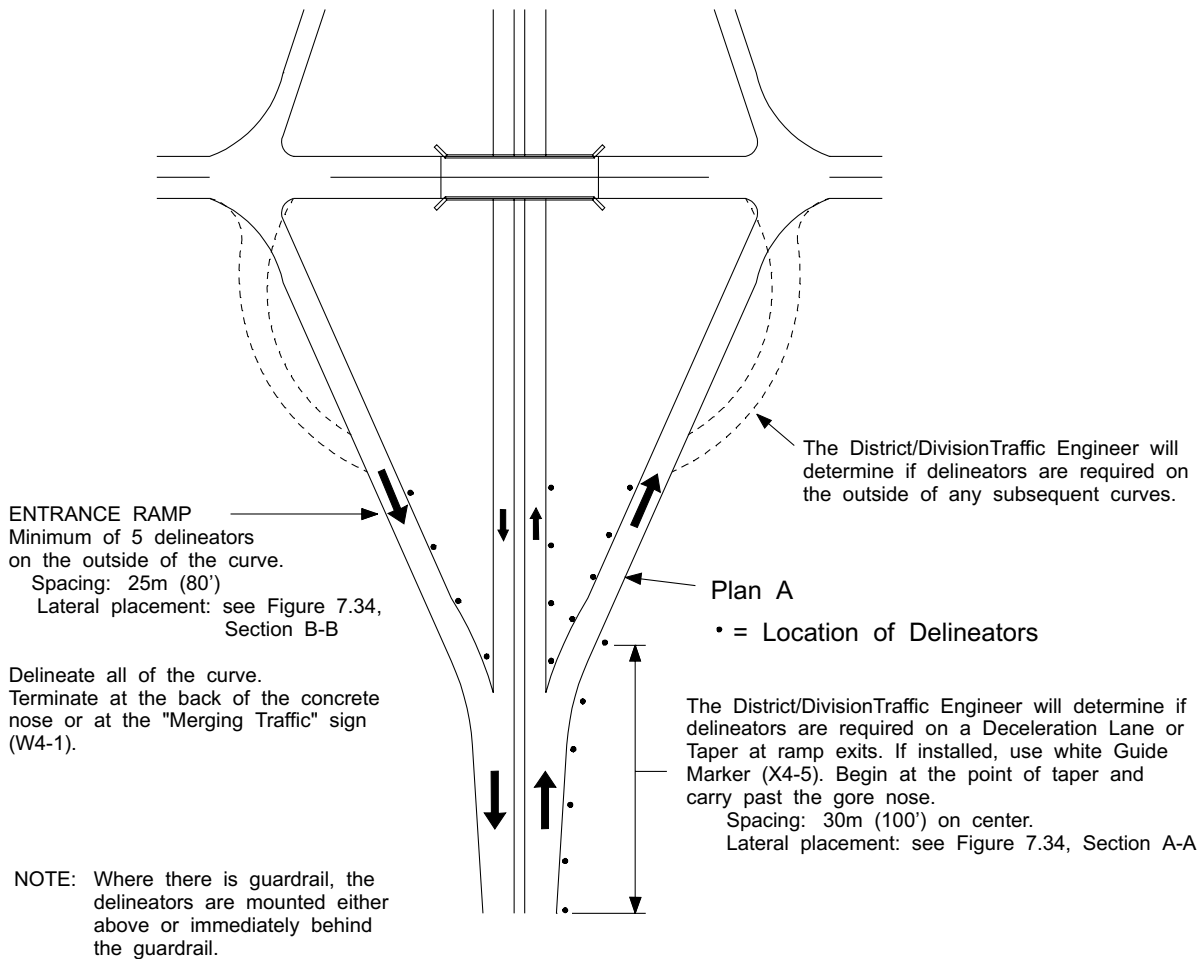
July 1, 1998

**DIAMOND INTERCHANGE DELINEATION -
PARTIAL AND FULL LIGHTING**

FIGURE
7.33



*Optional if no hazard exists

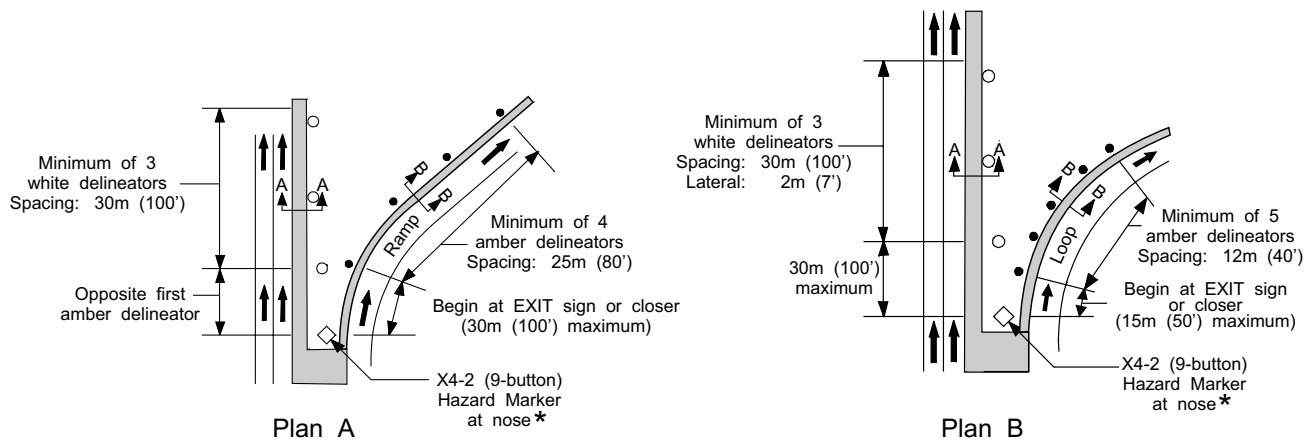


Text Ref.: 7-6.04.05

July 1, 1998

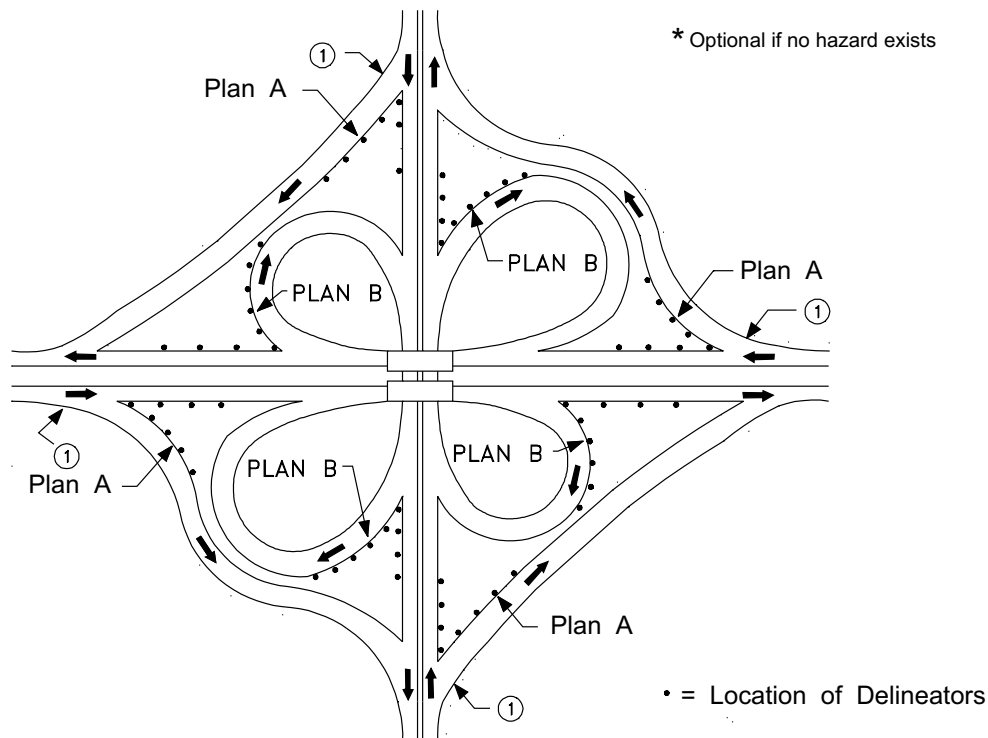
DIAMOND INTERCHANGE DELINEATION - UNLIT

FIGURE
7.34



NOTE: For examples of cross sections A-A and B-B from Plan A and Plan B, see Figure 7.34.

* Optional if no hazard exists



NOTE: Where there is guardrail, the delineators are mounted either above or immediately behind the guardrail.

① At unlit interchanges, the District/Division Traffic Engineer will determine if delineators are required on a Deceleration Lane or Taper at ramp exits. If installed, use white Guide Marker (X4-5). Begin at the point of taper and carry past the gore nose. Spacing: 30m (100') on center. Lateral placement: see Figure 7.34, Section A-A

Text Ref.: 7-6.04.05

July 1, 1998

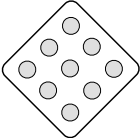
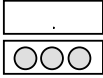
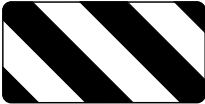
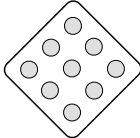
CLOVERLEAF INTERCHANGE DELINEATION - FULL LIGHTING

FIGURE
7.35

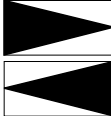
85th Percentile Speed MPH (KM/H)		Minimum Sight Distance Meters Feet	
30 (50) or less		155	500
31-40 (51-60)		185	600
41-50 (61-80)		245	800
51-60 (81-100)		305	1,000
61 (101) or greater		335	1,100
Text Ref.: 7-4.06.01			
July 1, 1991	MINIMUM PASSING SIGHT DISTANCE		CHART 7-3

85th Percentile Speed MPH (KM/H)		Distance Between Zones Meters Feet	
20-39 (30-59)		159	500
40-54 (60-89)		200	650
55 (90) and above		245	800
Text Ref.: 7-4.06.01			
July 1, 1991	MINIMUM DISTANCE OR GAP BETWEEN NO PASSING ZONES		CHART 7-4

Wide Angle VIP Retroreflective Sheeting (TYPE IX)

NAME	OBJECT MARKER	SIZE	COLOR	INFORMATION SEE MN MUTCD
Hazard Marker Type 1 (X4-2)		450 x 450 mm (18" x 18")	All Yellow or Yellow on Black	Section 3C-3
Culvert Marker Type 2 (X4-3)	 (vert. or horz.)	150 x 300 mm (6" x 12")	Yellow on White or All Yellow	Section 3C-3
Clearance Marker Type 3 (X4-4)	 (left or right)	300 x 900 mm (12" x 36") 450 x 900 mm (18" x 36")	Black on Yellow	Section 3C-3
End of Roadway Marker (X4-11)		450 x 450 mm (18" x 18")	All Red or Red on Black	Section 3C-4

Encapsulated Retroreflective Sheeting - (Type III)

Snowplow Marker (X4-5)		150 x 300 mm (6" x 12")	Black on Yellow	None
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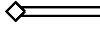
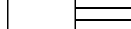
Text Ref.: 7-5.02

July 1, 1997

OBJECT MARKERS

 CHART
7-5

Wide Angle VIP Retroreflective Sheeting (TYPE IX)

NAME	DELINEATOR	SIZE	COLOR	INFORMATION SEE MN MUTCD
One Tenth Mile Delineator (X4-8)		100 x 100 mm (4" x 4")	White	Section 2D-46
Guide Delineator (X4-6)		200 x 600 mm (8" x 24")	Black top on White or Yellow	None
Chevron Alignment Sign (W1-8)		450 x 600 mm (18" x 24")	Black on Yellow	Section 2C-10
Alignment Delineator (X4-7)		100 x 200 mm (4" x 8")	White or Yellow	None

Type VII MD Retroreflective Sheeting

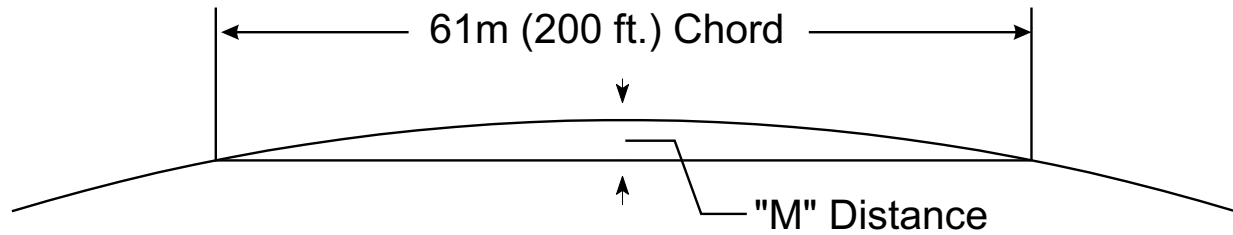
Cylinder Style		150 mm (6") Diameter 225 mm (9") Height	White or Yellow	Section 3D-4.5
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Text Ref.: 7-5.04

July 1,1998

DELINEATOR FABRICATION DETAILS

CHART
7-6



Take 61m (200 ft.) tape, chain, or rope and stretch it between two points on a curve. At the center (30.5m or 100 ft. mark), measure the distance in meters and millimeters (feet and inches) between the chord and the arc.

DEGREE OF CURVE RELATED TO "M" FOR A 61m (200 ft.) CHORD

Degree of Curve	Distance "M"		Distance "M"		Radius	
	meters	feet	millimeters	inches	meters	feet
0°30'	0.134	.44	14	5-1/2		
1°00'	0.265	.87	27	10-1/2	1745	5,730
1°30'	0.399	1.31	40	15-3/4	1165	3,820
2°00'	0.533	1.75	53	21	875	2,865
2°30'	0.664	2.18	66	26	700	2,292
3°00'	0.798	2.62	80	31-1/2	580	1,910
3°30'	0.933	3.06	93	36-3/4	500	1,637
4°00'	1.064	3.49	107	42	435	1,432
4°30'	1.198	3.93	119	47-1/4	390	1,273
5°00'	1.332	4.37	133	52-1/2	350	1,146
5°30'	1.466	4.81	147	57-3/4	320	1,042
6°00'	1.600	5.25	160	63	290	955
6°30'	1.734	5.69	174	68-3/8	270	881
7°00'	1.868	6.13	187	73-5/8	250	819
7°30'	2.002	6.57	200	78-7/8	235	764
8°00'	2.140	7.02	214	84-1/4	220	716
8°30'	2.274	7.46	227	89-1/2	205	674
9°00'	2.408	7.90	241	94-3/4	195	637
9°30'	2.545	8.35	255	100-1/4	185	603
10°00'	2.679	8.79	268	105-1/2	175	573

Text Ref.: 7-6.04.02

July 1, 1998

**FINDING THE DEGREE OF CURVE
FOR A HORIZONTAL CURVE**

CHART
7-7

Curve Radius (meters feet)		Guide Marker Spacing (meters feet)	
15	50	6	20
23	75	6	20
30	100	8	25
45	150	9	30
61	200	11	35
91	300	15	50
122	400	17	55
152	500	20	65
183	600	21	70
213	700	23	75
241	800	24	80
274	900	26	85
305	1000	27	90
366	1200	30	100
427	1400	34	110
488	1600	35	115
549	1800	38	125
610	2000	40	130
762	2500	46	150
914	3000	49	160

LEGEND:

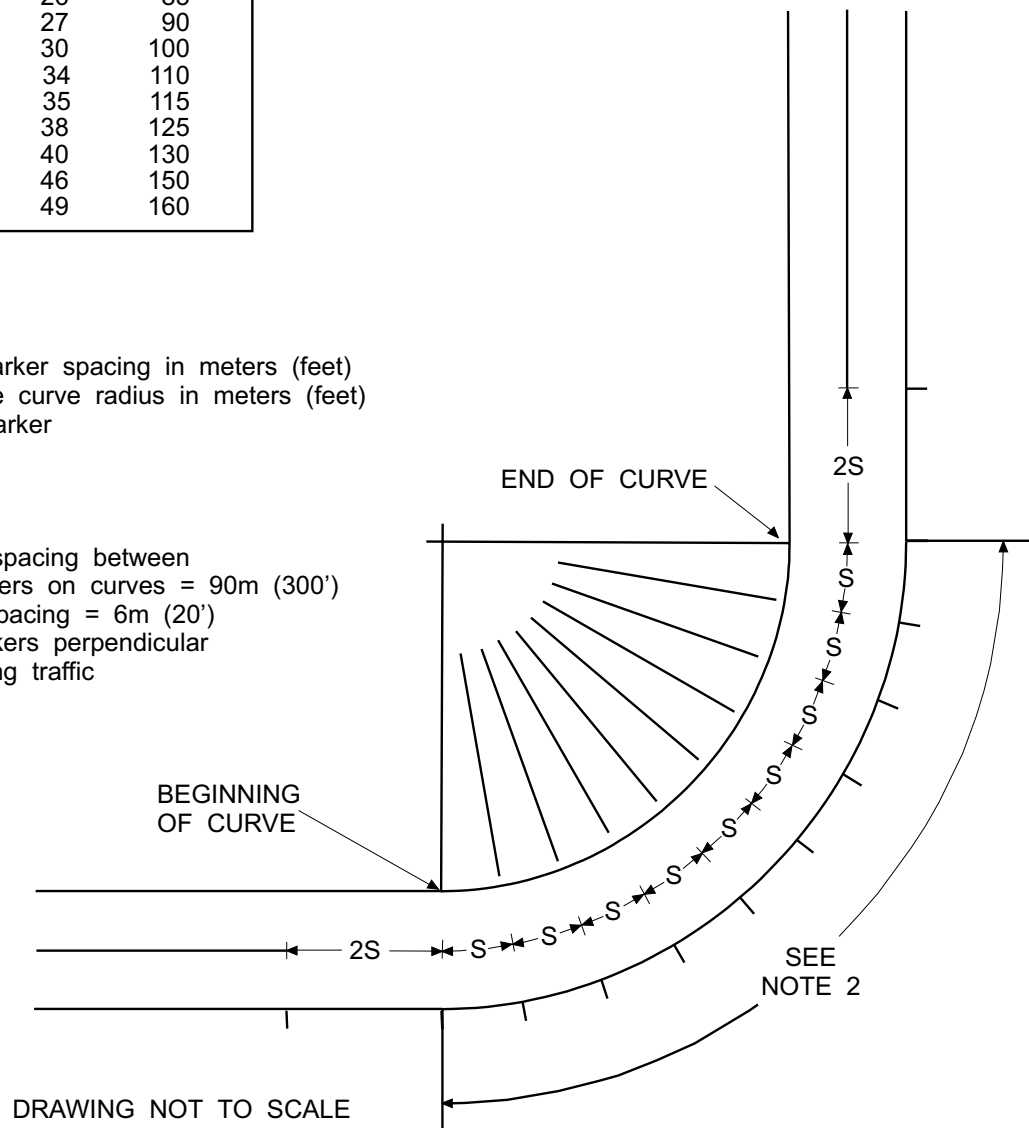
S = Guide marker spacing in meters (feet)

R = Centerline curve radius in meters (feet)

I = Guide marker

NOTES:

- 1) Maximum spacing between guide markers on curves = 90m (300')
- Minimum spacing = 6m (20')
- 2) Install markers perpendicular to oncoming traffic



Text Ref.: 7-6.04.02

July 1, 1998

DELINEATOR SPACING ON HORIZONTAL CURVES

CHART
7-8