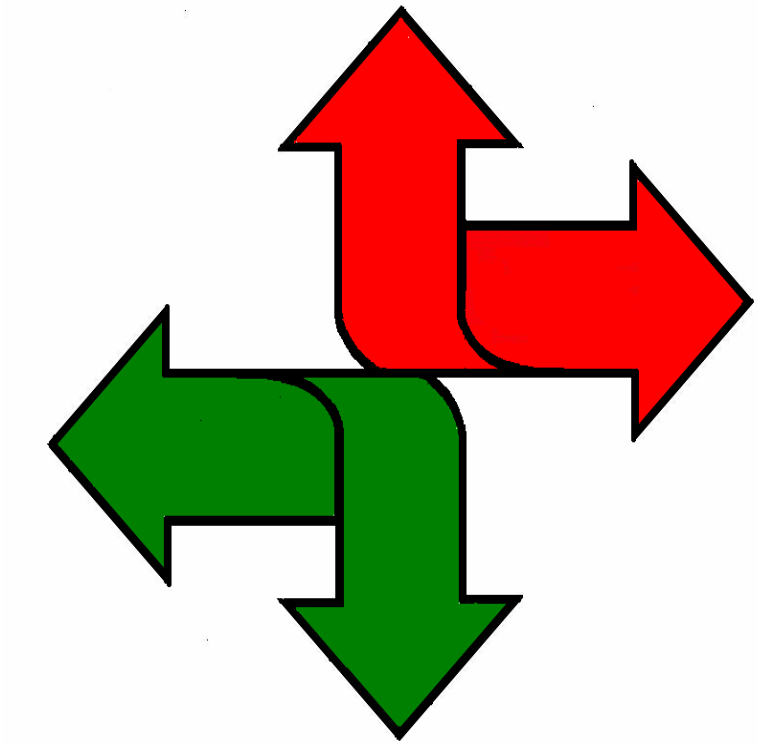
Handbook of
Traffic Control Practices for
Low Volume Rural Roads



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Handbook of
Traffic Control Practice
for Low Volume Rural Roads (LVR Handbook)

This handbook was revised by Kansas State University through a K-TRAN Project Sponsored by the Kansas Department of Transportation.

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Handbook of Traffic Control Practices for Low Volume Rural Roads

PREFACE

The purpose of the Handbook of Traffic Control Practices for Low Volume Rural Roads (LVR) Handbook is to assist local government units in providing safe local roads for the traveling public. It is recognized that funds for construction, maintenance and operation of the local road system are limited and, therefore, the Handbook is aimed at providing a rational balance between maximum safety and minimum cost.

The statewide use of the LVR Handbook should result in more consistent signing and marking of local roads, thus providing roads which better meet the expectancy of the drivers and are, therefore, safer. The consistent use of the practices may also decrease the legal liability of local government units in the event of lawsuits arising from roadway crashes.

The Handbook is intended for county and city engineers, county road supervisors, city street superintendents, township boards, and other local officials with road and street safety responsibilities.

This handbook is based on the 2003 version of the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD 2003) which provides guidelines for design, installation and use of traffic control devices (signs, signals, and markings) but the guidelines are not substitutes for engineering judgment. It is intended that the LVR Handbook suggest guidelines for use in conjunction with the MUTCD 2003 for traffic control device installation on low volume rural roads. This LVR Handbook supplements MUTCD 2003 but is not intended to be a replacement. It is desirable that every local government unit should have available for reference a copy of the latest MUTCD as presented on the FHWA website http://mutcd.fhwa.dot.gov, or the version adopted by KDOT. The latest version of the MUTCD is the standard that must be followed; the LVR Handbook is intended to provide completely compatible, supplementary material, but is not a standard. Its main objective is to assist persons in proper interpretation of MUTCD 2000.

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INTRODUCTION

The Problem

County and township roads carrying fewer than 400 vehicles per day are classified as low-volume rural roads (LVR) and make up a high percentage of the total rural road mileage. The many miles of these LVR present counties and townships with serious concerns, most of which are financial; i.e., how to provide construction and maintenance dollars to improve existing roads or simply maintain them at their current condition; replace or upgrade substandard bridges, and install or maintain necessary traffic signs or pavement markings. In other words, the problem is to provide a reasonably safe roadway system at reasonable cost. A desirable objective is to provide a roadway system in which a prudent driver, even a stranger to the area, will be able to safely travel the roads.

Purpose

The main purpose of this LVR Handbook is to assist the local government officials in providing traffic control and guidance for persons driving on LVR. The suggested practices in the LVR Handbook are in accordance, with the Manual on Uniform Traffic Control Devices, 2003 Edition (as of December 19, 2003) (MUTCD 2003) and, in some cases, address more specifically the application of MUTCD 2003 to LVR. The LVR Handbook also includes background information on the characteristics of LVR. Through the use of this background information, local governments should be able to better understand the problems of LVR and their users, and can therefore, provide a safer roadway.

In order to increase uniformity nationwide, the MUTCD 2003 includes guidance, standards, or warrants for most types of traffic control devices. The guidelines outline the decision process to be followed before a traffic control device is installed or removed. MUTCD 2003 states "the decision to use a particular device at a particular location should be made on the basis of an engineering study of the location." This LVR Handbook does not address all situations; however, it has been developed to provide guidance for its users. The need for the placement of traffic control devices as shown in the figures and discussed in the written material has been developed for typical situations as a result of past engineering studies and experience of the authors, with assistance from the Technical Advisory Committee.

Statements are made in the LVR Handbook, "if an engineering study indicates", "to be determined by the engineer," or “to be determined by engineering judgment.” MUTCD 2003 specifically states that the decision to use a device is based on engineering judgment and engineering studies.

These statements are relevant because MUTCD 2003 specifically indicates that while MUTCD 2003 provides standards for the design and application of traffic control devices, it should not be a substitute for engineering judgment.

The MUTCD 2003 defines an engineering study as: (Sec 1A-13)

"The comprehensive analysis and evaluation of available pertinent information, and the application of appropriate principles, standards, guidance and practice as contained in this *Manual* and other sources, for the purpose of deciding upon the applicability, design, operation or installation of a traffic control device. An engineering study shall be performed by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. An engineering study shall be documented."

The MUTCD 2003 defines engineering judgment as: (Sec 1A-13)

"The evaluation of available pertinent information, and the application of appropriate principles, standards, guidance and practices as contained in this *Manual* and other sources, for the purpose of deciding upon the applicability, design, operation or installation of a traffic control device. Engineering judgment shall be exercised by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. Documentation of engineering judgment is not required."

In such instances, reference is made to MUTCD 2003 which states, "Jurisdictions with responsibility for traffic control, that do not have qualified engineers on their staffs, should seek assistance from others such as the state transportation agency, their county, a nearby large city, or a traffic engineering consultant." It is clear that the decision to use traffic control devices rests with the jurisdiction responsible for the roadway. It may be a good idea for personnel to discuss this matter with legal counsel.

The LVR Handbook primarily relates to LVR signing. Such safety matters as bridge load limits, roadway cross section, roadway geometry, the removal of roadside obstacles albeit important, are addressed in other manuals, handbooks and guides (such as the Roadside Design Guide).

Background

Traffic control devices are generally defined as all signs, signals, markings, and other devices placed on, over, or next to a street or highway by authority of a public body or official having jurisdiction to regulate, warn, or guide traffic.

The need for uniformity in the meaning, design, usage, placement, and maintenance of traffic control devices has been recognized for many years. In response to this need, a manual for uniform traffic control devices for rural highways was first published in 1927. This was followed by a manual for urban streets in 1929. Combined manuals for rural and urban areas were published periodically until 1978 when the Manual on Uniform Traffic Control Devices (MUTCD) was approved and published by the Federal Highway Administration (FHWA) as the National Standard for all highways open to public travel. Subsequent publications of this National Standard were issued in 1988, 2000 and 2003. It is expected that the State of Kansas will adopt MUTCD 2003 as the manual and specification for a uniform system of traffic control devices on all public streets and highways in the state.

MUTCD 2003 Guidelines or Warrants

In order to increase uniformity nationwide, MUTCD 2003 includes guidance, standards, or warrants for most types of traffic control devices. The guidelines outline a decision process that should be followed before a traffic control device is installed or removed. The decision to use a particular device at a specific location should be made on the basis of an engineering study of the situation or on the basis of engineering judgment. MUTCD 2003 provides guidelines for design and use of traffic control devices (signs, signals, and markings) but the guidelines are not substitutes for engineering judgment. It is intended that the LVR Handbook provides guidance for use **in conjunction with** the MUTCD 2003 for traffic control device installation on low-volume rural roads. Therefore, this LVR Handbook is neither a substitute for engineering judgment nor a legal requirement for installation.

NEW FORMAT OF THE MUTCD 2000 and 2003

Starting with the Millennium Edition of the MUTCD (MUTCD 2000) a major change was made from previous MUTCD editions. The new format is an attempt to facilitate better understanding of the MUTCD requirements and differentiation between Standards that are mandatory and must be satisfied, Guidances that are recommended and should be followed, but not mandatory and Options that are permissive statements of practice that may be done but carry no requirement or recommendation statements have been collected under their appropriate headings. Basically, all the previous “shall” statements were collected and printed under the heading of “Standards”; all the previous “should” statements were collected and printed under the heading of “Guidance”; all the previous “may” (permissive) statements were collected and printed under the heading of “Options”. New sections, under the heading of “Support” are intended for informational purposes only, do not fall into any of the three main categories and contain no shall, should or may statements.

To emphasize and differentiate standards from guidance, options and support, standards are printed in bold print since MUTCD 2000. That will also be done in this handbook. Standards must be followed. All other statements in this LVR are considered good practice by the authors and most would fall under the MUTCD definition of "Guidance". There should be a good reason for deviating from guidance and the reason should be documented.

New MUTCD 2003 section on Low Volume Roads (Since MUTCD 2000)

The MUTCD 2003 has a section, "Part 5, Traffic Control Devices on Low-Volume Roads." It is important to understand how the MUTCD defines a low volume road (LVR).

Standard (MUTCD 2003, Section 5A.01)

A low-volume road shall be defined for this Part of the Manual as follows:

- **A. A low-volume road shall be a facility lying outside of built-up areas of cities, towns and communities, and it shall have a traffic volume of less than 400 AADT.**
- **B. A low-volume road shall not be a freeway, expressway, interchange ramp, freeway service road, or a road on a designated State highway system. In terms of highway classification, it shall be a variation of a conventional road or a special purpose road as defined in (MUTCD 2003) Section 2A.01.**
- **C. A low-volume road shall be classified as either paved or unpaved.**

Although Part 5 allows some lessening of standards for roadways that are eligible, most other parts of MUTCD 2003 still apply (and must be applied if there is any discrepancy). Also, other sections of MUTCD 2003 can always be applied, i.e., it is not mandatory to follow Part 5 even for low-volume roads. Also, it is not clear to the authors, exactly how "AADT 400" will be determined.

Compliance dates:

There are many changes in the new MUTCD 2003 due to new standards, etc. However, this does not mean a road authority has to immediately change all their traffic control devices. A phase-in period to conform to new standards has been established. A brief list of compliance dates is included at the end of this chapter for common signs.

MUTCD Section	Title	Requirement	Compliance Date
2B.04	STOP Sign	Install R1-3 plaque at all multiway STOP locations	1/17/04
2B.16	REDUCED SPEED AHEAD Sign	Install R2-5 series signs for speed zoning	1/17/08
2B.32	ONE WAY Signs	Install mandatory ONE WAY signs	1/17/08
2B.49, 2B.50	High Occupancy Vehicle Lanes	Replace R3-18 and R3-19 signs	1/17/07
2C.02	Application of Warning Signs	Replace minimum-size warning signs for MERGE (W4-1), NARROW BRIDGE (W5-2), TWO-WAY TRAFFIC (W6-3) and double arrow symbol (W12-1)	1/17/08
2C.24	Shoulder Signs	Replace symbol signs with word messages	1/17/11
2C.37	Crossing Signs	Replace advance and crossing signs with distance plaque and diagonal arrow symbol plaque	1/17/11
2D.38	Street Name Sign	Replace signs with 6-in. capital or 6-in. uppercase and 4.5-in. lowercase legends except on low-speed local streets	1/19/12
2E.29	Interchange Exit Numbering	Revise exit number plaques from 24 in. to 30 in.	1/17/08
2E.31	Advance Guide Sign	Relocate advance guide signs 0.5 to 1 mile in advance of exit gores	1/17/08
2F.05	Size of Lettering	Replace specific service signs with minimum size of 10 in. on freeways and expressways and 6 in. on conventional roads and ramps	1/17/11
3B.01, 3B.07	Yellow Centerline and Left Edge Line Markings and Warrants	Stripe additional roads where markings are mandatory	1/03/03
4E.06, 4E.08	Accessible Pedestrian Signals and Detectors	Revise existing accessible pedestrian signals	1/17/05
8B.02	Highway–Rail Grade Crossing Signs	Install retroreflective sheeting on crossbucks	1/17/05
9B.04	Bicycle Lane Signs	Install new R3-16a and R3-17a signs	1/17/06
9B.15	Bicycle Crossing Warning Signs	Revise crossing signs to new crossing concept	1/17/08
Sect. 9	Preferential Lane Symbol Markings	Revise bicycle lane markings from diamond symbol to BIKE LANE markings	1/17/08
Sect. 10	Transit Crossings	Install automatic gates, flashing light signals and blank-out signs at light rail transit crossings	1/17/06
10C.11	Highway Rail Advance Warning Signs	Replace light rail warning signs (W10-6 and W10-6a) with railroad warning signs (W10-1, W10-2, W10-3 and W10-4)	1/17/06

PRINCIPLES

More effective use of the LVR Handbook is possible when the user has an understanding of some principles relating to good operating practices. Included in the basic principles are driver expectancy, positive guidance, and consistency.

Driver Expectancy

Drivers, and people in general, expect things to operate in certain ways. When entering a dark room a person will expect to find an on-off toggle switch for the lights. One also expects the switch will operate up for on and down for off. When it works the other way around, or when there is a rheostat knob, it takes a bit longer to respond to what is actually there. The same situation occurs with drivers. When a driver's expectancy is incorrect, either it takes longer to respond properly or, even worse, the driver may respond poorly or wrongly. (Alexander, G.J. and H. Lunenfeld, 1972) If, for example, a curve sign shows a curve to the right but the road actually curves left, one can imagine the difficulty the driver has in properly negotiating the curve at night - especially a stranger to the area. This may seem to be an extreme example; however, this has been observed rather frequently in the "Winding Road Sign" in which the bottom or beginning curve points in the wrong direction.

What the driver expects on a road is greatly influenced by what was experienced on the previous section of road. Studies have shown that what a driver saw - presence or absence of traffic control devices, road surface type, condition and width, narrow bridges or culverts; etc., (this might be called the "roadway environment") - is what the driver expects for the next 1/2 to 1 mile.

Driver expectancy is affected not only by the very recent experiences but also by those things drivers have learned through past experiences, e.g., every highway-railroad at-grade crossing will have X-bucks and advance railroad crossing warning signs are at all railroad grade crossings, stop signs are red, curve warning signs are yellow and diamond shaped, etc.

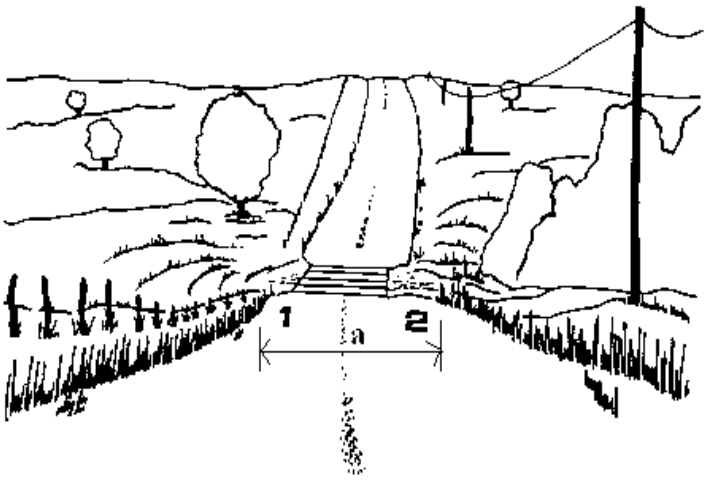
It follows that the consistent use and placement of traffic control devices can do a great deal toward ensuring that the driver's expectancy is appropriate. This is particularly true for drivers not familiar with the roadway. The unfamiliar driver should be considered when signing a roadway.

Driver expectancies are also affected by the type of road such as an interstate highway, state highway, county or township road. The driver expects to drive each of these with different levels of caution.

Positive Guidance

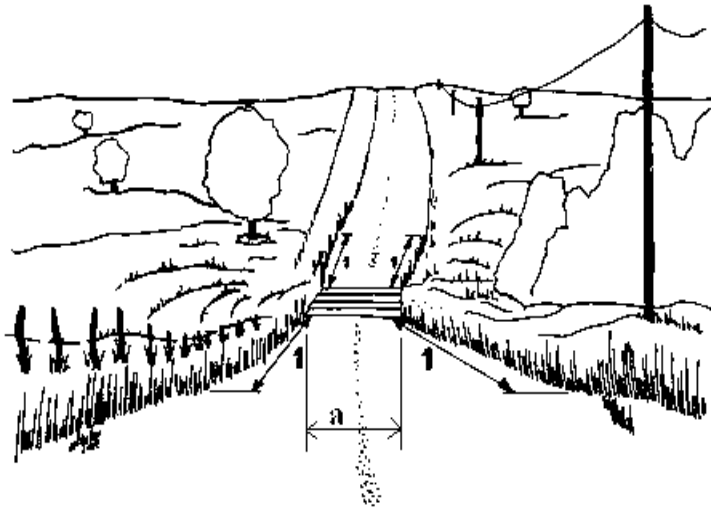
Positive guidance is the concept that a driver can be given sufficient information where he needs it and in a form he can best use it to safely avoid an obstacle. (Alexander, G.J. and H. Lunenfeld, 1973) Positive guidance can be given to the driver through combinations of signs, object markers, safe advisory speed signs, and probably most important of all, the view of the road ahead. If drivers can see the curves far enough ahead to judge their sharpness and adjust to a safe speed, or if intersections were visible and clear of sight obstructions, or if all narrow bridges and culverts were visible to drivers from both directions, drivers should need few signs. There would be little need for anything more than an occasional stop or yield sign to assign the right of way at the intersection of LVR roads with higher volume roads. The condition just described might be called "roadway positive guidance." Studies have shown that the edge of the roadway ahead is among the most important guidance information the driver uses. Using the edge of roadway in this manner provides an easy and effective way of providing positive guidance at narrow bridges and culverts or other roadside obstacles.

An Example of Positive Guidance - "Tapering" is a simple technique in which the traveled way (maintained part of the road) is gradually narrowed (tapered) some distance ahead of say, a narrow culvert. If tapering is used, the driver simply follows, as usual, the edge of roadway and thus is guided away from the roadside obstacle (See Figure 1-2). If tapering is not used, the driver may not see the end of the short culvert and if he continues to follow the edge of roadway (faulty guidance) he may drop a wheel off the end of the culvert. This is illustrated in Figure 1-1.



'**a**' **Note**: Road is wider than structure
FIGURE 1-1. Before Tapering Road

1. Roadway wider than culvert or bridge.
2. Roadway edge leads driver into culvert or ditch instead of on roadway.



'a' Note: Road is gradually narrowed to same width as structure
FIGURE 1-2. After Tapering Road

1. Tapered section - roadway edge leads away from ditch or culvert ends, i.e., roadway width is gradually reduced to width of structure. (See Chapter 4 for narrow bridge signing and marking)

Tapering Technique

A tapered roadway edge may be used to guide the driver away from hazardous obstacles such as bridge abutments, dropoffs, culverts or other objects, which narrow the roadway.

Minimum recommended taper lengths are shown in Table 1-1.

TABLE 1-1 - Minimum Taper Lengths, , L feet

*** W (feet)**	**Prevailing Speed**		
	Less then 30 MPH	**30-40 MPH**	**Over 40 MPH**
2 or less	**30'**	**50'**	**100'**
3	**45'**	**75'**	**150'**
4	**60'**	**100'**	**200'**
5	**75'**	**125'**	**250'**
6	**90'**	**150'**	**300'**

The taper lengths in Table 1-1 were adapted from Formulas found on page 6C-10, MUTCD 2000.

*See Figure 1-3

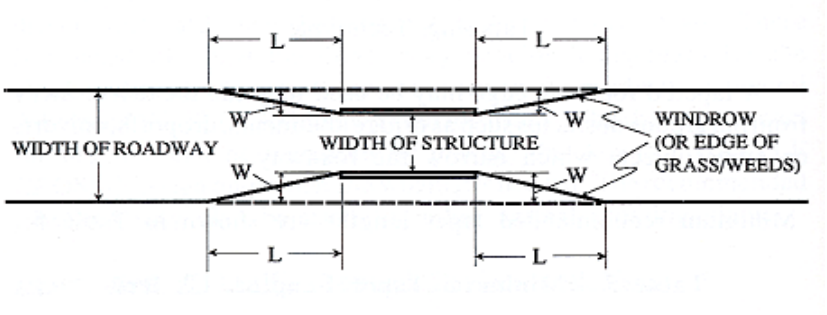


FIGURE 1-3. Taper Details

Reference

Safety at Narrow Bridge Sites. NCHRP Report 203, Transportation Board, Washington DC (June 1979).

Consistency

Consistency relates to the "sameness" of the nature of the road from one section to another. Inconsistencies are sudden changes in the nature of the road. Inconsistencies violate a driver's expectancy. A consequence either the road should be made consistent, which can be impractical, or something should be done to correct the driver's expectancy, i.e. restructure the driver's expectancy. In the case of a hidden curve in a nearly straight roadway, the use of a curve warning sign with, perhaps, an advisory speed plate should correctly restructure the driver's expectancy. After seeing the curve sign, with advisory speed plate, the driver expects the curve, knows whether the road curves left or right, and knows the speed at which the curve can be comfortably and safely driven.

Other examples of inconsistencies are:

- A 2-lane road suddenly narrowing to a 1-lane road.
- A blacktop road changing to a gravel road.
- A bridge narrower than the approaching roadway.
- A blind intersection in an area where most intersections have clear sight distances.

Whether or not a situation is an inconsistency may depend on the direction in which the driver is traveling, and what he/she has experienced in the last half-mile or so.

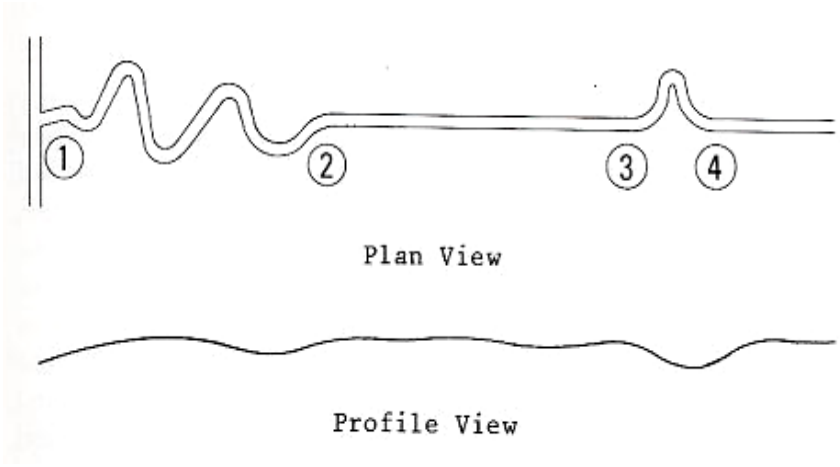


FIGURE 1-4. Plan and Profile Views of a Road

The driver, traveling from 1 to 4 in Figure 1-4, finds the first part of the road, 1 to 2, very consistent, i.e., there is hardly time to pick up speed before

seeing or being on another curve. After passing 2, the road is straight for as much as a mile, and the driver now expects the road to continue - straight - and what is seen confirms this expectancy as visual clues make the road appear to continue straight from 3 to 4. "Just a little dip," thinks the driver. What a surprise to have to suddenly handle three 30 mile-per-hour curves. Obviously, some expectancy restructuring should improve safety and signing is likely the best way to do it. For the driver traveling from 1 to 4, signs should not be needed at 1 or from 1 to 2 since the alignment is consistent. A curve warning sign prior to 3 (probably with an advisory speed plate) should be sufficient to give the driver enough information to handle the situation, i.e., the sign has satisfactorily changed his expectancy so, "what he expects is what he gets." Now, consider the driver traveling from 4 to 1. Likely, the driver will need an advance curve warning sign, with speed plate, placed prior to 4. From 3 to 2, the driver's expectancy builds and more of the same straight road is expected. Prior to 2, an advance "winding road sign" is likely needed for the unfamiliar driver to know what to expect.

Driving the roads is one way to identify inconsistencies. A useful technique for locating inconsistencies, information-deficient locations, and expectancy violating situations is the Commentary Driving Procedure discussed in Chapter 7.

As noted earlier, a driver's expectancy is influenced by the type of road being traveled and how the driver perceives the road. Traditionally, highways have been classified by administrative jurisdiction such as state, county, or township, by volume and most frequently according to function such as arterials, collectors or local service. It is impossible for a driver to perceive the administrative classification of roads without state, county or township route markers. It is difficult, if not impossible, for the driver to judge the function of the road or its volume without special training. What the driver does observe are the physical roadway characteristics that effect his/her perception of a reasonable or comfortable speed, and degree of vigilance required to drive a road safely, such as, width and type of surface, riding quality, road surface drainage, the presence or absence of traffic control devices, hills, and sharp curves. These things are what is important to consider when doing an engineering study or using engineering judgment when signing a particular road.

The key to adequate signing is driver perception and expectancy of the road and how it would be driven safely by a driver exercising reasonable care. It is important to understand that signing needs are based on how the driver perceives the road, which in turn influences how the driver drives the road.

For example, a prudent driver would drive a narrow bumpy road, such as shown in Figure 1-5, slowly and carefully. In the previous edition of the LVR Handbook, these types of roads (generally two wheel paths) were classified as driver perceived type “C”. Very few signs should be needed. On “higher” type

roads - wider, straighter and smoother – even prudent drivers tend to drive faster, have the right of way over "lower" type roads and more warning of inconsistencies may be required. In the previous edition of the LVR Handbook (second edition) these "higher" types of roads were classified as driver perceived type "A" (if paved) or driver perceived type "B" (generally three wheel paths) if gravel.

FIGURE 1-5. Narrow, Rough Road

Once the driver perceives a road's characteristics, e.g. rough and narrow vs. smooth and wide, it is assumed most drivers will drive the road accordingly; i.e., expect inconsistencies and be more alert and careful on the rough, narrow road. However, on higher types of roads such as those previously classified as driver perceived "B" or "A", (LVR Handbook, Second Edition) drivers expect consistency and it is more important to warn them of unexpected conditions, i.e., inconsistencies.

A rough, narrow road may require little or no positive guidance and minimal signing, however, an engineering study or engineering judgment should always be used on all types of LVR to determine the need for signing or not signing relative to driver perception and expectancy. Chapter 7, Self Assessment of LVR, will include examples of commentary driving and other evaluation methods that may be useful guidance for those wishing more information and detail on this subject.

Traffic Control Devices-General Principles

MUTCD Definitions:

The MUTCD 2003 defines Traffic control devices as all signs, signals, markings, and other devices used to regulate, warn or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility or bikeway by authority of a public agency having jurisdiction. They assist the driver in a number of ways, including warning of potential obstacles, assigning vehicular right-of-way at intersections, providing guidance in navigating the chosen route and informing the driver of regulations such as speed limits, no parking, and weight limits. Information may be given to the driver using a combination of the devices. Standardization of design and usage of traffic control devices helps the driver to quickly understand the information provided so that suitable action can be taken.

Requirements of Traffic Control Devices (TCD)

The MUTCD 2003 and this LVR Handbook set forth basic principles and guidelines that govern the design and usage of traffic control devices. It is important that these principles and guidelines be given consideration in the exercise of engineering judgment for the selection and usage of each device.

To be effective, a traffic control device should meet five basic requirements. They are:

1. Fulfill a need;
2. Command attention of drivers;
3. Convey a clear, simple meaning to drivers;
4. Command respect of drivers; and
5. Give adequate time for proper response by drivers.

These requirements are met through properly designing, placing, operating and maintaining traffic control devices. Basic requirements, considerations and device applications are outlined in Table 1-2.

Design of the TCD refers to size, color, shape, reflectorization and message. The design is important in drawing attention to the device, conveying a clear meaning, and when combined with proper placement, can provide an adequate time for response by the driver. Basic design principles of traffic control devices are included in MUTCD 2003. In the design of some devices, minor modification of specified design elements is allowed provided that the essential appearance characteristics are met.

TABLE 1-2: Traffic Control Device Requirements. (Source: ITE Traffic Control Devices Handbook, 2001)

Basic Requirement	Consideration Employed	Application to Traffic Control Devices
Fulfill a need	Design	Device revisions required after changes in traffic
	Operation	Appropriate device and equipment installed for traffic requirements
	Maintenance	Replacement of defective or illegible devices
	Uniformity	Appropriate standard device and application
Command attention	Design	Size, contrast, color, shape, composition, and illumination
	Placement	Within the viewer's cone of vision
	Maintenance	Legibility of device maintained with advance visibility and retroreflectivity
Convey a clear, simple meaning	Design	Shape, size, color, message simplicity
	Placement	Positioned to address the situation when applicable
	Operation	Consistency between similar situations
	Uniformity	Standard legends for similar situations
Give adequate time for proper response	Design	Legibility and size appropriate for roadway
	Placement	Appropriate legibility and location for adequate response time
	Operation	Placed, maintained, and operated in a uniform and consistent manner
	Uniformity	Facilitation of quicker responses by road users

Based on *MUTCD 2000*, Section 1A.02, p. 1A.1.

Sign Placement of a TCD should assure:

- It can be easily seen by a driver so it will command attention and will also provide an adequate time for driver response both day and night.
- It is properly positioned with respect to the location, object or situation to which it applies to aid in conveying the proper meaning.
- It is placed in a uniform and consistent manner.
- It is needed; unnecessary devices should be removed.

Maintenance of TCD should insure that legibility is retained for good visibility and driver respect. Maintenance includes removing weeds, brush, etc., which obstruct the driver's view of the device. Maintenance of devices should also insure that all devices meet current traffic conditions.

Uniformity or consistency means similar situations should be treated in a similar fashion. The use of uniform traffic control devices does not, in itself, constitute uniformity. The use of a standard device where it is not appropriate may be as bad or even worse than using a nonstandard device. Such misuse may result in disrespect for the device at those locations where the device is needed or the misuse might increase the risk of crashes.

Responsibility for the design, placement, operation, maintenance and uniformity of traffic control devices shall rest with the public agency or the official having jurisdiction.

References

Alexander G. J and H. Lunenfeld, "Some Factors Affecting Reception and Use of Information by Drivers", Public Roads (June 1972).

Alexander G. J and H. Lunenfeld, Positive Guidance in Traffic Control (Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, 1973).

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CHAPTER 2
TRAFFIC SIGNS

Handbook Note

In this section, and throughout the rest of this handbook, where a section is headed "Standard" followed by a reference to MUTCD 2003, it has been copied verbatim. If it is followed by "partial," it means that the complete section was not quoted but only the portion relative to LVR. Standards should be followed without deviation. All other statements are considered good practice by the authors and advisory committee i.e., guidance and should be followed unless an engineering study or judgment determines otherwise. It is strongly encouraged that reasons for alternative approaches be put in writing and filed. Attempts have been made to ensure that all statements in this handbook are consistent with MUTCD 2003; however, if there should be any discrepancies in content or interpretation, the current edition of the MUTCD governs.

GENERAL

All aspects of signing have been standardized including shape, color, design, size, placement, and reflectivity. Information and guidance are provided in the following sections.

Signs

Functionally, signs are classified as follows:

REGULATORY signs give notice of traffic laws or regulations. [They are established by ordinance or resolution of the jurisdictional authority.]

WARNING signs give notice of a situation that might not be readily apparent.

GUIDE signs show route designations, directions, distances, services, points of interest, and other geographical, recreational, or cultural information.

Requirements

Although MUTCD 2003 does not present a legal requirement to install any particular traffic control device, once the decision is made to install a particular device, the design and application of that device must conform to MUTCD 2003.

Or as stated in MUTCD 2003

Standard (MUTCD 2003, Section 1A.09)

This Manual describes the application of traffic control devices, but shall not be a legal requirement for their installation.

RESPONSIBILITY FOR TRAFFIC CONTROL DEVICES

Standard (partial) (MUTCD 2003, Section 1A.07)

23CFR [Federal Code Governing US Highways] 655.603 also states that traffic control devices on all streets and highways open to public travel in each state shall be in substantial conformance with standards issued or endorsed by the Federal Highway Administrator. [Done via the latest version of MUTCD and all updates, amendments, interpretations, etc.]

The MUTCD 2003 makes it clear that once the decision to install a particular traffic control device is made, it must conform to MUTCD 2003 or a similar state version. STANDARDIZATION OF LOCATION (MUTCD 2003, Section 2A.16)

Location

This section contains excerpts from MUTCD 2003 that are considered relevant to the LVR handbook. Sign location really cannot be standardized, i.e., engineering judgment is usually required. Several examples are presented later in this handbook.

Signs should be located on the right side of the roadway where they are easily recognized and understood by road users. Signs in other locations should be considered only as supplementary to signs in the normal locations, except as otherwise indicated.

Signs should be individually installed on separate posts or mountings except where:

A. One sign supplements another, or
B. Route or directional signs are grouped to clarify information to motorists, or
C. Regulatory signs that do not conflict with each other are grouped, such as turn prohibition signs posted with one-way signs, street name signs posted with a stop or yield sign, or a parking regulation sign posted with a speed limit sign.

Signs should be located so that they:

A. Are outside the clear zone unless placed on a breakaway or yielding support;
B. Optimize nighttime visibility;
C. Minimize the effects of mud splatter and debris;
D. Do not obscure each other; and
E. Are not hidden from view.

Standard (MUTCD 2003, Section 2A.16)

Signs requiring different decisions by the road user shall be spaced sufficiently far apart for the required decisions to be made safely. One of the factors considered when determining the appropriate spacing shall be the posted or 85th percentile speed.

Because regulatory and warning information is more critical to the road user than guidance information, regulatory and warning signing should be displayed rather than guide signing in cases where conflicts occur. Information of a less critical nature should be moved to less critical locations or omitted.

Mounting Height

Standard (partial) (MUTCD 2003, Section 2A.18)

Signs installed at the side of the road in rural districts shall be at least 5 ft, measured from the bottom of the sign to the near edge of the pavement. Where parking or pedestrian movements should occur, the clearance to the bottom of the sign shall be at least 7 ft.

The height to the bottom of a secondary sign mounted below another sign may be 1 foot less than the height specified.

Lateral Offset

Standard (partial) (MUTCD 2003, Section 2A.19) (See Figure 2-1)

Ground-mounted sign supports shall be breakaway, yielding or shielded with a longitudinal barrier or crash cushion if within the clear zone.

The minimum lateral offset from the edge of the shoulder (or if no shoulder exists, from the edge of the pavement) to the near edge of a roadside-mounted sign should be 6 ft. Roadside-mounted sign supports shall be breakaway, yielding, or shielded with a longitudinal barrier or crash cushion if within the clear zone. In areas where lateral offsets are limited [the case on many low-volume roads] a minimum lateral offset of 2 ft. may be used.

All supports should be located as far as practical from the edge of the shoulder. Advantage should be taken to place signs behind existing roadside

barriers, on over-crossing structures, or other locations that minimize the exposure of the traffic to sign supports.

Standard (MUTCD 2003, Section 2A.19)

If signs are placed on existing supports, they shall meet other placement criteria contained in [this manual].

Handbook Discussion

Standardization of location cannot always be obtained in practice; however, see Figure 2-1 for height and lateral location of signs of typical installations.

On many LVR, placing signs 6 ft from the edge of pavement will put the sign in a ditch, weeds or brush. In these cases the 2 ft minimum is generally appropriate. Engineering judgment should be used to determine the most appropriate offset for the best visibility to drivers.

Orientation

Signs should be vertically mounted at right angles to the direction of, and facing, the traffic that they are intended to serve.

Where mirror reflection from the sign face is encountered to such a degree as to reduce legibility, the sign should be turned slightly away from the road. Signs that are placed 30 ft or more from the traveled way should be turned toward the road. On curved alignments, the angle of placement should be determined by the direction of approaching traffic rather than by the roadway edge at the point where the sign is located.

Posts and Mountings

Standard (MUTCD 2003, Section 2A.21)

Sign posts, foundations, and mountings shall be so constructed as to hold signs in a proper and permanent position, and to resist swaying in the wind or displacement by vandalism. [See chapter 5 for details of sign installation and sign support systems.]

RETROREFLECTIVITY AND ILLUMINATION

Standard (MUTCD 2003, Section 2A.08)

Regulatory, warning, and guide signs shall be retroreflective or illuminated to show the same shape and similar color by both day and night, unless specifically stated otherwise in the text discussion in this Manual of a particular sign or group of signs.

The requirements for sign illumination shall not be considered to be satisfied by street or highway lighting. (See Chapter 7 for a discussion of a possible self assessment program.)

Minimum Retroreflectivity Levels (MUTCD 2003, Section 2A.09)

Handbook Discussion: This section of the MUTCD is reserved for future text based on FHWA rulemaking. It is expected that in the future, FHWA will provide guidance on this subject.

Maintenance

All traffic signs should be kept properly positioned, clean, and legible, and should have adequate retroreflectivity. Damaged or deteriorated signs should be replaced.

Employees of highway agencies, police, and other public agencies whose duties require that they travel on the roadways should be encouraged to report any damaged, deteriorated, or obscured signs at the first opportunity.

Steps should be taken to see that weeds, trees, shrubbery, and construction, maintenance, and utility materials and equipment do not obscure the face of any sign.

To insure adequate performance, agencies are encouraged to establish a schedule for both day and night inspections, cleaning and replacement of signs as needed.

Handbook Discussion

It is suggested that agencies consider one of the self assessment methods discussed in Chapter 7 – or develop one of their own. The particular method is less important than having one suitable for the resources available to the agency.

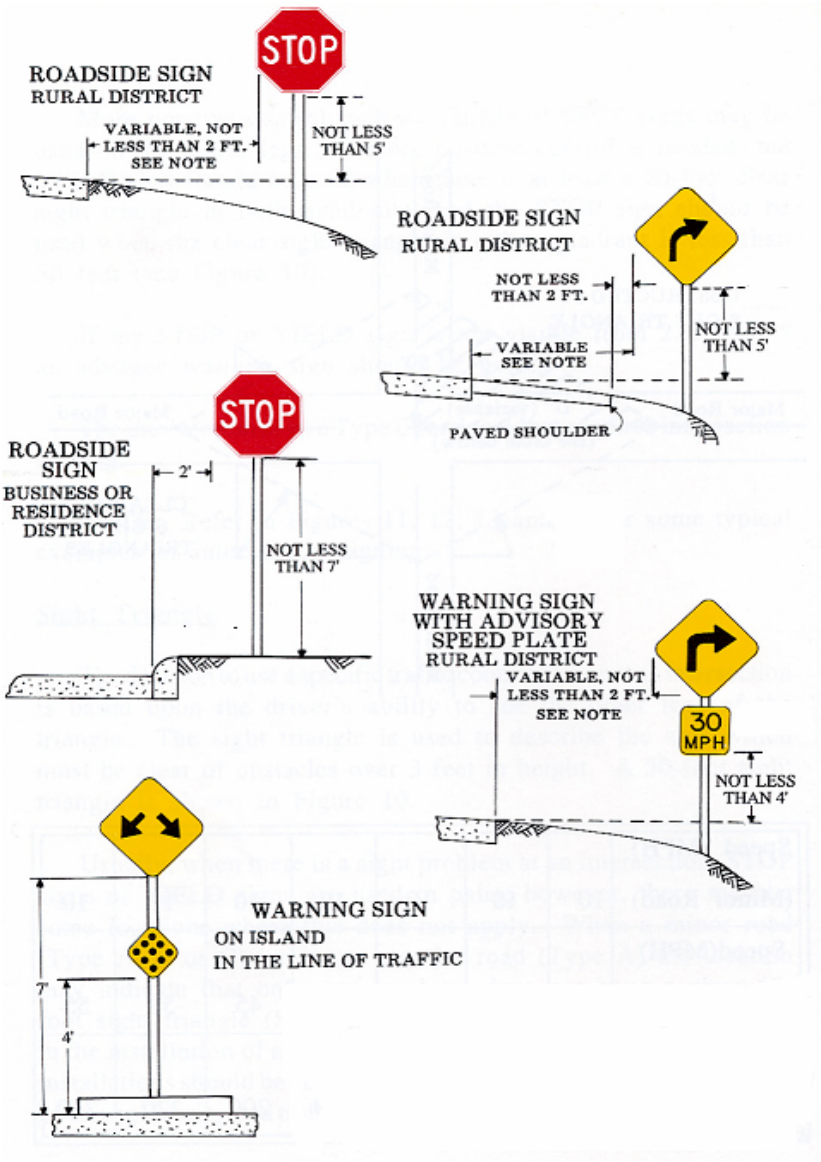


FIGURE 2-1. Height and Lateral Location of Signs
Note: Recommended lateral placement of signs is 6 ft. or greater from the traveled way; if clearance is not available the minimum should be 2 ft.

WARNING SIGNS

General: This section contains excerpts from the MUTCD 2003 that are considered relevant to the LVR Handbook with respect to warning signs. Details of specific, selected warning signs are covered in following sections.

Application of Warning Signs

Standard (MUTCD 2003, Section 2C.02)

The use of warning signs shall be based on an engineering study or on engineering judgment.

The use of warning signs should be kept to a minimum as the unnecessary use of warning signs tends to breed disrespect for all signs. In situations where the condition or activity is seasonal or temporary, the warning sign should be removed or completely covered when the condition or activity does not exist.

Design of Signs

Standard (MUTCD 2003, Section 2A.06)

Where a Standard word message is applicable, the wording shall be as herein [MUTCD] provided. Standardization of these designs does not preclude further improvement by minor changes in the proportion or orientation of symbols, width of borders, or layout of word messages, but all shapes and colors shall be as indicated.

Design of Warning Signs

Standard (MUTCD 2003, Section 2C.03)

All warning signs shall be diamond-shaped (square with one diagonal vertical) with a black legend and border on a yellow background unless specifically designated otherwise. Warning signs shall be designed in accordance with the sizes, shapes, colors, and legends contained in the "Standard Highway Signs" book. [Available from FHWA]

Handbook Discussion

For word signs, only minor changes should be considered. Also, all word messages shall use standard wording and letters as shown in the MUTCD 2003, the “Standard Highway Signs” book and the “Standard Alphabets for Highway Signs and Pavement Marking” (MUTCD 2003, Section 2A.14, Word Messages) For symbols only those shown in the MUTCD 2003 are allowed. (MUTCD 2003, Section 2A.13 Symbols).

If it is feasible, sight obstructions should be removed so that warning signs can be minimized. At all times signs shall be visible and kept clear of obstructions such as trees, bushes, and weeds.

Placement Of Warning Signs (MUTCD 2003, Section 2C.05)

Table 2-1 at the end of this section lists suggested sign placement distances for three conditions. This table is provided as an aid for determining warning sign location.

The distances contained in handbook Table 2-1, page 2-12, [MUTCD 2003, Table 2C-4], are for guidance purposes and should be applied with engineering judgment. Warning signs should not be placed so far in advance of the condition, that drivers might tend to forget the warning because of other driving distractions, especially in urban areas.

Minimum spacing between warning signs with different messages should be based on the estimated PIEV time for driver comprehension of and reaction to the second sign. In general, on LVR with 55 mph speed limit, they should not be closer than 200 ft.

The effectiveness of the placement of warning signs should be periodically evaluated under both day and night conditions.

Advance Warning Sign Placement

Warning signs shall be erected in accordance with the general requirements for sign position as described in MUTCD 2003 Section 2A-21 to 29 and Illustrated previously in this handbook.

Since warning signs are primarily for the benefit of the driver who is unacquainted with the road, it is very important that care be given to the placement of such signs. Warning signs should provide adequate time for the driver to perceive, identify, decide, and perform any necessary maneuver. This total time to perceive and complete a reaction to a sign is the sum of the times necessary for Perception (seeing), Identification (understanding), Emotion (decision making), and Volition (execution of decision), and is referred to as the PIEV time. A simple example would be the total time from when a motorist sees something blocking the road ahead to the instant he/she gets his/her foot on the brake, but does not include brake reaction time or braking time. The PIEV time can vary from about 2.5 seconds for general warning signs to 10 seconds for high driver judgment condition warning signs. The following Table 2.1 gives suggested minimum sign placement distances.

The values contained in the table are for guidance purposes and should be applied with engineering judgment. For help in determining an appropriate value, refer to the notes below Table 2-1 (Reprint of MUTCD 2003 Table 2C-4).

TABLE 2-1. Advance Placing Distance (MUTCD 2003 Table 2C-4)

Posted or 85th-Percentile Speed	Advance Placement Distance[1]								
	Condition A: Speed Reduction And Lane Changing In Heavy Traffic[2]	Condition B: Deceleration to the listed advisory speed (mph) for the condition[4]							
		0[3]	10	20	30	40	50	60	70
20 mph	225 ft	N/A[5]	N/A[5]	---	---	---	---	---	---
25 mph	325 ft	N/A[5]	N/A[5]	N/A[5]	---	---	---	---	---
30 mph	450 ft	N/A[5]	N/A[5]	N/A[5]	---	---	---	---	---
35 mph	550 ft	N/A[5]	N/A[5]	N/A[5]	N/A[5]	---	---	---	---
40 mph	650 ft	125 ft	N/A[5]	N/A[5]	N/A[5]	---	---	---	---
45 mph	750 ft	175 ft	125 ft	N/A[5]	N/A[5]	N/A[5]	---	---	---
50 mph	850 ft	250 ft	200 ft	150 ft	100 ft	N/A[5]	---	---	---
55 mph	950 ft	325 ft	275 ft	225 ft	175 ft	100 ft	N/A[5]	---	---
60 mph	1100 ft	400 ft	350 ft	300 ft	250 ft	175 ft	N/A[5]	---	---
65 mph	1200 ft	475 ft	425 ft	400 ft	350 ft	275 ft	175 ft	N/A[5]	---
70 mph	1250 ft	550 ft	525 ft	500 ft	425 ft	350 ft	250 ft	150 ft	---
75 mph	1350 ft	650 ft	625 ft	600 ft	525 ft	450 ft	350 ft	250 ft	100 ft

Notes:

[1] The distances are adjusted for a sign legibility distance of 175 ft for Condition A. The distances for Condition B have been adjusted for a sign legibility distance of 250 ft, which is appropriate for an alignment warning symbol sign.[2] Typical conditions are locations where the road user must use extra time to adjust speed and change lanes in heavy traffic because of a complex driving situation. Typical signs are Merge, Right Lane Ends. The distances are determined by providing the driver a PIEV time of 14.0 to 14.5 seconds for vehicle maneuvers (2001 AASHTO Policy, Exhibit 3-3, Decision Sight Distance, Avoidance Maneuver E) minus the legibility distance of 175 ft for the appropriate sign.

[3] Typical condition is the warning of a potential stop situation. Typical signs are Stop Ahead, Yield Ahead, Signal Ahead, and Intersection Warning signs. The distances are based on the 2001 AASHTO Policy, Stopping Sight Distance, Exhibit 3-1, providing a PI time of 2.5 seconds, a deceleration rate of 11.2 ft/second^2, minus the sign legibility distance of 175 ft.

[4] Typical conditions are locations where the road user must decrease speed to maneuver through the warned condition. Typical signs are Turn, Curve, Reverse Turn, or Reverse Curve. The distance is determined by providing a 2.5 second PIEV time, a vehicle deceleration rate of 10 ft/second^2, minus the sign legibility distance of 250 ft.

[5] No suggested distances are provided for these speeds, as the placement location is dependent on site conditions and other signing to provide an adequate advance warning.

Other miscellaneous warning signs that advise of potential hazards not related to a specific location may be installed in the most appropriate locations since they are not covered in the table. These include DEER CROSSING and

SOFT SHOULDER signs. Minimum spacing between warning signs with different messages normally should be based on the PIEV times for driver comprehension and reaction.

The effectiveness of the placement of any warning sign should be tested periodically by driving under both day and night conditions. For further information see MUTCD 2003, Section 2C.05.

Handbook Discussion

It is important to take great care to place signs only where they are needed in order to prevent breeding disrespect for the signs.

The two basic criteria for placement of advance warning signs are the approach speed and the reduced speed required to comply with the sign message. All signs should be located so as to be viewed by motorists without obstruction for a distance of at least 175 feet based upon deceleration from 55 mph to 30 mph Table 2-1 (Condition B, MUTCD 2003, Table 2C-4). This distance varies according to prevailing (operating) speeds if an engineering study so determines (See next section).

Placing signs in dips or beyond the crest of hills, and placing informational signs on curves should be avoided.

SELECTED WARNING SIGNS

The following pages of this section will illustrate several warning signs used frequently on low-volume roads. The first series will be Intersection Warning Signs (W2-1 through W2-6).

The intersection sign should illustrate and depict the general configuration of the intersecting roadway, such as cross road, side road, t-intersection, y-intersection, circular intersection (roundabout) or curvilinear alignment. Where the side roads are not opposite each other, the symbol for the intersection should indicate a slight offset.

The relative importance of the intersecting roadways may be shown by different widths of lines on the symbol.

Intersection signs (other than the Circular Intersection symbol (W2-6) sign and the T-intersection (W2-4) sign) should not be used on approaches controlled by STOP signs, YIELD signs, signals, or where Junction signing or advance route turn assembly signs are present.

W2-1

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-20

CROSS ROAD SIGN (W2-1) (MUTCD 2003, Section 2C.37)

The CROSS ROAD sign is intended for use on a through highway to indicate the presence of an obscured crossroad intersection. The relative importance of the intersecting roads may be shown by different widths of the line in the diagram. The diagram for a crossroad intersection with a slight offset should indicate that the side roads are not opposite each other. If the crossroad occurs in the vicinity of a curve, additional or skewed legs may be indicated on the diagram, the symbol may be modified appropriately.

EXAMPLE: Figure 2-3; p. 2-27

W2-2R

W2-3R

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-20

SIDE ROAD SIGN (W2-2, W2-3) (MUTCD 2003, Section 2C. 37)

The SIDE ROAD sign, showing a side-road symbol, either left or right, and at an angle of either 90 or 45 degrees, is intended for use in advance of a side-road intersection according to the same warrants as set forth for the CROSS ROAD sign. The relative importance of the intersecting roads may be shown by different widths of line in the diagram. If the side road occurs in the vicinity of a curve, the symbol may be modified appropriately.

W2-4

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-20

T- SYMBOL SIGN (W2-4) (MUTCD 2003, Section 2C.37)

The T - SYMBOL sign is intended for use to warn traffic approaching a T-intersection on the road where traffic must make a turn either to the left or the right. The relative importance of the intersecting roads may be shown by different widths of line in the diagram. It may be desirable to place a **TWO DIRECTIONAL LARGE ARROW (W1-7)** sign or chevrons on the far side of the T-intersection directly in line with approaching traffic.

EXAMPLE: Figures 2-4, pp. 2-28

W2-5

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-20

Y- SYMBOL SIGN (W2-5) (MUTCD 2003, Section 2C.37)

The Y- SYMBOL sign is intended for use to warn traffic approaching a Y-intersection on the road that forms the stem of the Y. The sign should not generally be used at a Y-intersection that is channelized by traffic islands. The relative importance of the intersecting roads may be shown by different widths of line in the diagram. It may be desirable to erect a TWO DIRECTIONAL LARGE ARROW (W1-7) sign at the fork of the Y directly in line with approaching traffic.

EXAMPLE: Figure 2-4; pp. 2-28

W2-6

30" x 30"
See MUTCD 2003
Page 2C-20

CIRCULAR INTERSECTION (W2-6) (MUTCD 2003, Section 2C.37)

The circular intersection symbol sign accompanied by an educational plaque may be installed in advance of a circular intersection. It should be installed on all approaches to a YIELD sign controlled roundabout intersection.

Handbook Discussion

MUTCD 2003 shows a TRAFFIC CIRCLE (W16-12p) educational plaque. There is a difference between traffic circles and roundabouts. If the circular intersection ahead is a roundabout, a ROUNDABOUT educational plaque should be used.

W3-1

W3-1a
Standard Size
36” x 36”
Minimum Size
30” x 30”
See MUTCD 2003
Page 2C-14

STOP AHEAD SIGN (W3-1a) (MUTCD 2003, Section 2C.29)

A STOP AHEAD sign is intended for use on an approach to a STOP sign that is not visible for a distance to permit the driver to bring his vehicle to a stop at the STOP sign (Handbook Table 2-1 provides guidance for placement.) Obstruction(s) causing the limited visibility may be permanent or intermittent. The STOP AHEAD sign shall be minimum of 30" x 30". It may also be used for emphasis where there is poor observance of the STOP sign.

EXAMPLES: Figure 2-3, 2-4; pp. 2-27, 2-28

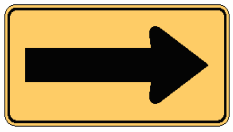
W3-2

W3-2a
Standard Size
36” x 36”
Minimum Size
30” x 30”
See MUTCD 2003
Page 2C-19

YIELD AHEAD SIGN (W3-2) (MUTCD 2003, Section 2C.29)

A YIELD AHEAD sign is intended for use on an approach to a YIELD sign that is not visible for a distance to permit the driver to bring his vehicle to a stop at the YIELD sign. (Handbook Table 2-1 provides guidance on placement.). Obstruction(s) causing the limited visibility may be permanent or intermittent. The YIELD AHEAD sign shall be a minimum of 30" x 30" in size.

EXAMPLES: Figure 2-4; pp. 2-28



W1-6R
Standard Size
48” x 24”
See MUTCD 2003
Page 2C-7

LARGE ARROW SIGN (W1-6R)

Standard (MUTCD 2003, Section 2C.09)

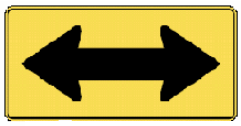
The One-Direction Large Arrow sign shall be a horizontal rectangle with an arrow pointing to the left or right.

If used, the One-Direction Large Arrow sign shall be installed on the outside of a turn or curve in line with and at approximately a right angle to approaching traffic.

The One-Direction Large Arrow sign shall not be used where there is no alignment change in the direction of travel, such as at the beginnings and ends of medians or at center piers.

The LARGE ARROW sign shall be a horizontal rectangle with a standard size of 48" x 24", having a LARGE ARROW (Wl-6R) or a TWO DIRECTIONAL LARGE ARROW (Wl-7). It shall have a yellow background with symbol in black. A LARGE ARROW sign is intended to be used to give

notice of a sharp change in alignment in the direction of travel. To be effective the LARGE ARROW sign should be visible for at least 500 feet and trial runs by day and night may be desirable to determine final positioning.



W1-7

Standard Size
48" x 24"
See MUTCD 2003
Page 2C-20

TWO DIRECTION LARGE ARROW SIGN (W1-7)

Standard (MUTCD 2003, Section C.38)

The Two-Direction Large Arrow (W1-7) sign shall be a horizontal rectangle.

If used, it shall be installed on the far side of a T-intersection in line with, and at approximately a right angle to, approaching traffic.

The Two-Direction Large Arrow sign shall not be used where there is no change in the direction of travel such as at the beginnings and ends of medians or at center piers.

The TWO DIRECTION LARGE ARROW sign shall be a horizontal rectangle with a standard size of 48" x 24", having a large arrow (Wl-6R) or a double head arrow (Wl-7). It shall have a yellow background with symbol in black. A TWO DIRECTION LARGE ARROW sign is intended to be used to give notice of a sharp change in alignment in the direction of travel.

EXAMPLE: Figure 2-4; p. 2-28

W1-8

Standard Size
18" x 24"
See MUTCD 2003
Page 2C-7

CHEVRON ALIGNMENT SIGN (Wl-8)

Standard (MUTCD 2003, Section 2C.10)

The Chevron Alignment sign shall be a vertical rectangle. No border shall be used on the Chevron Alignment sign.

If used, Chevron Alignment signs shall be installed on the outside of a turn or curve in line with and at approximately a right angle to approaching traffic.

The Chevron Alignment sign shall have a minimum size of 12" x 18". It shall have a yellow background with chevron symbol in black. The size of sign used should be determined by an engineering study or engineering judgment.

A Chevron Alignment sign may be used as an alternate or supplement to standard delineators and to the Large Arrow sign. Chevron Alignment sign is

intended to provide additional emphasis and guidance for vehicle operators as to changes in horizontal alignment of the roadway.

When used, Chevron Alignment signs, shall be installed, erected on the outside of a curve, sharp turn, or on the far side of an intersection, in line with and at approximately a right angle to approaching traffic.

Spacing of the signs should be such that the motorists always have two in view. To be effective, Chevron Alignment signs should be visible for at least 500 feet; trial runs by day and night may be desirable to determine final positioning. (See Appendix 4 for suggested placement guidelines.)

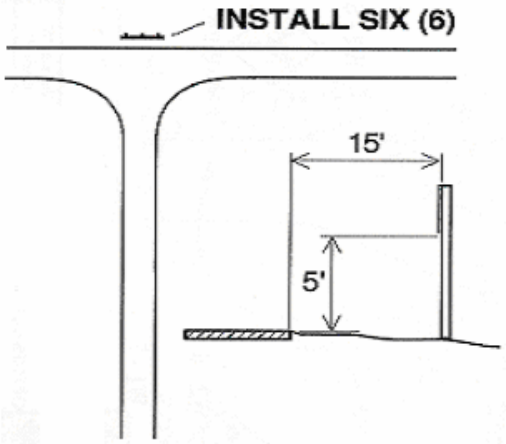
EXAMPLE: Figure 2-2; pp. 2-16

Replacement of the TWO DIRECTION LARGE ARROW at T-intersections

The Chevron alignment sign may be used in place of the two-directional large arrow at T-intersections. A series of six chevrons are placed side by side. (Three pointing left, three pointing right as shown in Figure 2-2, which shows typical chevron placements at T-intersections, used in place of the double arrow).

Two-post Structure

Three-post Structure



*NOTE:
Standard size: 18"x24"
or larger size signs may be used

FIGURE 2-2 Example Chevron Installation at T-intersection

Cattle Crossings

The cattle crossing sign is one of a series of nonvehicular Traffic Signs (MUTCD 2003, Section 2C-41) which includes cattle, pedestrians, deer and other standard symbols.

Standard: (MUTCD 2003, Section 2C.41)

When used at the crossing, nonvehicular signs shall be supplemented with a diagonal downward pointing arrow (W16-7p) plaque showing the location of the crossing.

W11-4

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-22

The Advance CATTLE CROSSING sign should be used if the cattle cross at least twice a day most of the year and/ or the stopping sight distance is inadequate.

Handbook Discussion

The Advance CATTLE CROSSING sign is intended to alert drivers that cattle may be crossing in the roadway ahead. There is a possibility that the driver may develop a disregard for the sign's meaning when cattle are not seen in the roadway at several CATTLE CROSSING sign locations. The driver's respect for the sign can be increased by placing the CATTLE CROSSING sign only when and where an engineering study or engineering judgment determines it is needed.

In general, nonvehicular signs should be used only at locations where the crossing activity is unexpected or at locations not readily apparent.

If cattle cross less than once a day but more than once a week, the responsible agency should use engineering judgment to decide whether to use permanent signs, temporary signs or no signs at all. The reasons for the decision should be recorded.

These guidelines may be used for other animal crossing signs.

When used in advance of a crossing, nonvehicular warning signs may be supplemented with supplemental plaques with the legend AHEAD XX FEET, or NEXT XX MILES to provide advance notice to road users of crossing activity.

For open range country a CATTLE CROSSING sign with a supplementary plate NEXT X MILES may be used.

Supplemental Plaques (MUTCD 2003, Section 2C.43)

W16-7P

MUTCD 2003
Page 2C-23

The supplemental plaque W16-7P is mandatory (standard) when a nonvehicular crossing sign is placed at a crossing.

Use of Supplemental Plaques (MUTCD 2003, Section 2C.43)

A supplemental plaque may be displayed with a warning sign when engineering judgment indicates that road users require additional information beyond that contained in the main message of the warning sign.

Standard: (MUTCD, Section 2C.43)

Supplemental plaques shall be used only in combination with warning or regulatory signs. They shall not be mounted alone or displayed alone. If used, a supplemental plaque shall be installed on the same post(s) as the warning sign.

Design of Supplemental Plaques

Standard (MUTCD 2003, Section 2C.44)

A supplemental plaque shall have the same color legend, border, and background as the warning sign with which it is displayed. Supplemental plaques shall be square or rectangular.

REGULATORY SIGNS

Application of Regulatory Signs

Standard: (MUTCD 2003, Section 2B.01)

Regulatory signs shall be used to inform road users of selected traffic laws or regulations and indicate the applicability of the legal requirements.

Regulatory signs shall be installed at or near where the regulations apply. The signs shall clearly indicate the requirements imposed by the regulations and shall be designed and installed to provide adequate visibility and legibility in order to obtain compliance.

Regulatory signs shall be retroreflective or illuminated to show the same shape and similar color by both day and night, unless specifically stated otherwise in the text discussion of a particular sign or group of signs.

The requirements for sign illumination shall not be considered to be satisfied by street, highway, or strobe lighting.

Intersections

It is desirable for a driver to have an unobstructed view of the intersection and a length of the intersecting road sufficient to permit stopping or slowing the vehicle to avoid collisions. The minimum sight distance considered safe under various conditions is related directly to vehicle speeds and to the distances traveled while the driver sees the situation, reacts and brakes, and should be determined by an engineering study.

Those unfamiliar with the principles of intersection sight distance should read Appendix 3.

Descriptions of Traffic Control Devices and Uses

Given below is MUTCD 2003 language relative to LVR for regulatory and warning signs for intersections.

REGULATORY SIGNS

R1-1

Standard Size
30" x 30"
Minimum Size
24" x 24"
See MUTCD 2003
Page 2B-9

STOP SIGN (R1-l) (MUTCD 2003, Section 2B.05)

Because the STOP sign causes an inconvenience to motorists, it should be used only where appropriate.

STOP signs should not be used unless engineering judgment indicates that one or more of the following conditions exist:

A. Intersection of a less important road with a main road where application of the normal right-of-way rule would not be expected to provide reasonably safe operation.

B. Street entering a through highway or street.

C. Unsignalized intersection in a signalized area.

D. High speeds, restricted view, or crash records indicate that a need for control by the STOP sign.

E. At Railroad Grade Crossings, under specific conditions (See chapter 3 for signing Railroad grade crossings).

SEE EXAMPLE: Figure 2-3, p.2-27

Handbook Discussion

In the State of Kansas, installation of a regulatory sign on a county or township road must be authorized by a resolution approved by the County Commissioners.

Additional Important Considerations

- STOP signs should not be used for speed control.
- STOP signs should be installed in a manner that minimizes the numbers of vehicles required to stop.
- The decision regarding the appropriate street to stop should be based on engineering judgment.
- A STOP sign should not be installed on the major street unless justified by a traffic engineering study.

Standard (MUTCD 2003, Section 2B.05)

Because the potential for conflicting commands could create driver confusion, STOP signs shall not be installed at intersections where traffic control signals are installed and operating except as noted in [MUTCD 2003 Section 4D.01].

Portable or part-time STOP signs shall not be used except for emergency and temporary traffic control zone purposes.

[MUTCD 2003, Section 4D.01 lists two exceptions:]

Standard (partial) (MUTCD 2003, Section 4D.01)

A. If the signal indication is flashing red at all times, or

B. If a minor street or drive is located within or adjacent to the area controlled by the traffic control signal, but does not require separate traffic signal control because an extremely low potential for conflict exists.

STOP Sign Placement

The STOP sign shall be installed on the correct side of the traffic lane to which it applies.

When visibility is restricted such that the clear distance to the STOP sign is not sufficient to permit a driver to safely stop a Stop Ahead sign shall be installed in advance of the STOP sign. (See Table 2-1 or MUTCD 2003 Table 2C-4 for guidance on the distance.)

STOP and YIELD signs shall not be mounted on the same post.

- Stop lines, when used, should be located at the point where the road user should stop.
- If only one stop sign is installed on an approach, it should be placed on the near, right side.
- Where roads intersect at an acute angle, the STOP sign should be set at an angle or shielded so it is out of view of the traffic to which it does not apply.
- Where there is a marked crosswalk at the intersection the STOP sign should be installed in advance of the crosswalk.

MULTIWAY STOP APPLICATIONS (MUTCD 2003, Section 2B.07)

Multiway stop control is used where volume on the intersecting roads is approximately equal if certain traffic conditions exist.

If the number of approach legs controlled by STOP signs at an intersection is 3 or more, the numeral on the supplemental plaque if used, shall correspond. At intersections where all approaches are controlled by STOP signs, a supplemental plaque (R1-3 or R1-4) shall be mounted below each STOP sign.

R1-3

Standard Size
12" x 6"

R1-4

Standard Size
18" x 6"

The decision to install multiway stop control should be based on an engineering study.

YIELD SIGN (Rl-2)

R1-2

Standard Size
36" x 36" x 36"
See MUTCD 2003
Page 2B-9

Standard (MUTCD 2003, Section 2B.08)

The YIELD sign shall be installed on the right side of the approach to which it applies. YIELD signs shall be placed on both the left and right sides of approaches to roundabout intersections with more than one lane on the signed approach where raised splitter islands are available on the left side of the approach. When the YIELD sign is installed at this required location and the sign visibility is restricted, a YIELD Ahead sign shall be installed in advance of the YIELD sign. (See Table 2-1 or MUTCD 2003, Table 2C-4 for guidance.)

The YIELD sign shall be located as close as practical to the intersection it regulates, while optimizing its visibility to the road user it is intended to regulate.

YIELD signs and stop signs shall not be mounted on the same post.

YIELD Sign Placement (MUTCD 2000, Section 2B.10)

The YIELD sign shall be located as close as practical to the intersection it regulates, while optimizing its visibility to the road user it is intended to regulate.

YIELD and STOP signs shall not be mounted on the same post.

YIELD lines, when used, should be located at a point where the road user should yield.

Where two roads intersect at an acute angle, the YIELD sign should be positioned or shielded so the legend is out of view to the traffic to which it does not apply.

Where there is a marked crosswalk at the intersection, the YIELD sign should be installed in advance of the crosswalk line nearest to the approaching traffic.

YIELD Sign Applications (MUTCD 2003, Section 2B.09)

YIELD signs may be used instead of STOP signs if engineering judgment indicates one or more of the following conditions exist.

A. When the ability to see potentially conflicting traffic is sufficient to allow a road user traveling at the posted speed, the 85th percentile speed, or the statutory speed to pass through the intersection or to stop in a safe manner.
B. If controlling a merge-type movement on the entering roadway where acceleration geometry and/or sight distance its not adequate for merging traffic operation.
C. At the second crossroad of a divided highway where the median width is 30 ft or greater. A STOP sign may be installed at the entrance to the first roadway and a YIELD sign may be installed at the entrance to the second roadway.
D. At any intersection where a special problem exists and where engineering study indicates the problem to be susceptible to correction by use of the YIELD sign.

See EXAMPLE: Figure 2-4; p. 2-27

Handbook Discussion

Note that condition A above, which should be followed unless an engineering study or engineering judgment determines otherwise, differs from

previous editions of the MUTCD and LVR handbook. For example, say 85th percentile speed is 50 mph. According to Table 2-1 (MUTCD 2C-4) a driver would need 250 ft of stopping sight distance for installing a YIELD sign.

However, currently the compliance date for the new language (MUTCD 2003) on the YIELD sign is January 17, 2011. Also, guidance on the use of the yield sign is under review by FHWA and could change in the near future (2005).

R2-1

Standard Size
24" x 36"

SPEED LIMIT SIGN (R2-1)

Standard (MUTCD 2003, Section 2B.13)

After an engineering study has been made in accordance with established traffic engineering practices, the speed limit sign shall display the limit established by law, ordinance, regulation or as adopted by the authorized agency. The speed limit shown shall be in multiples of 5 mph.

The most common practice is to use the 85th percentile speed. If a public jurisdiction is not familiar with common, appropriate methods to set proper speed limits, KDOT or a consultant should be contacted.

When a speed limit is to be posted, it should be the 85th percentile speed of free-flowing traffic, rounded up to the nearest 5 mph increment.

Location of Speed Limit Signs

Standard (MUTCD 2003, Section 2B.15)

Speed Limit (R2-1) signs, indicating speed limits for which posting is required by law, shall be located at the points of change from one speed limit to another.

At the end of the section to which a speed limit applies, a Speed Limit sign showing the next speed limit shall be installed. Additional Speed Limit signs shall be installed beyond major intersections and at other locations where it is necessary to remind road users of the speed limit that is applicable.

Speed Limit signs indicating the statutory speed limits shall be installed at entrances to the State and at jurisdictional boundaries of metropolitan areas.

At locations where the speed limit changes at a specific point on the roadway for opposite directions of traffic flow, be sure the speed limit signs are opposite each other to avoid overlapping speed zones.

Speed Reduction Signs (W3-5, W3-5a) (MUTCD 2003, Section 2C.30)

W3-5

Standard Size
30" x 30"

The speed reduction sign series W3-5, W3-5a are warning signs in MUTCD 2003. They are included in the Warning Sign section.

A speed reduction sign (W3-5 or W3-5a) should be used to inform road users of a reduced speed zone ahead when engineering judgment indicates the need for advance notice to comply with the posted speed limit ahead.

Standard: (MUTCD 2003, Section 2C.30)

W3-5a

Standard Size
30" x 30"

If used, Speed Reduction signs shall be followed by a Speed Limit (R2-1) sign installed at the beginning of the zone where the speed limit applies.

The speed limit displayed on the speed reduction sign shall be identical to the speed limit displayed on the subsequent Speed Limit sign.

SIGN PLACEMENT ILLUSTRATIONS

The following pages illustrate recommended sign placements. Engineering judgment should be used in all cases.

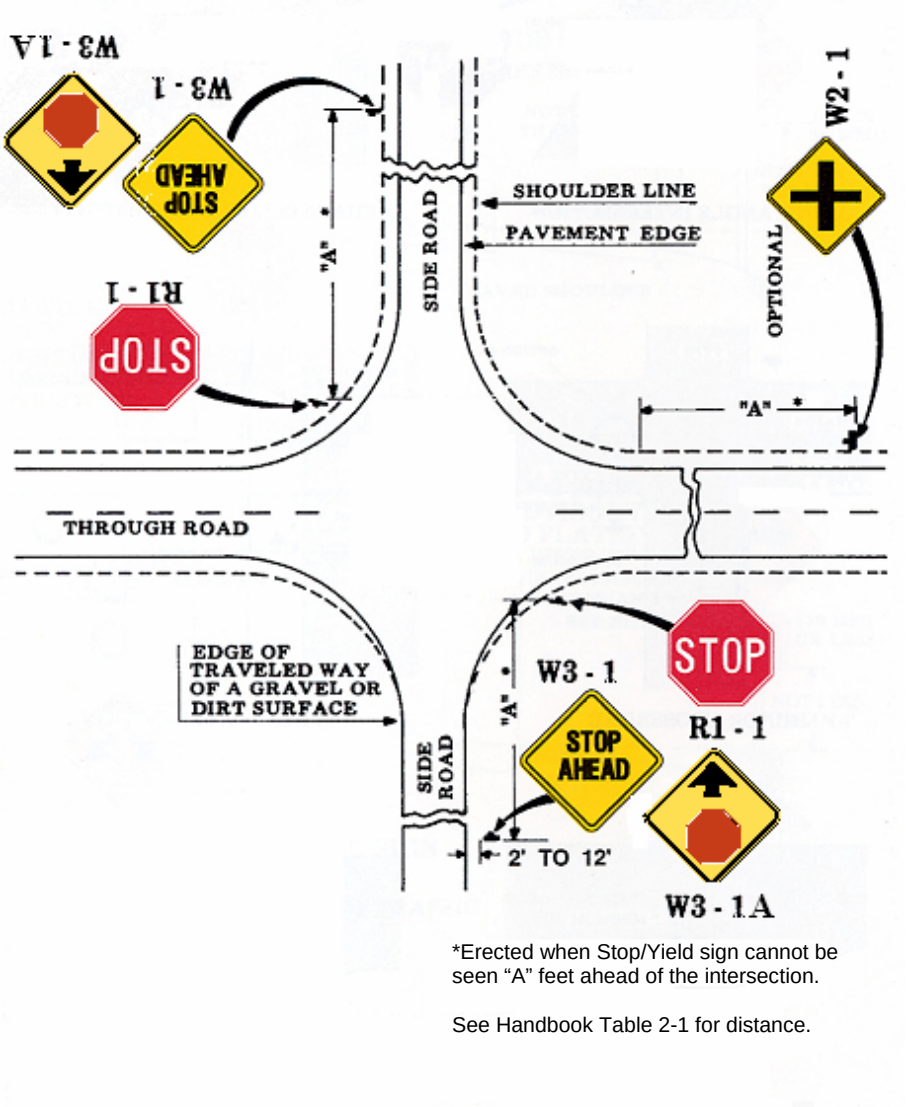
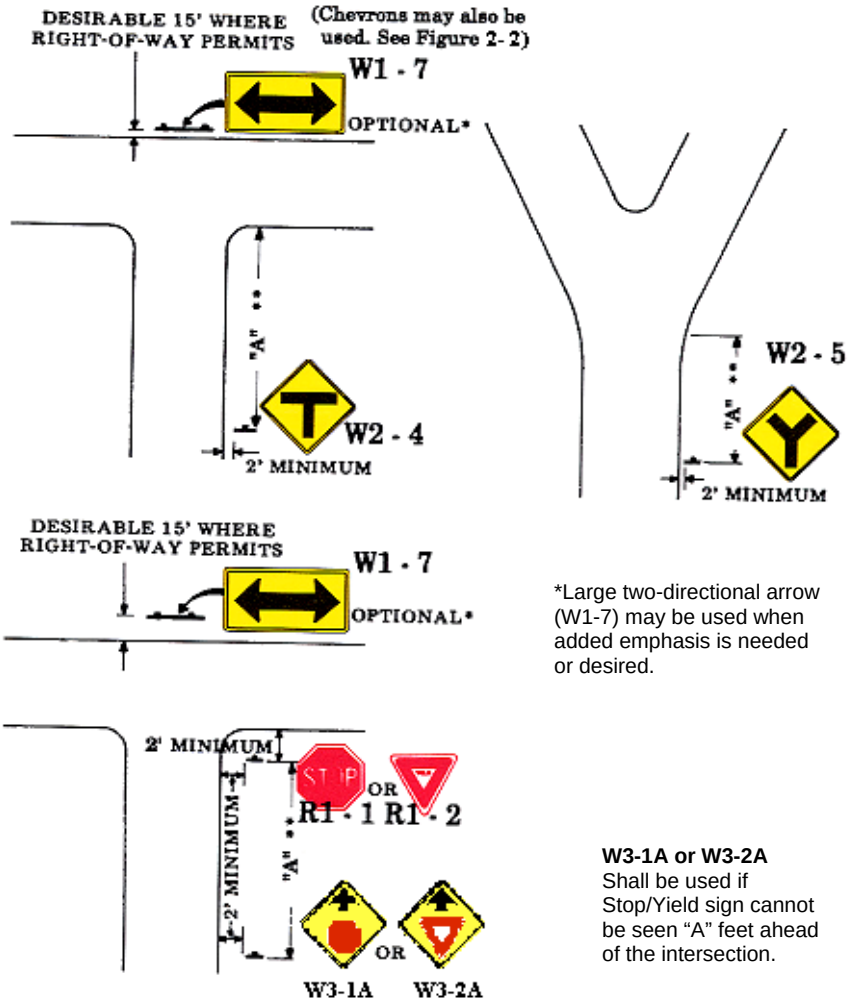


FIGURE 2-3. Example Location of Signs on a Wide Throated Intersection



*Large two-directional arrow (W1-7) may be used when added emphasis is needed or desired.

W3-1A or W3-2A
Shall be used if Stop/Yield sign cannot be seen "A" feet ahead of the intersection.

**(See Handbook Table 2-1, Page 2-9 for "A" Distances)

FIGURE 2-4. Example Location of Signs on T and Y Intersections
Note: Intended for use on minor roadways

HORIZONTAL ALIGNMENT SIGNS: TURNS AND CURVES

Handbook Discussion

Curve and turn signs are common on LVR, and their proper application may be important for reducing crash risk by enhancing driver expectancies of curves and turns ahead. This subsection addresses important issues related to signing curves and turns.

TURN and CURVE warning signs inform a driver of a change in the horizontal direction of the roadway. Before the decision can be made to use this type of sign, and which specific sign to use, engineering judgment should take many factors into consideration. First, the higher of the operating approach speeds prevailing speed or the established speed limit, must be compared with the advisory safe speed of the curve in order to establish whether a TURN sign or a CURVE sign is necessary as well as to determine the need for an advisory speed plate. (See section on Advisory Safe Speed Determination on p. 2.36) Other considerations include using engineering judgment to determine if the curve is consistent with the previous roadway alignment, and the nature of the road with regard to driver expectancy.

Steering a vehicle through a roadway curve does not in itself present a hazard. The potential hazard due to an alignment change occurs when it is unexpected or more severe than anticipated.

Change in MUTCD 2000 and 2003

Previous editions of the MUTCD clearly specified when a Turn (W1-1) or Curve (W1-2) sign must be used. If an engineering study with a ball bank indicator indicated that the curve advisory speed was 30 mph or less, a Turn sign would be used; whereas, if the advisory speed was greater than 30 mph a Curve sign would be used. In MUTCD 2000, continued in MUTCD 2003, the Curve/Turn speed distinctions have been maintained and should normally be used. *However, the MUTCD now allows the use of engineering judgment. (See note 1 under Table 2-2). This allows use of a curve sign on a low-speed road with a gradual change in horizontal alignment; and the use of a Turn sign on high-speed roads with a sharp change in alignment.* Unless there is good reason to do otherwise (which should be documented) the choice should be based on Table 2-2.

Horizontal Alignment Signs (W1-1 through W1-5) (MUTCD 2003, 2C.06)

The Horizontal Alignment Turn (W1-1), Curve (W1-2), Reverse Turn (W1-3), Reverse Curve (W1-4), or Winding Road (W1-5) signs may be used in advance of situations where the horizontal roadway alignment changes. A Large

Arrow (W1-6) sign may be used on the outside of the turn or curve. (See page 2-15)

The application of these signs should conform to MUTCD 2003 Table 2C-5 (Handbook Table 2-2 below) unless engineering judgment determines otherwise.

TABLE 2-2. Horizontal Alignment Sign Usage (Adapted from Table 2C-5, MUTCD 2003)

Number of Alignment Changes	Advisory Speed	
	≤ 30 MPH	> 30 MPH
1	Turn (W1-1)[1]	Curve (W1-2)[1]
2[2]	Reverse Turn[3](W1-3)	Reverse Curve[3](W1-4)
3 or more[2]	Winding Road[3](W1-5)	

Notes:

[1] Engineering judgment should be used to determine whether the turn or curve should be used.

[2] Alignment changes are in opposite directions and are separated by a tangent distance of 600 ft or less.

[3] A right Reverse turn (W1-3R), Right Reverse Curve (W1-4R), or Right Winding Road (W1-5R) Sign is used if the first change in alignment is to the right; a Left Reverse Turn (W1-3L), Left Reverse Curve (W1-4L), or Left Winding Road (W1-5L) sign is used if the first change in alignment is to the left.

Combination Horizontal Alignment/Advisory Speed Signs (MUTCD 2003, Section 2C.07)

The turn (W-1) sign or the curve sign (W1-2) sign may be combined with the Advisory Speed (W13-1) plaque to create a combination Horizontal Alignment/Advisory Speed (W1-2a) sign.

Standard (MUTCD 2003, Section 2C.07)

When used, the combination Horizontal Alignment/Advisory Speed sign shall supplement other advance warning signs and shall be installed at the beginning of the turn or curve.

The minimum size of the W1-2a sign shall be 48 inches x 48 inches for high-speed facilities, and 36 x 36 inches for low-speed facilities. (A W1-1a sign is shown on page 2-35). It is suggested in MUTCD 2003, that if the reduction in speed is 15 mph or greater, the supplemental combination Horizontal Alignment/Advisory Speed sign be used, and if the reduction is 25 mph or greater, one or more additional Curve Speed signs may be installed.

Description of Horizontal Alignment Signs and Uses (MUTCD 2003, Section 2C.06)

W1-1L

W1-1R

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-7

TURN SIGN (W1-1)

The TURN sign (W1-1R or W1-1L) was intended for use where engineering studies of roadway, geometric, and operating conditions show the advisory speed of a turn to be 30 MPH or less, and this advisory speed is equal to or less than the speed limit established by law or by regulation for that section of highway. MUTCD 2003 states that engineering judgment may be used to determine whether the Turn or Curve sign should be used. Where a TURN sign is used, a LARGE ARROW sign may be used on the outside of the turn. Additional protection may be provided by use of the ADVISORY SPEED plaque (W13-1).

Except in emergencies or when the condition is temporary, an Advisory Speed plaque shall not be installed until the recommended speed is determined by an engineering study.

EXAMPLE: Figure 2-9; p. 2-41

W1-2L

W1-2R

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-7

CURVE SIGN (W1-2)

The CURVE sign (W1 -2R or W1-2L) should be used where engineering judgment determines the need and, usually, conditions are such that the advisory speed is greater than 30 MPH and equal to or less than the speed limit established by law or by regulation for that section of highway. MUTCD 2003 states that engineering judgment may be used to determine whether the Turn or Curve sign should be used. Additional protection may be provided by use of the ADVISORY SPEED plaque.

EXAMPLE: Figure 2-10; p. 2-42

W1-3L

W1-3R

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-7

REVERSE TURN SIGN (Wl-3)

The REVERSE TURN sign is intended for use to mark two turns or a CURVE and a TURN in opposite directions as defined previously for TURN and CURVE signs that are separated by a tangent of 600 feet or less. If the first turn is to the right, a RIGHT REVERSE TURN sign (Wl-3R) shall be used and if the first turn is to the left, a LEFT REVERSE TURN sign (Wl-3L) shall be used.

For additional protection the ADVISORY SPEED plate may be used.

Engineering judgment may be used to decide between REVERSE CURVE and REVERSE TURN signs; however, Table 2-2 should normally be used.

W1-4R

W1-4L

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-7

REVERSE CURVE SIGN (Wl-4)

The REVERSE CURVE sign is intended for use to mark two curves in opposite directions, as defined previously for curve signs that are separated by a tangent of 600 feet or less. If the first curve is to the right, a RIGHT REVERSE CURVE sign (Wl-4R) shall be used, and if the first curve is to the left, a LEFT REVERSE CURVE sign (WI-4L) shall be used.

For additional protection the ADVISORY SPEED plate may be used.

Engineering judgment may be used to decide between REVERSE CURVE and REVERSE TURN signs; however, Table 2-2 should normally be used.

Handbook Discussion

Curve warning signs illustrating a more realistic diagram of the actual curve, other than those pictured in the MUTCD 2003 may provide more positive guidance under special conditions. If such a diagrammatic sign is used, it shall conform to the general specifications for sign design found in the MUTCD 2003.

W1-5L

W1-5R

Standard Size
30" x 30"
See MUTCD 2003
Page 2C-7

WINDING ROAD SIGN (Wl-5)

The WINDING ROAD sign is intended for use where there are three or more turns or curves, as defined previously for TURN and CURVE signs, separated by tangent distances of 600 feet or less. If the first turn or curve is to the right, a RIGHT WINDING ROAD sign (Wl-5R) shall be used and if the first curve or turn is to the left, a LEFT WINDING ROAD sign (WI-5L) shall be used.

If the WINDING ROAD sign is used it shall be erected in advance of the first curve.

Additional guidance may be provided by the installation of road delineation markers and by use of an ADVISORY SPEED plate.

The signs may include a distance plaque (MUTCD 2003, Section 2C.43) indicating a length of roadway over which the winding road condition exists.

Figure 2-6 illustrates the use of a winding road sign.

W13-1

Standard Size
24” x 24”
Minimum Size
18” x 18”
See MUTCD 2003
Page 2C-16

ADVISORY SPEED Plate (W13-1)

The ADVISORY SPEED plate is intended for use to supplement warning signs. It may be used in conjunction with any standard yellow warning sign to indicate the maximum recommended speed around a curve or through a location where a lower speed would be appropriate for same condition (determined by engineering judgment or an engineering study). It shall not be used alone. The combination Horizontal Alignment/Advisory Speed Sign shown below may also be used.

EXAMPLES: Figure 2-9, 2-20; pp. 2-41, 2-42

W1-2R with W13-1

W1-1a

Standard Size
30” x 30”
See MUTCD 2003
Page 2C-7

COMBINATION HORIZONTAL ALIGNMENT/ ADVISORY SPEED SIGN (W1-1a) (MUTCD 2003, Section 2C.07)

The Turn (W1-1a) sign or the curve (W1-2a) sign may be combined with the Advisory Speed (W13-1) plaque to create the combined sign (W1-1a)

W1-10

Standard Size
30” x 30”
See MUTCD 2003
Page 2C-7

COMBINATION HORIZONTAL ALIGNMENT/ INTERSECTION SIGN (W1-10)

The Turn (W1-1) sign or the curve (W1-2) sign may be combined with the cross road sign (W2-1) or the side road sign (W2-2 or W2-3) sign to create a combined sign (W1-10) that depicts the condition where an intersection or side road occurs on a curve or a turn.

ADVISORY SAFE SPEED, DETERMINATION

The advisory safe speed of a curve can be determined by the use of a ball bank indicator, also known as a slope meter (see Figure 2-5).

Ball Bank Indicator

The ball bank indicator can be attached to a vehicle's dash by using the rig shown in Figures 2-7 and 2-8.

The ball bank indicator rig shown has two adjustable straps - straps with a buckle device or two "D" rings - attached to the top of the ball bank indicator plate. The top straps have hooks to enable the use of the defroster vents. The bottom two straps are elastic straps with hooks on both ends. Hook one end to the plate and the other to the bottom of the dash.

FIGURE 2-5. A Curve and Its Diagrammatic Sign

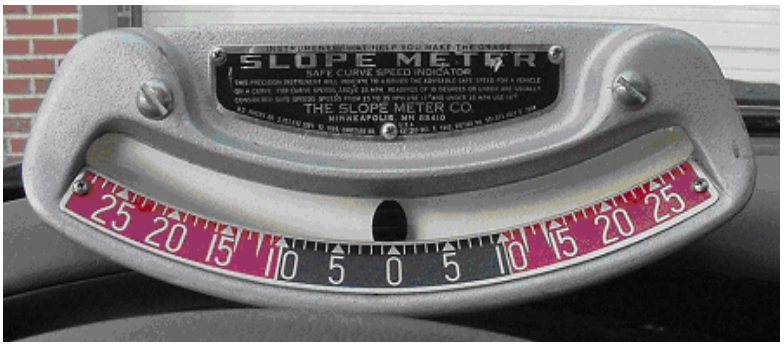


FIGURE 2-6. Ball Bank Indicator

Table 2-3 is intended for use in determining signing for Curves and Turns for LVR in good condition (relatively wide, with good geometrics and surface.) It may also be used for poor (narrow, rough, curvy) LVR roads if engineering judgment considers positive guidance from the road itself inadequate at specific locations.

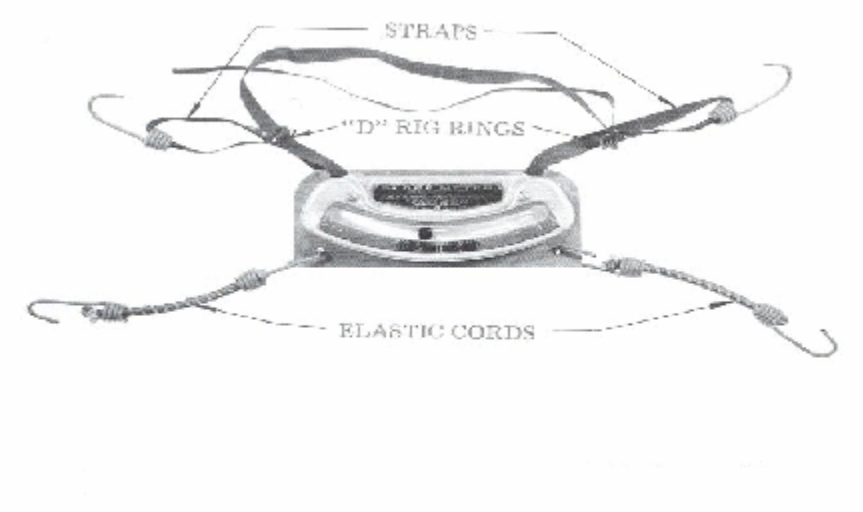


FIGURE 2-7. Example of Ball Bank Indicator Rig

A more permanent attachment is shown in Figure 2-7

Using the Ball Bank Indicator

The first trial run is made at a speed somewhat below the anticipated maximum safe speed. Subsequent trial runs are conducted with 5 mph speed increments. If a reading of 14 degrees or greater occurs at 20 mph or less then the safe speed is below 20 mph. The curve should be signed for that speed, i.e., 10 or 15 mph, at which a 14 degrees reading occurs. A reading of 12 degrees at a trial speed of 20, 25, and 30 mph indicates that the trial speed, i.e., 20, 25, or 30 mph is the safe speed. A reading of 10 degrees at speeds of 35 mph or greater indicates a safe speed of 35 mph or greater (Traffic Control Devices Handbook, 2001).

FIGURE 2-8. Example of Ball Bank Indicator Mounted permanently on Vehicle Dash

TABLE 2-3. Signing for Curves and Turns *
(Source: Kansas State University, LVR Handbook, 2nd edition)

Advisory Speed Based on Ball Bank Indicator

Operating Speed (Usually 85th Percentile Speed)	60	55	50	45	40	35	30	25	20
60			C	CA	CA	CA	TA	TA	TA
55				C	CA	CA	TA	TA	TA
50					C	CA	TA	TA	TA
45						C	TA	TA	TA
40							T	TA	TA
35								T	TA
30									T
25									
20 or less									

*optional, unofficial guidelines developed by Kansas State University.

Key
C - Curve Sign, Reverse Curve Sign
(or winding road sign if applicable)
T - Turn Sign, Reverse Turn Sign
(or winding road sign if applicable)
A - Advisory Speed Plate

NOTE: Refer to Figures 2-9 and 2-10 for some typical examples of curve and turn signing.

W1-8

Standard Size
18” x 24”
See MUTCD 2003
Page 2C-7

CHEVRON ALIGNMENT SIGN (Wl-8)

The CHEVRON ALIGNMENT sign shall be a vertical rectangle with a minimum size of 12" by 18". It shall have a yellow background with chevron symbol in black.

Chevron Alignment signs should be visible for a sufficient distance to provide the road user with adequate time to react to the change in alignment.

Chevron Alignment signs should be such that the road user always has at least two in view, until the change in alignment eliminates the need for the signs. (See Appendix 4 for one method of spacing and placement on curves).

W14-3

Standard Size
36” x 48” x 48”
See MUTCD 2003
Page 2C-17

NO PASSING ZONE SIGN (W14-3)

The NO PASSING ZONE sign should be used on paved two-lane roads to warn of the beginning of no-passing zones identified either by conventional pavement markings, DO NOT PASS signs, or both. When used, it shall be erected on the left side of the roadway at the beginning of the no-passing zones identified by pavement markings, DO NOT PASS signs, or both.

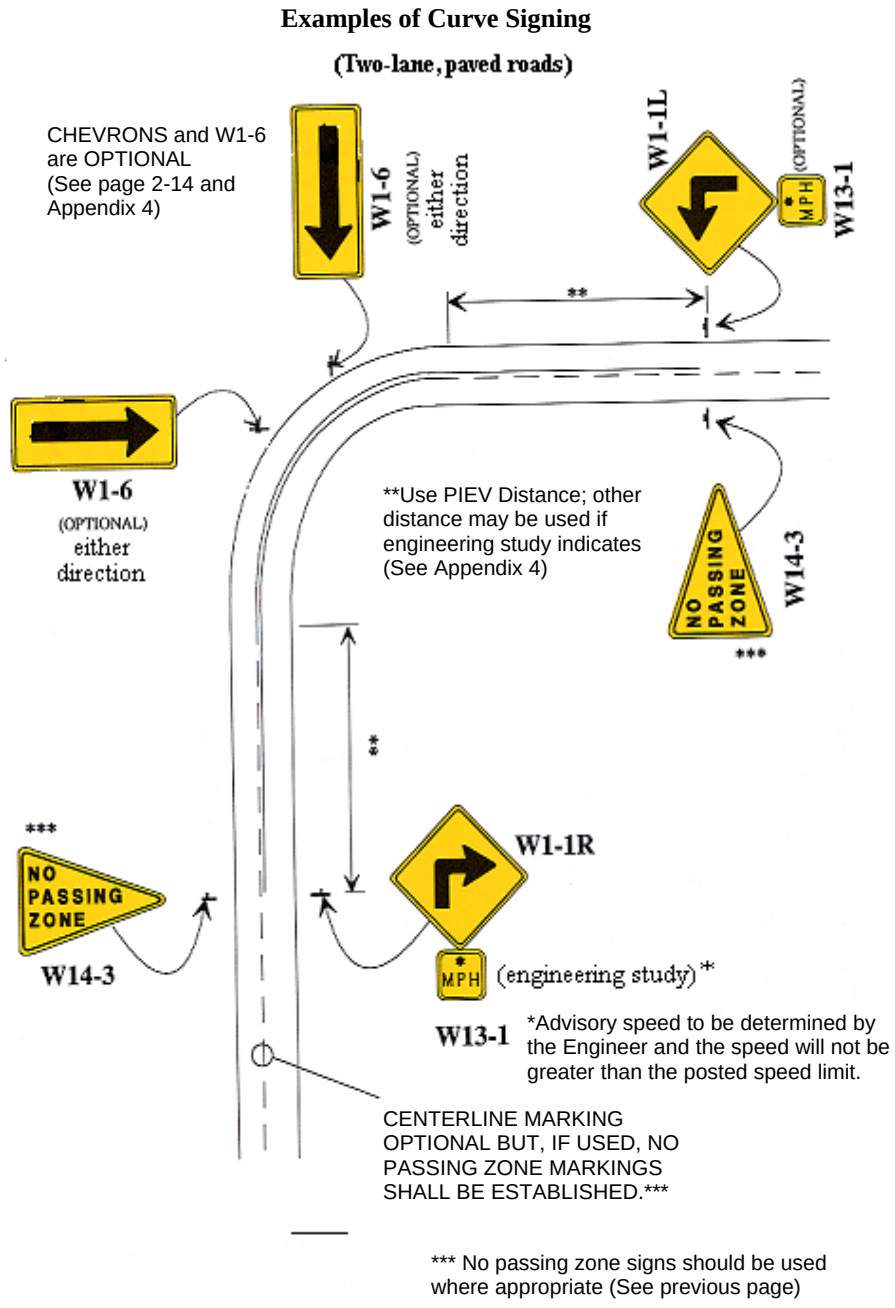


FIGURE 2-9. Example Signing and Pavement Marking on a Turn with Safe Driving Speed 30 MPH or Less

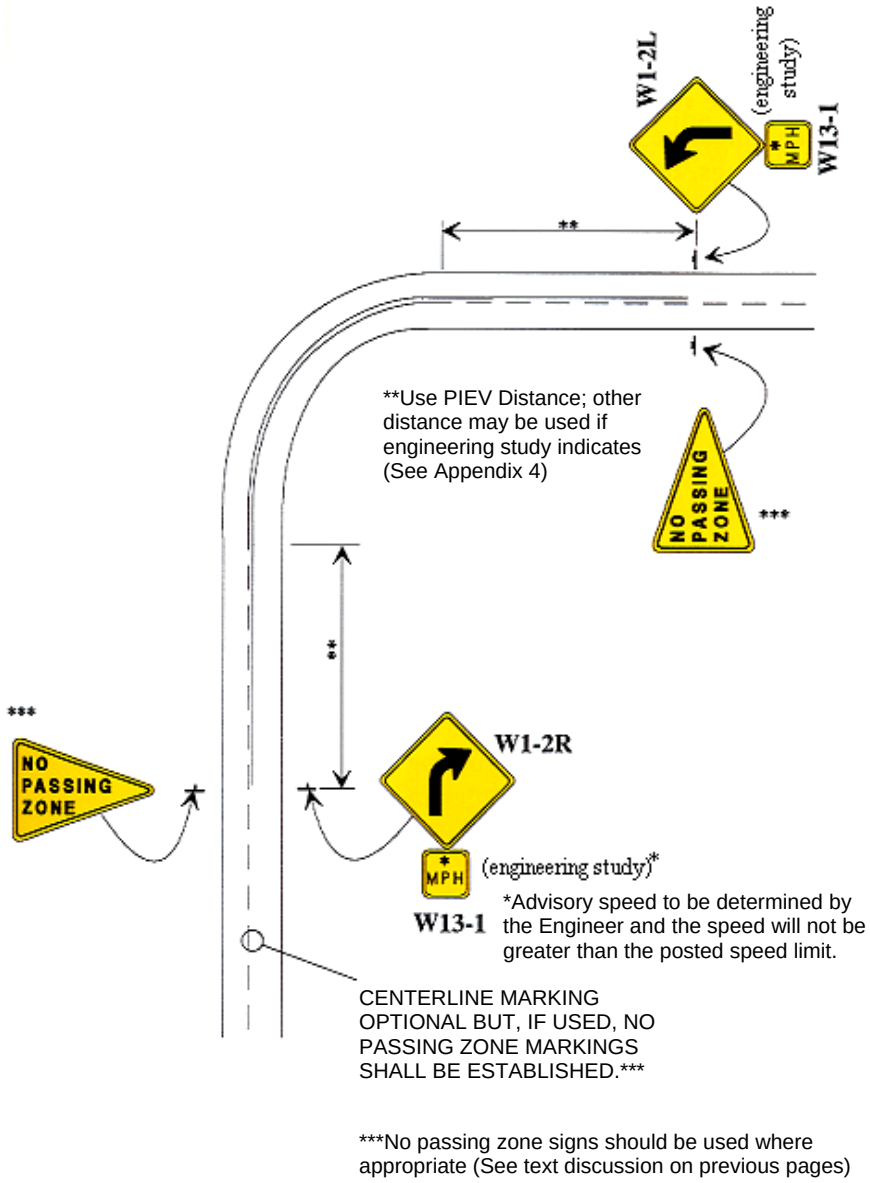


FIGURE 2-10. Example Signing and Pavement Marking on a Turn with Safe Driving Speed Between 35 and 50 MPH

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CHAPTER 3
HIGHWAY-RAIL INTERSECTION (HRI) SIGNING

(RAILROAD GRADE CROSSINGS)

Description and Use of Key Traffic Control Devices

There are three types of traffic control devices, which provide the driver with information about a Highway-Rail Intersection, commonly called grade crossings (HRI).

The RAILROAD CROSSING (Crossbuck) signs (R15-1) and if needed the accompanying sign (R15-2), to identify the existence of more than one track) are intended for use at each approach of the crossing itself (See Figure 3-1 on page 3-2). The placement and the maintenance of these signs are the responsibility of the railroad company in accordance with Kansas Statutes. Missing or damaged crossbucks should be reported to the railroad concerned or to the Coordinating Section in the KDOT Bureau of Design.

A strip of retro reflective white material not less than 2 inches in width shall be used on the back of each blade of each Crossbuck sign for the length of each blade, at all highway-rail grade crossings, except those where Crossbuck signs have been installed back-to-back. Back to back crossbucks are required by statute in Kansas.

A strip of retroreflective white material, not less than 2-inch in width, shall be used on each support at highway-rail grade crossings for the full length of the front and back of the support for the Crossbuck sign or Number of Tracks sign to near ground level. This is a recommended practice in Kansas as well as an MUTCD standard.

Two things should be pointed out in regard to the above standard; 1) it is the responsibility of the railroad involved and 2) it has a 10-year phase in period.

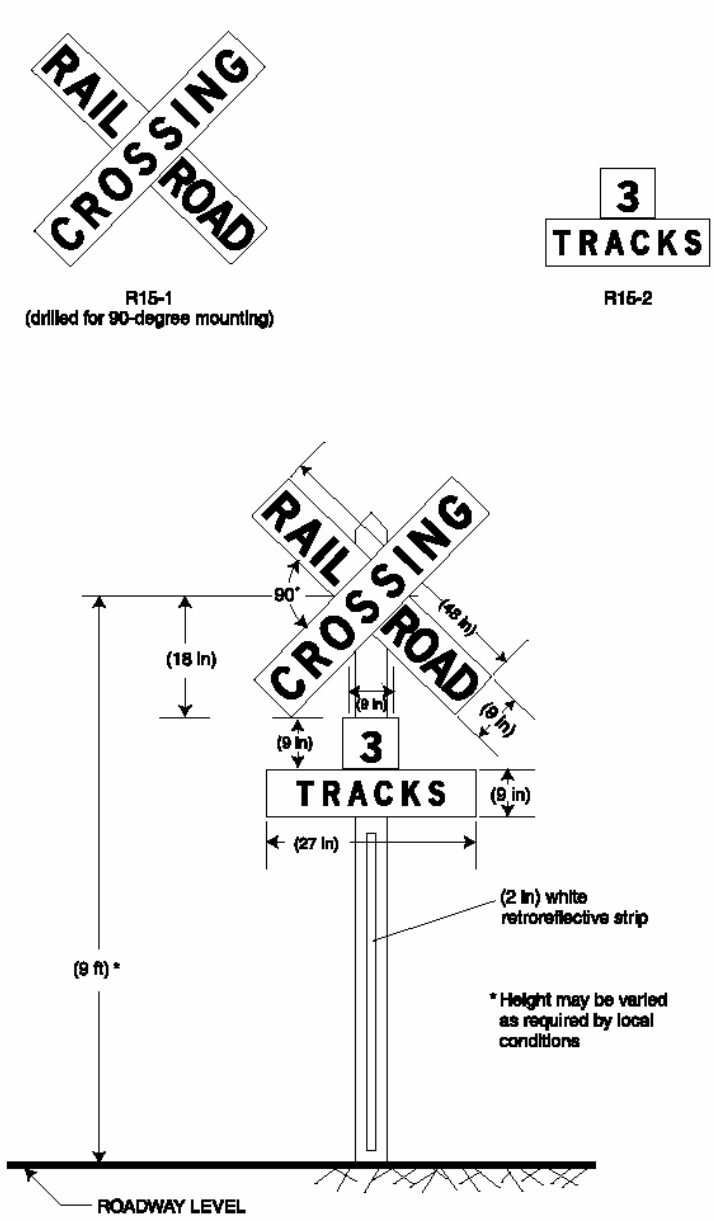
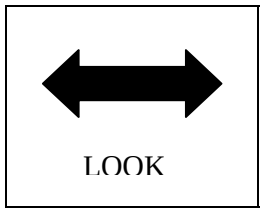


FIGURE 3-1: Highway-Rail Grade Crossing (Crossbuck) Signs **(**MUTCD 2003 Figure 8B-1)



Look Sign (R15-8) (MUTCD 2003, Section 8B.16)

The Look sign (R15-8) is an optional sign that may be mounted as a supplemental plaque on the crossbuck (R15-1) sign post or as a separate sign in the immediate vicinity of the highway-rail grade crossing on the railroad right-of-way.

Handbook Discussion

The look sign is relatively new sign (2000). Research has shown that it increased looking behavior of approaching drivers. Since it is installed on the crossbuck post, (a railroad sign in most states) on railroad property, railroad cooperation and permission should be obtained.

Highway-Rail Grade Crossing Advance Warning Signs (W10 Series) MUTCD 2003, Section 8B.03

W10-1

Standard Size
36" Diameter
See MUTCD 2003
Page 8B-5

RAILROAD ADVANCE Warning Signs (W10-1, 2,3,4)

According to the MUTCD 2003, a RAILROAD ADVANCE (W10-1) warning sign shall be used on each roadway in advance of every grade crossing, with very few exceptions. (See Standard below.) This sign is the responsibility of the local agency that has jurisdiction over the approaching roadway.

W10-2

Standard Size
30" x 30"
See MUTCD 2003
Page 8B-5

W10-3

Standard Size
30" x 30"
See MUTCD 2003
Page 8B-5

W10-4

Standard Size
30" x 30"
See MUTCD 2003
Page 8B-5

Standard (MUTCD 2003, Section 8B.03)

A Highway-Rail Grade Crossing Advance Warning (W10-1) Sign shall be used on each highway in advance of every highway-rail grade crossing except in the following circumstances:

A. **On an approach to a highway-rail grade crossing from a T-intersection with a parallel highway, if the distance from the edge of the track to the edge of the parallel roadway is less than 30 m (100 ft), and W10-3 signs are used on both approaches of the parallel highway; or**

B. On low-volume, low-speed highway crossing minor spurs or other tracks that are infrequently used and are flagged by train crews; or

C. In business districts where active highway-rail grade crossing traffic control devices are in use; or

D. Where physical conditions do not permit even a partially effective display of the sign.

According to MUTCD 2003 the W10-2, 3 and 4 signs should be installed on highways that are parallel to the railroad. The purpose of these signs is to warn a motorist making a turn that a railroad crossing is ahead. Where there is 100 feet or more between the railroad and the parallel highway, a W 10- 1 sign should be installed in advance of the railroad crossing and the W10-2, 3 or 4 signs on the parallel highway would not be necessary (See Figure 3-2)

W10-11

Standard Size
30" x 30"
See MUTCD 2003
Page 8B-9

Handbook Discussion

The W10-2, 3 and 4 may be modified or oriented to conform to the existing geometrics. For example, the W10-11 sign shown at the left is a W10-3 sign oriented for different geometrics. Other signs can be oriented or reversed as needed to satisfy the geometrics of the roadways and the railroad tracks.

STOP (R1-1) and YIELD (R1-2) Signs at Highway-Rail Grade Crossings

The use of the STOP and YIELD signs at

railroad-highway grade crossings is allowed under certain conditions (see next section for discussion) however, two things should be kept in mind:

1. The use of the STOP and YIELD is at the discretion of the responsible state agency and in Kansas, the decision is the responsibility of the Secretary of Transportation according to state statutes. K.S.A. allows the Secretary to designate crossings as dangerous and erect stop signs at them. Local governments should not erect stop signs at railroad-highway grade crossings unless approval of the secretary is obtained. (Contact the KDOT coordinating section.)
2. Their use is an option in MUTCD 2003 and only for highway-rail grade crossings that have two or more trains per day [defined as 720 trains per year] and are without automatic traffic control devices; otherwise, the decision should be made based on an engineering study.

Handbook Discussion

Several research studies have concluded that STOP signs at grade crossings have limited compliance, and should be limited to those grade crossings selected after need is established by a detailed traffic engineering study. Such crossings should have the following general characteristics:

- Highway should be secondary in character with low traffic counts.
- Train traffic should be substantial (at least two trains per day).
- Line of sight to an approaching train is restricted by physical features such that approaching traffic is required to reduce speed to 10 mph or less in order to stop safely for a train.
- At the stop line, there must be sufficient sight distance down the track to afford ample time for a vehicle to cross the track before the arrival of the train.

The engineering study may determine other compelling reasons for the need to install a STOP sign, such as an interim measure until active traffic control signals can be installed.

STOP signs shall not be used on primary through highways or at grade crossings with active traffic control devices.

The authors believe that the new condition "A" for the YIELD sign introduced in MUTCD 2000 and continued in MUTCD 2003, i.e. "When the ability to see all potentially conflicting traffic (train in this case) is sufficient to allow a road user traveling at the posted speed, 85^{th} –percentile speed, or the statutory speed to pass through the intersection or to stop in a reasonably safe manner" applies. Meeting this condition may require more sight distance than is available at most rural HRI.

Because this is a new concept, and somewhat controversial, the entire section 8B-08 is presented below as in MUTCD 2003:

STOP or YIELD Signs at Highway-Rail Grade Crossings (MUTCD 2003, 8B.08) (Check with the KDOT Coordinating Section on the applicability of this section and compatibility with State Statutes)

Option: (MUTCD 2003, Section 8B.07)

At the discretion of the State or State Law, STOP (R1-1) or YIELD (R1-2) signs may be used at highway-rail grade crossings that have two or more trains per day and are without automatic traffic control devices.

Support: (MUTCD 2003, Section 8B.07)

Two or more trains per day means an average of two or more trains per day operating over the highway-rail grade crossing for a 12-month period prior to the installation of the STOP or YIELD control sign.

Option: (MUTCD 2003, Section 8B.07)

For other highway-rail grade crossings with passive warning devices, STOP or YIELD signs may be used based on an engineering study

Guidance: (MUTCD 2003, Section 8B.07)

The engineering study should take into consideration such factors as highway and train traffic characteristics (including volume and speed), collision history, the need for active control devices, and sight distance to the approaching train.

Option: (MUTCD 2003, Section 8B.07)

If a STOP or YIELD sign is installed at a highway-rail grade crossing, it may be installed on the Crossbuck post or on a separate post at the point where the vehicle is to stop, or as near to that point as practical.

Standard (MUTCD 2003, Section 8B.07)

For all highway-rail grade crossings where STOP or YIELD signs are installed, the placement shall conform to the requirements of Chapter 2B [MUTCD 2003]. Stop Ahead (W3-1a) or Yield Ahead (W3-2a) Advance Warning signs shall also be installed if the criteria for their installation given in [MUTCD 2003] Section 2C.29 is met. (See Handbook pages 2-13 and 2-14.)

Examples of HRI Signing
(Source: KDOT Maintenance Manual, 1991)

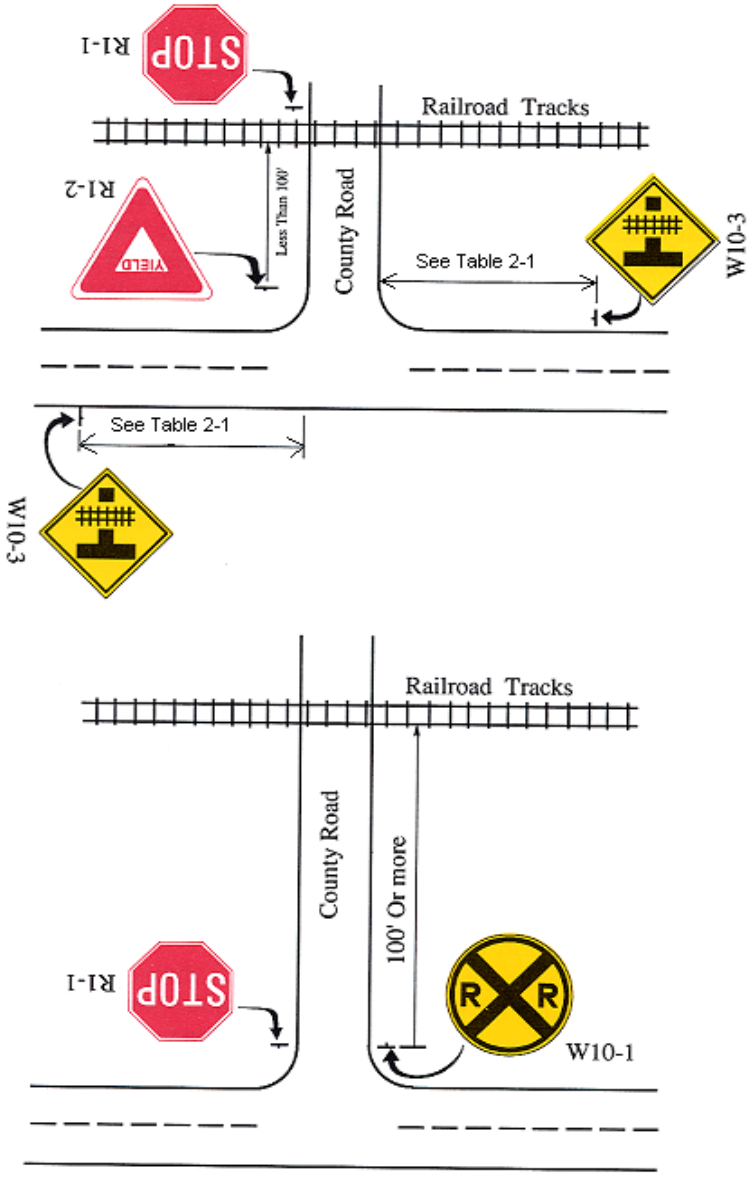


FIGURE 3-2. Advance Stop Warning for Parallel Railroad Grade Crossing
(See pages 3-14 through 3-17 for additional examples)

W10-12

Standard Size
30” x 30”

Skewed Crossing Sign (W10-12), MUTCD 2003, Section 8B.19

The Skewed Crossing (W10-12) sign may be used at a skewed highway-rail grade crossing to warn drivers that the railroad tracks are not perpendicular to the highway.

Guidance:

If the Skewed Crossing sign is used, the symbol should show the direction of the crossing (near left to far right as shown in the figure or the mirror image if the track goes from far left to near right). If the Skewed Crossing sign is used where the angle of the crossing is significantly different than 45 degrees, the symbol should show the approximate angle of the crossing.

Standard (MUTCD 2003, Section 8B.19)

The Skewed Crossing sign should not be used as a replacement for the required Advance Warning (W10-1) sign. If used, the Skewed Crossing sign shall supplement the W10-1 sign and shall be mounted on a separate post.

Handbook Discussion

At passive grade crossing it is the responsibility of the driver to look both ways to determine the presence or absence of a train in order to take proper action. At skewed crossings this action is more difficult because it requires greater head movement. Drivers should be made aware of the track orientation so that they better understand their need and/or are reminded of the added looking effort needed.

W10-11

Standard Size
24” x 30”

Storage Space Signs (W10-11, W10-11a, W10-11b)

A storage space (W10-11) sign supplemented by a word message storage distance (W10-11a) sign should be used where there is a highway intersection in close proximity to the highway-rail grade crossing and an engineering study determines that adequate space is not available to store a design vehicle(s) between the highway intersection and the train dynamic envelope (explained and illustrated in a following section).

W10-11a

Standard Size
24" x 30"

W10-11b

Standard Size
24" x 30"

The storage space (W10-11 and W10-11a) signs should be mounted in advance of the highway-rail grade crossing in an appropriate location to advise drivers of the space available for vehicle storage between the highway intersection and the highway-rail grade crossing.

Handbook Discussion

On LVR the most important "design vehicle" should probably be the school bus. It may be advisable to check storage distance at all grade crossings on school bus routes and consider using the storage space signs.

Pavement Marking

Standard (MUTCD 2003, Section 8B.20)

All highway-rail grade crossing pavement markings shall be retroreflectorized white. All other markings shall be in accordance with Part 3. Pavement markings in advance of a highway-rail grade crossing shall consist of an X, the letters RR, and no-passing marking (two-lane highways where centerline markings are used), and certain transverse lines as shown in (MUTCD 2003) Figures 8B-6 and 8B-7.

Identical markings shall be placed in each approach lane on all paved approaches to highway-rail grade crossings where the posted or statutory highway speed is 40 mph or greater.

Pavement markings shall not be required at highway-rail grade crossings where the posted or statutory highway speed is less than 40 mph, or in urban areas, if an engineering study indicates that other installed devices provide suitable warning and control.

When used, a portion of the pavement-marking symbol should be directly opposite the advance warning sign (See Figures 3-3 and 3-4). If needed, supplemental pavement marking symbol(s) may be placed between the advance warning sign and the crossing. Distances to the advanced warning sign are found in Table 2-1.

Stop Lines (MUTCD 2003, Section 8B.21)

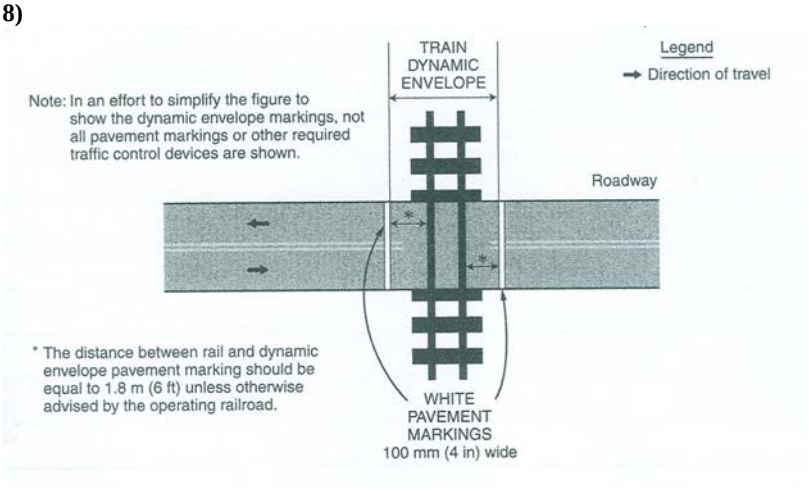
The stop line should be a transverse line at a right angle to the traveled way at a point where a vehicle is to stop or to as near to that point as possible. The stop line should be placed approximately 8 ft from the gate (if present), but no closer than 15 ft from the nearest rail.

Dynamic Envelope Markings

Beginning with MUTCD 2000 train dynamic envelope markings were added. Dynamic Envelope is defined as: the clearance requested for the train and its cargo overhang due to any combination of loading, lateral motion or suspension failure (See figure below).

An engineering study (that should included appropriate railroad personnel) may determine that, where there is a grade crossing near a highway intersection, vehicles might stop within the dynamic envelope area. This situation could result in a train-vehicle crash. Thus MUTCD 2003 has the option of using Dynamic Envelope Markings to reduce the risk of such an occurrence. When used, the markings are white (or a contrasting color), 4 inches wide and installed as shown in the figure.

Typical Train Dynamic Envelope Pavement Markings (MUTCD Figure 8B-8)



No Passing Zone Signs (W14-3) - The "No Passing Zone" sign may be installed at crossings to supplement no passing pavement markings. The sign is to be placed on the left side of the highway at the beginning of the no passing zone. The no passing zone should be 200 ft preceding the grade crossing.

Advisory Speed Plate (W13-1) - The advisory speed plate may be used when sight or geometric conditions for safe stopping distance require a speed lower than the posted speed limit. The advisory speed plate should not be erected until the recommended speed has been determined by an engineering study of the specific crossing. The advisory speed plate must be mounted on the same assembly and is normally below the advance warning sign (W-10 series).

Supplemental Distance Plaque (W16-2)

A supplemental distance plaque may be displayed with a warning sign (such as the Highway-Rail grade crossing Advance Warning Sign W10-1) when engineering judgment indicates the road users requires additional information.

Handbook Discussion

A supplemental distance plaque may be helpful to drivers in location where the actual grade crossing is not clearly visible from the point where they can see the grade crossing advance warning sign (usually considered to be 175 feet from the sign), e.g. because of a curve or other sight impediment or distraction.

Research has indicated that supplemental plaques help drivers to better orient themselves to the grade crossing.

Illumination at Grade Crossings- Handbook Discussion

At grade crossings where railroad operations are conducted at night, particularly where train speeds are low, where crossings are blocked for long periods, or crash history indicates that motorists experience difficulty in seeing trains or control devices during the hours of darkness, illumination at and adjacent to the crossing may be installed to supplement other traffic control devices where an engineering analysis determines that better visibility of the train is needed. Regardless of the presence of other control devices, illumination will aid the motorist in observing the presence of railroad cars on a crossing where the gradient of the vehicular approaches is such that the headlights of an oncoming vehicle shine under or over the cars.

Recommended types and locations of luminaries for grade crossing illumination are contained in the American National Standard Practice for Roadway Lighting, RP8*. In any event, luminaries shall be so located and light there from so directed to adequately illuminate the side of the train. Care must be taken to not interfere with aspects of the railroad signal system and not interfere with the field of view of the locomotive crew. An engineering study should determine the proper placement.

*Available from the Illuminating Engineering Society, New York, N.Y. 10017

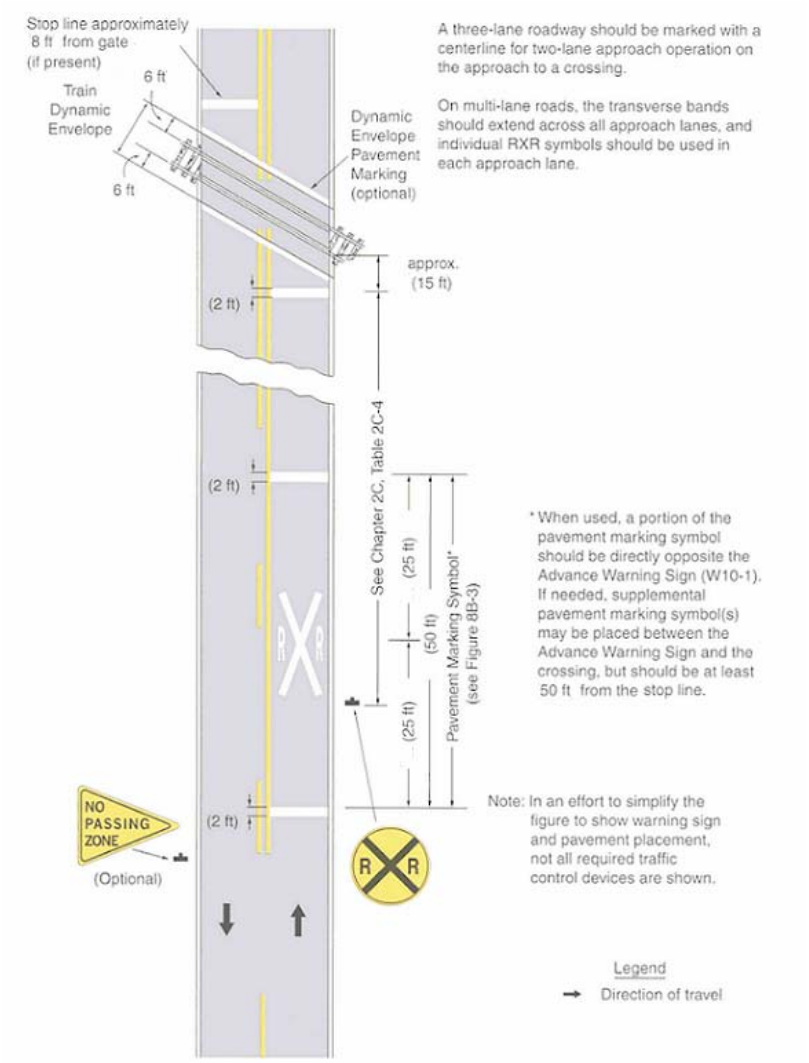


FIGURE 3-3. Example Placement of Warning Signs and Pavement Markings at Railroad-Highway Grade Crossings [Source: MUTCD 2003, Figure 8B-6, page 8B-11] [See next page for alternative (narrow) pavement markings]

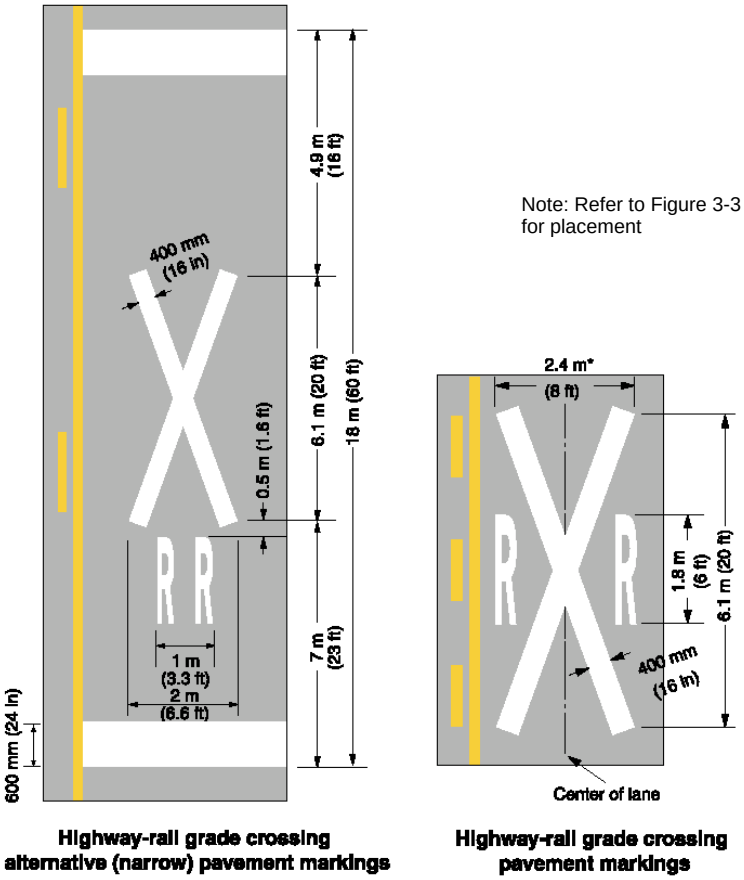
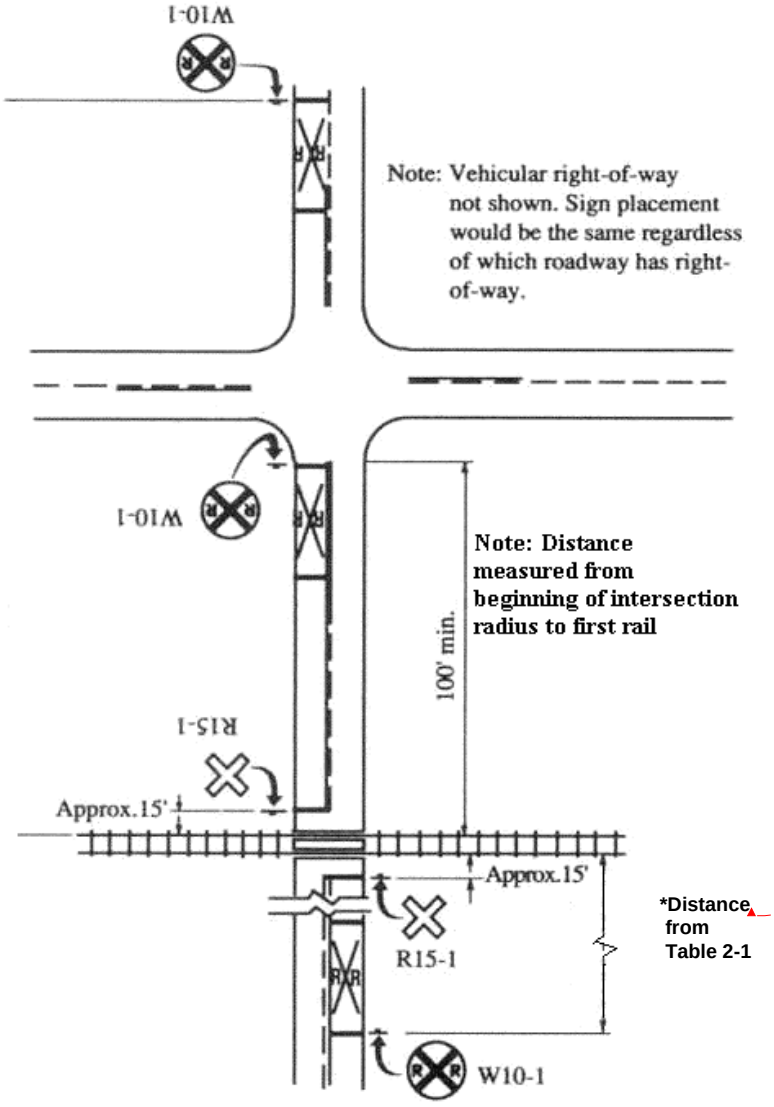


FIGURE 3-4. Example Highway-Rail Grade Crossing Pavement Markings**.**

EXAMPLES OF GRADE CROSSINGS WITH TYPICAL SIGN PLACEMENT FOR VARIOUS COMMON LAYOUTS



*Distance from Table 2-1

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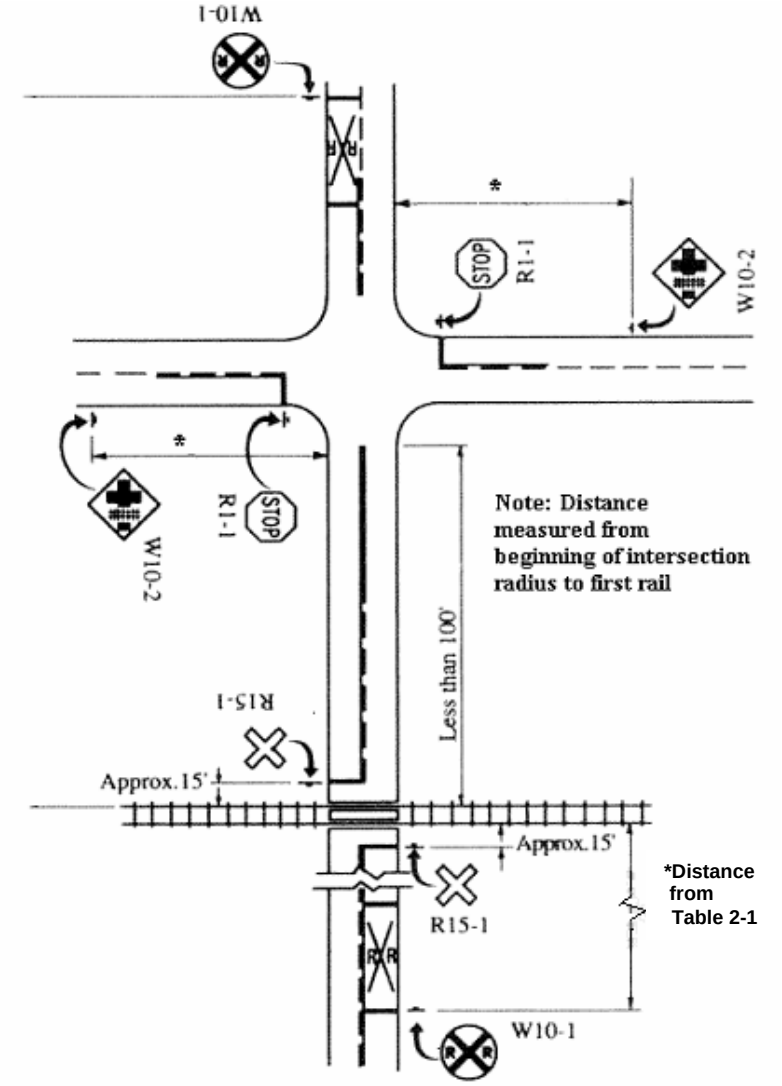
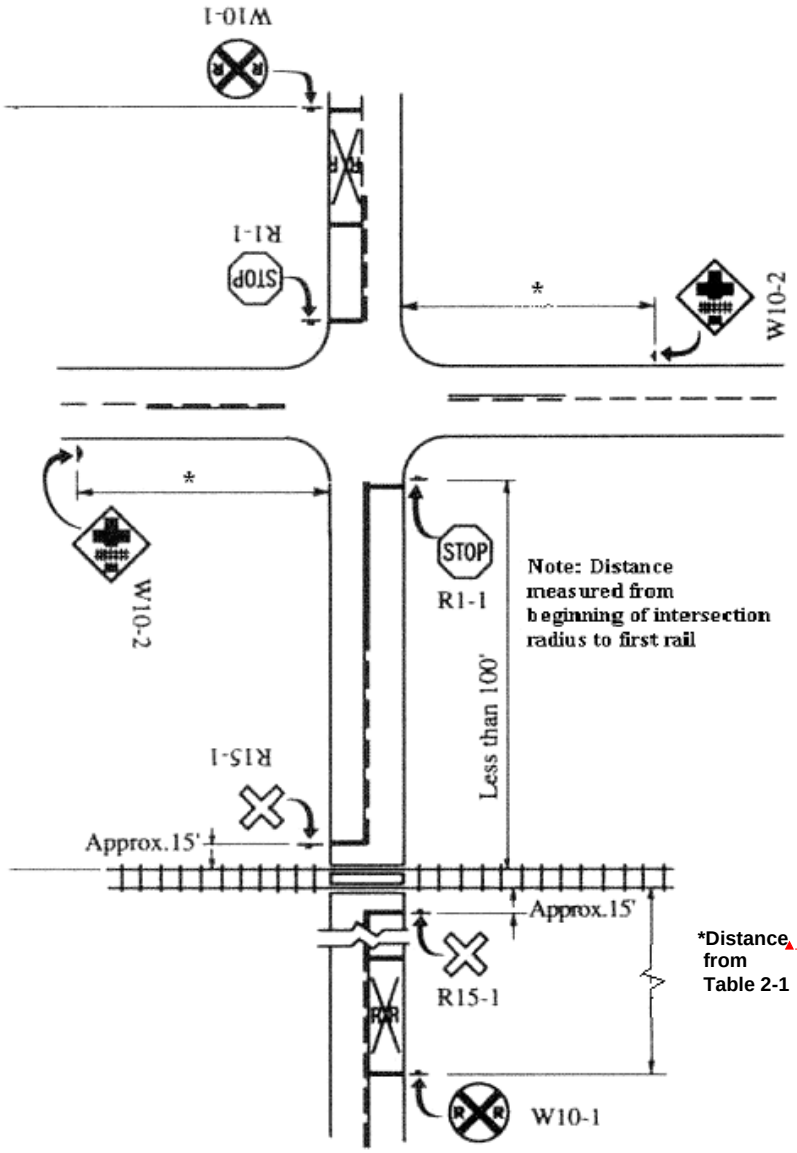
FIGURE 3-5: Example Sign Placement where parallel Road is over 100 feet from crossing.



*Sign placement of the W10-2, W10-3 or W10-4 shall be in accordance with Table 2-1 using the speed of the turning maneuver, and shall be measured from the highway intersection.

FIGURE 3-6: Example Sign Placement Where Parallel Road is within 100 feet of the Crossing and Parallel Road Traffic must stop**.**



*Distance from Table 2-1

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*Sign placement of the W10-2, W10-3 or W10-4 shall be in accordance with Table 2-1 using the speed of the turning maneuver, and shall be measured from the highway intersection.

FIGURE 3-7: Example Sign Placement Where Parallel Road is within 100 feet of Crossing and Intersecting Road Traffic must stop.

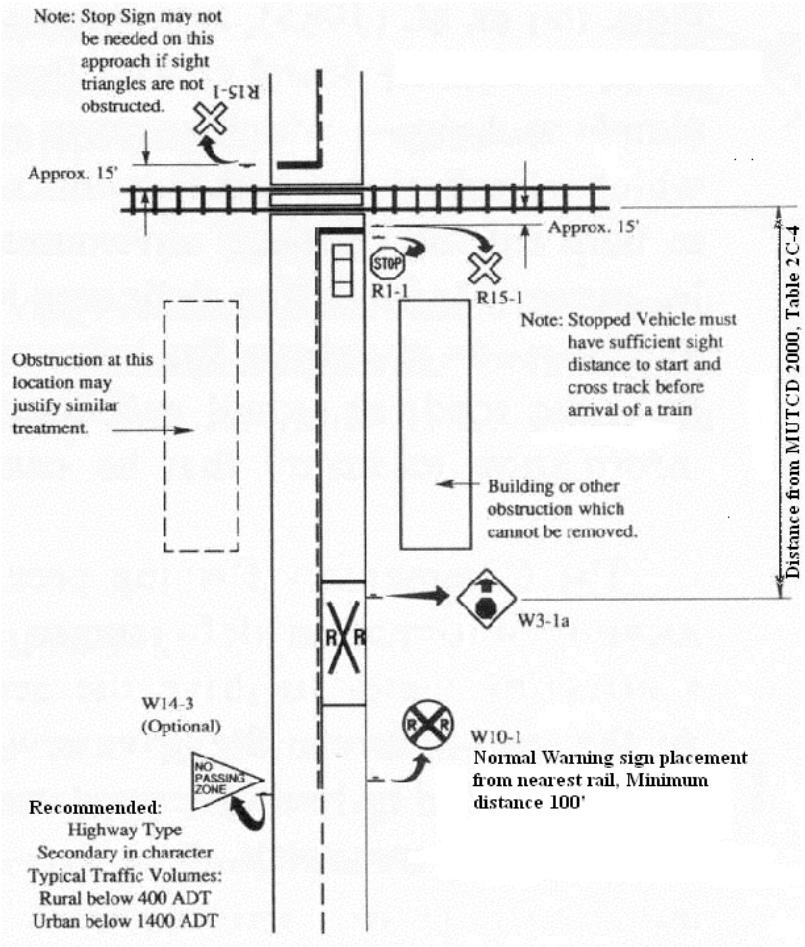


FIGURE 3-8: Example Application of a Stop Sign at a Crossing

Low Ground Clearance Highway-Rail Grade Crossing Sign (W10-5) (MUTCD 2003, Section 8B.16)

W10-5

Standard Size
30"x30"

If the highway profile conditions are sufficiently abrupt to create a hang- up situation for long wheelbase vehicles or for trailers with low ground clearance, the Low Ground Clearance Highway-Rail Grade Crossing (W10-5) sign should be installed in advance of the highway-rail grade crossing.

Because this symbol might not be readily recognizable by the public, the Low Ground Clearance Highway-Rail Grade Crossing (W10-5) warning sign should be accompanied by an educational plaque, LOW GROUND CLEARANCE. The LOW GROUND CLEARANCE educational plaque may remain in place as long as it is in serviceable condition (see MUTCD 2003, Section 2A.13).

Auxiliary plaques such as AHEAD, NEXT CROSSING, or USE NEXT CROSSING (with appropriate arrows), or a supplemental distance plaque should be placed below the W10-5 sign at the nearest intersecting highway where a vehicle can detour or at a point on the highway wide enough to permit a U-turn.

If engineering judgment of roadway geometric and operating conditions confirms that vehicle speeds across the railroad tracks should be below the posted speed limit, a W13-1 advisory speed plaque should be posted.

CHAPTER 4
NARROW BRIDGES, CULVERTS AND ROADSIDE OBSTACLES

General

Bridges and culverts that are narrower than the approach roadway and narrow roadways with obstacles adjacent to the shoulder violate the driver's expectancy and are, therefore, considered to be inconsistencies. As such, positive guidance should be provided so that the driver has sufficient information to safely negotiate the narrow bridge, culvert or adjacent obstacle. This section covers several different, but related, problems - narrow bridges and culverts, one-lane bridges and culverts, and roadside obstacles.

Description of Traffic Control Devices and Uses

W5-2

Standard Size
30” x 30”
See MUTCD 2003
Page 2C-17

NARROW BRIDGE Sign (W5-2) (W5-2a) (MUTCD 2003, Section 2C.16 and 5C.05)

A NARROW BRIDGE (W5-2) (MUTCD 2003, 2C.16) should be used in advance of any bridge or culvert having a two-way roadway clearance of 16 to 18 feet or any bridge or culvert having a roadway clearance less than the width of the approach. Additional emphasis should be provided by the use of object markers, delineators and/or pavement markers. (See handbook figure 4-1.)

A NARROW BRIDGE (W5-2) (MUTCD 2003, 5C.05) may be used on an approach to a bridge or culvert that has a clear width less than that of the approach roadway.

Handbook Discussion

The language in Part 5 (5C.05) changes the meaning of Section 2C.16 from “guidance” to an “option.”

Tapering should also be considered on LVR with bridges and culverts that are narrower than the approaches.

A NARROW BRIDGE sign may be used in advance of a bridge or culvert on which the approach shoulders are narrowed or eliminated.

The Narrow Bridge (W5-2a) symbol sign is no longer an acceptable sign and is not found in MUTCD 2003 as research indicates it is not well understood by drivers.

EXAMPLES: Figure 4-2, 4-3; pp. 4-8, 4-9

W5-3

Standard Size
30” x 30”
Minimum Size
24” x 24”
See MUTCD 2003
Page 5C-3

ONE-LANE BRIDGE Sign (W5-3), MUTCD 2003, 2C.17

A ONE LANE BRIDGE (W5-3) sign should be used on two-way roadways in advance of any bridge or culvert:

A. Having a clear roadway width of less than 16 ft, or

B. Having a clear roadway width of less than 18 ft when commercial vehicles constitute a high proportion of the traffic, or

C. Having a clear roadway width of 18 ft or less, where the sight distance is limited on the approach to the structure.

Additional emphasis should be provided by the use of object markers, delineators, and/or pavement markings.

EXAMPLES: Figure 4-2, 4-3; pp. 4-8, 4-9

W8-3

Standard Size
36” x 36”
See MUTCD 2003
Page 2C-14

PAVEMENT ENDS Sign (W8-3) (MUTCD 2003, 2C.25)

A PAVEMENT ENDS (W8-3) word message sign should be used where a paved surface changes to either a gravel treated surface or an earth road surface.

MUTCD 2003, Part 5, 5C.08, changes “should” (guidance) in the above sentence to “may” option.

W5-1

Standard Size
36” x 36”
See MUTCD 2003
Page 2C-11

ROAD NARROWS Sign (W5-1) (MUTCD 2003, 2C.15)

A ROAD NARROWS (W5-1) sign should be used in advance of a transition on two-lane roads where the pavement width is reduced abruptly to a width such that vehicles might not be able to pass without reducing speed.

MUTCD 2003, Part 5 does not have a ROAD NARROWS sign.

Handbook Discussion

Since the driver's expectancy changes with the physical characteristics of the roadway, the degree of positive guidance required also changes. The following guidelines are intended for use at or near a narrow or one-lane bridge or culvert. These guidelines are divided according to the type of road on which they are to be used. Engineering judgment should be used.

Paved or wide (22 ft or greater) smooth gravel road: (See handbook Figures 4-2 through 4-4)

1. A NARROW BRIDGE sign or a ONE-LANE BRIDGE sign should be used on each approach.
2. Type 3 object markers (see Figures 4-2 and 4-3) shall be used on each approach.
3. The approaches to the structures should be tapered (see page 1-8)
4. Guardrail may be used.
5. Delineators may be used.
6. Pavement markings may be used.

Gravel road with two or three wheel paths:

1. A NARROW BRIDGE sign or a ONE-LANE BRIDGE sign may be used.

2. Type 3 object markers shall be used on each approach, UNLESS the approaches to the structure are tapered such that the structure is no longer narrower than the roadway (see page 1-8). If tapering is used, Type 3 object markers may be used to warn of additional objects (e.g. concrete bridge rails).

In addition to the signs, which designate narrow bridges or culverts, or one-lane bridges or culverts, the existence of the structures and/or adjacent obstacles can be shown through the use of object markers (see Figures 4 -1 through 4 -5) or other means of positive guidance. Since it is generally believed that the driver gets the most information from the physical characteristics of a roadway, there is a greater potential for providing the driver with positive guidance by modifying the physical characteristics to lead the driver safely through the area. This is the principle involved in the practice of tapering the approach of a roadway so that it gradually narrows to the width of the structure (See page 1-8).

OBJECT MARKERS (from MUTCD 2003, Chapter 3C, page 3C-1)

Object Marker Design and Placement Height (MUTCD 2003, 3C.01)

Object markers are used to mark obstructions within or adjacent to the roadway.

Standard (MUTCD 2003, Section 3C.01)

When used, object markers shall consist of an arrangement of one or more of the following types:

Type 1—either a marker consisting of nine yellow retroreflectors, each with a minimum diameter of 3 inch, mounted symmetrically on a yellow (OM1-1) or black (OM1-2) diamond panel 18 inch or more on a side; or on an all-yellow retroreflective diamond panel (OM1-3) of the same size.

Type 2—either a marker (OM21V or OM21H) consisting of three yellow retroreflectors, each with a minimum diameter of 3 inch, arranged either horizontally or vertically on a white panel measuring at least 6x12 in.; or on an all-yellow horizontal or vertical retroreflective panel, (OM2-2V or OM2-2H) measuring at least 6 x 12 inches.

Type 3—a striped marker, 12 x 36 inches, consisting of a vertical rectangle with alternating black and retroreflective yellow stripes sloping downward at an angle of 45 degrees toward the side of the obstruction on which traffic is to pass. The minimum width of the yellow stripe shall be 3 inch.

Placement

When used for marking objects in the roadway or objects that are 8 ft or less from the shoulder or curb, the mounting height to the bottom of the object marker should be at least 4 ft above the surface of the nearest traffic lane.

When used to mark objects more than 8 ft from the shoulder or curb, the mounting height to the bottom of the object marker should be at least 4 ft above the ground.

When object markers or markings are applied to an object that by its nature requires a lower or higher mounting, the vertical mounting height may vary according to need.

Markings for Objects in the Roadway

Standard (MUTCD 2003, Section 3C.02)

Obstructions within the roadway shall be marked with a Type 1 or Type 3 object marker. In addition to markers on the face of the obstruction, warning of approach to the obstruction shall be given by appropriate pavement markings (see MUTCD 2003 Section 3B.10).

Standard (MUTCD 2003, Section 3C.02)

The alternating black and retroreflective yellow stripes (OM-3L, OM-3R) shall be sloped down at an angle of 45 degrees toward the side on which traffic is to pass the obstruction. If traffic can pass to either side of the obstruction, the alternating black and retroreflective yellow stripes (OM-3C) shall form chevrons that point upwards.

Markings for Objects Adjacent to the Roadway (MUTCD 2003, 3C.03)

Objects not actually in the roadway may be so close to the edge of the road that they need a marker. These include underpass piers, bridge abutments, handrails and culvert headwalls. In other cases there may not be a physical object involved, but other roadside conditions such as narrow shoulder drop-offs, gores, small islands and abrupt changes in the roadway alignment may make it undesirable for a driver to leave the roadway and therefore would create a need for a marker. Note: Type 2 or 3 may be used for these purposes.

Standard (MUTCD 2003, Section 3C.03)

If used, the inside edge of the marker shall be in line with the inner edge of the obstruction.

Handbook Discussion

To provide additional emphasis to required object markers, large surfaces such as bridge piers may be painted with diagonal stripes, 12 inch or greater in width, similar in design to the Type 3 object marker.

End of Roadway Markers (MUTCD 2003, 3C.04)

The end-of-roadway marker shall be one of the following: a marker consisting of nine red retroreflectors, each with a minimum diameter of 3 inch, mounted symmetrically on a red (OM4-1) or black (OM4-2) diamond panel (OM4-3) 18 inch or more on a side; or on a retroreflective red diamond panel 18 inch or more on a side.

Where conditions warrant, more than one marker, or a larger marker with or without a Type III barricade (see MUTCD 2003 Section 3F.01), may be used at the end of the roadway.

Standard (MUTCD 2003, Section 3C.04)

The minimum mounting height to the bottom of an end-of-the-roadway marker shall be 4 ft. above the edge of the pavement.

Appropriate advance warning signs (see MUTCD 2003, Chapter 2C) should be used.

See Figure 4-1 on the next page for Typical Object Markers and Typical End of Road Markers.

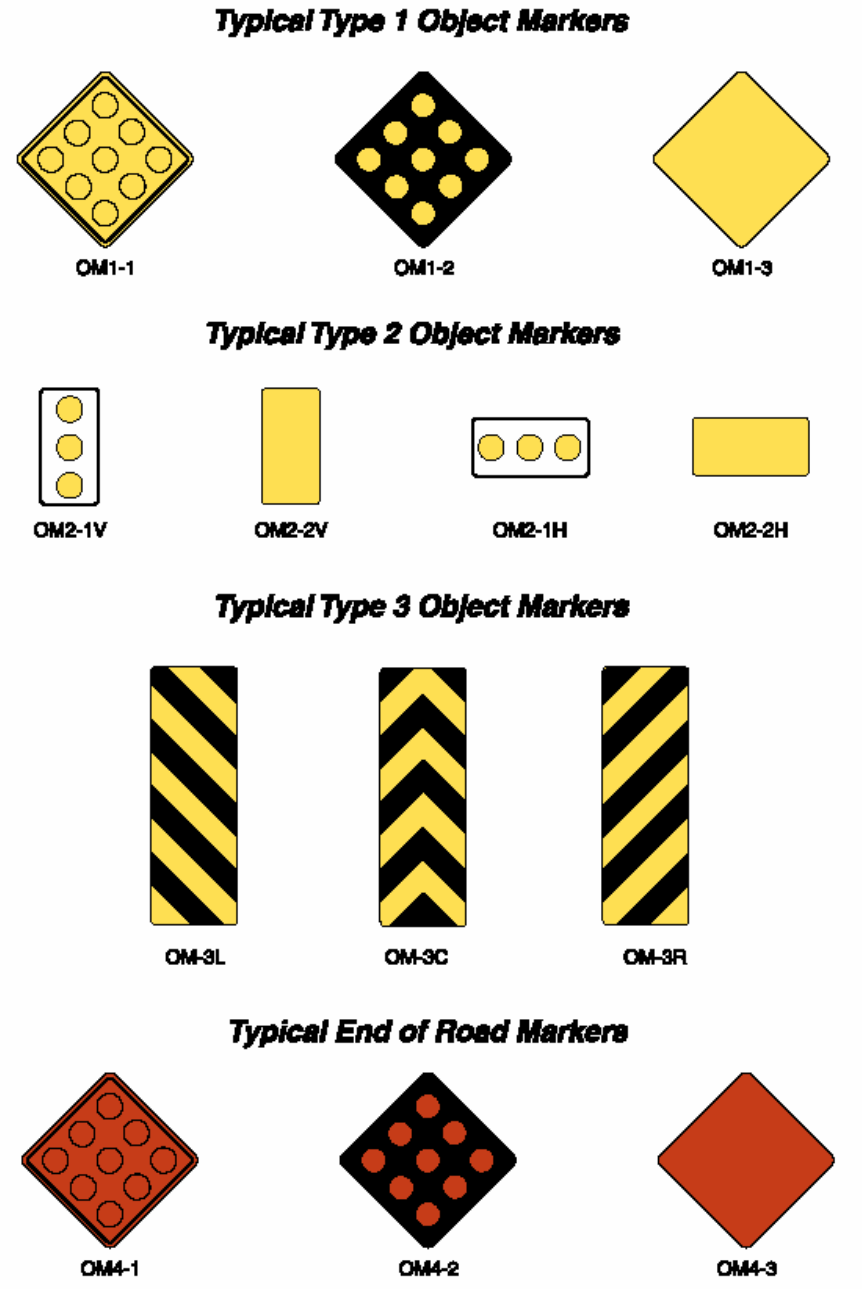
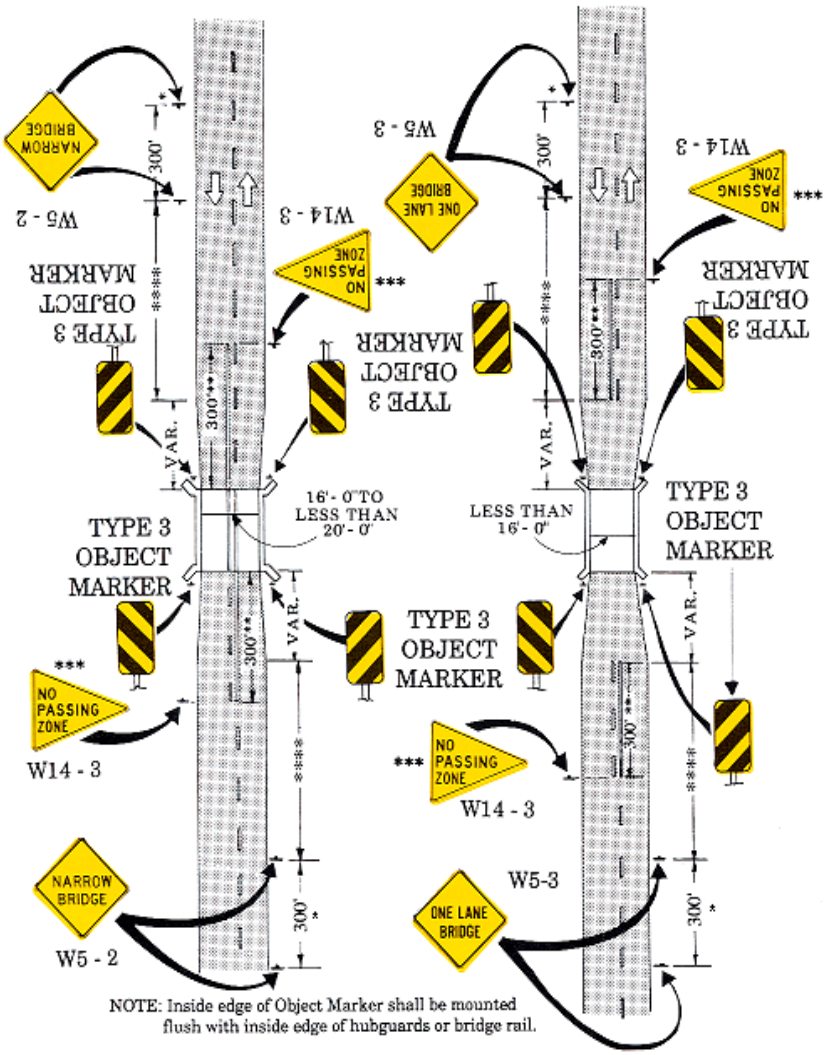
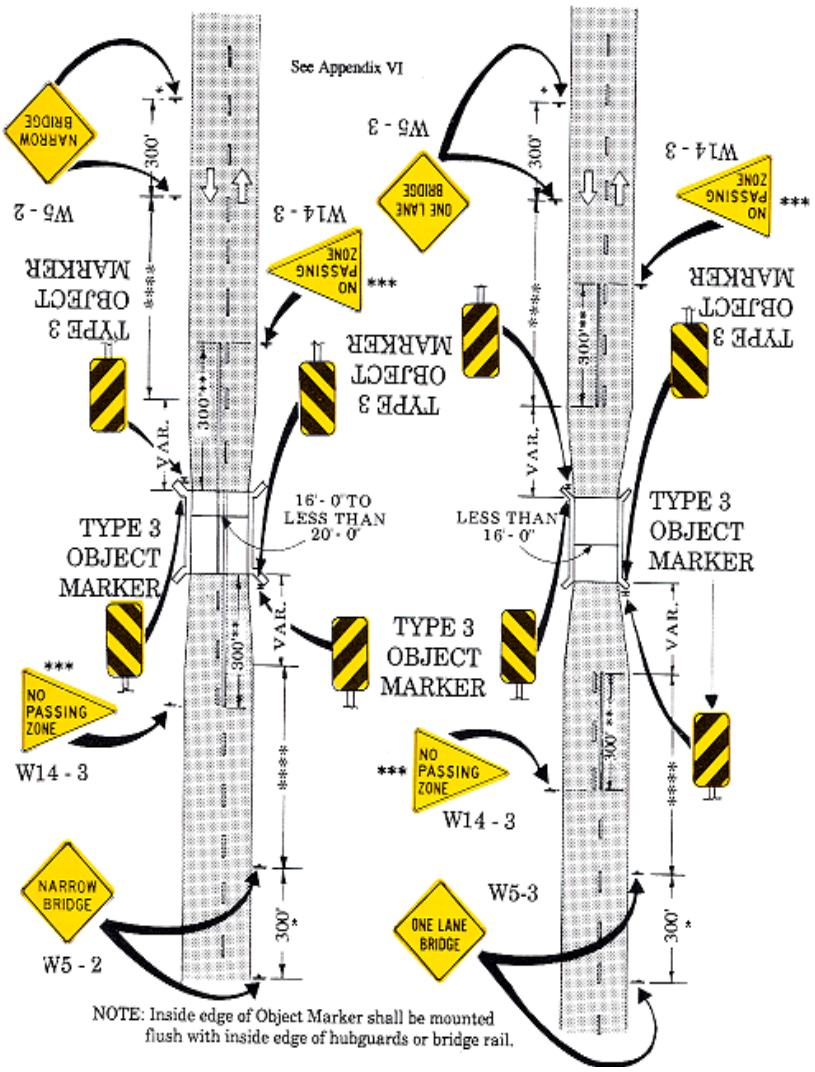


FIGURE 4-1. Example Type 1, Type 2 and Type 3 Object Markers (From MUTCD 2003, page 3C-2)



*If an engineering study determines the need, an additional sign may be erected at the 300 ft. distance shown.
**Nominal Distance-other distance may be used if engineering study indicates.
***No Passing Zone Signs should be used on major roads.
****Use PIEV Distance-other distance may be used if engineering study indicates. (See MUTCD 2003), 2C-4, Handbook Table 2-1)

FIGURE 4-2. Example Signing and Marking for a Narrow Structure and a One-Lane Structure. **Alternate A: Type 3 Object Markers on all four corners**. (See Figure 4-3 for Alternate B for use of Type 3 Object Markers, Double Faced, positioned on the right side of each approach.)



*If an engineering study shows a need, an additional sign may be erected at the 300 ft. distance shown.
**Nominal Distance-other distance may be used if engineering study indicates.
***No Passing Zone Signs should be used on major roads.
****Use PIEV Distance-other distance may be used if engineering study indicates.
(See MUTCD 2003. 2C-4. Handbook Table 2-1)

FIGURE 4-3. Example Signing and Marking for a Narrow Structure and a One-Lane Structure. **Alternate B: Type 3 Object Markers on both sides of single post positioned on right side of each approach.** Note that this "staggering" allows farmers better opportunity to move large equipment across without hitting the markers, (See Figure 4-2 for Alternate A for use of Type 3 Object Markers on all four corners).

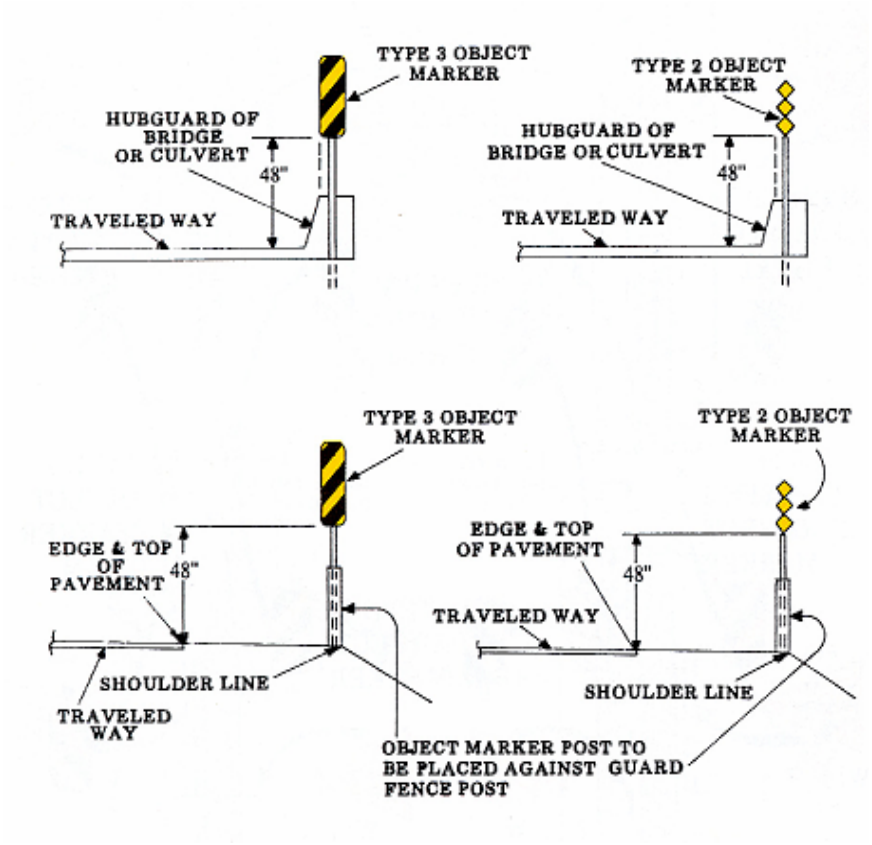


FIGURE 4-4. Example Mounting of Object Marker

Handbook Discussion: Marking Narrow Structures

For certain narrow structures that may be used by equipment wider than the structure, the mounting height of the object markers may be adjusted to a lower height according to need, based on engineering judgment.

If the mounting height of the object markers is lower than normal height, the maintenance of the object markers may require the removal of vegetation, debris or other obstruction to maintain good visibility of the object marker.

The local authority installing the traffic control devices should retain permanent documentation of the locations and justification for erecting lower object markers.

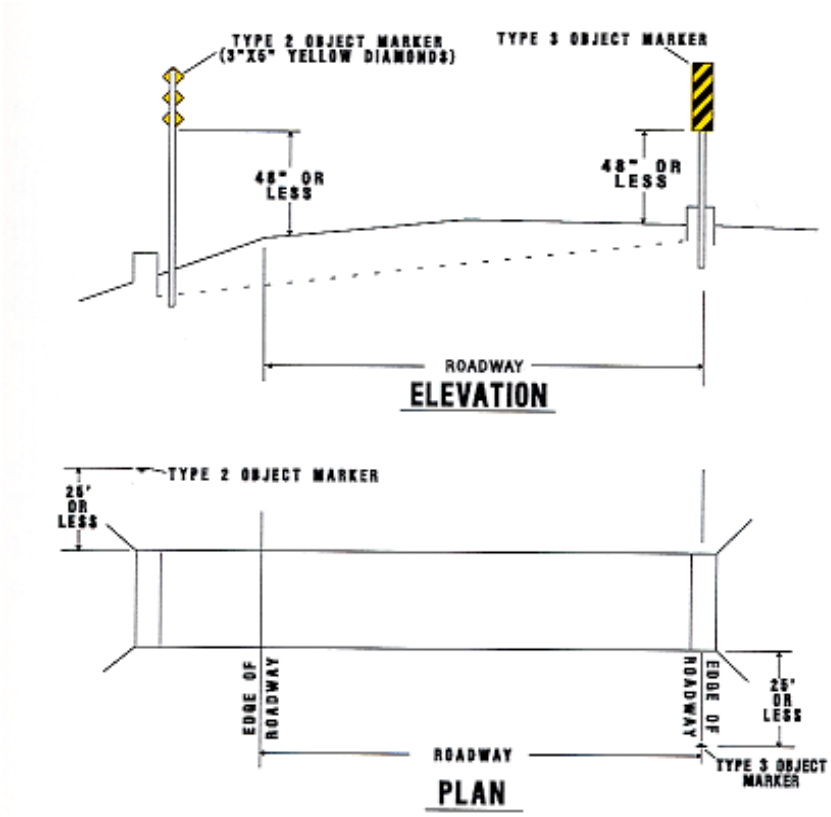


FIGURE 4-5. Example Mounting of Object Marker on Narrow Bridge, which is used by Wide Farm Equipment

Handbook Discussion

The authors believe that MUTCD 2003, Part 5 provides little guidance for markings on LVR. In general, narrow (12 to 16 ft) LVR, sometimes with only two wheel tracks (formerly classified as Type C in previous LVR handbook editions) need only a minimum of traffic control devices – signs and markings. Drivers need only be made aware of a changed condition such as an unexpected abrupt change in width, alignment, surface condition or hidden objects close to the traveled way. On these types of LVR engineering judgment may determine that the NO TRAFFIC SIGNS sign (W18-1) (MUTCD 2003, 5C.12) may be appropriate.

The W18-1 warning sign with the legend NO TRAFFIC SIGNS may be used only on unpaved, low-volume roads to advise users that no signs are

installed along the distance of the road. If used it should be placed at the beginning of the section and at points where users would enter the section, or where, based on engineering judgment a user would need this information. The key is the use of engineering judgment and consideration for a driver unfamiliar with the road.

Centerline Markings, (MUTCD 2003, 5E.02)

Centerline markings should be used on paved LVR where engineering judgment or an engineering study indicates a need for them.

Standard (MUTCD 2003, Section 3B.01)

Centerline markings shall be placed on all paved urban arterials and collectors that have a traveled way of (20 ft) or more in width and an ADT of 6,000 vehicles per day or greater. Centerline markings shall also be placed on all paved two-way streets or highways that have three or more lanes for moving motor vehicle traffic.

Centerline markings should be placed on paved urban arterials and collectors that have a traveled way of 6.1 m (20 ft) or more in width and an ADT of 4,000 vehicles per day or greater. Centerline markings should also be placed on all rural arterials and collectors that have a traveled way of 5.5 m (18 ft) or more in width and an ADT of 3,000 vehicles per day or greater. Centerline markings should also be placed on other traveled ways where an engineering study indicates such a need.

Engineering judgment should be used in determining whether to place centerline markings on traveled ways that are less than 4.9 m (16 ft) wide because of the potential for traffic encroaching on the pavement edges, traffic being affected by parked vehicles and traffic encroaching into the opposing traffic lane.

Where centerline markings are installed, no-passing zone markings in conformance with MUTCD 2003 section 3B.02 shall also be installed.

Standard (MUTCD 2003, Section 3B.02)

No passing zones shall be marked by either the one direction no-passing zone pavement markings or the two-direction no-passing zone pavement markings described [in MUTCD 2003] and shown in Figures 3B-1 and 3B-2 [in MUTCD 2003].

Edge Line Markings (MUTCD 2003, 5E.03)

Edge line markings should be considered for use on paved LVR based on engineering judgment or an engineering study.

Edge line markings may be placed on highways with or without centerline markings.

Edge line markings may be placed on paved LVR for roadway features such as horizontal curves, narrow bridges, pavement width transitions, curvilinear alignment and at other locations based on engineering judgment or an engineering study.

Warrants for Use of Edge Lines

Standard (MUTCD 2003, Section 3B.07)

Edge line markings shall be placed on paved streets or highways with the following characteristics:

A. Freeways;
B. Expressways; and
C. Rural arterials with a traveled way of 6.1 m (20 ft) or more in width and an ADT of 6,000 vehicles per day or greater.

Edge line markings should be placed on paved streets or highways with the following characteristics:

A. Rural arterials and collectors with a traveled way of (20 ft) or more in width and an ADT of 3,000 vehicles per day or greater.
B. At other paved streets and highways where an engineering study indicates a need for edge line markings.

Edge line markings should not be placed where an engineering study or engineering judgment indicates that providing them is likely to decrease safety.

WEIGHT LIMIT SIGNS (R12-1 to R12-5)

R12-1
Standard Size
24" x 30"

R12-2
Standard Size
24" x 30"

R12-3
Standard Size
24" x 36"

R12-4
Standard Size
36" x 24"

R12-5
Standard Size
24" x 36"

WEIGHT LIMIT Signs (R12-1 to 5)

Due to seasonal weakening of the road surface, obsolescence of bridges or pavements, or other impairment of roadways, it is often necessary to limit the load permitted on a roadway.

If used, the Weight Limit sign shall be located in advance of the applicable section of highway or structure. Weight Limit Ahead signs can also be used.

If used, the weight limit sign with an advisory distance ahead legend should be placed at approach road intersections or other points where prohibited vehicles can detour or turn around.

The Weight Limit sign (R12-1) carrying the legend WEIGHT LIMIT (X) TONS, may be used to indicate restrictions pertaining to total vehicle weight restrictions including load.

In areas where multiple regulations are applicable, a sign combining the necessary messages on a single panel may be used, such as WEIGHT LIMIT (X) TONS PER AXLE, (XX) TONS GROSS (R12-4).

Posting of specific load limits may be accomplished by use of the Weight Limit symbol sign (R12-5). A sign containing the legend WEIGHT LIMIT on the top two lines, and showing three different truck symbols and their respective weight limits for which restrictions apply may be used, with the weight limits shown to the right of each symbol as (XX) T. A bottom line of legend stating GROSS WT may be included if needed for enforcement purposes.

LOW WATER STREAM CROSSINGS

Low water stream crossings, (LWSCs or fords – See figure 4-6 for picture), are rarely encountered by the driver; therefore, they can be considered inconsistencies and should be well marked. Engineering judgment should be used.

These signs are not specifically shown in MUTCD 2003. However, when used they shall conform to criteria in sections 2C.02 and 2C.03 of MUTCD 2003, which covers the application and design of warning signs.

The FLOOD AREA AHEAD sign shall consist of black letters and border on a yellow background. It shall conform to MUTCD 2003 standards for warning signs as covered in Sections 2C.02 and 2C.03.

The IMPASSABLE DURING HIGH WATER sign shall consist of black letters and borders on a yellow background. It shall conform to MUTCD standards for warning signs. (MUTCD 2003, Sections 2C.02 and 2C.03)

The DO NOT ENTER WHEN FLOODED sign shall consist of black letters and border on a white background. It shall conform to MUTCD standards for regulatory signs. (MUTCD 2003, Sections 2B.01, 2B.02 and 2B.03)

A supplemental DISTANCE ADVISORY plate should be used if the location of an LWSC is not apparent from a point in advance of the crossing at least as great as the distances shows in Figure 2.1 (MUTCD 2003, Table 2C-4). The plate would normally display the legend "XX FEET" based on engineering judgment, and would be placed directly beneath and on the same post as the FLOOD AREA AHEAD sign (See Figure 4-7). The plate shall consist of black letters and border on a yellow background. It shall not be used alone.

An **ADVISORY SPEED** plate may be used if an engineering study or engineering judgment determines that the maximum recommended speed at an LWSC is less than the usual operating speed. If used, the plate shall be placed directly beneath and on the same post as the FLOOD AREA AHEAD sign unless a supplemental DISTANCE ADVISORY plate is used i.e., the two plates should not be used together (See Figure 4-7).

Handbook Discussion

Experience reported by persons having responsibility for road systems including LWSCs indicates some concern with liability problems growing out of their use (Carstens and Woo, 1981). However, a majority of officials having this experience report that they are satisfied with LWSCs and the road users seem to accept them.

This experience suggests that a risk analysis generally will show that the potential for crashes and liability will be reduced, rather than increased, when a LWSC is substituted for a bridge that is structurally deficient or functionally obsolete. An engineering study or engineering judgment should be used to determine that adequate warning of the presence of a LWSC be given to minimize the risk of crashes.

At LWSCs, debris or mud may remain on the roadway after floodwaters have receded and erosion of the roadway may have occurred. Thus, it is important that road segments with LWSCs be checked following heavy rains so that any required maintenance may be performed promptly or that the road can be closed if necessary.

On major LVR, the three signs FLOOD AREA AHEAD, IMPASSABLE DURING HIGH WATER and DO NOT ENTER WHEN FLOODED, should be used (see Figure 4-7).

On minor LVR, the FLOOD AREA AHEAD sign should be used. The IMPASSABLE DURING HIGH WATER and/or DO NOT ENTER WHEN FLOODED signs may be used in addition.

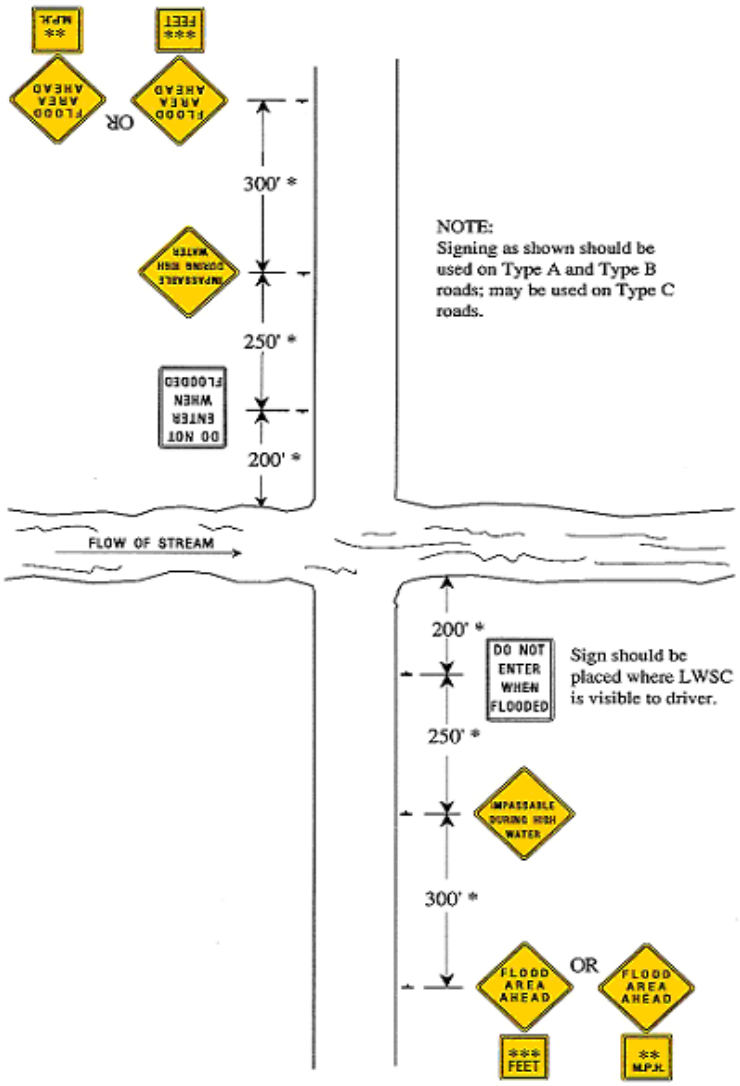
For all LVR, if only one sign is used, it should be the FLOOD AREA AHEAD sign. If, more than one sign is used, the first sign should be the FLOOD AREA AHEAD sign.

The placement of the sign(s) may vary depending on the usual operating speed and the terrain. It is important not to overload the driver too much information or too many tasks to perform, such as a steep grade to negotiate with the FLOOD AREA AHEAD sign on the steep grade. In a case such as this it is best to warn of the steep grade and also warn of the LWSC before the grade. Distances longer or shorter than those shown in Figure 4-7 may be used if an engineering study or engineering judgment so indicates.

Reference

R. L. Carstens and R. Yun-Hao Woo, Liability and Traffic Control Considerations for Low Water Stream Crossings (Ames, Iowa: Engineering Research Institute, Iowa State University, April 1981).

FIGURE 4-6. Low Water Crossing



*distance may vary according to an engineering study or engineering judgment
(See MUTCD 2003, 2C-4, Handbook Table 2-1, page 2-9)

FIGURE 4-7. Example Signing of Low Water Stream Crossing

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CHAPTER 5
SIGN INSTALLATION AND SIGN SUPPORT SYSTEMS

Introduction

Most of the material on the sign installation in this chapter is reproduced with minor editing, from the USDOT, FHWA, Maintenance of Small Traffic Signs; A guide for Street and Highway Maintenance Personnel, FHWA-RT-90-002, Washington, DC, 1990

General Location Guidelines

All locations for signs should be carefully checked before installing the sign to assure that there is no sight obstruction between the sign's location and the motorist's point of observation.

According to Kansas State statutes, before digging or installing posts at any location, underground utilities must be contacted. Most can be contacted by calling 1-800-DIG-SAFE. Please note that not all utilities are associated with DIG SAFE.

Some of the common problem placements to be avoided are:

- Beyond the crest of a hill;
- Where there are dips in the roadway;
- Where a sign could be obscured by parked cars or farm machinery;
- Where a sign would create an obstruction for pedestrians, joggers, or bicyclists;
- Where a sign would interfere with the driver's visibility of dangerous locations or objects;
- Where sign visibility would be impaired due to existing overhead illumination;
- Where signs are vulnerable to roadside splatter, or to being covered with snow by plowing operations;
- Where signs are too close to trees or other foliage that could cover the sign face, or could grow and cover the sign face. Remember, it doesn't take long or cost much to cut brush out of the way.

If a roadway design does not permit adequate placement of the required signs, then it may be worthwhile to consider a revision in the geometric design of the roadway. A bad geometric design cannot be corrected by signing**.**

The longitudinal location of signs along the highway depends on the type of sign used, the nature of the message, and the desired motorist response.

As a general rule of thumb,

Warning signs are normally placed in advance of the condition to which they call attention. Regulatory signs are placed where their mandate or prohibition applies or begins.

Guide signs are placed at varying locations to inform drivers of their route of travel, destinations, and points of interest.

Although signs with different purposes should not be located closer together than 200 feet if it can be avoided, signs at intersections and in urban areas cannot always meet the requirements.

Signs should be placed so as to be compatible with other signs in the area and with other roadway features in the area. For example, speed limit signs should not be placed just before an intersection, school zones, or a problem curve, which is posted with a lower speed. Before placing warning signs, - (Handbook Table 2-1, page 2-X) - "A Guide for Advance Warning Sign Placement Distance" should be used to determine minimum warning sign placement distances 2C-4 in MUTCD 2003.

Lateral Clearance for roadside signs is the distance from the edge of the roadway (edge of pavement) to the nearest edge of the sign.

All signs, regardless of size, constitute a potential hazard for the motorist. Therefore, signs are normally located as far from the roadway **as practical.**

The MUTCD 2003 states "normally, signs should not be closer than 6 feet from the edge of the shoulder or, if no shoulder, 12 feet from the edge of the traveled way". On most local roads and streets, particularly in rural areas, these distances are unrealistic, impractical and/or undesirable. On rural, low-volume roads with no shoulder and narrow right-of-way, these distances would put signs in the bushes or weeds and not meet the "prime directive" of having signs easily seen by drivers, "visibility of utmost importance."

As a general rule, the following guidelines should be followed:

- Get as close as possible to the 6 feet distance from the edge of roadway.
- All signs should be at least 2 feet outside the shoulder or, if none, 2 feet

outside the traveled way. Otherwise, trucks or other large vehicles using the shoulder may hit the sign.

- Signs should be located at least 2 feet behind the curb when curb sections are used. This will help insure the trucks and other large vehicles pulling up next to the curb will not hit the sign.

Handbook Discussion - Fundamentals of Sign Location

It is of the greatest importance that the placement of a traffic sign ensures that:

1. It can be easily seen by a driver and will command respect.
2. It is properly positioned to convey the proper meaning with respect to the situation.

MUTCD sets guidelines on sign placement. However, these are meant to be used with engineering judgment. Sign positioning, as defined in the manual, is associated with an assumed set of conditions portraying a typical situation. Since no two roadways are exactly alike, it follows that these basic standards are intended only as a guide. The guidelines provided in the MUTCD should be tempered by the existing conditions to assure that the sign will be seen by the drivers, and that the drivers will have adequate response time.

Jurisdictions with responsibility for traffic control should have qualified traffic engineering expertise on their staff or should seek assistance from their state Department of Transportation, county, nearby large city, traffic consultant or Local Technical Assistance Program (Technology Transfer Center at the University of Kansas).

Installing New Post and Sign

The proper steps in installing a new post and sign in a rural setting are:

- Use a cap to protect the driver--these caps are available in a variety of sizes and shapes for the various sizes and shapes of the posts,

- Measure and mark the post 5 feet from the bottom of the sign. Then drive the post to that mark. Bolt the sign to the post.

- For a wooden post, attach the sign first, then measure and mark 5 feet from the bottom of the sign.

- Measure the remaining length of the post, and dig a hole that deep. It is important to tamp soil in around the pole for stability.

SAFE SIGN SUPPORT SYSTEMS

Introduction

The information in this chapter is taken from USDOT, FHWA, Maintenance of Small Traffic Signs; A guide for Street and Highway Maintenance Personnel, FHWA-RT-90-002, Washington, DC, 1990.

Wood Posts

Wood posts are the most common sign support. Posts of the proper size and installation will break off when hit by a vehicle. They should be southern yellow pine, grade 2 or equivalent, and pressure treated.

Small supports. A 4" x 4" is the largest undrilled wood post recommended to act as a breakaway support (See Figure 5-1). Posts should be buried in firm ground to a minimum recommended depth of 3 feet. You may need to bury the post deeper to reduce vandalism. Do not encase post in concrete. One or two posts (One post at each end of sign; not a single post made of two rails bolted together) may be used.

Large supports should be drilled. A 6" x 8" wood post can be used if the cross section is weakened by drilling two 3-inch holes as shown in the lower drawing (drill perpendicular to roadway).

Sign panels. Sign panels should be bolted to the post with oversized washers. This will prevent the panel from separating from the post on impact and then penetrating a windshield. Set the bottom of the sign panel at a minimum of 5 feet above the roadway. This will limit the chance of the sign and post rotating and hitting the car's windshield.

There are many other products available commercially for sign supports. Use depends on local requirements and costs. Three common post types are discussed below.

Perforated Square Steel Tube (PSST)

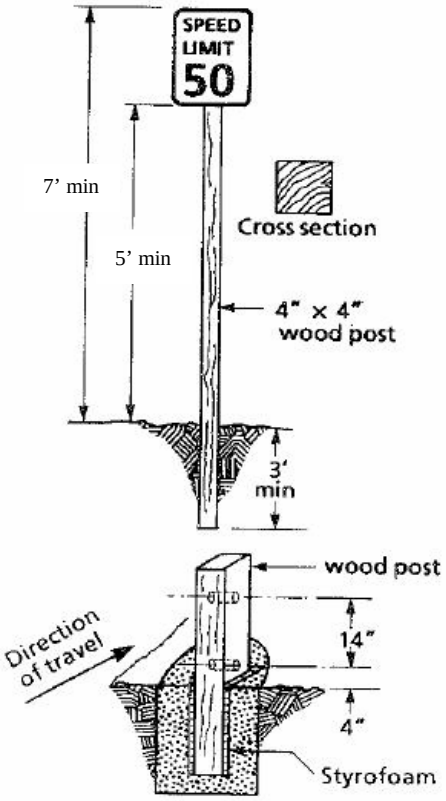
Another signpost is the perforated square steel tube design. It is used in many localities (See Figure 5-2).

Post support. Posts can be driven into the ground. Do not place concrete around the post. A broken or damaged post is easier to remove if it is not driven or set into the ground more than 3 feet).

Breakaway devices. Sleeve assemblies like the one shown in Figure 5-2 will increase the safety of a sign when it is hit and make it easier to repair. After the

sign has been hit, the broken stub of the post can be removed from the base sleeve and a new signpost put back in place.

Sign panels. Attach the sign panels tightly to the post and use oversized washers to keep the sign from breaking loose from the post when a vehicle hits it. Sign panels should be mounted a minimum of 5 feet or 7 feet above the roadway, as appropriate for rural or urban, respectively.



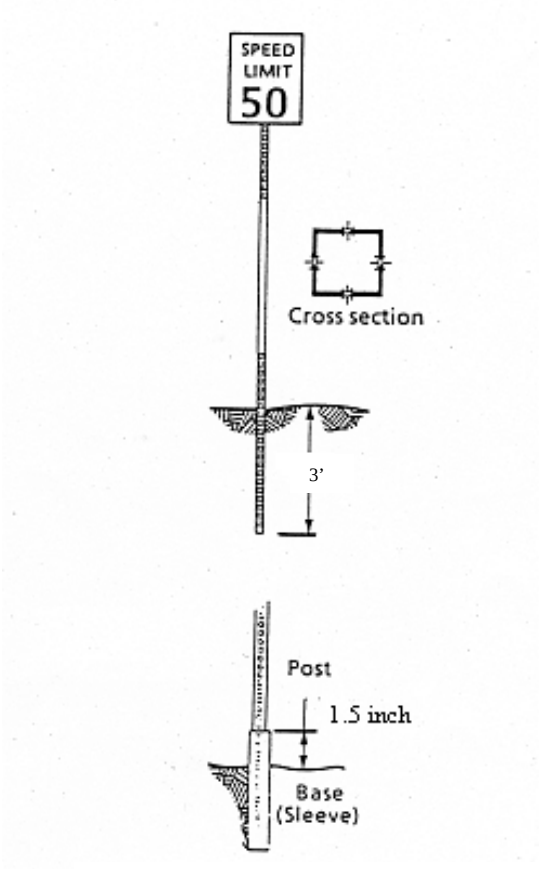
3" diameter drilled holes

(optional)

Maximum Post Sizes to be breakaway

Max. Sign Panel	Post Size
18" x 24"	4" x 4" nom.
30" x 30"	4" x 6" nom. (2" holes)
36" x 48"	6" x 6" nom. (2" holes)

FIGURE 5-1. Example Wood Post



Maximum Post Size to be breakaway

Max. Sign size	Post Size
(30" x 30")	(2.25 " x 2.25 " x 0. 105 ")

FIGURE 5-2. Example Perforated Steel Tube Design

U-Channel Steel Post

The U-channel rolled steel post is the second most common small sign support. It is considered breakaway since it will bend, break or pull out of the ground when it is hit (See Figure 5-3).

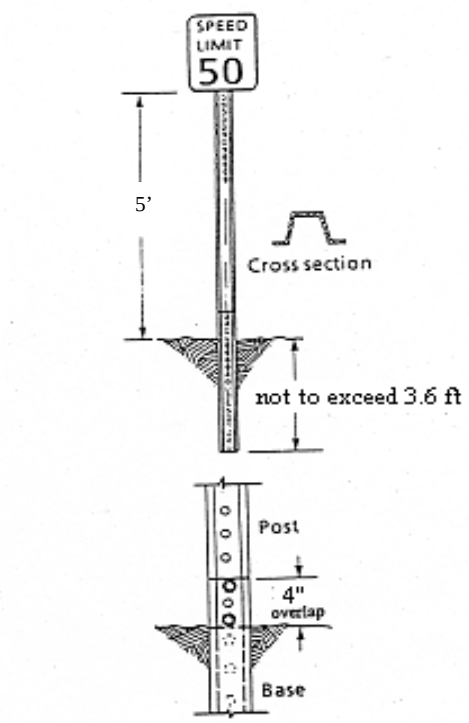
Post support. The post should be driven into the ground and not encased in concrete. In order to more easily extract damaged posts, drive the posts no deeper than 3.5 ft.

Breakaway devices. Commercial splices can be purchased to install at ground level (see Figure 5-3, lower drawing). They allow the post to break off on

impact. These devices improve safety when the post is hit, will make repair easier, and will make it possible to use a U-channel post when it has to be placed in a concrete area.

An alternate installation is to set a stub post in concrete with a 4-inch length available to bolt to the signpost as a base connection.

Sign panels. Sign panels should be securely bolted to the post with oversized washers. This will prevent the panel from separating from the post on impact and then penetrating a windshield. Set the bottom of the sign panel a minimum of 5 feet or 7 feet above the roadway, as appropriate for rural or urban, respectively. This limits the chance of the sign hitting a car's windshield.



Maximum Post Size to be breakaway

Max. Size Panel	Post Size
(18" x 24")	2 lb/ft
(30" x 30")	3 lb/ft
(36" x 48")	2 @ 2lb/ft

FIGURE 5-3. Example U Channel Steel Post

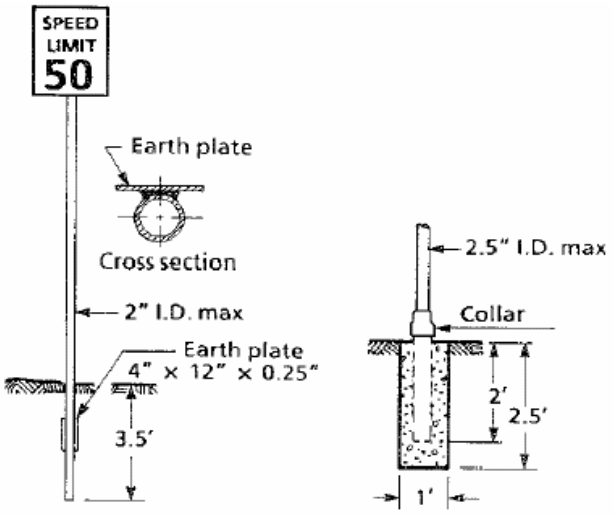
Steel Pipe Post

Steel pipe posts are used less frequently than wood or U-channel posts, but are often used in cities to support small signs. Standard steel pipe, schedule 40, galvanized, should be used.

Post support. Steel pipe posts can be driven directly into the ground to a depth of at least 3.5 feet. A steel plate (earth plate) measuring 4" x 12" x 0.25" should be welded or bolted to the pipe (see figure 5-4) to keep the sign from rotating in the wind and to help in driving the post.

Breakaway devices. A collar assembly (see example in the lower drawing) is recommended. A collar assembly consists of a concrete footing 2.5' deep x 1' diameter, a 2-foot pipe base (usually one pipe size larger than the post), and a pipe reduction collar. When the pipe post is hit, the post usually shears off just above the collar. This speeds repair and replacement by installing a new collar. Often the pipe post can be reused.

Sign panels. Sign panels should be securely attached to the pipe post using pipe clamps. This prevents the sign panel from rotating or slipping loose from the post if it is hit. Tight fasteners will limit the danger of a sign penetrating a windshield when a vehicle hits. Sign panels should be mounted a minimum of 5 feet above the roadway.



Maximum Post Size

Max. Sign Panel	Pipe Size
30” x 30”	2.0 in I.D.
36” x 48”	2.5 in I.D.

FIGURE 5-4. Example Steel Pipe Post

Reference

USDOT, FHWA, Maintenance of Small Traffic Signs; A guide for Street and Highway Maintenance Personnel, FHWA-RT-90-002, Washington, DC, 1990.

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CHAPTER 6
TEMPORARY TRAFFIC CONTROL

CONSTRUCTION AND MAINTENANCE

The special condition of construction and/or maintenance zones causes an inconsistency for the driver and therefore, advance notice appropriate for the work being performed should be provided.

Note that MUTCD now covers requirements found in the Americans with Disabilities Act of 1990 (ADA). This means that in cases where TTC affects pedestrian routes they must be accessible to all, e.g. blind pedestrians, wheel chair users, etc.

As stated in MUTCD 2003

The control of road users through a temporary traffic control zone shall be an essential part of highway construction, utility work maintenance operations, and incident management.

Whenever the acronym "TTC" is used in this handbook Chapter, as in MUTCD 2003, it refers to "temporary traffic control."

Standard (MUTCD 2003, Section 6A.01)

The needs and control of all road users (motorists, bicyclists, and pedestrians within the highway, including persons with disabilities in accordance with the Americans with Disabilities Act of 1990 (ADA), Title II, Paragraph 35.130) through a TTC zone shall be an essential part of highway construction, utility work, maintenance operations, and the management of traffic incidents. The primary function of TTC is to provide a reasonably safe and efficient movement of road users through or around TTC zones while reasonably protecting workers, responders to emergencies and equipment.

Handbook Discussion

Engineering judgment should be used. If there is any doubt regarding the adequacy of the temporary traffic control, local agencies should seek assistance from the State, a County or consultant knowledgeable (for example, trained and/or certified) in proper, temporary traffic control practices. As stated in MUTCD 2003, 6B.01: Each person whose actions affect TTC zone safety, from the upper-level management through the field workers, should receive training appropriate to the job decisions each individual is required to make. Only those individuals who are trained in proper TTC practices and have a basic understanding of the principles (established by applicable standards and

guidelines, including those of MUTCD 2003) should supervise the selection, placement, and maintenance of TTC devices used for TTC zones and for incident management. In all cases, applicable sections of the MUTCD 2003, particularly Part 6 (TTC) or Part 5, (LVR) should be followed.

The MUTCD 2003 gives a thorough guide for the use of traffic control devices at construction and maintenance zones. The current term for these devices is, "Temporary Traffic Control" and it is Part 6 of MUTCD 2003. For maintenance and minor construction on LVR, there may not be a need for the sequence of construction approach warning signs prescribed for major operations. Engineering judgment must be used in all cases.

LVR Temporary Traffic Control

As stated in MUTCD 2003, Part 5, Section 5G.02, Traffic Control Devices for Low-Volume Roads (TCD/LVR) (defined by MUTCD 2003 as roads with AADT 400 vehicles or less): Maintenance activities may not require extensive temporary traffic control if the traffic volumes and speeds are low.

However, MUTCD 2003, Part 6 should be consulted for specific traffic control requirements and examples where construction on maintenance work is planned. The traffic operations shown in [MUTCD 2003] Figures 6H-1, 6H-11, 6H-13, 6H-15 and 6H-16 of Part 6 are among those that may be most applicable on low-volume roads. Also MUTCD 2003, Chapter 5, has some key guidance that should be considered; some of this is reproduced in the following paragraphs.

The safety of road users, including pedestrians and bicyclists, as well as personnel in work zones, should be an integral and high priority element of every project in the planning, design, maintenance, and construction phases. Part 6 should be reviewed for additional criteria, specific details, and more complex temporary traffic control zone requirements. The following principles should be applied to temporary traffic control zones:

A. Traffic movement should be disrupted as little as possible.
B. Road users should be guided in a clear and positive manner while approaching and within construction, maintenance, and utility work areas.
C. Routine inspection and maintenance of traffic control elements should be performed both day and night.
D. Both the contracting agency and the contractor should assign at least one person on each project to have day-to-day responsibility for assuring that the traffic control elements are operating effectively and any needed operational changes are brought to the attention of their supervisors.

Traffic control in temporary traffic control zones should be designed on the assumption that road users will only reduce their speeds if they clearly perceive a need to do so, and then only in small increments of speed. Temporary traffic control zones should not present a surprise to the road user. Frequent and/or abrupt changes in geometrics and other features should be avoided. Transitions should be well delineated and long enough to accommodate driving conditions at the speeds vehicles are realistically expected to travel.

A Traffic Control Plan (see MUTCD 2003 Section 6C.01) should be used for a temporary traffic control zone on a low-volume road to specify particular traffic control devices and features, or to reference typical drawings such as those contained in MUTCD 2003 Part 6.

Handbook Discussion

Speed reduction countermeasures and enforcement can be effective in reducing traffic speeds in temporary traffic control zones. To be effective, speed reduction should be reasonable and enforced.

The alternatives presented here should provide sufficient guidance for the case of maintenance or minor construction on low-volume roads. If an adequate detour is available, it may be better to close the road to through traffic during maintenance or construction. (See MUTCD 2003, Figure 6H-13, page 6H-31)

For more extensive construction or maintenance, follow the guidelines as set for by MUTCD 2003, Part 6. It should be noted that such construction and maintenance, regardless of whether it is being done by public or private agencies, if it is being done on a public roadway, the guidelines should be followed.

Good public relations may contribute to the success of any local construction and or maintenance project. Good public relations should be maintained by applying the following principles: (From MUTCD 2003, 2B.01)

A. The needs of all road users should be assessed such that appropriate advance notice is given and clearly defined alternative paths are provided.
B. The cooperation of the various news media should be sought in publicizing the existence of and reasons for TTC zones because news releases can assist in keeping the road users well informed.
C. The needs of abutting property owners, residents, and businesses should be assessed and appropriate accommodations made.
D. The needs of emergency service providers (law enforcement, fire, and medical) should be assessed and appropriate coordination and accommodations made.

E. The needs of railroads and transit should be assessed and appropriate coordination and accommodations made.
F. The needs of operators of commercial vehicles such as buses and large trucks should be assessed and appropriate accommodations made.

Some typical signs and examples follow; starting with Figure 6-1 on page 6-11.

TTC Signing

MUTCD 2003 requires that all necessary signs be in place before any temporary route is opened to traffic.

Standard (MUTCD 2003, Section 6B.01)

Before any new detour or temporary route is opened to traffic, all necessary signs shall be in place. All TTC devices shall be removed as soon as practical when they are no longer needed. When work is suspended for short periods of time, TTC devices that are no longer appropriate shall be removed or covered.

Note also, that to establish or maintain credibility of TTC in active work zones, it is important to cover or remove TTC devices when they are no longer needed or when work is suspended.

ROAD (STREET) CLOSED Sign (R11-2)

The ROAD (STREET) CLOSED sign shall have a standard, and minimum, size of 48" x 30".

The ROAD (STREET) CLOSED sign should be used when the roadway is closed to all road users except contractors' equipment or officially authorized vehicles. The R11-2 sign should be accompanied by appropriate warning and detour signing.

The ROAD (STREET) CLOSED sign should be installed at or near the center of the roadway on or above a Type III barricade that closes the roadway [MUTCD 2003] 6F.08).

The ROAD (STREET) CLOSED sign shall not be used where road user flow is maintained or where the actual closure is some distance beyond the sign.

Local Traffic Only Signs (R11-3a, R11-4)

Standard (MUTCD 2003, Section 6F.08)

The local Traffic Only Signs should be used where road user flow detours to avoid a closure some distance beyond the sign, but where the local road users can use the roadway to the point of closure. These signs should be accompanied by appropriate warning and detour signing.

In rural applications, the Local Traffic Only sign should have the legend ROAD CLOSED XX KM (MILES) AHEAD LOCAL TRAFFIC ONLY (R11-3a). (MUTCD 2003, 6F.09)

Position of Advance Warning Signs

Where the highway conditions permit, warning signs should be placed in advance of the temporary traffic control zone at varying distances depending on roadway type, condition and posted speed. Handbook Table 6-1 (MUTCD 2003, Table 6C-1, p.6C-4) contains information regarding the spacing of advance warning signs. Where a series of two or more advance warning signs is used, the closest sign to the temporary traffic control zone should be placed approximately 100 ft for low-speed urban streets and 500 feet on rural highways.

R11-3a
60” x 30”
See MUTCD 2003
Page 2B-44

R11-4
60” x 30”
See MUTCD 2003
Page 2B-44

Advance Warning Area (MUTCD 2000, Section 6C.04)

On the urban streets, the effective placement of the first warning sign in the feet should range from 4 times the speed limit to 8 times the speed limit in MPH, with the high end of the range being used when speeds are relatively high.

Since rural highways are normally characterized by higher speeds, the effective placement of the first warning sign in feet should be substantially longer – from 8 to 12 times the speed limit in MPH. Since two or more advance warning signs are normally used for these conditions, the advance warning area should extend 1500 ft or more for open highway conditions (see Table 6-1, for suggested advance warning sign placement. Note that only the distances for the rural roads are reproduced).

TABLE 6-1. Suggested Advance Warning Sign Placement for Rural Roads

Road Type	Distance Between Signs(feet)		
	A	B	C
Rural	500	500	500

Distances are shown in feet. The column headings A, B and C are the dimensions shown in handbook, Figures 6-1 & 6-2, (next two pages.) The A dimension is the distance from the transition or point of restriction to the first sign. The B dimension is the distance between the first and second signs. The C dimension is the distance between the second and the third signs. (The third sign is the first one in a three-sign series encountered by a driver approaching a temporary traffic control zone.)

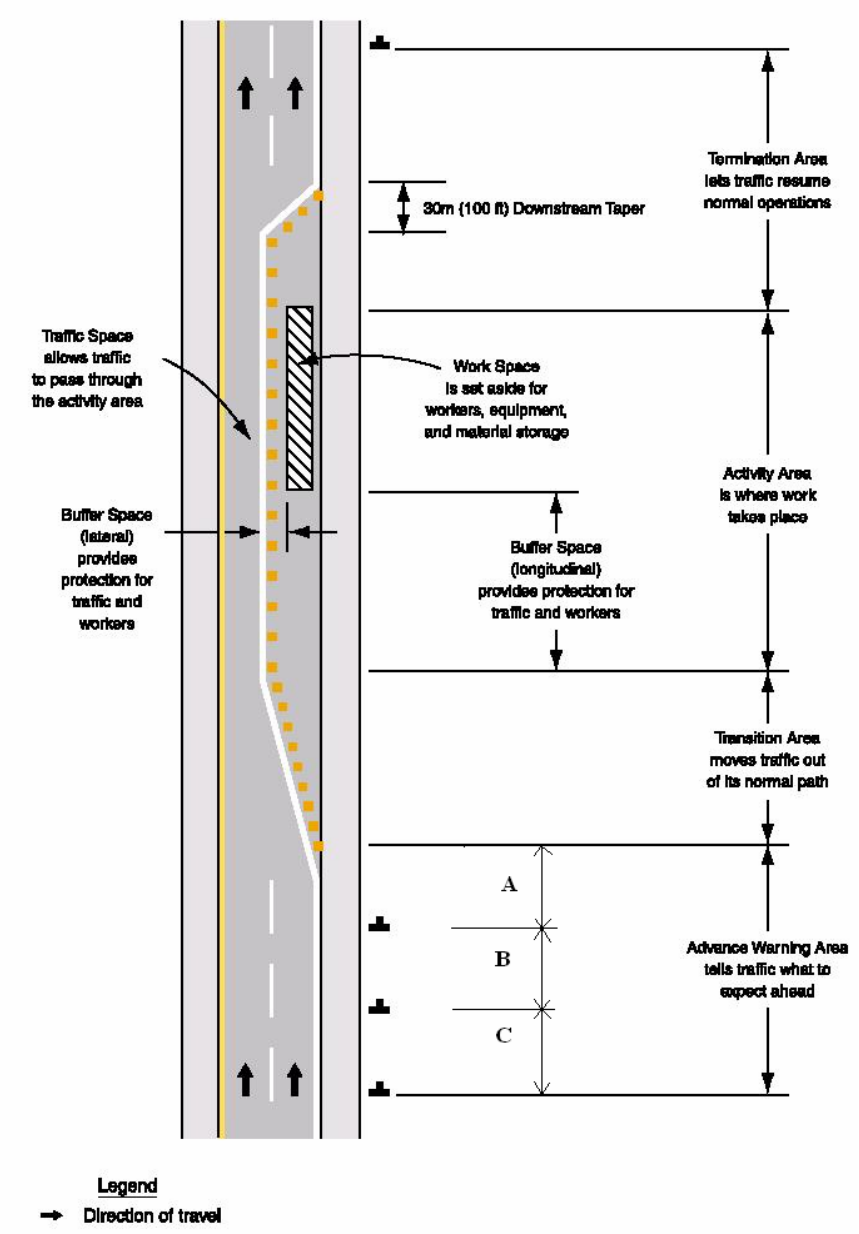


FIGURE 6-1. Component Parts of a Temporary Traffic Control Zone (Included for Definitions Only) (Source MUTCD, Figure 6C-1, p. 6C-3)

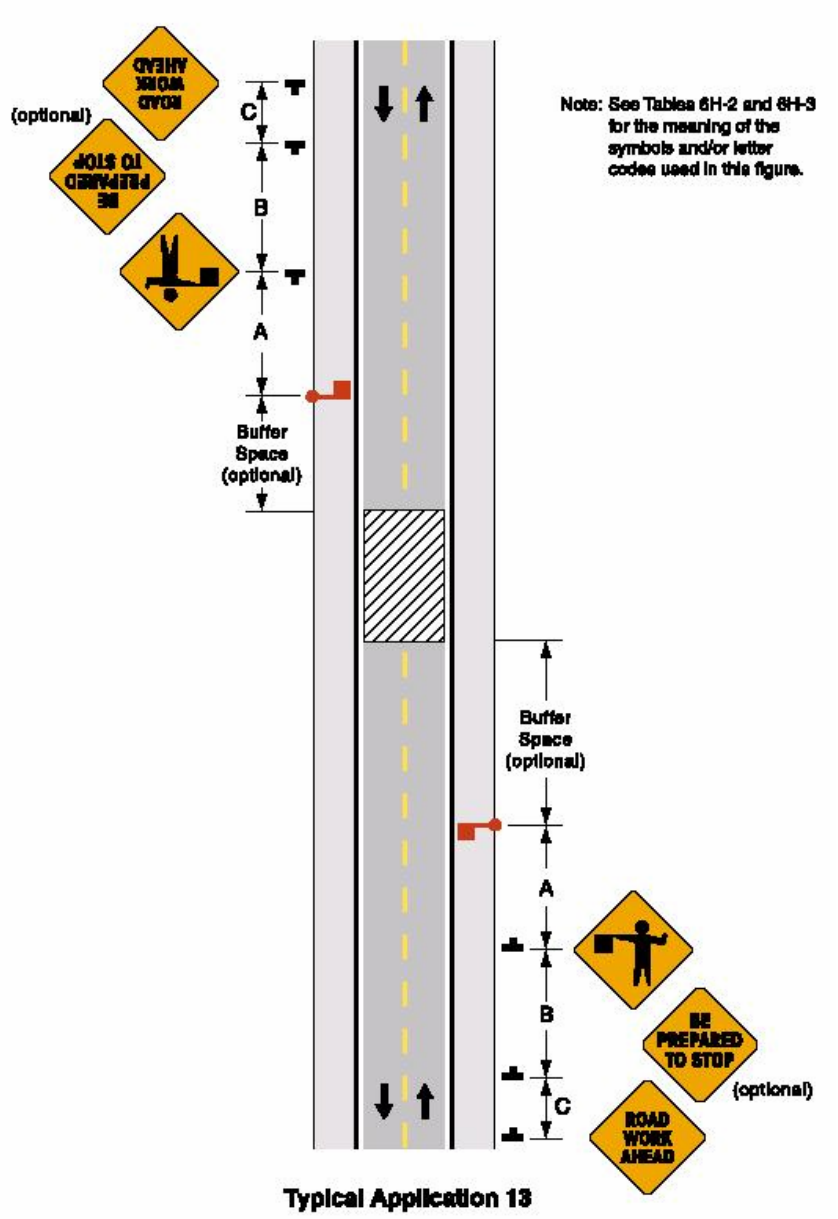


FIGURE 6-2. Temporary Road Closure
(Source: MUTCD 2003, Figure 6H-13, p. 6H-31)

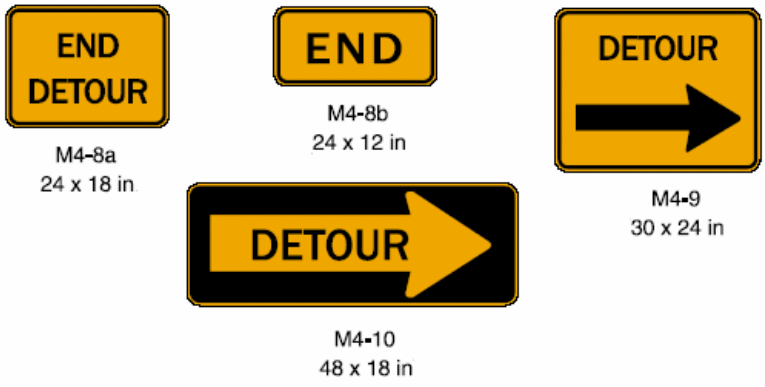
Detour Signs (MUTCD 2003, Section 6F.52)

General Discussion:

The DETOUR ARROW sign (M4-10) is used at a point where a detour roadway or route has been established due to the closure of a street or highway to through traffic. It should normally be mounted just below the ROAD CLOSED sign or the LOCAL TRAFFIC ONLY sign.

The DETOUR Arrow sign uses a horizontal arrow pointed to the right or left as required at each location. Each detour shall be adequately marked with standard temporary route markers and destination signs as a responsibility of the highway agency.

The DETOUR sign (M4-9) is to be used for unnumbered routes; for use in emergency situations; for periods of short durations; or where, over relatively short distances, it is not necessary to show route markers to guide traffic along the detour and back to its desired route. A STREET NAME sign should be placed above or incorporated in the DETOUR sign (M4-9) to indicate the name of the roadway for which the detour was established.



The END DETOUR sign (M4-8a and M4-8b) may be used to advise the motorist that the detour has ended. The END DETOUR sign may be used on either numbered highways or unnumbered roadways. If used on a numbered highway, it should be erected above a route marker located near the end of the detour.

Advance Warning Signs (MUTCD 2003, Section 6F.16)

Where highway conditions permit, warning signs should be placed in advance of the TTC zone at varying distances depending on roadway type,

condition and posted speed. MUTCD 2003, Table 6C-1 (LVR Handbook, Table 6-1) provides guidance on the spacing of advance warning signs.

W20-2
(36” x 36”)

DETOUR Sign (W20-2)

The DETOUR Sign (W20-2) shall have the legend DETOUR, XX ft, XX Miles, or AHEAD. It should be used in advance of a road user detour over a different roadway or route.

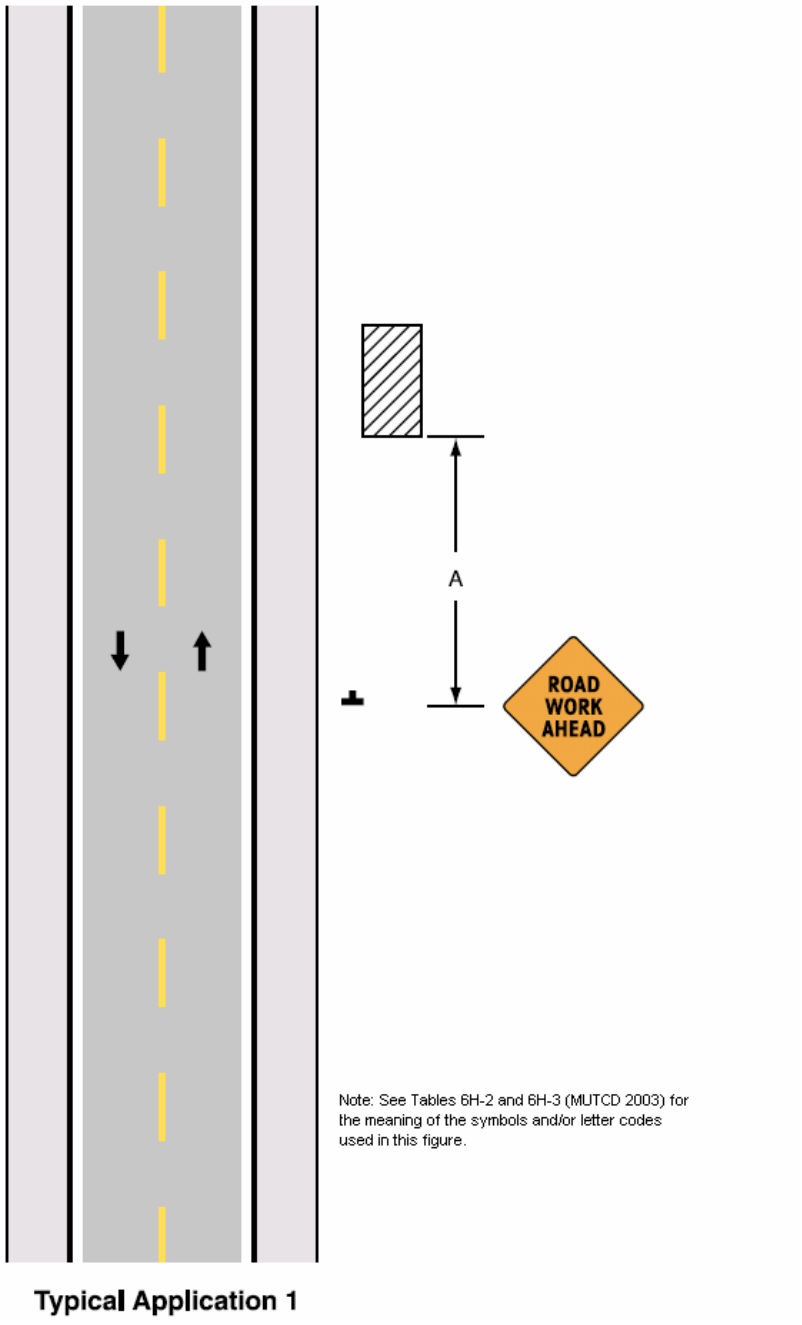


FIGURE 6-3. Work Beyond the Shoulder
Source: MUTCD 2003, Figure 6H-1

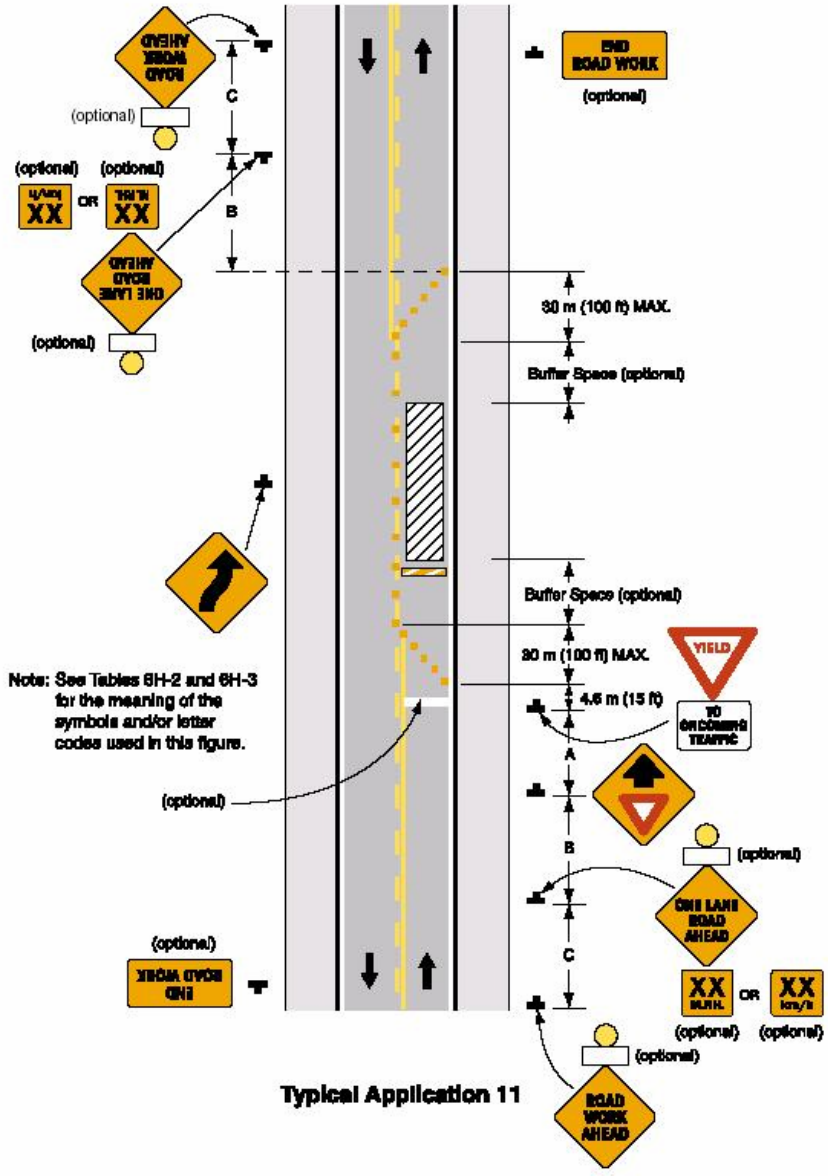


FIGURE 6-4. Lane closure on Low-Volume Two-Lane Road (TA-11)
Source: MUTCD 2003, Figure 6H-11

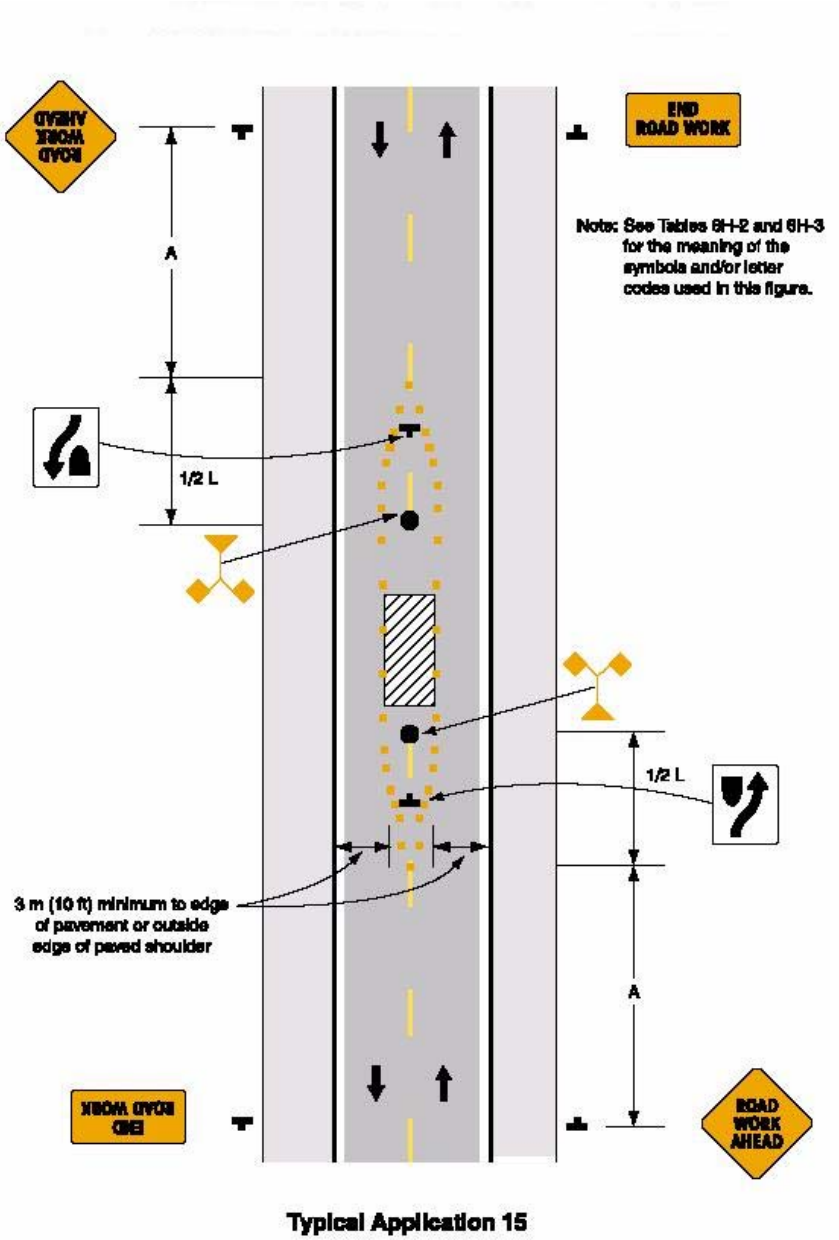


FIGURE 6-5. Work in center of Low-Volume Road (TA-15)
Source: MUTCD 2003, Figure 6H-15

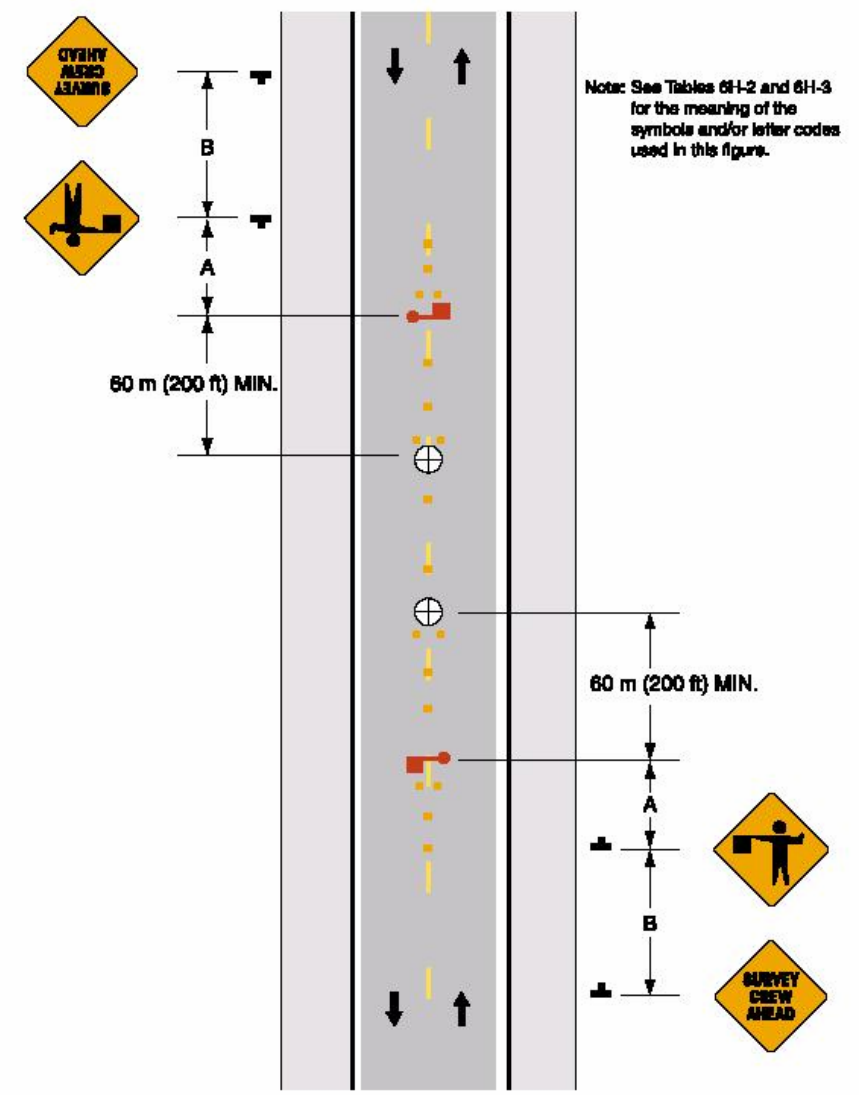


FIGURE 6-6. Surveying Along Centerline of Low-Volume Road (TA-16)
Source: MUTCD 2003, Figure 6H-16

CHAPTER 7
SELF ASSESSMENT OF LVR

General

There are several strategies or methods that personnel responsible for public safety on the local roadways-county's or road supervisors, etc can implement to insure that road signs and markings are properly installed and maintained. The commentary driving method, developed and promoted by Kansas State University (KSU) is efficient and cost effective and highly recommended. A few methods will be briefly presented below. Nothing in this LVR Handbook is intended to imply that any one of the methods is *the* one method that should be used. However, it is important that every jurisdiction has a policy (preferably written) describing some method that works for them.

Public jurisdictions have a duty to sign and/or mark certain specific operating conditions, to install devices that conform to the MUTCD, and to maintain these devices. Local agencies should have a policy and/or practice, which include some systematic means to insure compliance with the above. Four are discussed below.

Discussed here will be:
1. General Inspection Guidelines,
2. Commentary Driving,
3. A Sign Management System, and
4. Road Safety Audits and Reviews.

The extent of the system depends upon the particular needs and resources of each jurisdiction.

General Inspection Guidelines

The following sign inspection guidelines may be beneficial (ITE, 2001).

A traffic control device must be periodically reviewed in the field either as a maintenance requirement or to determine whether the device is fulfilling its purpose. Inspection of traffic control devices can be triggered for a number of reasons:

- Periodic maintenance inspection
- Investigation of a citizen complaint
- Safety study or investigation of crashes
- Determination of retroreflectivity
- Operational evaluation of recently completed projects

Each visit to a location should review the effectiveness of all traffic control devices even though the trip to the site may have been initiated for only one device or one particular reason.

Any inspection should document that the traffic control devices were reviewed in the field by the agency personnel to supply evidence that the device were in place at that time and in satisfactory operational condition. The documentation, at a minimum, should indicate date, time, name of inspector, location, any observations and recommendations for traffic control device improvements or replacement. If improvements or replacements are recommended, there should be documentation that the work was accomplished. It is important that highway signs have proper retroreflectivity. Night inspection should be considered. This is important for the safety of the motoring public at night. It may become more important in the future as retroreflectivity standards or guidelines are developed by the FHWA. Driving the roads to observe signs as a driver would is an effective means of observing how they appear to drivers. A formal method for accomplishing this is described in the next section.

Commentary Driving

Commentary driving is one of several techniques low-volume road officials have available to conduct studies to help determine the effect of traffic control devices. It is highly useful in doing safety evaluations of LVR quickly and cheaply.

The information that a driver receives form the road should be correct, pertinent, concise and presented in such a way that it is readily understood and usable to the driver. If this information is not consistent with what drivers expect to receive or should receive, the result is a violation of a driver's expectancy of the roadway environment and could result in an increased reaction time and possible driver error.

The commentary driving procedure is highly useful in doing signing/safety evaluations of Low Volume Rural (LVR) Roads. Commentary driving is a simple technique, which requires no special equipment, and from which information is gathered concerning the roadway environment, to help rid the roadway environment of all information-deficient locations. Information-deficient locations are specific locations on the roadway where the information as received by the driver from the roadway is not sufficient to give the driver the needed information to insure that he can safely traverse the roadway, i.e., additional signing or marking may be helpful.

The commentary driving procedure is a useful technique for locating information deficiencies along a roadway. It requires a driver/evaluator to drive the section of road to be evaluated. As the road is driven the driver/evaluator records his expectancies of the road and he records comment on

locations/conditions which violate his expectancy. Commentary driving does not by itself necessarily constitute an engineering study.

Any locations with information deficiencies are noted on an Information Log for the route being evaluated, noting location by mileage and comments on the situation. Remember, the method is only meant to flag **possible** information deficient locations that need further study. At this point, flagging locations for further, future study does not mean that they are actually deficient.

After doing the "commentary" on a section of road, the evaluator should return (at a later date) and do a more detailed study of locations perceived to be potentially deficient by the driver in the "commentary."

The detailed study may result in specific recommendations for changes in signs, pavement markings, clearing of weeds or brush which obstruct view of signs, etc. The purpose of the changes is to remove any information deficiency(ies) noted in the detailed study. It is also possible the detailed study will conclude that no deficiency exists and no change is necessary.

Information Logs have been developed for nine typical situations (and "other") to aid in the detailed study of the location. The following is a list of Information Deficiency Logs available:

1. Stop-controlled intersection
2. Narrow/one-lane bridge
3. Horizontal curve
4. Tangential intersection
5. Interaction which requires a turn
6. Railroad-highway grade crossing
7. Uncontrolled Y-intersection
8. Low water stream crossing
9. Height/weight limit restrictions
10. Other

Information Check Lists and Forms can be found in Appendix 5.

Details of the commentary driving procedure and self taught training materials are available through the Civil Engineering Department at Kansas State University or the T^2 Center at the University of Kansas.

References for additional information

Commentary Driving, Training Video and Self Instructional Manual, Kansas State University, Civil Engineering Department, Manhattan, KS (Ph. 785-532-5862). Also available from the T^2 Center at the University of Kansas.

Bob L. Smith and David K. Murdock, "Commentary Driving on Low-Volume Roads: Training and Use," Transportation Research Record 1055, Transportation Research Board, Washington, D.C., 1986.

Sign Management System

As stated in the Institute of Transportation Engineers, Traffic Control Devices Handbook (ITE, TCDH) (ITE, 2001): The need for a detailed management system will vary with the miles of roadway under jurisdiction, the number of traffic control devices installed and the capabilities of the agency. However, an agency should know the number and location of traffic control devices in its system, maintain them in good operating condition for the public and be responsive to any public concerns relative to the devices.

Most local jurisdictions use some form or portion of a management system. Details may be found in the Traffic Control Devices Handbook, Chapter 3, Maintenance Practices, (ITE 2001). The actual system should be developed by the local agency, tailored to their specific needs. However, every jurisdiction should have as a minimum, some sort of sign inventory system. See Handbook Chapter 8 for a detailed discussion of a sign inventory system.

A list of possible activities is presented here. Activities associated with a sign management system may include (ITE 2001):

A. Need:
    1. Inventory of traffic control devices
    2. Feedback – complaints, inspection, surveillance
    3. MUTCD applications
    4. Safety/liability concerns
    5. Traffic control device programs- signing, markings, traffic signals, railroad grade crossings, school zones, temporary traffic control
B. New Traffic Control Devices:
    1. Traffic control device evaluations
    2. Traffic control on newly completed projects
    3. Devices resulting from change in standards or policies
C. Maintenance activities:
    1. Routine maintenance–cleaning, repair of deterioration, vegetation control, post repair, device replacement, relamping, removal, operational review, contract maintenance.
    2. Emergency maintenance–damage due to vehicle collisions, outages, missing devices.
    3. Vandalism-graffiti removal/cleaning, replacement
D. Infrastructure:
    1. Personnel – organization, job descriptions, productivity, service levels
    2. Equipment- utilization, special equipment, rental versus ownership

3. Budget- personnel, equipment, materials, contracts
4. Materials- bulk purchase, specifications, contract services
5. Facilities- fabrication shops, bulk storage, inventory storage
6. Signal maintenance shops- repair, testing, inventory

E. Management Control:
   1. Organization and supervision
   1. Agency policies
   2. Material control and accounting
   3. Technical Expertise and control

Appendix 1 provides additional information on a sign inventory system.

Road Safety Audits and Reviews

In the late 1990's, FHWA was promoting Road Safety Audits (RSA) to improve roadway safety. RSA is a technique initiated in England and used heavily in Australia, New Zealand and a few other countries. Several U.S states have conducted pilot projects. Kansas DOT performs a form of RSA on existing state highways on a county-by-county basis. Overall, it consists of driving all the roads, noting potential areas of concern and writing a report. Most road safety professionals call this a Road Safety Audit Review (RSAR).

RSA

In recent years, RSA are being adapted for different situations and can take many forms. As originally developed, it is defined as: the formal explanation of an existing or future road project or any other project which interacts with road users, in which an independent qualified examiner reports on the project's accident potential and safety performance.

The essential elements of the above definition are that:

- It is a formal process
- It is an independent process
- It is carried out by a team or individual with appropriate experience and training
- It is restricted to road safety issues
- The outcome is a report that identifies road safety deficiencies and, if appropriate, makes recommendations aimed at removing or reducing deficiencies.
- The report must be formally addressed by the appropriate road decision makers

RSAR

An RSA can be performed on existing highways although it is more correctly called a Road Safety Audit Review (RSAR). An RSAR may be performed by a team or by an individual; the team or individual should have experience and/or expertise in signing and marking of LVR.

The ITE Handbook suggests an RSA for Traffic Control Devices would follow the steps in Table 7-1. These steps would also constitute an RSAR. When conducted by or under the supervision of an engineer and documented, it could be considered an engineering study.

TABLE 7-1. Suggested Road Safety Audit Questions for Traffic Control Devices (Source: ITE 2000)

1. Are road users using the roadway facilities as intended?
2. Are the roadway alignment, width, condition and travel path apparent day and night?
3. Is the traffic control device needed?
4. Are there roadway features or traffic conflicts that are not readily apparent requiring warning signs and markings?
5. Do the roadway design, geometrics and operations form a consistent pattern having broad usage or do they impose some unexpected operational problems?
6. Are the interactions of vehicles and/or road users obscured by horizontal or vertical curves, vegetation, or other vehicles?
7. Is the application in conformance with the MUTCD or is it a unique application?
8. Is the device the appropriate shape, color, legend and size?
9. Is the message clear and concise?
10. Are the device placement and spacing adequate to provide a reasonable time to read and react to the message? (Check vehicle speed, sign legibility, pavement marking location and response time.)
11. Are the road users responding to traffic control device in an appropriate manner?
12. Is the traffic control device frequently obscured by other vehicles?
13. Is the device legible, at the appropriate time for the road user, both daytime and at night?
14. Are the signs, markings and signals consistent with each other?
15. Are advance warning signs or markings needed?
16. Would redundant signing or pavement legends be a benefit?
17. Are the route markers and destination and distance signing consistent?
18. Where a marked route turns, is advance signing provided with conforming route markers following the turn?

For more information on RSAR for local agencies, see NCHRP Synthesis 321, Roadway Safety Tools for Local Agencies, Transportation Research Board, Washington, D.C., 2003, Chapter 3.

Night-time Visibility

The use of a "Retroreflectometer" may some day become a requirement to verify the retroreflective condition of all traffic control devices within the jurisdiction of the agency. However, an expensive and time-consuming retroreflectometer may not be necessary if adequate sign inspection is documented. Also, a high retroreflector reading does not ensure that a sign has adequate night visibility to an approaching driver.

The agency should establish a written policy regarding the maintenance and inspection of all traffic control devices. A written traffic control device inspection program shows intent and when used properly, should provide the agency with good tort liability protection. Part of that policy could be a section regarding sign retroreflectivity. The policy could include but is not limited to the following:

1. Review each traffic control device bi-annually regarding retroreflectivity.
2. A checklist of times to be reviewed should be part of the policy.
3. The inspection would be conducted at night and the agency should train personnel in the proper methods to complete this type of inspection.
4. Any signage not meeting the guidelines set forth in the written checklist would be scheduled for replacement.
5. Records are to be kept as long as the sign remains at that location.

It is likely that there may be multiple options to determine and maintain adequate nighttime visibility of signs. This concept may allow local agencies to implement the method(s) most suitable to them. Some of the possible methods available are:

- Nighttime sign inspection by trained observers,
- Expected service life,
- Inspection panels,
- Measured retroreflectivity values,
- Control signs, or
- Other methods.

Note: It may be advantageous for local governments to have a sign inventory system. Sign Management Systems are discussed in the next chapter.

Deficiency Checklists

All methods of analyzing LVR should be greatly aided by the use of the checklists in Appendix 5. The checklists have been developed for nine typical situations and "other".

Other Self Assessment Methods

It is emphasized that no one method is best for all local agencies. A local agency must decide for itself what works for them. The important thing is that they have one that works and follow it on a consistent basis that they deem appropriate for their agency.

References

Institute of Transportation Engineers, Traffic Control Devices Handbook 2001, Editor: James L. Pline, Publication No. IR-112.

CHAPTER 8
INVENTORY SYSTEMS FOR TRAFFIC CONTROL DEVICES

The material in this chapter is reproduced with permission from the "Iowa Traffic Control Devices and Pavement Markings: A Manual for Cities and Counties", Iowa DOT, Ames, IA 2001

An inventory of signs and markings is a critical element for effective governmental transportation management practices. The investment in signs and markings is significant when considering all the assets of a government agency. The ideal inventory system would track signs and markings from initial installation, through inspections and maintenance, and until removal from the system.

FIGURE 8-1. Rural highway with signs and pavement markings

A traffic control device inventory can be a valuable asset. This inventory can provide documentation of the condition of specific signs and markings in place for any given period. In addition, pertinent inspection and maintenance activities would be noted in the inventory and available for use by the agency.

An inventory system has many uses. It can identify signs for replacement based on criteria such as age or condition. Recording and evaluating maintenance and replacement history can help an agency to identify high-vandalism areas or sign locations with visibility or operational deficiencies. In addition, planning and budgeting for sign replacement or expansion of new development areas is much easier to accomplish with inventory records identifying existing signs and required maintenance activities. A sign inventory

can be used to manage personnel and maximize production by combining work orders and scheduling routine maintenance activities. The system can track responses to requests and complaints, resulting in an improved level of service to the public.

FIGURE 8-2. Vandalized Speed Limit sign

FIGURE 8-3. Vandalized sign

A critical element of a successfully operating inventory is the involvement of all staff whose job requires an interest in traffic control devices. Involvement of all available staff is particularly important for the staff responsible for collecting the original data, maintaining traffic control devices, and keeping the

inventory system current. An efficient inventory system results from involvement of all interested parties.

Choosing a System

Inventory systems range from very basic to quite sophisticated depending on the resources available to and the needs of an agency. A very basic inventory system might consist of manual records, such as paper files of activities or a card system, to maintain the system and keep it current.

Many transportation agencies use an automated or computerized system. Each agency should consider several factors before making a selection between one of the many computer programs available:

- agency requirements
- computer capabilities
- availability of trained staff to support the system and keep it current
- improved accuracy and production with use of laptop computers for field operations

When selecting an inventory system, the following issues should be addressed:

- Does the system match the selected data elements? Are all data elements recorded?
- Is there an understanding of the basic features of a software program as compared to data elements?
- Do the hardware and software requirements of computer programs match the existing computer system?
- Have user support and references been reviewed?
- What does the initial cost include?
- Are there maintenance costs with the program?

Software that provides basic inventory features has been developed and is available at minimal cost to local agencies. These programs can be effectively used as a low-cost supplement to a sign management system.

Developing the System

Development of the system should involve key personnel, including management representatives, office staff, work crew supervisors, sign workers, and other affected offices within the agency. The development of an inventory system should also include all critical tasks: selecting and purchasing software, collecting initial data, daily operations, and reporting procedures, along with ancillary tasks such as enforcement and risk management.

Choosing a Reference System

Several reference systems can be considered to locate traffic control devices for the inventory. The chosen reference system should be compatible with other systems within the agency and use the same reference points. The most common references used are shown in the following list:

- route/milepost/distance
- route/mile point/distance
- link/node/distance
- route/intersection/direction/distance
- global positioning systems, which may offer additional location options for the future
- linear referencing systems

Each of these reference methods has particular advantages to consider, but the most important factors are compatibility with other agency systems, staff buy-in, and ease of use.

Determining Elements of the Inventory

Inventory data elements are selected to provide most appropriate information to meet agency needs. These elements can be divided into three categories: core, critical, and desirable.

Core Elements. Core data elements reveal location, description, condition, and inspection and maintenance history. Core elements are essential to an inventory. These elements identify replacements, provide documentation in tort liability, and furnish benefits in management and budgeting.

Core elements typically include the following:

- location
- position
- sign code (*MUTCD* designation)
- sign condition
- maintenance activities
- installation, inspection, and maintenance dates

Critical Elements. Critical data elements provide more information about devices. These elements are valuable in keeping proper inventories in stock and can provide additional information that supports the agency in tort liability issues. With data from the following critical element list, an agency can document that traffic control devices comply with established standards and guidelines.

Critical elements normally include the following:

- dimensions
- sheeting type
- sign blank type
- post/support type and condition
- sign orientation
- posted speed limit at the time activities were conducted

Desirable Elements. Desirable data elements can provide additional information about sign installation that can help with maintenance and replacement activities.

Desirable elements include the following:

- offset
- height
- retroreflectivity (documentation will be more important when minimum standards are adopted nationally)
- inspector name
- sign identification number, if different from *MUTCD*
- images of the sign
- comments
- other reference numbers

Collecting the Data

The most formidable task after selecting an inventory management system, whether manual or computerized, is the collection of initial data. In addition to a significant investment in staff time, collection costs can range from $2 to $5 per sign. To reduce initial cost and staff time, phased data collection can be considered. A systematic approach should be developed that completes the task within a reasonable time, i.e., four years or less. Data may be collected by area or sign type. Regular agency staff, temporary employees, or consultants can be used to collect this data, but all should be properly trained. It is very important that initial information be accurate.

When the initial data collection effort is organized, the following recommendations should be considered and/or followed:

- Select a standard approach that matches other databases within the agency, if possible.
- Decide whether to use route names or route numbers for location.
- What signs should be included? All or one specific type, such as regulatory signs?
- How do we determine whose sign is it?
- Train personnel to collect and enter data.

- Determine the area to be inventoried (do only a section each year until the initial data collection is completed.)
- Decide whether to use manual data collection, laptop computers, or photo/video logging to gather initial data.

Maintaining the Inventory

After an inventory system has been adopted and initial data collection activities are completed, the next critical task is keeping the system current. If the inventory is not up to date, much of the value and the investment in resources will be lost in a relatively short time.

A work order process is a common method of keeping inventories current. With this procedure, work orders are completed at the time any activity is finished. Usually, the field crews that perform the work are best qualified to record the data. Pen-based computers have been used successfully for this purpose in some agencies. It is important to enter this information into the database on a regular schedule, daily if possible.
Documentation of important daily activities should be a key factor in software selection.

Inventories of traffic control devices can be a very valuable asset for any transportation agency. However, development and establishment can involve a significant investment in staff time and funding. Continued maintenance of the system is mandatory for efficient and effective operation.

Please refer to the following sources for more in-depth information

Institute of Transportation Engineers, *Traffic Signing Handbook*

Institute of Transportation Engineers, *The Traffic Safety Toolbox: A Primer on Traffic Safety.*

APPENDIX 1
MAINTENANCE CHECK AND SIGN INVENTORY

General

An ongoing maintenance system can be beneficial to a local jurisdiction by improving motorist safety as well as providing a greater degree of protection from liability claims. A maintenance system may include a sign inventory, a citizen service request, a method for rating maintenance priorities, and a routine inspection. The scope of the system will vary depending upon the size and complexity of the jurisdiction.

Some of the information, which may be included in a sign inventory, includes a record of:

1. type and size of sign,
2. time, date, and by whom the sign was installed or inventoried,
3. location of the sign,
4. condition of the sign, to include a note as to whether or not the sign is reflectorized; and
5. time, date, and by whom any maintenance was performed on the sign.

The record should be updated whenever a revision is made or maintenance is performed on the sign, and there should be a policy that establishes specified intervals for updating the records. Sign inventory card systems that are inexpensive, simple, and adaptable to all levels of roads, are available from commercial sources! A simple form is shown on the next page.

All signs should be checked periodically and local government employees should be instructed to watch for, and report problems whenever they drive the roads.

Marked Signs

Identifying and recovering signs that have been removed by vandals is much easier if each has a special number stamped, engraved, etched or painted on it. The numbering may be quite simple merely having the abbreviation or number of the county, for example.

Reference

"Advanced Road Program", National Association of County Engineers, Action Guide series (July 1972) p.23

TRAFFIC CONTROL DEVICES INSPECTION SHEET *

County
Township_____Road Identification_____Location,direction_____
Beginning point_____

Odometer Reading	Side of Road	Sign No.	Sign I.D.	Sign Type	Inspection Data (Note Condition)			
					Date	Action Taken	Date	Action Taken
Inspector								

x - sign is OK
0 - needs attention

SheetNo._____/_____

EXAMPLE TRAFFIC CONTROL DEVICES INSPECTION SHEET

County

Township_____Road Identification_____Location,direction____

Beginning point_____

Odometer Reading	Side of Road	Sign No.	Sign I.D.	Sign Type	Inspection Data (Note Condition)			
					Date	Action Taken	Date	Action Taken
0.00	Rt.	1	R1-1	Stop	x			
0.82	Rt.	2	W2-1	Int.	x			
		2	W13-2	Avg. Speed Pl.	x			
1.00	L & R	3	R1-1	Stop	x			
1.18	L	4	W2-1	Int.	x			
1.25	L & R	5	OM-2	Obj. Mk.	1-OM-2 missing	OM-2 Replaced 1-4-90		
2.00	L & R	6	R1-1	Stop	x			
2.3	R	7	W10-1	RR Adv.	x			
2.5	L	7	W10-1	“	x			
3.0	L & R	9	R1-1	Stop	bullet holes			
3.2	R	10	W5-2	Narrow Br.	x			
3.3	L & R	11	OM-3	Obj. Mk.	x			
3.31	L & R	12	0M-3	“	x			
3.41	L	13	R1-1	Yield	x			
4.0	R	14	R1-1	Stop	x			
4.2	R	15	W1-2	Curve	Poor re-flectivityx			
4.7	L	16	W1-2	Curve	x			
6.0	L & R	18	R1-1	Stop	Too low	Sign raised 1-3-80		
Inspector					ADM	ADM		

x - sign is OK

0 - needs attention

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APPENDIX 2
SETTING UP A CITIZEN SERVICE REQUEST

(This section is provided for those jurisdictions, which do not currently have a service request system and are interested in starting one.)

All requests should be made to one office. The office should be available to receive requests or notices of problems concerning roadways and traffic control devices. The following action is suggested:

1. Record date and time of the request,
2. Record name, address and telephone number of the requester (if anonymous, so state),
3. Record location and description of problem,
4. Prioritize the problem according to an established priority system based upon potential criticality of having an accident (see Priority System Considerations),
1. Ask for local law enforcement support at location, if necessary, until action can be taken,
2. Investigate, if necessary, in order to determine necessary corrective action,
3. Contact maintenance personnel and instruct them to take appropriate action, immediately in case of a high priority ranking,
4. Record time, date and to whom the corrective action instruction were assigned,
9. Record date and time that corrective action was completed,
10. Upon completion of action, notify the person who made the request about corrective action taken, and express appreciation for assistance,
11. Maintain a record system of all complaints, and file according to location, and
12. Provide for periodic review of records, noting recurring problems that may need special attention.

Priority System Considerations

The following list contains several factors that may be included in developing a priority system for selecting the order of responding to citizen service requests:

1. The immediate risk, e.g., a STOP sign down should be replaced as soon as possible
2. The number of accidents in a given area,
3. The severity of accidents in a given area,
4. The volume of traffic in a given area,
5. The amount of work to be done by the Highway Department as a total,
6. The availability of resources,

SERVICE REQUEST FORM

Work Order

Request: Date_____ Time_____

Requestor: _____

Address: _____

Telephone: _____

Location: _____

_____

Description: _____

_____

_____

Call Taken by: _____

Corrective
Action:

Priority:
Assigned to: _____

Date_____ Time_____

Action Taken: _____

_____

_____

_____

Requestor Contacted: _____ Yes

_____ Requested not to be contacted

APPENDIX 3
INTERSECTION SIGHT DISTANCE

General Considerations

Each intersection contains several potential vehicle conflicts. The possibility of these conflicts actually occurring can be greatly reduced through the provisions of proper sight distances and appropriate traffic controls. The avoidance of accidents and the efficiency of traffic operations still depend on the judgment, capabilities, and the response of the individual driver.

The operator of a vehicle approaching an intersection at-grade should have an unobstructed view of the entire intersection and sufficient lengths along the intersecting highway to permit control of the vehicle to avoid collisions, should a crossing vehicle be on a collision course. When traffic at the intersection is controlled by signals or signs, the unobstructed views may be limited to the area of control. The sight distance considered safe under various assumptions of physical conditions and the driver behavior is directly related to vehicle speeds and to the resultant distances traversed during perception and reaction time and braking.

Minimum Sight Triangle

There must be unobstructed sight distance to the intersection ahead along both approaches of both roads at an intersection and also across their included corners for a distance along the cross road sufficient to allow the operators of vehicles, approaching simultaneously, to see each other in time to prevent collisions at the intersection. Each driver has three possible actions: to accelerate, to slow down, or to stop. For each, the space-time-velocity relations determine the minimum sight triangle required to be free of obstructions or, if a sight triangle below the desirable minimum distance(s) must be used, they fix the necessary modifications in approach speeds or suggest appropriate traffic control device.

Any object within the sight triangle that constitutes a sight obstruction should be removed or lowered if possible. Such objects include cut slopes, hedges, bushes, trees or tall crops. This is covered in state statutes.

Approach Sight Triangles

Figure A3-1, A shows typical clear sight triangles to the left and to the right for a vehicle approaching an intersection. These are referred to as “Approach Sight Triangles” (AASHTO, 2001)

Departure Sight Triangles

Figure A3-1, B shows a typical clear sight distance for a driver stopped at a stop or yield controlled intersection to start up and safely cross the intersection. These are referred to as “Departure Sight Triangles”. (AASHTO, 2001)

No Stop or Signal Control at Intersection

The following guidelines are based on information from guidelines for Geometric Design of Very Low-Volume Local Roads with ADT ≤ 400 (VLVLR) (AASHTO 2001). If one or more legs of the intersection exceed 400 vehicles per day, intersection sight distance should be designed in accordance with Chapter 9 of the AASHTO Policy on Geometric Design of Highways and Streets ("Green Book") (AASHTO 2001).

Case I Enabling Vehicles to Adjust Speed

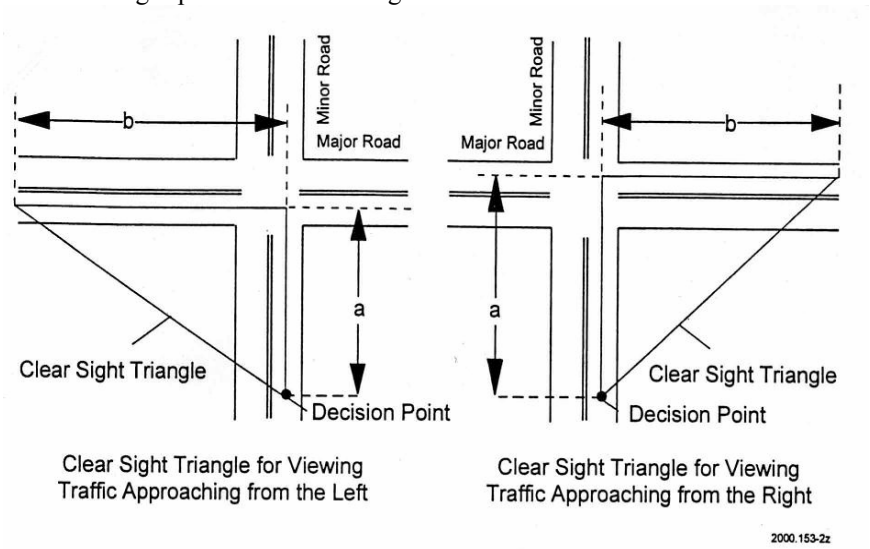
Where a crossing is not controlled by YIELD signs, STOP signs or traffic signals, the operator of a vehicle approaching an intersection should be able to perceive a hazard in sufficient time to alter the speed of his vehicle as necessary before reaching the intersection. The clear sight area should include adequate length along both intersecting roadways (both directions) as well as their respective included corner, so that the approaching driver can see any potentially conflicting vehicle in time to slow or stop. The minimum time in which deceleration can be started is the driver perception and reaction time which, can be assumed to be two seconds which is a fairly conservative value. In addition, the driver should begin actual braking some distance from the intersection to accomplish deceleration to avoid collision. An arbitrary minimum for the distance from an intersection, where a driver can first see a vehicle approaching the intersection on the intersecting road, is that traversed during two seconds for perception and reaction plus one additional second to actuate braking or accelerating to regulate speed.

TABLE A3-1: The distances traveled by a vehicle in three seconds are:
(Source: LVR Handbook Second Edition)

Speed, mph	Distance, feet
10	45
15	70
20	90
25	110
30	130
35	155
40	180
50	220
60	260

Under case I for given speeds, the minimum sight triangle is determined by these minimum distances along the road. Referring to Figure A3-1, highway 'a' (major road) with 50 mph speed and highway 'b' (minor road) with 30 mph speed would require an unobstructed sight triangle between points on highways

a and b with legs extending at least 220 feet and 130 feet, respectively, from the intersection. These or greater distances should permit a prudent driver on either road to change speed before reaching the intersection.



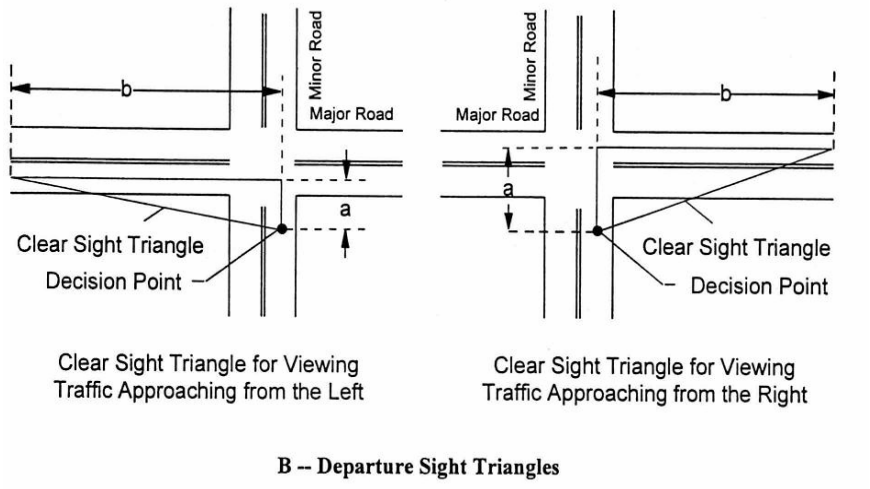


FIGURE A3-1. Clear Sight Triangles for Intersection Approaches (AASHTO, 2001)

Intersections with sight triangles having road distances no greater than those indicated above are not necessarily risk free since there is possible confusion

between vehicle operators and the possibility of a driver on one highway being confronted with a succession of vehicles on the intersecting highway when the time and distance are sufficient only to avoid one vehicle. Even where only one vehicle on each of adjacent legs approaches an intersection, both vehicles may begin to slow down (or speed up) and reach the intersection at the same time. One important factor is that a vehicle approaching a *noncontrolled* intersection must yield the right-of-way to vehicles approaching the intersection on the right.

Noncontrolled intersections should be used only in the design of rural intersections on lightly traveled two lane roads where the cost of achieving greater sight distance is prohibitive. *Where this minimum triangle cannot be provided, traffic control devices should be used to slow down or stop vehicles on one road even if both roads are lightly traveled*.

The preferred design for "noncontrolled" crossings allows the operators of vehicles on both highways to see the intersecting highway in sufficient time to stop the vehicle before reaching the intersection. The safe stopping distances for intersection design are the same as those used for design in any other section of highway. The minimum stopping sight distances are:

TABLE A3-2: Recommended Sight Distance Guidelines for New Construction (Source: AASHTO 2001)

Design speed (MPH)	Safe stopping distance (Feet)	Sight Distance* guidelines VLVLR (AASHTO, 2001) (Feet)
20	125	80
25	150	95
30	200	120
35	250	140
40	325	170
50	475	255
60	650	350

*when the grade along an intersection approach exceeds 3%, the leg along the clear sight triangle along that approach should be multiplied by the appropriate adjustment factor.

The AASHTO 2001 distances are less than the safe stopping distance and are based on the following reasoning:

"Where a clear sight triangle whose legs correspond to the stopping sight distances of their respective approaches can be provided, this will provide an even greater margin of safety. However, since field observations show that motorists slow down to some extent on approaches to uncontrolled intersections,

the provision of a clear sight triangle with legs equal to the full stopping sight distance is not essential" (AASHTO, 2001)

For two highways of known design speeds, the sight triangle determined by the safe stopping sight distance is a safer design than that with the adjusted speed distances. Engineering judgment should be used. An operator sighting a vehicle on the intersecting road may stop, if necessary, or otherwise change speed to avoid hazard. Confusion of the drivers is possible because both may slow down and reach the intersection at the same time. However, this danger is slight because of the great number of speed-change possibilities, the time available, and the normal decrease in speed as an intersection is approached under such conditions.

Because of the very low traffic volume present, no departure sight triangle is needed (AASHTO, 2001)

Case II - Yield Control for Minor Roads

This type of design requires that the minor roadway be posted with yield signs as its legs intersect the major roadway. Reference is made to Figure A3-1.

The sight distance for the vehicle operator on the minor road must be sufficient to allow the operator to observe a vehicle on the major roadway, approaching from either the left or the right, and then through perception, reaction and braking time, bring the vehicle to a stop (when necessary) prior to reaching the intersecting roadway. Whenever practical, sight distance along the legs of the appropriate approach triangle should be at least equal to the full intersection sight distances for yield controlled intersections presented in Chapter 9 of the AASHTO "Green Book" (AASHTO, 2001). Where a proper sight distance cannot be achieved for the driver of the vehicle on the minor road, it may be necessary to have a posted speed reduction as the minor road approaches the major cross road. Engineering judgment should be used.

Where an obstruction, which cannot be removed except at prohibitive cost, fixes the vertices of the sight triangle at points that are less than the safe stopping distances from the intersection, vehicles may be brought to a stop (after sighting other vehicles on the intersecting road) only if they are traveling at a speed appropriate to the available sight distance. If vehicles on one of the roads are permitted to travel at the design speed, the critical corresponding speed on the other road can be evaluated in terms of the design speed and the dimensions to the known obstruction.

Referring to Figure A3-2, in the typical case speed V_a. is known and a and b are the known distances to the sight obstruction from the respective paths of vehicles A and B. The critical speed (V_b) of vehicle B can then be evaluated in terms of these known factors. Distance d_a is the minimum stopping distance for

vehicle A. When vehicle A is at a distance d_a from the intersection and the drivers of vehicles A and B first Sight each other, vehicle B is at a distance d_b from the intersection.

By similar triangle proportion

$$d_b = \frac{ad_a}{d_a - b}$$

and the critical speed V_b is that for which the stopping distance is d_b. The signs of road B, showing the safe speed with which to approach the intersection, should be so located that a driver can reduce his speed to V_b by the time he reaches the point that is the distanced d_b from the intersection. Similar calculations may be used to determine how far back an obstruction need be moved to provide sufficient sight for safe driving at desired vehicle speeds on the respective roads. Proper adjustments to all distances must be made where any of the intersection approach legs are on other than a level grade.

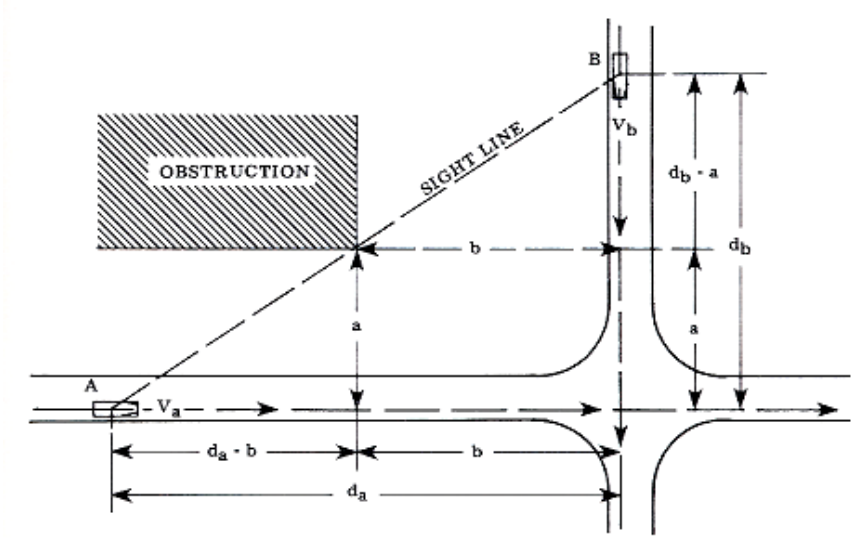


FIGURE A3-2. No Stop or Signal Control at Intersection-Case I and II-

According to AASHTO, VLVLR (AASHTO, 2001), in constrained situations, stopping sight distances determined from the Green Book, Exhibit 8 should be used. Where traffic ranges from 100 to 250 vehicles per day, the sight distance in Exhibit 8 in the column headed "Higher Risk" should be used (AASHTO, 2001)

US Customary

Design speed (mph)	Minimum sight distance (ft) for specified design traffic volumes and location types			
	0–100 veh/day	100–250 veh/day		250-400 veh/day
	All locations	"Lower risk" locations[1]	"Higher risk" locations[2]	All locations
15	65	65	65	65
20	90	90	95	95
25	115	115	125	125
30	135	135	165	165
35	170	170	205	205
40	215	215	250	250
45	260	260	300	300
50	310	310	350	350
55	365	365	405	405
60	435	435	470	470

[1] away from intersections, narrow bridges, railroad-highway grade crossings, sharp curves, and steep downgrades

[2] near intersections, narrow bridges, or railroad-highway grade crossings, or in advance of sharp curves or steep downgrades

FIGURE A3-3. Minimum Sight Distance for specified Design traffic Volumes and Location types [Exhibit 8, AASHTO, VLVLR (AASHTO, 2001)]

No separate sight triangles need to be considered in this traffic range. Previously mentioned grade adjustment factors may apply.

On higher volume roadways where there are no constrained situations, since some vehicles may have to yield (stop), departure sight triangles should be considered. An engineering study or engineering judgment should be used.

Case III- Stop Control on the Minor Road:

All vehicles on the minor road are required to stop; therefore no approach triangles such as those shown in Figure A3-1 are necessary. However, the STOP sign must be visible far enough in advance so that drivers can safely stop. An engineering study or engineering judgment should determine if a STOP AHEAD sign should be installed and/or a lowered speed limit should be established.

Departure sight triangles to both the left and right, such as those shown in Figure A3-1B should be provided for each stop or yield controlled approach. Whenever practical, the sight distance should be equal to the full intersection sight distance for stop-controlled intersection as presented in Chapter 9 of the "Green book" (AASHTO, 2001). For constrained situations the departure distance along the major road should be appropriate for the design speed of the major road as determined by the Green Book, Exhibit 8 (AASHTO, 2001). For

lower volume roads in the range of 100 to 250 vehicles per day, the VLVLR guidelines are:

"The sight distances in the column of Figure A3-3 headed "higher risk" locations should be used, because this column is appropriate for application to intersections. The vertex of the departure sight triangle on the minor road should be 14.4 ft from the edge of the major-road traveled way (1, 6)" (AASHTO, 2001).

Reference

American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Rural Highways (Washington, D.C.: American Association of State Highway Officials, 2000), pp. 739-745

Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400) AASHTO 2001

APPENDIX 4
SUGGESTED SPACING AND PLACEMENT FOR CHEVRON ALIGNMENT SIGNS

MUTCD 2000 requires that at least two chevrons be visible to the driver throughout the curve. Guidelines that should achieve this are presented below.

In 1981 a study was done by University of Kansas student Mohammad Ebtekar in cooperation with the Kansas Department of Transportation (KDOT) titled "Effectiveness of Chevron Alignment Markers." The following is based on his work.

Table A4-1 on page A4-3 gives guidelines for the spacing of chevrons on curves of differing radius (curves with small radii). The table is based on the equation:

$$4.5\sqrt{R-50}$$

where S is the spacing distance (value) between chevrons, and R is the curve radius. The S values in Table A4-1 are adjusted by rounding to a few incremental values and are presented as Sc (chart spacing values). These chart spacing distance values are then used to determine a uniform spacing between chevrons.

The following example illustrates the procedure for chevron spacing (see Figure A4-1).

Given:

A curve of radius (R) = 286 ft and a distance to be marked by chevrons of (X) = 408 ft. X is the distance on the curve between the intersection of the sightlines with the road edge.

1. Determine the spacing value (Sc) from table 10.

   -Sc=75 ft for a curve with 286 ft radius.

2. Determine the number of spaces needed to uniformly place the chevrons along the curve.

   Number of Spaces (N) = $\frac{\text{DISTANCE TO BE MARKED}}{\text{SPACING VALUE}}$

$$-or\ N = \frac{X}{Sc} = \frac{408}{75} = 5.44$$

3. Round off the number of spaces to a reasonable whole number (Nr). In this case Nr = 5.

4. Determine the actual space between the markers (Sa).

   Space Between Chevrons = DISTANCE TO BE MARKED / NUMBER OF SPACES

$$-or\ Sa = \frac{X}{N\,r} = \frac{408}{5} = 81.6\ ft.$$

5. Therefore 6 markers (number of spaces (N) plus one) will be needed to mark out five spaces, each a distance of 81.6 ft apart. Twelve chevron signs ((N+1)2, two for each marker) will be needed to be able to view the markers from either direction on the curve.

In Summary, the procedure for spacing chevrons is as follows:

1. Determine the beginning and ending point of installation.

2. Determine the distance (X) between the beginning and ending points.

3. Determine the spacing value (Sc) from Table A4-1 using the given curve radius (R).

4. Determine the number of spaces:

$$N = \frac{X}{Sc}$$

3. Round the number of spaces (N) to a reasonable whole number (Nr). In this case Nr = 5.

6. Determine the actual spacing distance between the chevrons:

$$Sa = \frac{X}{N\,r}$$

7. Use (N+I) markers spaced at intervals a distance of Sa apart, and 2(N+I) chevron signs so the signs will be visible on both sides of the curve.

If it is necessary to have "key" (warning, regulatory, etc.) signs preceding the curve points A and B (see Figure A4-2), they should be located using the following procedure.

From a point P that is 300 feet in advance of the curve and 4 feet to the right of the centerline, view the angle 0 between the sign at point A and the sign to the left of point A (or the sign to the right of point B, at point B). Place the key sign on a line from point P at approximately the same angle 0 to the right of point A (or to the left of point B) and at a point on that line with a distance Sa (actual

spacing distance) to the right of point A (or left of point B). Point C on figure A4-2 is the suitable location for a key sign using this procedure.

It should be noted that special curve situations will arise in which a combination of vertical and horizontal curvature will require consideration by the engineer.

TABLE A4-1: Suggested Spacing and Placement for Chevron Alignment Signs

Design Speed (0.08 Max Super)	Degree (D)	Radius (R)	Distance (Sc) ft
60 MPH	1E00'	5730'	200'
60 MPH	2E00'	2865'	200'
60 MPH	3E00'	1910'	200'
60 MPH	4E00'	1432'	150'
50 MPH	5E00'	1146'	150'
50 MPH	6E00'	955'	125'
50 MPH	7E00'	819'	125'
40 MPH	8E00'	716'	125'
40 MPH	9E00'	637'	100'
40 MPH	10E00'	573'	100'
40 MPH	11E00'	521'	100'
40 MPH	12E00'	477'	100'
30 MPH	13E00'	441'	100'
30 MPH	14E00'	409'	75'
30 MPH	15E00'	382'	75'
30 MPH	16E00'	358'	75'
30 MPH	17E00'	337'	75'
30 MPH	18E00'	318'	75'
30 MPH	19E00'	302'	75'
30 MPH	20E00'	286'	75'

The above chart is based on the equation S = 4.5 V -R-50. The S values have been adjusted to provide the incremental values shown in the chart. The chart values (Sc) are intended as guides. Chevron Alignment Sign spacing

should be uniform throughout a given installation; therefore adjustments in the chart values may be made.

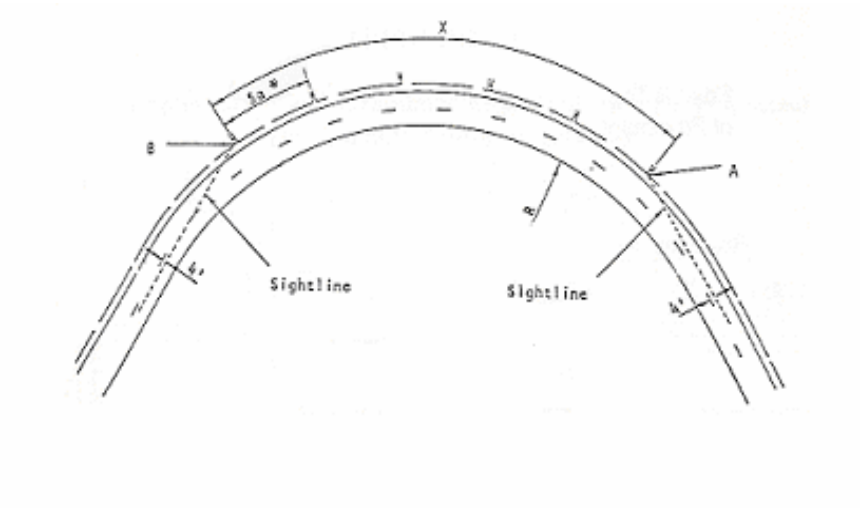


FIGURE A4-1. Diagram to Illustrate Placing of Chevron Signs and Curves.

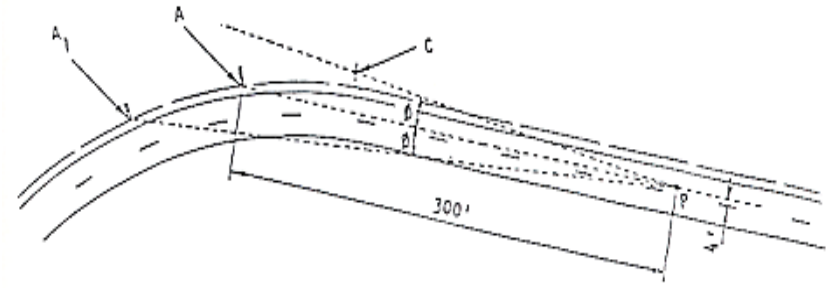
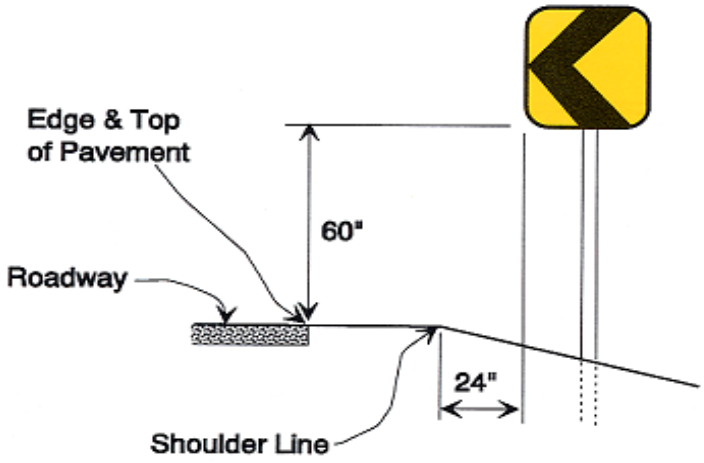
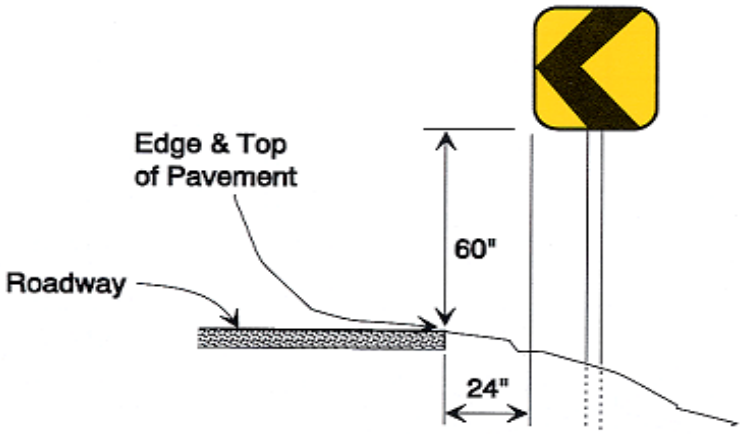


FIGURE A4-2. Diagram to Illustrate Placing Key Signs at Beginning of Chevron Signs and Curves



Note: Chevrons should be installed on break-away sign posts.



Max. Lateral Spacing up to 12'

FIGURE A4-3. Installation Policy (KDOT)

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APPENDIX 5
CHECKLISTS TO ASSIST INVESTIGATION OF SUSPECTED PROBLEM LOCATIONS

General

The checklists presented in this appendix should be appropriate to assist in an engineering study independent of commentary driving.

Description of the Forms

Each checklist has three parts. Part I requires some basic information related to the site. Specifically it requires the following items:

- Route ID (identification) - either by number and/or name.
- Location - to locate a specific situation note its distance (in tenths of mile) from a reference point such as the starting point for the survey or nearest intersection.
- Approach Direction - Circle the direction of travel based on map or route designation.
- Date/ Time - self-explanatory.
- Inspector(s) (evaluator(s)) - enter names or initials.
- Approach Speed During Survey - This is the speed at which the driver approached the site during the initial survey.
- Speed Limit Posted or Estimated - Enter the speed limit and check whether it was posted at any point leading up to the site or that it was not posted and was estimated.
- Decision Sight Distance - Using the speed limit if posted, or the maximum of the approach speed or estimated speed, circle the appropriate decision sight distance value. From this distance upstream of the beginning of the site, e.g., the point of curvature, start of bridge or width transition, etc., initial observations are to be made regarding several checklist questions presented in part II.

<u>A special note about Decision Sight Distance</u>

Standard geometric design requires that stopping sight distance be provided continuously so that it is possible for the motorist to stop safely in the event that an object is in the travel lane. However, to detect a hazard or situation ahead and respond to it safely, longer distances are often required so that the motorist can have adequate time to assess the situation, make a decision, and act accordingly.

Decision sight distance meets this need. It is defined as the distance at which a driver can detect a hazard in an environment of visual clutter, recognize it (or its threat potential), select an appropriate speed and path, and perform the required action safely and effectively (McGee, 1982). Its application to

information systems for two lane rural roads involves determining critical points where the driver needs certain information relative to an impending potentially hazardous situation.

Decision sight distance values for various speeds are tabled below, along with stopping sight distance.

TABLE A5-1. Decision sight distance values for various speeds (Source: McGee, 1982).

SPEED (mi/h)/km/h		SIGHT DISTANCES (ft./meters) FOR			
		STOPPING		DECISION	
30	50	200	61	550	168
40	60	300	91	750	229
50	80	450	137	900	274
60	100	650	198	1150	351

Part II is a series of suggested questions, which serve as a checklist to evaluate the nature of the deficiency. At a location approximating the decision sight distance for the appropriate speed, the investigator(s) should assess the visibility of the specific situation and the presence and use of appropriate warning signs and other devices, e.g., markings, panels, delineators, chevrons, etc. for each of the situations there are specific questions. They are designed and structured to lead the investigator through a systematic evaluation of the adequacy of the information system and identification of the deficiencies. These are minimum sets of suggested questions that may be modified or added to depending upon the specific location. No two situations of the same type are identical with regard to the specific geometrics, land development, traffic, etc some jurisdictions may want to modify these questions to reflect their special policies, highway characteristics, topography, etc.

It should be noted that while surveys during the night would be useful, it is recommended that the surveys be performed during the day. At first thought, it would seem that the night-time would be the more critical time with regard to providing driver information needs while in fact there are some situations where the loss of daylight visibility creates a problem which would not otherwise occur during the daylight hours, more problems arise during the day. Because the whole visual scene is available to the driver during the day, there are competing and conflicting information sources that do not occur at night. At night, motorists can get information regarding the path of the road from the headlight

beam of the opposing vehicles. For instance, there may be less apprehension exhibited approaching a sharp crest curve on a narrow road at night than at day, because the driver knows that if a vehicle is over the crest, the oncoming headlight beam will be visible.

Although the investigation will usually be conducted during the daylight hours, it is important to consider any special problems or deficiencies that would occur at night. Hence, the last question in part II is to remind the investigator to consider the information sources for the nighttime condition. Also, if the survey is being conducted at a time other than when the roadside vegetation is at its most dense growth, the investigator is prompted to consider this situation in the investigation.

Part III (usually on last page of checklist provides a checklist of suggested treatments appropriate to the situation being investigated. The list is intended merely to motivate the investigator into considering several options. The investigator may check off one or more possible solutions for further consideration upon return to the office and subsequent discussion with the responsible engineer.

The list of suggested treatments provided for all the situations is not likely to be all-inclusive. Other treatments could be added depending on the policy and design standards of the jurisdiction.

Use Of Information Deficiency Checklists

Multi-page checklists have been developed for the following nine typical roadway situations:

1) Stop-controlled intersection
2) Narrow/one-lane bridge
3) Horizontal curve
4) Tangential intersection
5) Railway-highway grade crossing
6) Uncontrolled Y-intersection
7) Low water stream crossing
8) Height/weight limit restrictions

In addition a general information deficiency checklist (“other situations”) is provided that could be adapted to any roadway situation not covered in one of the above specific situation checklists.

TABLE A5-2: Basic Decision Sight Distance Values for Checklists

CHECKLIST	ASSUMED MANEUVER
Intersection (Stop Controlled)	Stop
Narrow/One-Lane Bridge	Reduction to 10 mph
Horizontal Curve	Reduction to 15 mph
Tangential Intersection	Reduction to 15 mph
Rail Grade Crossing	Stop
Uncontrolled Y Intersection	Reduction to 20 mph
Low Water Crossing	Stop
Height/Water Restriction	Stop
Other	Stop

NOTE: (a) 3.0 sec. Used for perception reaction time
(b) (9 ft./sec.^{2}) used for deceleration

Exhibit-A5-1

INFORMATION DEFICIENCY EVALUATION CHECKLIST FOR

STOP-CONTROLLED INTERSECTION

PART I

ROUTE ID _____ INTERSECTING ROUTE _____

APPROACH DIRECTION N S E W (circle)

DATE _____ TIME _____ AM PM INSPECTORS _____

APPROACH SPEED DURING SURVEY _____MPH (KM/H)

SPEED LIMIT: a) Posted ___MPH (KM/H) or b) Estimated ___MPH (KM/H) (one entry)

DECISION SIGHT DISTANCE (circle one set)

SPEED (max of above)								
	mph	30	35	40	45	50	55	60
	km/h	48.3	56.3	64.4	72.4	80.5	88.5	96.6
DSD	(feet)	220	275	345	420	500	585	680
	(meters)	67.1	83.8	105.2	128.0	152.4	178.3	207.3

PART II

(1) Is the intersection directly visible from decision sight distance?
___Yes ___No

(2) Is the stop sign clearly visible from decision sight distance?
___Yes ___No

If no, go to (4)

(3) From decision sight distance, can you determine that the stop sign applies to you? ___Yes ___No

If yes, go to (6)

(4) Is there a STOP AHEAD warning sign present? ___Yes ___No

If no, go to (6)

(5a) Is the STOP AHEAD warning sign clearly visible on the approach? ___Yes ___No

(5b) Is the STOP AHEAD warning sign designed according to the specifications in the MUTCD? ___Yes ___No

(5c) Is the STOP AHEAD warning sign properly located? (i.e., neither too far upstream such that you would "forget" it or too close to the intersection such that you would not have sufficient time to stop) (Check Table of Placement Distances for Advance Warning Signs in MUTCD) ___Yes ___No

(6) Do other informational sources (i.e., roadway surface edges, terrain cuts, brush/tree line, shoulder edges, centerlines, etc.) provide information suggesting either 1) that the situation ahead is not a stop-controlled intersection, 2) that stop sign does not apply to your approach, or 3) that the stop controlled intersection is located further down stream than it actually is? ___Yes ___No

If yes, then identify those sources and describe how they provide confusing, conflicting or misleading information: _____

_____

_____

_____

_____

(7) Is the presently available information sufficient for you to recognize the stop-controlled intersection at a distance such that you can stop safely? ___Yes ___No

(8) Would the presently available information be sufficient for you to recognize that a stop-controlled intersection is located downstream:

- during nighttime conditions? ___Yes ___No
- when the roadside vegetation is at its densest growth? ___Yes ___No

PART III

SUGGESTED TREATMENTS

___ Install STOP AHEAD warning sign
___ Improve visibility of STOP AHEAD warning sign
___ Relocate STOP AHEAD warning sign
– Move closer to intersection by ____ feet (meters)
– Move back from intersection by ____ feet (meters)
___ Replace non-standard warning sign with standard STOP AHEAD warning sign
___ Improve sight distance to intersection
___ Improve visibility of stop sign
___ Install stop lines
___ Improve markings at intersection
___ Improve signings at intersection
___ Correct for confusing, conflicting or misleading information:

_____
_____
_____

___ Implement other treatment:

_____
_____
_____

Exhibit-A5-2

INFORMATION DEFICIENCY EVALUATION CHECKLIST FOR

NARROW/ONE-LANE BRIDGES

PART I

ROUTE ID _____ LOCATION: _____ MILES (KM) FROM REFERENCE POINT _____

APPROACH DIRECTION N S E W (circle)

DATE _____ TIME _____ AM PM INSPECTORS _____

APPROACH SPEED DURING SURVEY _____MPH (KM/H)

SPEED LIMIT: a) Posted ___MPH (KM/H) or b) Estimated ___MPH (KM/H) (one entry)

DECISION SIGHT DISTANCE (circle one set)

SPEED (max of above)								
	mph	30	35	40	45	50	55	60
	km/h	48.3	56.3	64.4	72.4	80.5	88.5	96.6
DSD	(feet)	220	275	345	420	500	585	680
	(meters)	67.1	83.8	105.2	128.0	152.4	178.3	2073

PART II

(1) Is the bridge directly visible from decision sight distance?
___Yes ___No

If no, go to (3)

(2) From decision sight distance, can you perceive the reduced roadway width at the bridge? ___Yes ___No

If yes, go to (5)

(3) Is there a NARROW BRIDGE or ONE-LANE BRIDGE warning sign present? ___Yes ___No

If no, go to (5)

(4a) Is the warning sign accurate? (i.e., the ONE-LANE BRIDGE is applicable to bridges with usable roadway widths less than 4.9m or 5.5m (16 ft or 18 ft) if a significant number of wide vehicles cross the bridge or if the approach alignment is winding) ___Yes ___No

(4b) Is the warning sign clearly visible on the approach?
___Yes ___No

(4c) Is the warning sign designed according to the specifications in the MUTCD?
___Yes ___No

(4d) Is the warning sign properly located? (i.e., neither too far upstream such that you would "forget" it or too close to the bridge such that you would not have sufficient time to select a safe speed and decelerate to it) (Check Table of Placement Distances for Advance Warning Signs in MUTCD) ___Yes ___No

(4e) Is there a supplemental speed advisory plate attached to the warning sign?
___Yes ___No

(5) Do other informational sources (i.e., hazard panels, guardrails, edgelines, roadway edges, bridge abutments, etc.) provide information suggesting 1) that the situation ahead is not a narrow/one-lane bridge, 2) that usable roadway width across the bridge is wider than it actually is, or 3) that a narrow/one-lane bridge is located further downstream? ___Yes ___No

If yes, then identify those sources and describe how they provide confusing, conflicting or misleading information: _____

_____

_____

_____

_____

(6) Is the sight distance to opposing vehicles sufficient for you to make a safe decision on whether you can safely cross the bridge and to safely execute the selected maneuver? ___Yes ___No

(7) Is the presently available information sufficient for you to recognize the narrow/one-lane bridge at a distance such that you can decelerate safely to a safe and comfortable crossing speed? ___Yes ___No

(8) Would the presently available information be sufficient for you to recognize that a narrow/one-lane bridge is located downstream:

- during nighttime conditions? ___Yes ___No
- when the roadside vegetation is at its densest growth? ___Yes ___No

PART III

SUGGESTED TREATMENTS

___ Install NARROW BRIDGE warning sign
___ Install ONE-LANE BRIDGE warning sign
___ Improve visibility of advance warning sign
___ Relocate advance warning sign
-- Move closer to bridge by ____ feet (meters)
-- Move back from bridge by ____ feet (meters)
___ Replace non-standard warning sign with standard warning sign
___ Install supplemental speed advisory plate; suggested speed is ___MPH (KM/H)
___ Install other advance warning signs, i.e.,
___ Curve warning
___ Intersection warning
___ Low overhead clearance
___ Other (specify) _____

_____

___ Improve pavement markings at bridge (i.e., tapered approach treatment)
___ Install hazard panels at bridge
___ Improve visibility of bridge
___ Correct for confusing, conflicting or misleading information:

_____

_____

_____

___ Implement other treatment:

_____

_____

_____

Exhibit-A5-3

INFORMATION DEFICIENCY EVALUATION CHECKLIST FOR

HORIZONTAL CURVES

PART I

LOCATION: _____ MILES (KM)
FROM
ROUTE ID _____ REFERENCE POINT _____

APPROACH DIRECTION N S E W (circle)

AM
DATE _____ TIME _____ PM INSPECTORS _____

APPROACH SPEED DURING SURVEY _____MPH (KM/H)

SPEED LIMIT: a) Posted ___MPH (KM/H) or b) Estimated ___MPH (KM/H) (one entry)

DECISION SIGHT DISTANCE (circle one set)

SPEED (max of above)								
	mph	30	35	40	45	50	55	60
	km/h	48.3	56.3	64.4	72.4	80.5	88.5	96.6
DSD	(feet)	220	275	345	420	500	585	680
	(meters)	67.1	83.8	105.2	128.0	152.4	178.3	207.3

PART II

(1) From decision sight distance, is it clearly visible that there is a curve ahead? ___Yes ___No

If no, go to (3)

(2) From decision sight distance, can you perceive the degree of curvature (i.e., sharpness) of the curve? ___Yes ___No

If yes, go to (5)

(3) Is there a curve, turn, reverse curve, reverse turn, or winding road warning sign present? ___Yes ___No

If no, go to (5)

(4a) Is the warning sign accurate? ___Yes ___No

(4b) Is the warning sign clearly visible on the approach?
___Yes ___No

(4c) Is the warning sign properly designed? ___Yes ___No

(4d) Is the warning sign properly located? (i.e., neither too far upstream such that you would "forget" it or too close to the curve such that you would not have enough time to select a safe speed and decelerate to it) (Check Table of Placement Distances for Advance Warning Signs in MUTCD) ___Yes ___No

(4e) Is there a supplemental speed advisory plate attached to the warning sign?
___Yes ___No

(5) Do other informational sources (i.e., markings, roadway, shoulders, delineators, brush/tree line terrain cut, Chevrons, etc.) provide information suggesting 1) that curve is flatter than it actually is or 2) that the curve can be driven at a speed higher than what would be considered the safe speed?
___Yes ___No

If yes, then identify those sources and describe how they provide confusing, conflicting or misleading information: _____

_____

_____

_____

_____

(6) Is the presently available information sufficient for you to select a safe and comfortable speed for the curve and safely decelerate to that speed?
___Yes ___No

(7) Would the presently available information be sufficient for you to select a safety and comfortable speed for the curve and safely decelerate to that speed:

- During the nighttime conditions? ___Yes ___No
- When the roadside vegetation is at its densest growth? ___Yes ___No

PART III

SUGGESTED TREATMENTS

___ Install curve warning sign
___ Install turn warning sign
___ Install reverse curve warning sign
___ Install reverse turn warning sign
___ Install winding road warning sign
___ Install supplemental speed advisory plate; suggested speed is ___MPH (KM/H)
___ Improve visibility of advance warning sign
___ Relocate advance warning sign
-- Move closer to curve by ____ ft. (meters)
-- Move back from curve by ____ ft. (meters)
___ Replace non-standard warning sign with standard warning sign
___ Install post mounted delineators
___ Install large arrow sign
___ Install Chevron alignment signs
No. of Chevron signs ____
___ Improve sight distance through curve
___ Improve pavement markings on curve (i.e., widen edgelines)
___ Correct for confusing, conflicting or misleading information:

_____

_____

_____

___ Implement other treatment:

_____

_____

_____

Exhibit-A5-4

INFORMATION DEFICIENCY EVALUATION CHECKLIST FOR

TANGENTIAL INTERSECTIONS

PART I

ROUTE ID _____ INTERSECTING ROUTE _____

APPROACH DIRECTION N S E W (circle)

DATE _____ TIME _____ AM PM INSPECTORS _____

APPROACH SPEED DURING SURVEY _____MPH (KM/H)

SPEED LIMIT: a) Posted ___MPH (KM/H) or b) Estimated ___MPH (KM/H) (one entry)

DECISION SIGHT DISTANCE (circle one set)

SPEED (max of above)								
	mph	30	35	40	45	50	55	60
	km/h	48.3	56.3	64.4	72.4	80.5	88.5	96.6
DSD	(feet)	220	275	345	420	500	585	680
	(meters)	67.1	83.8	105.2	128.0	152.4	178.3	2073

PART II

(1) From decision sight distance, is it clearly visible that there is a curve ahead? ___Yes ___No

(2) Is the intersecting side road clearly visible from decision sight distance? ___Yes ___No

If no, go to (4)

(3) From decision sight distance, can you recognize that the situation downstream is a horizontal curve with a tangentially intersecting side road/driveway? ___Yes ___No

If yes, go to (6)

(4) Are there warning signs present? ___Yes ___No

If no, go to (6)

(5a) What types of warning signs are present?

___ Curve warning sign
___ Intersection warning sign
___ Modified curve warning sign showing intersecting side road
___ Other (specify) _____

_____

(5b) Is the warning sign(s) clearly visible on the approach?
___Yes ___No

(5c) Is the warning sign properly located? (i.e., neither too far upstream such that you would "forget" it or too close to the curve such that you would not have enough time to select a safe speed and decelerate to it) (Check Table of Placement Distances for Advance Warning Signs in MUTCD) ___Yes ___No

(5d) Is there a supplemental speed advisory plate attached to the warning sign?
___Yes ___No

(6) Do other informational sources (i.e., brush/tree line, telephone lines, terrain cut, shoulder edges etc.) provide information suggesting 1) that the situation ahead is only a curve, or 2) that the route continues straight ahead? ___Yes ___No

If yes, then identify those sources and describe how they provide confusing, conflicting or misleading information: _____

_____
_____
_____
_____

(7) Is information provided that would enable you to select a safe path?
___Yes ___No

If yes to question #7, then

(8a) What types of information are provided:

- Post mounted delineators? ___Yes ___No
- Chevrons? ___Yes ___No
- Large arrow signs? ___Yes ___No
- Other guidance information? ___Yes ___No

  Specify _____

  _____

- Navigational Information? ___Yes ___No

  Specify _____

  _____

(8b) Is the provided information clearly visible on the approach?
___Yes ___No

(8c) Is the provided information properly designed? ___Yes ___No

(8d) Is the provided information properly located? ___Yes ___No

(9) Is the presently available information sufficient for you to recognize the tangential intersection at a distance such that you can select a safe speed and path and safely traverse the curve? ___Yes ___No

(10) Would the presently available information be sufficient for you to recognize that there is a tangential intersection ahead?

- During the nighttime conditions? ___Yes ___No
- When the roadside vegetation is at its densest growth? ___Yes ___No

PART III

SUGGESTED TREATMENTS

___ Install a modified curve or turn warning sign which shows the curve and the intersecting side road

___ Install supplemental speed advisory plate: suggested speed is ___MPH (KM/H)

___ Improve visibility of advance warning sign

___ Relocate advance warning sign
-- Move closer to curve by ___ ft (meters)
-- Move back from curve by ___ ft (meters)

___ Replace existing warning sign(s) with modified curve or turn warning sign

___ Install post-mounted delineators

___ Install Chevron alignment signs
No. of Chevron signs ___

___ Improve visibility of the curve

___ Install directional assembly in advance of intersection
Specify _____

_____

___ Install destination signs in advance of intersection
Specify _____

_____

___ Install directional assembly at intersection
Specify _____

_____

___ Improve visibility of existing navigational guide signs
Specify sign _____

___ Replace existing navigational guide signs with properly designed guide signs
Specify sign _____

___ Relocate existing navigational guide signs
Specify sign _____
-- Move closer to intersection by ___ ft (meters)
-- Move back from intersection by ___ ft (meters)

___ Relocate large arrow sign

___ Relocate Chevron alignment signs

___ Improve sight distance through curve

___ Improve pavement markings through intersection (e.g., apply dotted edgeline through intersection)

___ Correct for confusing, conflicting or misleading information:

_____

_____

_____

___ Implement other treatment:

_____

_____

_____

Exhibit-A5-5

INFORMATION DEFICIENCY EVALUATION CHECKLIST **FOR**

RAILROAD-HIGHWAY GRADE CROSSINGS

PART I

LOCATION: _____ MILES (KM)
FROM
ROUTE ID _____ REFERENCE POINT _____

APPROACH DIRECTION N S E W (circle)

AM
DATE _____ TIME _____ PM INSPECTORS _____

APPROACH SPEED DURING SURVEY _____MPH (KM/H)

SPEED LIMIT: a) Posted ___MPH (KM/H) or b) Estimated ___MPH (KM/H) (one entry)

DECISION SIGHT DISTANCE (circle one set)

SPEED (max of above)								
	mph	30	35	40	45	50	55	60
	km/h	48.3	56.3	64.4	72.4	80.5	88.5	96.6
DSD	(feet)	220	275	345	420	500	585	680
	(meters)	67.1	83.8	105.2	128.0	152.4	178.3	207.3

PART II

(1) Is the railroad grade crossing clearly visible from decision sight distance? ___Yes ___No

If no, go to (3)

(2) Are the control devices (i.e., crossbucks, signals and/or gates) clearly visible from decision sight distance? ___Yes ___No

(3) Is there a railroad advance warning sign? ___Yes ___No

If no, go to (5)

(4a) Is the railroad advance warning sign clearly visible on the approach?
___Yes ___No

(4b) Is the railroad advance warning sign designed according to the specifications in the MUTCD? ___Yes ___No

(4c) Is the railroad advance warning sign properly located? (i.e., neither too far upstream such that you would "forget" it or too close to the intersection such that you would not have sufficient time to make and execute a safe crossing decision) (Check Table of Placement Distances for Advance Warning Signs in MUTCD) ___Yes ___No

(4d) Is there a supplemental speed advisory plate attached to the railroad advance warning sign? ___Yes ___No

(5) Is the crossing controlled by the train-activated signals and/or gates?
___Yes ___No

If yes, go to (7)

(6) Is there sufficient intersection sight distance both to the left and to the right for you to make a safe crossing decision? ___Yes ___No

(7) Do other informational sources (i.e., other signs, markings, roadway, telephone line, etc.) provide information suggesting either 1) that the situation ahead is not a railroad-highway grade crossing, 2) that the type of control at the grade crossing is different than it actually is, and/or 3) that the grade crossing is located further downstream? ___Yes ___No

If yes, then identify those sources and describe how they provide confusing, conflicting or misleading information: _____

_____

_____

_____

_____

(8) Is the presently available information sufficient for you to recognize the railroad-highway grade crossing at a distance such that you can make a safe crossing decision and execute the selected maneuver? ___Yes ___No

(9) Would the presently available information be sufficient for you to make a safe crossing decision and to execute the selected maneuver:
- During the nighttime conditions? ___Yes ___No
- When the roadside vegetation is at its densest growth? ___Yes ___No

(10) Does the crossing have a sufficiently rough surface such that it requires a deceleration to a crossing speed less than the approach speed? ___Yes ___No

(11) Is the presently available information sufficient to allow you to select a safe and comfortable crossing speed and to safely cross? ___Yes ___No

(12) Would the presently available information be sufficient to allow you to select a safe and comfortable crossing speed and to safely cross:
- During the nighttime conditions? ___Yes ___No
- When the roadside vegetation is at its densest growth? ___Yes ___No

PART III

SUGGESTED TREATMENTS

___ Install railroad advance warning sign
___ Improve visibility of railroad advance warning sign
___ Relocate railroad advance warning sign
– Move closer to intersection by ___ ft (meters)
– Move back from intersection by ___ ft (meters)
___ Replace non-standard warning sign with standard railroad advance warning sign
___ Install supplemental speed advisory plate; suggested speed is ___MPH (KM/H)
___ Improve approach sight distance to:
___ Left leg of crossing
___ Right leg of crossing
___ Improve visibility of crossing control devices (i.e., crossbucks, signals, gates)
___ Correct for confusing, conflicting or misleading information:

_____
_____
_____

___ Implement other treatment:

_____
_____
_____

Exhibit-A5-6

INFORMATION DEFICIENCY EVALUATION CHECKLIST FOR

UNCONTROLLED Y-INTERSECTION

PART I

ROUTE ID _____ INTERSECTING ROUTE _____

APPROACH DIRECTION N S E W (circle)

DATE _____ TIME _____ AM PM INSPECTORS _____

APPROACH SPEED DURING SURVEY _____MPH (KM/H)

SPEED LIMIT: a) Posted ___MPH (KM/H) or b) Estimated ___MPH (KM/H) (one entry)

DECISION SIGHT DISTANCE (circle one set)

SPEED (max of above)								
	mph	30	35	40	45	50	55	60
	km/h	48.3	56.3	64.4	72.4	80.5	88.5	96.6
DSD	(feet)	220	275	345	420	500	585	680
	(meters)	67.1	83.8	105.2	128.0	152.4	178.3	2073

PART II

(1) Is the Y-intersection clearly visible from decision sight distance?
___Yes ___No

If yes go to (4)

(2) Is there a Y-intersection warning sign present? ___Yes ___No

If no, go to (4)

(3a) Is the Y-intersection warning sign clearly visible on the approach?
___Yes ___No

(3c) Is the Y-intersection warning sign properly located? (i.e., neither too far upstream such that you would "forget" it or too close to the intersection such that you would not have sufficient time to make and execute a safe route selection decision) (Check Table of Placement Distances for Advance Warning Signs in MUTCD) ___Yes ___No

(3d) Is there a supplemental speed advisory plate attached to the Y-intersection warning sign? ___Yes ___No

(4) Do other informational sources (i.e., other signs, markings, delineators, brush/tree line, roadway, etc.) provide information suggesting either 1) that the situation ahead is not a Y-intersection or 2) that the Y-intersection is located further downstream? ___Yes ___No

If yes, then identify those sources and describe how they provide confusing, conflicting or misleading information: _____

_____

_____

_____

_____

(5) Is information provided that would enable you to make a safe route selection decision? ___Yes ___No

If no, go to (7)

(6a) What types of information are provided:

- advance route designation information? ___Yes ___No
- advance destination information? ___Yes ___No
- guidance information provided at the intersection? ___Yes ___No
- navigational information provided at the intersection? ___Yes ___No
- route confirmation information provided beyond the intersection? ___Yes ___No

(6b) Is the provided information clearly visible on the approach? ___Yes ___No

(6c) Is the provided information properly designed? ___Yes ___No

(6d) Is the provided information properly located?
___Yes ___No

(7) Is the presently available information sufficient for you to recognize the Y-intersection at a distance such that you can select your route and execute a safe turning maneuver? ___Yes ___No

(8) Would the presently available information be sufficient for you to recognize the Y-intersection and select your route:
- During the nighttime conditions? ___Yes ___No
- When the roadside vegetation is at its densest growth? ___Yes ___No

PART III

SUGGESTED TREATMENTS

___ Install Y-intersection warning sign
___ Install supplemental speed advisory plate;
suggested speed is ___MPH (KM/H)
___ Improve visibility of Y-intersection warning sign
___ Relocate Y-intersection warning sign
-- Move closer to curve by ___ ft (meters)
-- Move back from curve by ___ ft (meters)
___ Replace existing warning signs with standard Y-intersection warning sign
___ Install an advance route turn assembly (consisting of two route markers and two advance turn arrows) in advance of the Y-intersection
___ Install destination signs in advance of the Y-intersection
___ Install a directional assembly (consisting of two route markers and two directional arrows) at the form of the Y directly in line with approaching traffic
___ Install a double-headed large arrow sign at the fork of the Y directly in line with approaching traffic
___ Install route confirmation signs beyond the Y-intersection
___ Improve visibility of existing navigational guide signs
Specify sign _____
___ Replace existing navigational guide signs with properly designed signs
Specify signs _____
___ Relocate existing navigational guide signs
Specify sign _____
-- Move closer to intersection by ___ ft (meters)
-- Move back from intersection by ___ ft (meters)
___ Improve visibility of the intersection
___ Correct for confusing, conflicting or misleading information:
_____
_____
_____
___ Implement other treatment:
_____
_____
_____

Exhibit-A5-7

INFORMATION DEFICIENCY EVALUATION CHECKLIST FOR

LOW WATER STREAM CROSSINGS

PART I

ROUTE ID _____ LOCATION: _____ MILES (KM) FROM REFERENCE POINT _____

APPROACH DIRECTION N S E W (circle)

DATE _____ TIME _____ AM PM INSPECTORS _____

APPROACH SPEED DURING SURVEY _____MPH (KM/H)

SPEED LIMIT: a) Posted ___MPH (KM/H) or b) Estimated ___MPH (KM/H) (one entry)

DECISION SIGHT DISTANCE (circle one set)

SPEED (max of above)								
	mph	30	35	40	45	50	55	60
	km/h	48.3	56.3	64.4	72.4	80.5	88.5	96.6
DSD	(feet)	220	275	345	420	500	585	680
	(meters)	67.1	83.8	105.2	128.0	152.4	178.3	207.3

PART II

(1) Is the low water stream crossing clearly visible from decision sight distance?
___Yes ___No

If no, go to (3)

(2) From decision sight distance, can you see if there is water flowing in the crossing? ___Yes ___No

If yes, go to (5)

(3) Are there advance warning signs present? ___Yes ___No

If no, go to (5)

(4a) What warning signs are present:

- FLOOD AREA AHEAD? ___Yes ___No
- IMPASSABLE DURING HIGH WATER? ___Yes ___No
- Other warning signs? ___Yes ___No

If yes, specify _____

_____

(4b) Are the warning sign(s) clearly visible on the approach:

- FLOOD AREA AHEAD? ___Yes ___No
- IMPASSABLE DURING HIGH WATER? ___Yes ___No
- Other warning signs?

_____ ___Yes ___No

_____ ___Yes ___No

(4c) Are the warning sign(s) properly designed:

- FLOOD AREA AHEAD? ___Yes ___No
- IMPASSABLE DURING HIGH WATER? ___Yes ___No
- Other warning signs?

_____ ___Yes ___No

_____ ___Yes ___No

(4d) Are the warning sign(s) properly located:

- FLOOD AREA AHEAD? ___Yes ___No
- IMPASSABLE DURING HIGH WATER? ___Yes ___No
- Other warning signs?

_____ ___Yes ___No

_____ ___Yes ___No

(4e) Are there any supplemental distance plaques attached to any of the pertinent warning signs? ___Yes ___No

If yes, specify which warning sign(s) _____

_____

_____

(4f) Are there any supplemental advisory speed plates attached to any of the pertinent warning signs? ___Yes ___No
If yes, specify which warning sign(s) and the speed(s) _____

_____

_____

(5) Is there a DO NOT ENTER WHEN FLOODED regulatory sign present?
___Yes ___No
If no, go to (7)

(6a) Is the regulatory sign clearly visible on the approach?
___Yes ___No

(6b) Is the regulatory sign properly designed? ___Yes ___No

(6c) Is the regulatory sign properly located? ___Yes ___No

(7) Do other informational sources (i.e., roadway surface, brush/tree line, markings, edgelines, etc.) provide information suggesting either 1) that the situation ahead is <u>not</u> a low water stream crossing, 2) that the sag is shallower than it actually is, or 3) that the low water stream crossing is located further downstream than it actually is? ___Yes ___No

If yes, then identify those sources and describe how they provide confusing, conflicting or misleading information: _____

_____

_____

_____

_____

(8) Is the presently available information sufficient for you to recognize the low water stream crossing at a distance such that you can make a safe crossing decision and execute your selected maneuver? ___Yes ___No

(9) Would the presently available information be sufficient for you to recognize the low water stream crossing at a distance such that you can make a safe crossing decision and execute the selected maneuver:

- During the nighttime conditions? ___Yes ___No
- When the roadside vegetation is at its densest growth?
  ___Yes ___No

PART III

SUGGESTED TREATMENTS

___ Install FLOOD AREA AHEAD warning sign
___ Install IMPASSABLE DURING HIGH WATER warning sign
___ Install DO NOT ENTER WHEN FLOODED regulatory sign
___ Improve visibility of advance warning sign(s)
___ Replace existing warning signs with standard FLOOD AREA AHEAD and IMPASSABLE DURING HIGH WATER warning signs
___ Relocate advance warning signs
Specify sign _____
-- Move closer to crossing by ___ ft (meters)
-- Move back from crossing by ___ ft (meters)
___ Install supplemental speed advisory plate; suggested speed is ___MPH (KM/H)
___ Relocate DO NOT ENTER WHEN FLOODED regulatory sign
-- Move closer to crossing by ___ ft (meters)
-- Move back from crossing by ___ ft (meters)
___ Improve visibility of low water stream crossing
___ Install depth gauge at crossing
___ Correct for confusing, conflicting or misleading information:

_____

_____

_____

___ Implement other treatment:

_____

_____

_____

Exhibit-A5-8

GENERAL INFORMATION DEFICIENCY EVALUATION CHECKLIST FOR

OTHER SITUATIONS

PART I

ROUTE ID _____ LOCATION: _____ MILES (KM) FROM REFERENCE POINT _____

APPROACH DIRECTION N S E W (circle)

DATE _____ TIME _____ AM PM INSPECTORS _____

APPROACH SPEED DURING SURVEY _____MPH (KM/H)

SPEED LIMIT: a) Posted ___MPH (KM/H) or b) Estimated ___MPH (KM/M) (one entry)

DECISION SIGHT DISTANCE (circle one set)

SPEED (max of above)								
	mph	30	35	40	45	50	55	60
	km/h	48.3	56.3	64.4	72.4	80.5	88.5	96.6
DSD	(feet)	220	275	345	420	500	585	680
	(meters)	67.1	83.8	105.2	128.0	152.4	178.3	2073

PART II

(1) Is the [specific situation] clearly visible from decision sight distance?
___Yes ___No

If yes, go to (4)

(2) Is there a [situation-specific] warning sign present?
___Yes ___No

If no, go to (4)

(3a) Is the warning sign accurate? ___Yes ___No

(3b) Is the warning sign clearly visible on the approach? ___Yes ___No

(3c) Is the warning sign properly designed? ___Yes ___No

(3d) Is the warning sign properly located (Check Table of Placement Distances for Advance Warning Signs)? ___Yes ___No

(3e) Is there a supplemental advisory speed plate attached to the warning sign? ___Yes ___No

(4) Do other informational sources (i.e., markings, delineators, brush/tree line, etc.) provide information suggesting either: 1) that the situation ahead is not a [specific situation] or 2) that the [specific situation] is located further downstream than it actually is? ___Yes ___No

If yes, then identify those sources and describe how they provide confusing, conflicting or misleading information: _____

_____

_____

_____

_____

(5) Is the presently available information sufficient for you to recognize that a [specific situation] is downstream? ___Yes ___No

(6) Would the presently available information be sufficient for you to recognize that a [specific situation] is downstream:

- during nighttime conditions? ___Yes ___No
- when the roadside vegetation is at its densest growth? ___Yes ___No

(7) Is the presently available information sufficient for you to decide on an appropriate control action and to execute the selected maneuver? ___Yes ___No

(8) Would the presently available information be sufficient for you to decide on an appropriate control action and to execute the selected maneuver:

- during nighttime conditions? ___Yes ___No
- when the roadside vegetation is at its densest growth? ___Yes ___No

PART III

SUGGESTED TREATMENTS

___ Install [situation-specific] warning sign
___ Improve visibility of [situation-specific] warning sign
___ Relocate advance warning sign
-- Move closer to structure by ___ ft (meters)
-- Move back from structure by ___ ft (meters)
___ Replace non-standard warning sign with standard warning sign
___ Install supplemental speed advisory plate;
suggested speed is ___MPH (KM/H)
___ Improve visibility of situation
___ Correct for confusing, conflicting or misleading information:

_____
_____
_____

___ Implement other treatment:

_____
_____
_____

APPENDIX 6
Conversions and Formulas

Length

Inches	x 0.0833	= Feet
Inches	x 0.028	= Yards
Feet	x 12	= Inches
Feet	x 0.33	= Yards
Feet	x 0.06	= Rods
Feet	x 1.5	= Links
Yards	x 36	= Inches
Yards	x 3	= Feet
Yards	x 0.18	= Rods
Links	x .22	= Yards
Links	x .66	= Feet
Rods	x 198	= Inches
Rods	x 16.5	= Feet
Rods	x 5.5	= Yards
Miles	x 5,280	= Feet
Miles	x 1,760	= Yards
Miles	x 320	= Rods

Area

Square Inches	x 0.007	= Square Feet
Square Feet	x 144	= Square Inches
Square Feet	x 0.11	= Square Yards
Square Yards	x 1,296	= Square Inches
Square Yards	x 9	= Square Feet
Square Yards	x 0.03	= Square Rods
Square Rods	x 272.25	= Square Feet
Square Rods	x 30.25	= Square Yards
Square Miles	x 640	= Acres
Acres	x 43,560	= Square Feet
Acres	x 4,840	= Square Yards
Acres	x 160	= Square Rods

Conversions and Formulas (contd.)

Volume

Cubic Feet	x 1,728	= Cubic Inches
Cubic Feet	x 0.04	= Cubic Yards
Cubic Feet	x 7.48	= Gallons
Cubic Yards	x 27	= Cubic Feet
Cubic Yards	x 202	= Gallons
Quarts	x 2	= Pints
Quarts	x 0.25	= Gallons
Gallons	x 8	= Pints
Gallons	x 4	= Quarts
Gallons	x 0.13	= Cubic Feet

Force

Ounces	x 0.06	= Pounds
Pounds	x 16	= Ounces
Tons (short)	x 2,000	= Pounds
Tons (metric)	x 2,204	= Pounds

Velocity

Miles/Hour	x 88	= Feet/Minute
Miles/Hour	x 1.47	= Feet/Second

Surveyor's Measure

7.92 Inches = 1 Link
25 Links = 1 Rod
4 Rods = 1 Chain = 66 Feet
10 Square Chains = 1 Acre
160 Square Rods = 1 Acre
640 Acres = 1 Square Mile
36 Square Miles (6 miles sq.) = 1 Township

Metric Conversion Factors

Length		
Inches	x 25.40	= Millimeters (mm)
Inches	x 2.540	= Centimeters (cm)
Inches	x 0.0254	= Meters (m)
Feet	x 0.305	= Meters (m)
Yards	x 0.91	= Meters (m)
Rods	x 0.199	= Meters (m)
Miles	x 1.61	= Kilometers (km)

Area		
Square Inches	x 6.45	= Square Centimeters
Square Feet	x 0.093	= Square Meters
Square Yards	x 0.836	= Square Meters
Acres	x 4,047	= Square Meters
Square Miles	x 2.59	= Square Kilometers

Volume		
Cubic Inches	x 16.4	= Cubic Centimeters
Cubic Feet	x 0.028	= Cubic Meters
Cubic Yards	x 0.765	= Cubic Meters
Gallons (U.S.)	x 3.8	= Liters
Gallons (U.S.)	x 0.0038	= Cubic Meters
Acre-feet	x 1,233	= Cubic Meters

Mass		
Ounces (avdp)	x 28.35	= Grams
Pounds (avdp)	x 0.4536	= Kilograms
Tons (short)	x 907.2	= Kilograms
Tons (metric)	x 1,000	= Kilograms

Force		
Pounds (force)	x 4.45	= Newtons
Kilograms	x 9.81	= Newtons

Metric Conversion Factors (contd.)

Density		
Pounds/ Cubic Foot	x 16.20	= Kilograms/ Cubic Meter
Pounds/ Cubic Yard	x 0.5933	= Kilograms/ Cubic Meter
Stress		
Pounds/ Square Foot	x 47.9	= Newtons/ Square Meter
Pounds/ Square Inch	x 6.9	= Kilonewtons/ Square Meter
Pressure		
Pounds/ Square Inch	x 6,895	= Pascals (Pa)
Pounds/ Square Foot	x 47.88	= Pascals (Pa)
Newtons/ Square Meter	x 1.00	= Pascals (Pa)
Flow		
Gallons (U.S.)/ Minute	x 0.0038	= Cubic Meters/ Minute
Gallons (U.S.)/ Minute	x 0.06309	= Liters/ Second (L/s)
Cubic Feet/ Second	x 28.317	= Liters/ Second (L/s)
Velocity		
Miles/Hour	x 1.609	= Kilometers/ Hour (km/hr)
Miles/Hour	x 0.4470	= Meters/ Second (m/s)
Feet/Second	x 0.3048	= Meters/Second (m/s)
Temperature		
Fahrenheit	x 5/9(°F-32)	= Celsius
Celsius	x 9/5(°C+32)	= Fahrenheit

Converting Common Fractions to Decimals

Fraction	Decimal Equivalent
1/2	0.50
1/3	0.33
2/3	0.67
1/4	0.25
2/4	0.50
3/4	0.75
1/5	0.20
2/5	0.40
3/5	0.60
4/5	0.80
1/6	0.17
2/6	0.33
3/6	0.50
4/6	0.67
5/6	0.83
1/7	0.14
2/7	0.29
3/7	0.43
4/7	0.57
5/7	0.71
6/7	0.86
1/8	0.13
2/8	0.25
3/8	0.38
4/8	0.50
5/8	0.63
6/8	0.75
7/8	0.88

Converting Common Fractions to Decimals (contd.)

Fraction	Decimal Equivalent
1/10	0.10
2/10	0.20
3/10	0.30
4/10	0.40
5/10	0.50
6/10	0.60
7/10	0.70
8/10	0.80
9/10	0.90
1/12	0.08
2/12	0.17
3/12	0.25
4/12	0.33
5/12	0.42
6/12	0.50
7/12	0.58
8/12	0.67
9/12	0.75
10/12	0.83
11/12	0.92
1/16	0.06
2/16	0.13
3/16	0.19
4/16	0.25
5/16	0.31
6/16	0.38
7/16	0.44
8/16	0.50
9/16	0.56
10/16	0.63
11/16	0.69
12/16	0.75
13/16	0.81
14/16	0.88
15/16	0.94

Perimeter, Area, and Volume Formulas

Perimeter	
Scalene Triangle	$P = a + b + c$
Isosceles Triangle	$P = 2a + b$
Equilateral Triangle	$P = 3s$
Quadrilateral	$P = a + b + c + d$
Rectangle	$P = 2l + 2w$
Square	$P = 4s$
Circle	$C = \pi d$ or $C = 2\pi r$

Area	
Rectangle	$A = lw$
Square	$A = lw$ or $A = s^2$
Parallelogram	$A = bh$
Triangle	$A = 1/2bh$
Trapezoid	$A = 1/2h\ (b_1 + b_2)$
Circle	$A = \pi r^2$
Cube	$A = 6e^2$

Volume	
Cylinder	$V = bh$
Rectangular Solid	$V = lwh$
Cube	$V = e^3$
Circular Cylinder	$V = \pi r^2 h$
Pyramid	$V = 1/3bh$
Cone	$V = 1/3bh$ or $1/3\pi r^2 h$
Sphere	$V = 4/3\pi r^3$ or $V = (4\pi r^3)/3$

Safety

Review all operating procedures to assure that activities are performed in the safest manner. Safety is everyone's responsibility. When performing duties in presence of traffic, review necessary traffic control requirements.

Signs and Markers
Uniform Color Code

Utility Location and Coordination Council

Red:	Electric power lines, cables, or conduits
	Lighting cables
Yellow:	Gas or gaseous materials
	Oil or petroleum materials
	Steam
Orange:	Alarm lines, cables, or conduits
	Communication lines, cables, or conduits
	Signal lines, cables, or conduits
Blue:	Irrigation lines
	Slurry lines
	Water lines
Green:	Drain lines
	Sewers

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