pennsylvania
DEPARTMENT OF TRANSPORTATION
PennDOT Local Technical Assistance Program

Local Safe Roads Communities Program

Derry Township,

Dauphin County, PA

Confidential: Traffic Engineering and Safety Study
This document was prepared by the Department of Transportation as an in-depth safety study for the purpose of improving highway safety and is legally protected pursuant to 75 Pa. C.S. 3754 and 23 U.S.C. 409.

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Introduction

Purpose of the Report

The purpose of this report is to provide your community with a head-start on a systematic safety improvement program focused primarily on implementing low-cost safety features to improve local road safety in Pennsylvania. A systematic safety improvement program is essentially a plan to gain knowledge about high crash potential locations and implement countermeasures to mitigate those risks.

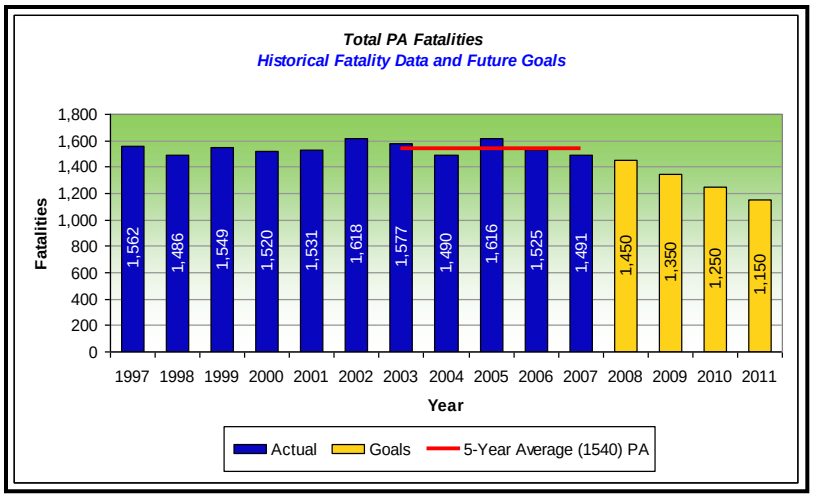
The audience for this report is the officers and employees of your municipality. This report is not intended for the general public. In fact, this report is a traffic and safety study which is considered confidential by both state and federal law (see box note on cover page for details).

This confidentiality is intended to protect municipalities from potential liability that might be created by the study, thus freeing municipal officials to research high crash risk locations within their municipalities toward the goal of improving the safety of their roadway system. This study is intended to demonstrate how high safety risk locations may be improved, quite possibly using low-cost countermeasures. A Roadway Safety Improvement Plan, together with real improvements, will ultimately reduce a municipality's exposure to liability.

Purpose of the Local Safe Roads Communities Program

The purpose of the Local Safe Roads Communities Program (LSRCP) is to measurably improve safety on locally owned roads within Pennsylvania. Currently, about 19% of the fatalities and 29% of the crashes occur on locally owned roads in Pennsylvania. In accordance with the national emphasis on improving transportation safety, PennDOT has established a safety mission with specific statewide goals. To achieve those goals, local road safety must also improve by reducing crashes about 20%.

The LSRCP intends to help communities through the establishment of a Roadway Safety Improvement Plan, and also by specifically examining several high crash locations in the community. The LSRCP is being implemented in about 10 communities each year across Pennsylvania.



Some Safety Facts

Nationally, there are about 42,000 fatalities and almost 3 million people injured in crashes on our roads every year. In Pennsylvania, there are about 1,500 fatalities each year. About 19% of those fatalities are on

local roads. In the last decade, road safety has improved by about 25% (source: FHWA), but the number of fatalities, crashes, and the economic loss to our society is still staggering.

PennDOT has a plan to reduce fatalities in Pennsylvania to meet national safety goals (see figure). As part of those national and statewide goals, safety on local roads needs to improve also. Thus, PennDOT created the Local Safe Roads Communities Program to help assist municipalities in achieving safety improvements.

Where are the Typical Safety Problems?

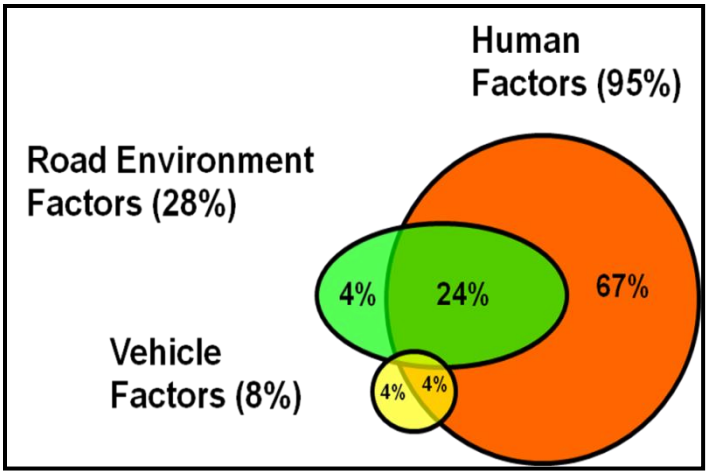
FHWA (Federal Highway Administration) is focusing on several areas to improve safety: intersections, roadway departures, and pedestrians.

- FHWA reports that driving near and through intersections is one of the most complex challenges that motorists face. Intersection crashes account for more than 45 percent of all reported crashes, and 21 percent of fatalities.
- FHWA reports that over half of the people killed on our nation's highways died when their vehicle left their lane and crashed. Many of these crashes involve driving too fast (speeding) and vehicles leaving the roadway around curves. Others involve hitting cars head-on, or leaving the roadway and hitting trees, utility poles, and other hazards.
- FHWA reports that there are about 5,000 pedestrian deaths each year (11%), and that pedestrian deaths are disproportionally represented by the young and the old.

Is There a Single Safety Solution?

Unfortunately, there is not a single solution that will make every road and/or intersection safer. There is a wide variety of factors that contribute to crashes—and many situations are unique. FHWA considers three primary factors that contribute to crashes—human factors, which account for as much as 95 percent of crashes (speeding, distracted, driving under the influence, etc…), vehicle factors (brake failure, car fires, etc…), and roadside environment factors (pavement conditions, weather, signs, signals, etc…).

This study will focus largely on road environment factors through field views, research, crash analysis, and discussions with municipal staff to determine the root causes of the crashes at particular locations selected by municipal officials through discussion with our safety engineers. After the root causes of the crashes have been identified, we will suggest appropriate low-cost and long



term safety improvements and countermeasures.

FHWA and PennDOT have identified many strategies to improve safety on our roads. FHWA and PennDOT are both focusing on the three safety areas identified above (intersections, roadway departures, and pedestrians). For each of these safety risk areas, they have identified a comprehensive safety strategy that includes good road design, consistent enforcement of laws, and sustained education of motorists/pedestrians.

This report focuses on one of these strategies, good road design. As part of good road design, there are many simple and cost effective measures to improve safety, called low-cost safety improvements.

What are Low-Cost Safety Improvements?

Low-cost safety improvements are safety countermeasures to address specific crash causes at an intersection or roadway. They are part of a comprehensive strategy to improve safety on our roads, and are the focus of the Local Safe Roads Communities Program.

Low-cost safety improvements focus on countermeasures that can quickly and cost-efficiently be applied to an intersection or roadway. These measures can include traffic signs, pavement markings, improving sight distance, and many others. Although some of these measures may seem simple, they are proven to have positive effects to reduce crashes. For example, providing a stop bar at a stop sign controlled intersection improves the motorist's recognition of the stop condition, and can reduce potential crashes by 15% (source: FHWA).

Example Low-cost Safety Improvements: Repaint Centerline, Trim Trees, Add Stop Bar, Add Skip Lines

In addition to the low-cost safety improvements, longer term solutions will be identified, if appropriate. Longer term solutions could include roadway widenings, roadway realignments, traffic signals, and others.

What is in the Report?

This report contains the following sections:

- **Introduction** – this section provides an overview of the Local Safe Roads Communities Program, general safety related information, and how to use this report.
- **Community Overview** – this section provides an overview of transportation safety in the community.
- **Safety Suggestions** – this section of the report provides a list of prioritized safety locations and identifies the overall issue, provides a crash evaluation, presents any field view data, explains possible causes, and details any potential solutions for each safety location.
- **Roadway Safety Improvement Plan** – this section provides information on developing a systematic safety improvement process for the community.
- **Appendix Materials** – the appendix to the report contains supporting materials to assist the community with implementation of the suggested safety enhancements and also developing the overall plan.

How was this Report Prepared?

PennDOT, through the LTAP, has crafted a methodology that allows traffic safety engineers to quickly identify a few of the high crash locations within communities, focusing specifically on local roads, and local road intersections with PennDOT roads, and to develop low-cost solutions to mitigate the crash potential at those locations. Further, this process of identifying and evaluating high crash potential locations and implementing safety improvements, conducted initially by the traffic safety engineers, may be transferred to community officials, encouraging the development of plans for systematically continuing the safety effort.

The steps involved in achieving these outcomes are as follows:

- Step 1: Contact with Community officials
- Step 2: Collect Background Data from the local PennDOT Engineering District
- Step 3: Converse with Local Community Staff
- Step 4: Conduct a Field Visit and Working Meeting
- Step 5: Complete necessary documentation

The LSRCP will provide each of the participating communities with the following:

- A prioritized list of locations within the community with high crash potential.
- A short term plan that identifies safety improvements to locations with high crash potential.
- A long term process that enables the community to continually monitor, evaluate, implement, and update its safety improvement program.

- Identification of potential resources that would enable the community to plan, design, fund, and implement safety improvements.

What Should the Community do Next?

The community should examine the suggestions to enhance safety at the locations in the report, and determine if the recommended measures are appropriate. If so, the community should plan resources to implement the measures. If not, the community should develop appropriate measures and implement those at the priority locations.

After measures have been implemented at the priority locations, the community should monitor the safety impacts at each of the locations. This can be done by examining motorist behavior at the locations and by analyzing crash data. These steps should be performed right after the measures have been implemented, again after three to six months, and again after one year. If necessary, adjustments to the safety improvements or additional safety improvements may be required.

After the initial few locations have been addressed, the community may move down the list and begin to develop safety plans for the next locations. This process of evaluating past safety improvements and developing improvements for additional locations should be repeated annually. More information on this process is contained in the section, Roadway Safety Improvement Plan.

About six months after the report is delivered an LTAP representative will telephone an official at the municipality to discuss the countermeasures implemented, their effectiveness, and the municipality's experience with the Local Safe Roads Communities Program and its contribution to an effective and ongoing Roadway Safety Improvement Plan.

What if the Community Needs Additional Help?

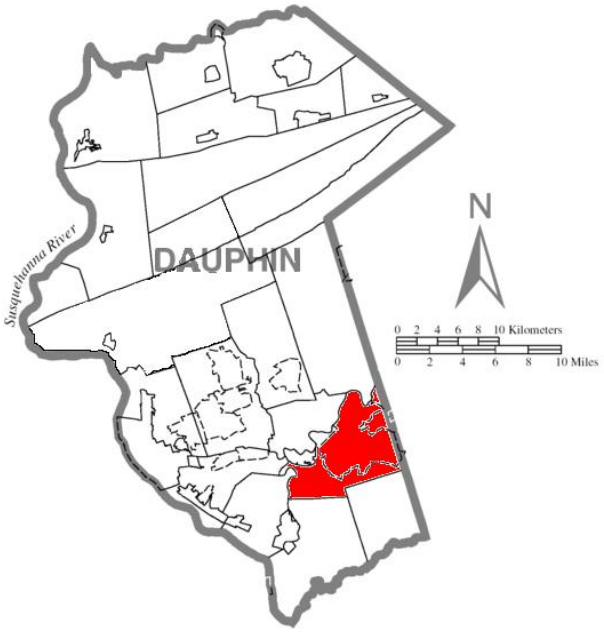
You can always call LTAP for additional questions or assistance. In addition, PennDOT Municipal Services Representatives can help, especially with issues related to state highways.

- Call: 1-800-FOR-LTAP
- Write: LTAP – Local Technical Assistance Program
  Pennsylvania Department of Transportation
  Bureau of Planning and Research
  400 North Street, 6th Floor
  Harrisburg, PA 17120
- E-mail: **ltap@state.pa.us**
- Web Site: **www.ltap.state.pa.us**

Community Overview – Derry Township

This Local Safe Roads Communities report focuses on Derry Township, Dauphin County, Pennsylvania. Derry Township is located in southeastern Dauphin County east of the City of Harrisburg. Derry Township is a Township of the Second Class that has a population of 21,273 residents as of the 2000 census. The initial analysis of Pennsylvania Department of Transportation (PennDOT) crash data showed that on local roads and the intersections of local roads and state roads, Derry Township had 7 fatalities, 1069 reported crashes, and a crash rate of approximately 5.0 per 100 population from January 1, 2005 to December 31, 2009.

Important – In addition to taking part in the Local Safe Roads Communities Program (LSRCP), Derry Township has simultaneously taken part in LTAP's sister program called the Walkable Communities Program (WCP) which focuses on addressing pedestrian safety concerns instead of vehicular safety concerns on local municipal roads. A WCP report has been completed on behalf of the Township in addition to the following LSRCP report. Please note that certain priority safety locations discussed as part of this report overlap with the WCP report. The Township should consult each Program's report when planning improvement efforts.



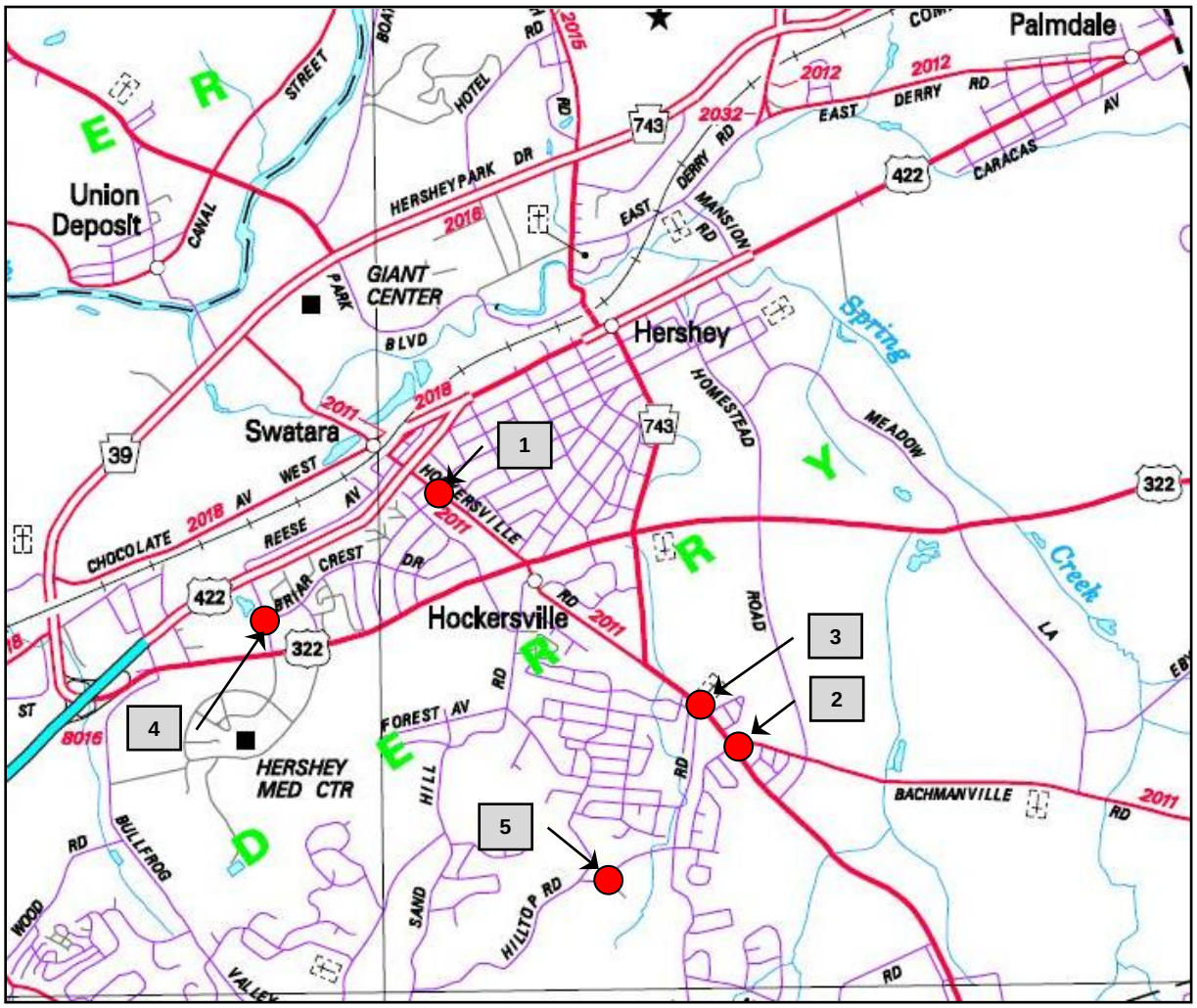
Safety Suggestions

Prioritized List of Locations

Derry Township identified several locations as priority safety locations during the initial interview with local community staff. The locations were identified by the Township

based on their knowledge of crash records, history, and safety concerns. This report focuses on five (5) of the priority safety locations which can be found on the map provided below. Each safety location is discussed throughout the remainder of this report. The locations are as follows:

1. Intersection of Hockersville Road (SR 2011) and Areba Avenue (T-711)
2. Intersection of Fishburn Road (SR 0743), Bachmanville Road (SR 2011) and Harvey Road (T-462)
3. Intersection of Fishburn Road (SR 0743) and Church Road (T-568)
4. Intersection of University Drive (T-320) and Briarcrest Drive (T-321)
5. Horizontal Curves on Hilltop Road (T-351) just east of the intersection with Clark Road (T-574)



General Guidance – The following is a list of steps that the Township should consider in order to address their safety concerns at each safety location and start to implement the potential solutions presented within this report. Please note that the Township may need to hire a licensed engineer to diagnose the causation factors and to implement some of

the potential solutions found within this report, especially those relating to the roadway infrastructure.

1. Complete any traffic studies and roadway evaluations.
2. Identify the underlying problems/deficiencies.
3. Implement short-term solutions tailored to correct the problems/deficiencies.
4. Identify still existent problems/deficiencies and implement mid-term solutions to remediate them.
5. If the underlying problem/deficiencies are still not corrected, begin to program the long-term solutions. Keep in mind that during the planning of long-term solutions, the Township should incorporate as many solutions as possible to avoid additional construction costs in the future. Example: Incorporate medians, reconstructed superelevation, improved wearing course, and improved drainage into a single long-term solution.
6. Implement long-term solutions.

Before discussing each safety location, note that field view observations, discussions with municipal personnel, and traffic engineering experience are largely responsible for the content and findings of this report.

Manual on Uniform Traffic Control Devices (MUTCD) Update Status – The Federal Highway Administration's (FHWA) update to the *Manual on Uniform Traffic Control Devices (MUTCD 2009 Edition)* was officially published in December 2009 and became effective in January 2010. Even though the MUTCD 2009 Edition has been published, be aware that the Pennsylvania Department of Transportation (PennDOT) has given notice in the January 16, 2010 *Pennsylvania Bulletin* that the amendments and modifications in the MUTCD 2009 Edition will not apply here in Pennsylvania, for now. PennDOT has determined that the MUTCD 2009 Edition includes a significant number of changes from the previous MUTCD 2003 Edition that will require considerable review, and will thus not accept the MUTCD 2009 Edition until its review is complete. Until further notice is provided in the *Pennsylvania Bulletin*, the provisions of the MUTCD 2003 Edition shall continue to provide the regulatory standards and guidance for installing and maintaining traffic control devices in this Commonwealth under 67 Pa. Code Chapter 212.

Thus, this Local Safe Roads Communities report will reference and cite the MUTCD 2003 Edition where applicable pertaining to potential solutions. In addition, the MUTCD 2009 Edition may be referenced and cited where LTAP feels the information contained within the MUTCD 2009 Edition provides additional, non-regulatory information.

Depending on when your community implements potential solutions contained within this report, you should ensure that the correct version of the MUTCD is used as adopted by PennDOT. LTAP is available to answer questions pertaining to the current use of the MUTCD 2003 Edition and the future use of the MUTCD 2009 Edition.

Location 1: Intersection of Hockersville Road (SR 2011) and Areba Avenue (T-711)

Issue: Derry Township is concerned about the safety of motorists turning out of Areba Avenue (T-711) onto or across Hockersville Road (SR 2011), specifically from the westbound approach.

Crash Evaluation: The following crash evaluation stems from reportable crash data obtained from PennDOT. The crash data covered the most recent five years of available crash data as of the time this report was written (2005-2009).

According to the crash data, six (6) reportable crashes occurred at the intersection of Areba Avenue and Hockersville Road. The crash types consisted of the following:

- Angle – 5 crashes
- Rear-End – 1 crash

The cited reasons for these crashes consisted of the following:

- Westbound motorists proceeding without clearance – 2 crashes
- Eastbound motorist proceeding without clearance – 1 crash
- Eastbound motorist running the stop sign – 1 crash
- Southbound motorist making an improper/careless turn – 1 crash
- Driver was distracted – 1 crash

All six crashes occurred during daylight conditions and the majority of the crashes (5 of the 6) occurred when the road surface was dry. One (1) crash occurred when the road surface was wet.

Based on PennDOT crash history data, there appears to be a crash trend related to motorists on the side streets proceeding without clearance and striking southbound traveling vehicles. Note that this evaluation does not take into consideration non-reportable crashes.

Field View Data:

Hockersville Road (SR 2011)

- Roadway Classification: Urban Minor Arterial
- Average Daily Traffic (ADT): Approximately 7,330 vehicles per day (PennDOT's Internet Traffic Monitoring System (iTMS) data)
- 3% truck traffic (PennDOT's iTMS data)
- 35 MPH posted speed limit
- North/south oriented two-lane, two-way, and partially curbed
- Free flowing (no traffic control)
- Double yellow centerline and white edge lines
- Dashed white edge lines provided through the intersection
- Variable width paved shoulders
- CROSS ROAD (W2-1) warning sign and ADVISORY SPEED (30 MPH) (W13-1) plaque provided in advance of the intersection in the southbound direction
- Utility poles located along the roadway
- Houses located on the southeast and northwest corners of the intersection
- Parking lots located on the northeast and southwest corners of the intersection

Areba Avenue (T-711)

- Roadway Classification: Urban Collector
- Average Daily Traffic (ADT): Approximately 2,805 vehicles per day (PennDOT's iTMS data)
- 3% truck traffic (PennDOT's iTMS data)
- 25 MPH posted speed limit
- East/west oriented two-lane, two-way, and curbed
- Stop-controlled on both approaches
- No pavement markings provided
- Utility poles located along the roadway
- Sidewalk provided on the northern side
- Moderate uphill grade on the westbound approach
- Overhead lighting provided on the northeast corner of the intersection

Northbound Hockersville Road Approaching Areba Avenue

Southbound Hockersville Road Approaching Areba Avenue

Eastbound Areba Avenue Approaching Hockersville Road

Westbound Areba Avenue Approaching Hockersville Road

Probable Causes: There are several possible reasons for the safety concerns at this intersection and they include:

- The corner sight distance to the left and right for motorists attempting to turn out of Areba Avenue may be insufficient due to the vertical crest curve just north of the intersection and the nearby trees and residential landscaping.

- The upward grade on the westbound approach of Areba Avenue may make it difficult to pull out in a timely manner, specifically during slippery conditions and for larger/heavier trucks.
- Though there is a CROSS ROAD (W2-1) warning signs posted along the southbound approach of Hockersville Road, Areba Avenue is not well defined, which may limit driver awareness of the approaching intersection.

Westbound Areba Avenue looking left onto Hockersville Road

Eastbound Areba Avenue looking left onto Hockersville Road

Potential Solutions:

Since Hockersville Road (SR 2011) is a state highway, the Township will need to work with PennDOT to implement any study findings and/or proposed intersection improvements within PennDOT right-of-way to ensure all appropriate permits are obtained.

Studies – perform the following studies in order to obtain existing information for the approach roadways:

1. Spot-Speed Study: Conduct a vehicular spot-speed study in accordance with PennDOT Publication 212's Appendix to determine the 85th percentile speed along Hockersville Road near the intersection with Areba Avenue (See Appendix A-1). If necessary, LTAP can assist the Township in performing the study. The results of the spot-speed study will quantify the existing speeds along Hockersville Road and allow the Township to make well informed decisions related to law enforcement and what improvements to implement.

2. Sight Distance: Conduct corner sight distance surveys in accordance with PennDOT Publication 212 to determine if there is adequate sight distance for vehicles turning onto or out of Areba Avenue from or to Hockersville Road based on the 85th percentile speed along Hockersville Road (See Appendix A-2). If necessary, LTAP can assist the Township in performing the sight distance surveys.

Short-term Solutions – depending on the results of the studies listed above, consider providing the following short-term improvements in advance of and/or at the intersection:

1. Basic Treatments:
    a. Intersection Warning Signs: Ensure that the CROSS ROAD (W2-1) warning sign along the southbound approach of Hockersville Road is properly placed in accordance with Chapter 2C of the MUTCD (See Appendix A-3). Also, consider adding a CROSS ROAD (W2-1) warning sign (See Appendix A-4) to the northbound approach of Hockersville Road. Consider using oversized (48"x48") signs and supplementing them with one of the following placards, using them consistently between the two approaches to the intersection (listed in order of preference):
        i. SINGLE-LINE ADVANCE STREET NAME sign (W16-8) (See Appendix A-4)
        ii. (__) FEET plaque (W16-2) (See Appendix A-4)
        iii. ADVISORY SPEED (W13-1) plaque, if needed and based on the findings of the corner sight distance surveys (See Appendix A-4)
        iv. AHEAD (W16-9P) plaque (See Appendix A-4)
    b. Regulatory Signs: Consider adding retroreflective material in the channel posts of the STOP (R1-1) signs on the Areba Avenue approaches (See Appendix A-5).

c. Guide Signs: Consider using larger letter sizes (8") on the STREET NAME signs (D3-1) (See Appendix A-6) and install these signs in opposite corners of the intersection to help emphasize the intersection.
d. Retroreflectivity: Use high intensity retroreflective material (ASTM Type III) or better for all signs (See Appendix A-7).
e. Pavement Markings:
    i. Consider adding double yellow centerline pavement markings and white edge line pavement markings to the Areba Avenue approaches, as appropriate (See Appendix A-8).
    ii. Consider supplementing the STOP signs (R1-1) on Areba Avenue with stop bars to guide driver's to the point that maximizes their sight distance (See Appendix A-8).
    iii. Consider dashing the double yellow centerline pavement markings along Hockersville Road through the intersection in accordance with Pub 111M, TC-8600 (See Appendix A-8). The length and spacing between each dash should be similar to the "Dotted Extension Line". Also, consider revising the dashed white edge lines to follow this same pattern. This will provide a visual cue to the motorists along Hockersville Road that there is an intersecting side road approaching.

2. Maintenance Treatments:
    a. Sight Lines: If the required minimum sight distance is not available, cut/trim/remove any vegetation, embankments, and other obstructions that may be limiting the sight distance for motorists turning onto or out of Areba Avenue. Because the removal of vegetation, especially trees, is usually a sensitive topic for local residents, very specific obstructions should be identified during the corner sight distance study and considered for removal based on the severity of how much the object limits sight distance. Title 75, PA Motor Vehicle Code Section 6112 and Section 212.6 of PennDOT Publication 212 provide local municipalities with the authority to require property owners to remove obstructing objects that are hazards (See Appendix A-9). Continually monitor and cut/trim/remove any vegetation that may be limiting sight distance.
    b. Signing and Pavement Markings: Continually restripe faded pavement markings and replace faded and/or damaged signs. Establish a schedule for inspection, cleaning, and replacement. In accordance with Section 2A.08 of the 2009 MUTCD (See Appendix A-7), an assessment or management method that is designed to maintain sign retroreflectivity shall be used. A FREE sample management tool can be found on LTAP's website by clicking on the following link:

        LTAP Website: https://www.dot7.state.pa.us/LTAP/

        Click on "New Items" and under "LTAP News / Events" the Township will find information related to the FREE sign inventory and management tool. If the Township has questions about the tool, please contact LTAP.

3. Other Treatments:
    a. ADA Ramps: Consider upgrading the curb ramps to meet current ADA standards. PennDOT's specific requirements for ADA compliant curb ramps can be found in PennDOT Publication 72M, Standards for Roadway Construction, Standard Drawing Number RC-67M. RC-67M provides numerous curb ramp details for numerous variations of sidewalk/intersection designs. PennDOT Publication 13M Chapters 6.6 and 6.7, Design Manual 2: Highway Design, also address the design of curb ramps at intersections. While the standards described in RC-67M only apply to new and alteration construction projects, the Township should take a proactive approach to update and reconstruct curb ramps to meet the new standards.
    b. Enforcement: Consider using law enforcement to enforce speed regulations, especially along the Hockersville Road approaches to the intersection.

Mid-term Solutions – if safety concerns still exist after the implementation of the short-term solutions, consider providing the following improvements in advance of and/or at the intersection:

1. Basic Treatments:
    a. Regulatory Signs: Consider completing an engineering and traffic study in accordance with Section 212.111 of PennDOT Publication 212 to determine if a NO LEFT TURN restriction is warranted and appropriate to restrict motorists from turning left onto Hockersville Road from Areba Avenue (See Appendix A-10). If warranted, install NO LEFT TURN (R3-2) signs at the intersection as specified in PennDOT Publication 236M (See Appendix A-10). This solution should be considered if there is an adjacent intersection that will provide safer left-turning egress and will not adversely affect operations.

2. Enhanced Basic Treatments:
    a. Warning Signs: Consider installing a second, identical set of oversized intersection warning signs and placards on the left side of Hockersville Road in advance of the intersection (See Appendix A-4).
    b. Flashing Beacons: Consider supplementing the warning signs with flashing beacons. Be sure not to overuse these devices. Flashing beacons should only be used at high crash locations (See Appendix A-11).

Long-term Solutions – if safety concerns still exist after the implementation of the short-term and mid-term solutions, consider providing the following improvements in advance of and/or at the intersection:

1. Roadway Improvements:
    a. Vertical Alignment:

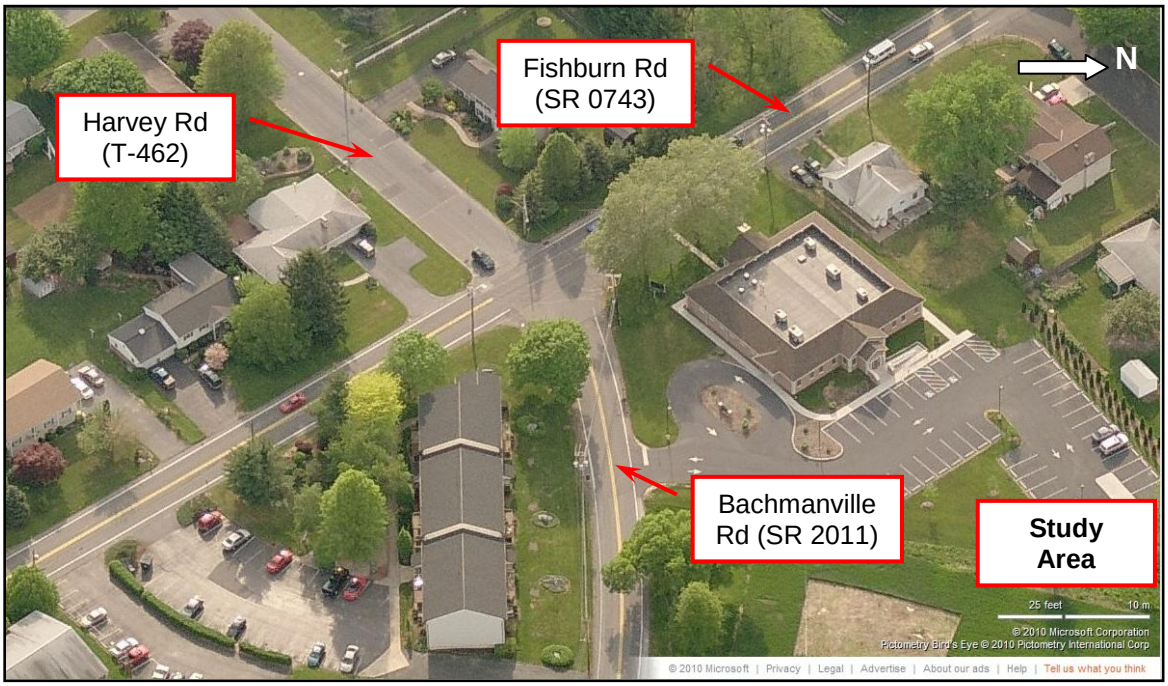
i. Consider revising the vertical alignment on Hockersville Road to the north of the Areba Avenue intersection to soften the vertical crest curve and improve intersection sight distance.
ii. Depending on the future growth of the area and the traffic demand on Areba Avenue, consider regrading the westbound approach to soften the vertical curve leading up to the intersection. Flattening the approach grade even if only for 2 or 3 car lengths from the intersection to provide a somewhat level staging area should improve sight distance and safety.

2. Other Treatments: Depending on the future growth of the area and the traffic demand at the intersection, consider providing a traffic signal, if warranted and justified. Engineering and traffic studies will need to be completed to evaluate this solution in order to determine the feasibility.

Location 2: Intersection of Fishburn Road (SR 0743), Bachmanville Road (SR 2011) and Harvey Road (T-462)

Please note that this safety location is included and discussed as part of LTAP's Walkable Communities Program Report for Derry Township.

Issue: Fishburn Road (SR 0743) is a heavily traveled commuter route and Derry Township is concerned about the safety of motorists turning onto or crossing over Fishburn Road (SR 0743) from Harvey Road (T-462) specifically during morning and evening peak traffic periods. The Township also indicated that motorists may be using Harvey Road (T-462) as a bypass to Church Road (T-568) and that motorists on Fishburn Road (SR 0743) may be speeding.



Crash Evaluation: The following crash evaluation stems from reportable crash data obtained from PennDOT. The crash data covered the most recent five years of available crash data as of the time this report was written (2005-2009).

According to the crash data, ten (10) reportable crashes occurred at the intersection of Fishburn Road, Bachmanville Road, and Harvey Road. The crash types consisted of the following:

- Angle – 6 crashes
- Rear-End – 3 crashes (2 northbound and 1 southbound)
- Hit Fixed Object – 1 crash

The cited reasons for these crashes consisted of the following:

- Too fast for conditions – 3 crashes (2 southbound and 1 northbound)
- Proceeding without clearance – 3 crashes (2 westbound and 1 eastbound)

- Improper/careless turn – 2 crashes (1 northbound and 1 southbound)
- Tailgating – 1 crash (northbound)
- Other improper driver actions – 1 crash (northbound)

All of the crashes occurred on weekdays and it appears that at least five (5) of the ten (10) crashes occurred during the AM or PM peak periods. Nine (9) of the ten (10) crashes occurred during daylight conditions and one (1) crash occurred under street light. The majority of the crashes (9 of the 10) occurred when the road surface was dry and one (1) crash occurred when the road surface was snow covered.

Based on PennDOT crash history data, there appears to be a trend of crashes occurring during the weekday peak travel periods. Note that this evaluation does not take into consideration non-reportable crashes.

Field View Data:

Fishburn Road (SR 0743)

- Roadway Classification: Urban Minor Arterial
- Average Daily Traffic (ADT): Approximately 11,535 vehicles per day south of Harvey Road and approximately 14,150 vehicles per day north of Harvey Road (PennDOT's iTMS data)
- 8% truck traffic south of Harvey Road and 4% truck traffic north of Harvey Road (PennDOT's iTMS data)
- 35 MPH posted speed limit
- North/south oriented two-lane, two-way, and uncurbed
- Free flowing (no traffic control)
- Double yellow centerline and white edge lines
- Dashed white edge lines provided through the intersection
- Minimal width (~2') paved shoulders
- Numerous obstructions (e.g. embankments, trees, utility poles, stones, and mailboxes) located adjacent to the roadway
- Numerous driveway access points located along the roadway
- CROSS ROAD (W2-1) warning signs provided in advance of the intersection in both directions

Bachmanville Road (SR 2011)

- Roadway Classification: Urban Collector
- Average Daily Traffic (ADT): Approximately 1,415 vehicles per day (PennDOT's iTMS data)
- 9% truck traffic (PennDOT's iTMS data)
- 35 MPH posted speed limit
- East/west oriented two-lane, two-way, and uncurbed
- Stop-controlled
- Double yellow centerline and white edge lines
- Minimal width (~2') paved shoulders
- Numerous obstructions (e.g. trees, utility poles, stones, and mailboxes) located adjacent to the roadway

- Numerous driveway access points located along the roadway
- JCT (M2-1) PENNSYLVANIA ROUTE (743) MARKER provided in advance of the intersection

Harvey Road (T-462)

- Roadway Type: Township Road
- Average Daily Traffic (ADT): Unknown
- 25 MPH posted speed limit
- East/west oriented two-lane, two-way, and curbed
- Stop-controlled
- No pavement markings
- No paved shoulders
- Overhead lighting provided on the northwest corner of the intersection
- Utility poles located along the roadway
- WATCH CHILDREN (W15-2) sign provided at the entrance

Northbound Fishburn Road Approaching Harvey Road

Southbound Fishburn Road Approaching Harvey Road

Eastbound Harvey Road Approaching Fishburn Road

Looking East at Bachmanville Road

Probable Causes:

Fishburn Road (SR 0743) is a heavily traveled commuter route during peak periods and according to the Township, motorists on SR 0743 may be speeding. There are several possible reasons for the safety concerns at this intersection and they include:

- There may be a limited number of acceptable gaps for motorists turning onto or crossing SR 0743 from Harvey Road, specifically during peak periods.
- Motorists attempting to cross SR 0743 may have difficulty judging the gaps in traffic, especially if motorists on SR 0743 are speeding.
- Though there are CROSS ROAD (W2-1) warning signs posted along SR 0743 prior to the intersection, due to the numerous driveways located along the roadway, motorists looking for the intersection may not be able to see it far enough in advance to indicate their intent to turn, decelerate from their operating speed and safely make the turn.
- Motorists may be traveling too fast for conditions along SR 0743.

Potential Solutions:

Since SR 0743 is a state highway, the Township will need to work with PennDOT to implement any study findings and/or proposed intersection improvements within PennDOT right-of-way to ensure all appropriate permits are obtained.

Studies – perform the following studies in order to obtain existing information for the approach roadways:

1. Spot-Speed Study: Conduct vehicular spot-speed studies in accordance with PennDOT Publication 212's Appendix to determine the 85th percentile speeds along SR 0743 near the intersection with Harvey Road (See Appendix A-1). If necessary, LTAP can assist the Township in performing these studies. The results of each spot-speed study will quantify the existing speeds along SR 0743 and allow the Township to make well informed decisions related to law enforcement and what improvements to implement.

2. Sight Distance: Conduct corner sight distance surveys in accordance with PennDOT Publication 212 to determine if there is adequate sight distance for vehicles turning onto or out of Harvey Road from or to Fishburn Road based on the 85th percentile speed along Fishburn Road (See Appendix A-2). If necessary, LTAP can assist the Township in performing the sight distance surveys.

3. Gap Study: Motorists attempting to turn onto or cross over SR 0743 may not be able to find and/or judge an adequate gap in the traffic to safely complete their intended maneuver. Normally inadequate gaps are caused by high volume traffic flows that are evenly dispersed. A motorist's gap acceptance, the minimum distance between approaching vehicles where he or she feels it is safe to enter, decreases the longer he or she waits. After waiting for a significant period of time, the motorist might become frustrated and attempt to enter prematurely. To determine if there is a gap acceptance issue, consider completing a gap study to determine if there are adequate gaps in the SR 0743 traffic. These studies should be completed during peak traffic conditions because these time periods are typically when gap acceptance issues are most evident.

Short-term Solutions – depending on the results of the studies listed above, consider providing the following short-term improvements in advance of and/or at the intersection:

1. Basic Treatments:
    a. Intersection Warning Signs: Ensure that the CROSS ROAD (W2-1) warning signs along SR 0743 are properly placed in accordance with Chapter 2C of the MUTCD (See Appendix A-3). Also, consider using oversized (48"x48") signs and supplementing them with one of the following placards, using them consistently between the two approaches to the intersection (listed in order of preference):
        i. DOUBLE-LINE ADVANCE STREET NAME sign (W16-8A) (See Appendix A-4)
        ii. (__) FEET plaque (W16-2) (See Appendix A-4)
        iii. AHEAD plaque (W16-9P) (See Appendix A-4)
    b. Regulatory Signs: Consider adding retroreflective material in the channel posts of the STOP signs (R1-1) on the minor street approaches (See Appendix A-5).
    c. Guide Signs: Consider using larger letter sizes (8") on the STREET NAME signs (D3-1) (See Appendix A-6) to help emphasize the intersection.

d. Retroreflectivity: Use high intensity retroreflective material (ASTM Type III) or better for all signs (See Appendix A-7).
e. Pavement Markings:
   i. Consider adding double yellow centerline pavement markings and white edge line pavement markings to the Harvey Road approach, as appropriate (See Appendix A-8).
   ii. Consider supplementing the STOP sign (R1-1) on Harvey Road with a stop bar to guide driver's to the point that maximizes their sight distance (See Appendix A-8).
   iii. Consider dashing the double yellow centerline pavement markings along SR 0743 through the intersection in accordance with Pub 111M, TC-8600 (See Appendix A-8). The length and spacing between each dash should be similar to the "Dotted Extension Line". Also, consider revising the dashed white edge lines to follow this same pattern. This will provide a visual cue to the motorists along SR 0743 that there is an intersecting side road approaching.

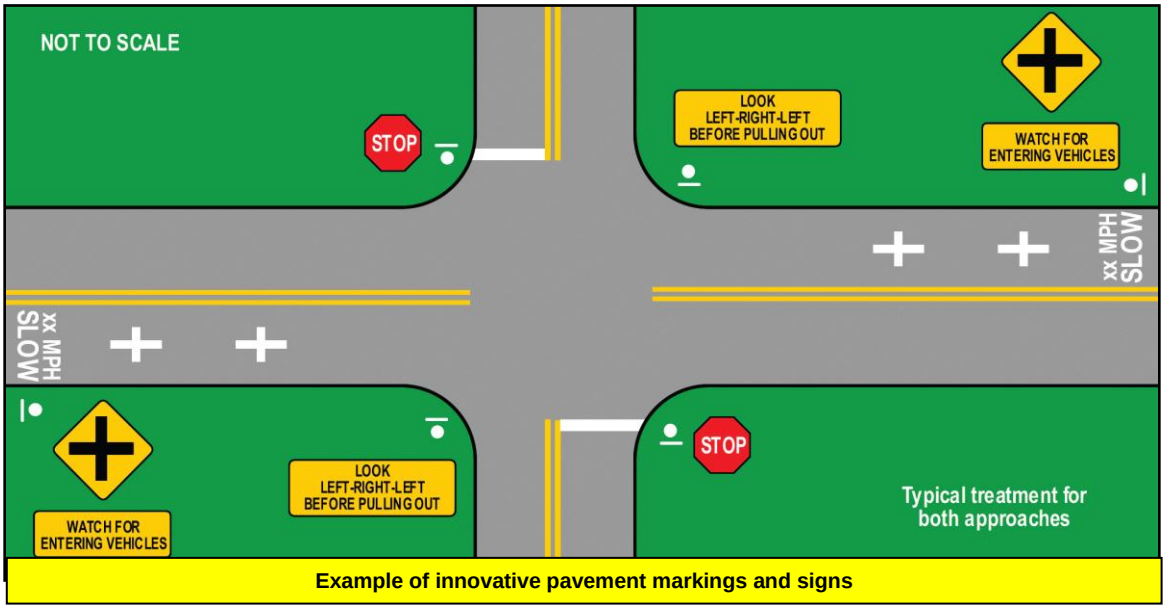
2. Maintenance Treatments:
   a. Sight Lines: If the required minimum sight distance is not available, cut/trim/remove any vegetation, embankments, and other obstructions that may be limiting the sight distance for motorists turning onto or out of Harvey Road. Because the removal of vegetation, especially trees, is usually a sensitive topic for local residents, very specific obstructions should be identified during the corner sight distance study and considered for removal based on the severity of how much the object limits sight distance. Title 75, PA Motor Vehicle Code Section 6112 and Section 212.6 of PennDOT Publication 212 provide local municipalities with the authority to require property owners to remove obstructing objects that are hazards (See Appendix A-9). Continually monitor and cut/trim/remove any vegetation that may be limiting sight distance.
   b. Signing and Pavement Markings: Continually restripe faded pavement markings and replace faded and/or damaged signs. Establish a schedule for inspection, cleaning, and replacement. In accordance with Section 2A.08 of the 2009 MUTCD (See Appendix A-7), an assessment or management method that is designed to maintain sign retroreflectivity shall be used. A FREE sample management tool can be found on LTAP's website by clicking on the following link:

      LTAP Website: https://www.dot7.state.pa.us/LTAP/

      Click on "New Items" and under "LTAP News / Events" the Township will find information related to the FREE sign inventory and management tool. If the Township has questions about the tool, please contact LTAP.

3. Other Treatments:
   a. Enforcement: Consider using law enforcement to enforce speed regulations, especially along the SR 0743 approaches to the intersection.

b. Speed Trailers: Consider utilizing speed trailers on SR 0743 that provide visual feedback to motorists on how fast they are traveling.
c. Innovative signs and pavement markings: If the gap study indicates that there are inadequate gaps or issues assessing an adequate gap, a potential solution includes providing pavement markings at a fixed distance from the intersection to physically show an adequate gap. The motorists on Harvey Road must be informed not to enter the intersection if approaching vehicles are closer than the pavement markings. Since the pavement markings are used to guide vehicles from side street approaches as to a suitable available gap for making turning or crossing maneuvers, ensure the pavement markings are placed such that there is suitable available gap between the pavement markings and the intersection for motorists on Harvey Road to safely proceed (See Appendix A-12).



Example of innovative pavement markings and signs

Mid-term Solutions – if safety concerns still exist after the implementation of the short-term solutions, consider providing the following improvements in advance of and/or at the intersection:

1. Enhanced Basic Treatments:
   a. Warning Signs: Consider installing a second, identical set of oversized intersection warning signs and placards on the left side of SR 0743 in advance of the intersection (See Appendix A-4).

2. Other Treatments:
   a. If speeding issues on SR 0743 are still a concern, consider installing painted yellow median islands with milled rumble strips on the approaches of SR 0743 in order to narrow the lanes through the intersection. Also provide milled rumble strips on the outside shoulders

adjacent to the white edge lines of the SR 0743 approaches. For more information on proper placement, go to http://www.tfhrc.gov/safety/pubs/08063/08063.pdf.

Example of painted yellow median island and milled rumble strips

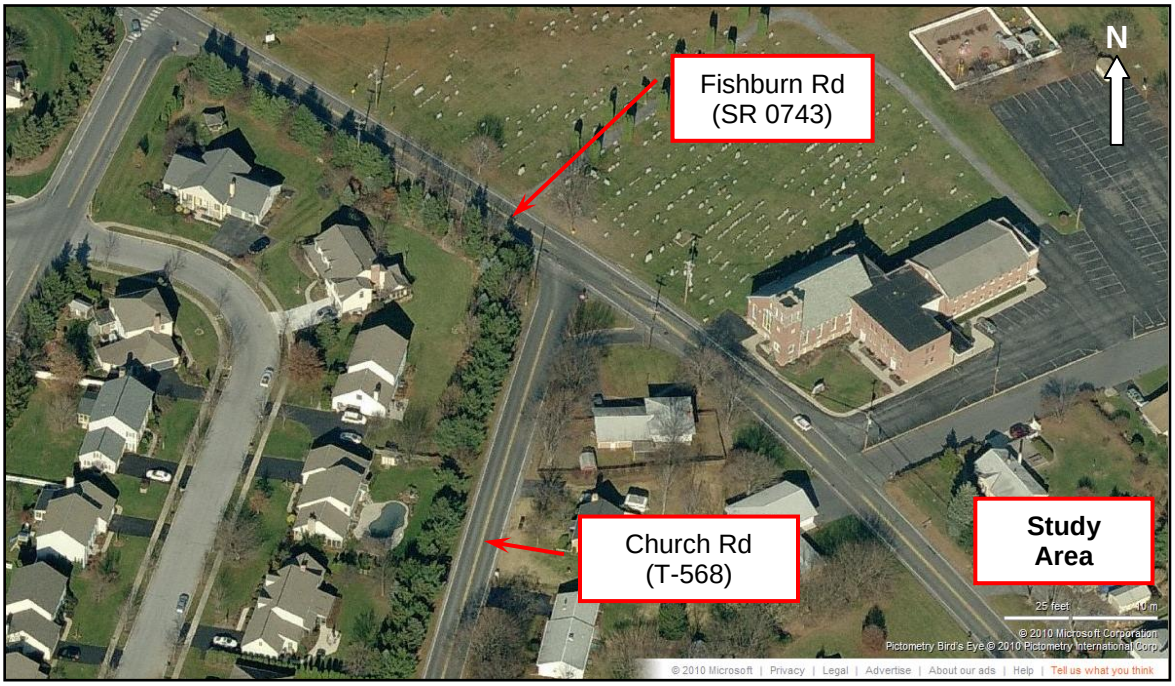
Long-term Solutions – if safety concerns still exist after the implementation of the short-term and mid-term solutions, consider providing the following improvements in advance of and/or at the intersection:

1. Enhanced Basic Treatments:
    a. Flashing Beacons: Consider supplementing the intersection warning signs with flashing beacons. Be sure not to overuse these devices. Flashing beacons should only be used at high crash locations (See Appendix A-11).

2. Roadway Improvements:
    a. Turn Lanes: Depending on the future growth of the area and the traffic demand on SR 0743 and the intersecting side roads, consider providing left-turn lanes, right-turn lanes, or a combination of both on the SR 0743 approaches to the intersection in order to remove vehicles from the traffic flow. An engineering and traffic study will need to be completed to evaluate the turning volumes/conflicts and the required storage lengths. This solution may also require extensive roadway widening, utility relocation, ROW acquisitions, and pavement marking/signing enhancements along SR 0743.

Location 3: Intersection of Fishburn Road (SR 0743) and Church Road (T-568)

Issue: Fishburn Road (SR 0743) is a heavily traveled commuter route and Derry Township is concerned about the safety of motorists turning onto Fishburn Road (SR 0743) from Church Road (T-568), specifically during morning and evening peak traffic periods. The Township also indicated that motorists on Fishburn Road (SR 0743) may be speeding and the intersection may meet warrants for traffic signal control.



Crash Evaluation: The following crash evaluation stems from reportable crash data obtained from PennDOT. The crash data covered the most recent five years of available crash data as of the time this report was written (2005-2009).

According to the crash data, six (6) reportable crashes occurred at the intersection of Fishburn Road and Church Road. The crash types consisted of the following:

- Angle – 3 crashes
- Hit Fixed Object – 2 crashes
- Rear-End – 1 crash

The cited reasons for these crashes consisted of the following:

- Too fast for conditions – 3 crashes (2 eastbound and 1 northbound)
- Proceeding without clearance – 2 crashes (eastbound)
- Improper/careless turn, turning from wrong lane – 1 crash

All of the crashes occurred during daylight conditions on weekdays and it appears that four (4) of the six (6) crashes occurred during the AM or PM peak periods. Four (4) of

the six (6) crashes occurred when the road surface was dry and two (2) crashes occurred when the road surface was wet.

Based on PennDOT crash history data, there appears to be a trend of crashes occurring during the weekday peak travel periods. Note that this evaluation does not take into consideration non-reportable crashes.

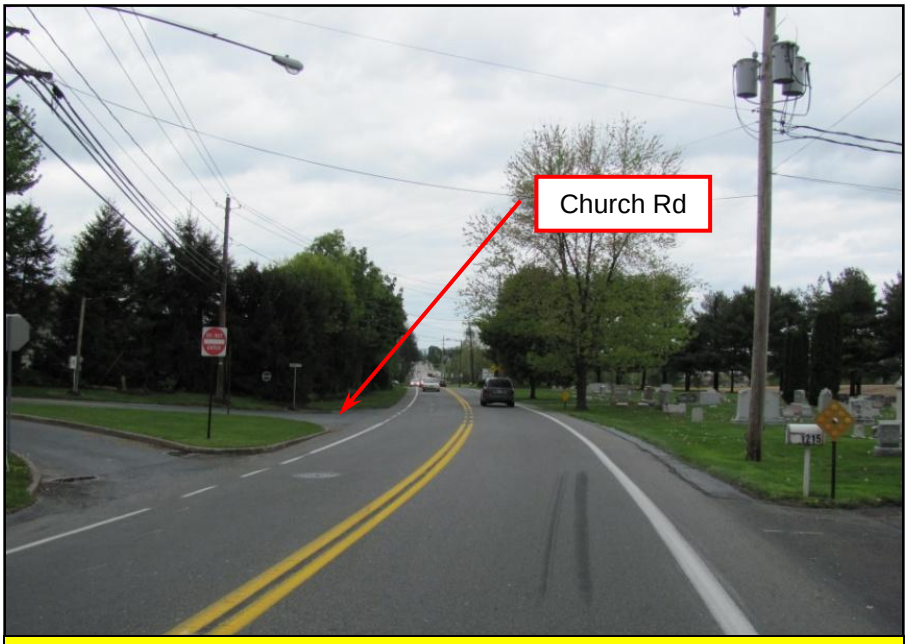
Field View Data:

Fishburn Road (SR 0743)

- Roadway Classification: Urban Minor Arterial
- Average Daily Traffic (ADT): Approximately 14,150 vehicles per day (PennDOT's iTMS data)
- 4% truck traffic (PennDOT's iTMS data)
- 35 MPH posted speed limit
- North/south oriented two-lane, two-way, and uncurbed
- Free flowing (no traffic control)
- Double yellow centerline and white edge lines
- Dashed double yellow centerline and dashed white edge line provided through the intersection
- Minimal width (~2') paved shoulders
- Numerous obstructions (e.g. embankments, trees, utility poles, and mailboxes) located adjacent to the roadway
- Numerous driveway access points located along the roadway

Church Road (T-568)

- Roadway Classification: Urban Collector
- Average Daily Traffic (ADT): Approximately 2,805 vehicles per day (PennDOT's iTMS data)
- 5% truck traffic (PennDOT's iTMS data)
- 25 MPH posted speed limit
- East/west oriented two-lane, two-way, and partially curbed
- Stop-controlled
- Channelized right-turn lane with a grass island provided
- Double yellow centerline and white edge lines
- Minimal width (~2') paved shoulders
- Numerous obstructions (e.g. trees, fences, and mailboxes) located adjacent to the roadway
- Driveway access point located within the channelized right-turn lane
- Line of large trees on the northwest corner
- Overhead lighting provided on the southwest corner
- OBJECT MARKER (OM1-3) located on the far side of the intersection



Northbound Fishburn Road Approaching Church Road

Southbound Fishburn Road Approaching Church Road

Eastbound Church Road Approaching Fishburn Road

Eastbound Channelized Right-Turn Lane on Church Road Approaching Fishburn Road

Probable Causes:

Fishburn Road (SR 0743) is a heavily traveled commuter route during peak periods, and according to the Township, motorists on SR 0743 may be speeding. Church Road is also a fairly busy collector roadway, especially during peak periods. There are several possible reasons for the safety concerns at this intersection and they include:

- The corner sight distance to the left and right for motorists attempting to turn out of Church Road may be insufficient due to nearby vegetation, changes in horizontal alignment along SR 0743, and Church Road egress vehicle blockage.
- There may be a limited number of acceptable gaps for motorists turning onto SR 0743 from Church Road, specifically during peak periods.
- Due to the numerous driveways located along the SR 0743, motorists looking for Church Road may not be able to see it far enough in advance to indicate their intent to turn, decelerate from their operating speed and safely make the turn.
- Motorists may be traveling too fast for conditions along SR 0743.
- Inadequate traffic control devices.

Sight line looking left out of Church Road

Sight line looking right out of Church Road

Northbound SR 0743 approaching Church Road

Potential Solutions:

Since SR 0743 is a state highway, the Township will need to work with PennDOT to implement any study findings and/or proposed intersection improvements within PennDOT right-of-way to ensure all appropriate permits are obtained.

Studies – perform the following studies in order to obtain existing information for the approach roadways:

1. Spot-Speed Study: Conduct vehicular spot-speed studies in accordance with PennDOT Publication 212's Appendix to determine the 85th percentile speeds along SR 0743 near the intersection with Church Road (See Appendix A-1). If necessary, LTAP can assist the Township in performing these studies. The results of each spot-speed study will quantify the existing speeds along SR 0743 and allow the Township to make well informed decisions related to law enforcement and what improvements to implement.

2. Sight Distance: Conduct corner sight distance surveys in accordance with PennDOT Publication 212 to determine if there is adequate sight distance for vehicles turning onto or out of Church Road from or to SR 0743 based on the 85th percentile speed along SR 0743 (See Appendix A-2). If necessary, LTAP can assist the Township in performing the sight distance surveys.

3. Gap Study: Motorists attempting to enter SR 0743 may not be able to find and/or judge an adequate gap in the traffic to safely enter. Normally inadequate gaps are caused by high volume traffic flows that are evenly dispersed. A motorist's gap acceptance, the minimum distance between approaching vehicles where he or she feels it is safe to enter, decreases the longer he or she waits. After waiting for a significant period of time, the motorist might become frustrated and attempt to enter prematurely. To determine if there is a gap acceptance issue, consider completing a gap study to determine if there are adequate gaps in the SR 0743 traffic. These studies should be completed during peak traffic conditions because these time periods are typically when gap acceptance issues are most evident.

Short-term Solutions – depending on the results of the studies listed above, consider providing the following short-term improvements in advance of and/or at the intersection:

1. Basic Treatments:
    a. Intersection Warning Signs: Consider providing one of the following warning signs along each approach of SR 0743 in advance of the Church Road intersection:
        i. To emphasize the Church Road intersection only, install SIDE ROAD (W2-2) warning signs (See Appendix A-4).
        ii. To emphasize the horizontal curve on SR 0743 as well as the Church Road intersection, install CURVE SIDE ROAD (W1-10 series) warning signs (See Appendix A-4). Please note that the CURVE SIDE ROAD (W1-10 series) signs can be modified to match the curve to the left and the side road to the left in the northbound direction and vice versa for the southbound direction.
        iii. To emphasize the offset side road intersections of Church Road and Robin Road, install OFFSET SIDE ROAD RIGHT (W2-1-1R) warning signs (See Appendix A-4).

Whatever signs are used, ensure that they are properly placed in accordance with Chapter 2C of the MUTCD (See Appendix A-3). Also, consider using oversized (48"x48") signs and supplementing them with one of the following placards (listed in order of preference):

i. SINGLE-LINE ADVANCE STREET NAME sign (W16-8) or DOUBLE-LINE ADVANCE STREET NAME sign (W16-8A) (See Appendix A-4)
ii. (__) FEET plaque (W16-2) (See Appendix A-4)
iii. AHEAD (W16-9P) plaque (See Appendix A-4)
iv. ADVISORY SPEED (W13-1) plaque, if needed and based on the findings of the corner sight distance surveys (See Appendix A-4)

b. Additional Warning Signs:
   i. Consider replacing the OBJECT MARKER located opposite the Church Road approach with a LARGE DOUBLE ARROW (W1-7) sign to emphasize the stop-condition and let motorists know that the approaching intersection is a T-intersection (See Appendix A-4).
   ii. Consider providing either a DOUBLE ARROW (W12-1) sign or yellow delineator on the approach end of the island on Church Road to emphasize the split in the roadway (See Appendix A-4).
c. Regulatory Signs: Consider adding retroreflective material in the channel posts of the STOP (R1-1) signs on Church Road (See Appendix A-5).
d. Guide Signs:
   i. If SIDE ROAD (W2-2) signs, CURVE SIDE ROAD (W1-10 series) signs, or OFFSET SIDE ROAD RIGHT (W2-1-1R) signs are not installed, consider installing SINGLE-LINE ADVANCE STREET NAME signs (D3-2) (See Appendix A-6) on the approaches of SR 0743 in advance of the intersection with Church Road.

Example of an ADVANCE STREET NAME sign (D3-2)

   ii. Consider using larger letter sizes (8") on the STREET NAME signs (D3-1) (See Appendix A-6) and install these signs in opposite corners of the intersection to help emphasize the intersection.
e. Retroreflectivity: Use high intensity retroreflective material (ASTM Type III) or better for all signs (See Appendix A-7).
f. Pavement Markings:
   i. Consider supplementing the STOP signs (R1-1) on Church Road with stop bars to guide driver's to the point that maximizes their sight distance (See Appendix A-8).
   ii. Consider extending the double yellow centerline pavement markings on Church Road to the stop bar (if installed). Also

consider adding pavement markings around the channelized right-turn island (see concept plan below).

2. Maintenance Treatments:
   a. Sight Lines: If required minimum sight distance is not available, cut/trim/remove any vegetation, embankments, and other obstructions that may be limiting the sight distance for motorists turning onto or out of Church Road. Title 75, PA Motor Vehicle Code Section 6112 and Section 212.6 of PennDOT Publication 212 provide local municipalities with the authority to require property owners to remove obstructing objects that are hazards (See Appendix A-9). Continually monitor and cut/trim/remove any vegetation that may be limiting sight distance. Also, continually cut/trim/remove any vegetation that may be blocking the view of traffic signs.
   b. Signing and Pavement Markings: Continually restripe faded pavement markings and replace faded and/or damaged signs. Establish a schedule for inspection, cleaning, and replacement. In accordance with Section

2A.08 of the 2009 MUTCD (See Appendix A-7), an assessment or management method that is designed to maintain sign retroreflectivity shall be used. A FREE sample management tool can be found on LTAP's website by clicking on the following link:

LTAP Website: https://www.dot7.state.pa.us/LTAP/

Click on "New Items" and under "LTAP News / Events" the Township will find information related to the FREE sign inventory and management tool. If the Township has questions about the tool, please contact LTAP.

c. Shoulder Drop-off Elimination: According to the American Association of State Highway and Transportation Officials (AASHTO) 2" drop-offs or greater can create an unsafe condition and should be repaired immediately. Drop-offs adjacent to the roadway should be filled and compacted to eliminate them (See Appendix A-13).

3. Other Treatments:
   a. Enforcement: Consider using law enforcement to enforce speed regulations, especially along the SR 0743 approaches to Church Road.
   b. Speed Trailers: Consider utilizing speed trailers along SR 0743 that provide visual feedback to motorists on how fast they are traveling.

Mid-term Solutions – if safety concerns still exist after the implementation of the short-term solutions, consider providing the following improvements in advance of and/or at the intersection:

1. Enhanced Basic Treatments:
   a. Warning Signs: Consider installing a second, identical set of oversized intersection warning signs and placards on the left side of SR 0743 (See Appendix A-4).

2. Roadway Improvements:
    a. Shoulder Widening: Consider providing paved shoulders on both sides of SR 0743. Shoulders are safety features because they provide space that allows motorists a recovery area and room to get out of the travel lane and avoid crashes. This solution may require extensive roadway widening, earthwork, utility relocation, ROW acquisitions, and pavement marking/signing enhancements along SR 0743.

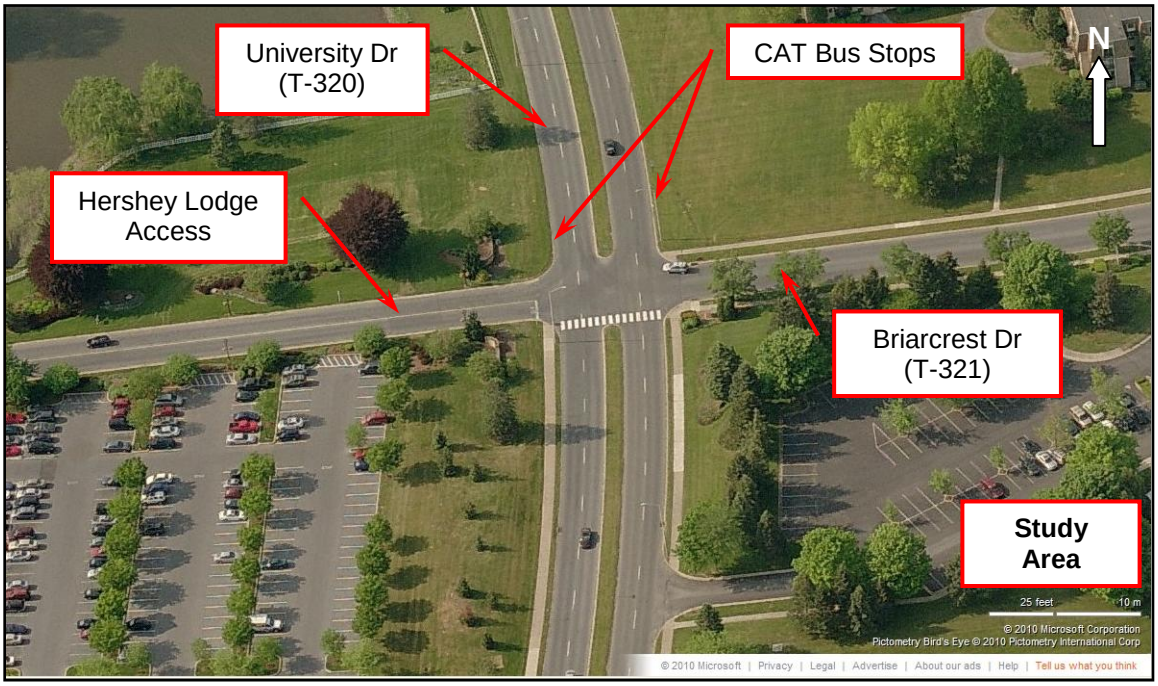
Long-term Solutions – if safety concerns still exist after the implementation of the short-term and mid-term solutions, consider providing the following improvements in advance of and/or at the intersection:

1. Roadway Improvements:
    a. Realignment: In conjunction with plans for new developments in the area, consider realigning the Church Road approach to eliminate the skew.
    b. Driveway Relocation: Consider relocating the driveway that currently accesses the right-turn lane of Church Road.
    c. Turn Lanes: Depending on the future growth of the area and the traffic demand on SR 0743 and Church Road, consider providing left-turn lanes, right-turn lanes, or a combination of both on the SR 0743 approaches to the intersection in order to remove vehicles from the traffic flow. An engineering and traffic study will need to be completed to evaluate the turning volumes/conflicts and the required storage lengths. This solution may also require extensive roadway widening, utility relocation, ROW acquisitions, and pavement marking/signing enhancements along SR 0743.

2. Other Treatments:
    a. Traffic Signal: In conjunction with the turn lane analyses, complete an engineering and traffic study in accordance with PennDOT Publication 212 and the MUTCD to determine if a traffic signal is warranted and justified at the intersection. If warranted and justified, consider installing a traffic signal at the intersection.

Location 4: Intersection of University Drive (T-320) and Briarcrest Drive (T-321)

Issue: Derry Township is concerned about the safety of motorists turning onto or out of Briarcrest Drive (T-321)/Hershey Lodge from or to University Drive (T-320) or crossing over University Drive. The Township also expressed concerns about the nearby Capitol Area Transit (CAT) bus stop locations along University Drive and the possible need for transit shelters.



Crash Evaluation: The following crash evaluation stems from reportable crash data obtained from PennDOT. The crash data covered the most recent five years of available crash data as of the time this report was written (2005-2009).

According to the crash data, eleven (11) reportable crashes occurred at the intersection of University Drive and Briarcrest Drive. The crash types consisted of the following:

- Angle – 10 crashes
- Same Direction Sideswipe – 1 crash

The cited reasons for these crashes consisted of the following:

- Proceeding without clearance – 6 crashes (4 westbound and 2 eastbound)
- Improper/careless turn – 4 crashes (3 southbound and 1 northbound)
- Turning from wrong lane – 1 crash (northbound)

Nine (9) of the eleven (11) crashes occurred during daylight conditions and two (2) crashes occurred under street light. Six (6) of the eleven (11) crashes occurred when the road surface was dry, four (4) crashes occurred when the road surface was wet, and one (1) crash occurred when the road surface was snow covered.

Based on PennDOT crash history data, there appears to be a crash trend related to motorists on the side streets proceeding without clearance and motorists on University Drive making improper/careless turns. Note that this evaluation does not take into consideration non-reportable crashes.

Field View Data:

University Drive (T-320)

General

- Roadway Classification: Urban Collector
- North/south oriented divided roadway with an approximately 10' wide grassy median
- 2 lanes in each direction
- Free flowing (no traffic control)
- Type 3 marked crosswalk provided across the southern side of the intersection

Northbound

- Average Daily Traffic (ADT): Approximately 3,540 vehicles per day (PennDOT's iTMS data)
- 2% truck traffic (PennDOT's iTMS data)
- 25 MPH posted speed limit
- Curbed
- No paved shoulders
- One shared through/left-turn lane and one shared through/right-turn lane
- Broken white centerline and no edge lines
- Overhead lighting provided along roadway
- Bus stop located just north of Briarcrest Drive
- Sidewalk on the right side of the roadway south of Briarcrest Drive

Southbound

- Average Daily Traffic (ADT): Approximately 2,140 vehicles per day (PennDOT's iTMS data)
- 2% truck traffic (PennDOT's iTMS data)
- 25 MPH posted speed limit
- Curbed
- No paved shoulders
- One shared through/left-turn lane and one shared through/right-turn lane
- Broken white centerline and no edge lines
- Overhead lighting provided along roadway
- Bus stop located just to the north of the Hershey Lodge Access
- Sidewalk on the right side of the roadway south of the Hershey Lodge Access

Briarcrest Drive (T-321)

- Roadway Classification: Urban Collector
- Average Daily Traffic (ADT): Approximately 2,510 vehicles per day (PennDOT's iTMS data)
- 5% truck traffic (PennDOT's iTMS data)
- 25 MPH posted speed limit
- East/west oriented two-lane, two-way, and curbed

- Stop-controlled
- No centerline or edge lines
- No paved shoulders
- Sidewalks on both sides of the roadway
- Provides access to apartment style housing and commercial/retail land uses

Hershey Lodge Access

- Roadway Type: Private Road
- Average Daily Traffic (ADT): Unknown
- 15 MPH posted speed limit
- East/west oriented two-lane, two-way, and curbed
- Stop-controlled
- Single yellow centerline pavement markings and no edge lines
- Faded stop bar and STOP pavement markings provided
- No paved shoulders
- No sidewalks
- Boulders located at the corners of the intersection
- Primary access to the Hershey Lodge complex which provides hotel, conference center, special event, and restaurant accommodations

Northbound University Drive Approaching Briarcrest Drive

Southbound University Drive Approaching Briarcrest Drive

Eastbound Hershey Lodge Access Approaching University Drive

Looking East along Briarcrest Drive

Probable Causes: There are several possible reasons for the safety concerns at this intersection and they include:

- There is likely a substantial population of motorists not familiar with the surrounding roadway network due to the trip generation characteristics of the nearby Hershey Lodge and retail outlets
- There may be a limited number of acceptable gaps for motorists turning onto or crossing University Drive from either Briarcrest Drive or the Hershey Lodge Access, especially during morning and evening peak periods.
- Motorists attempting to turn left onto Briarcrest Drive or into the Hershey Lodge may have difficulty judging the gaps in the opposing traffic.
- The CAT bus stops appear to be located away from existing pedestrian accommodations such as sidewalks and the bus stops may need additional traffic control devices.

Studies – perform the following studies in order to obtain existing information for the approach roadways:

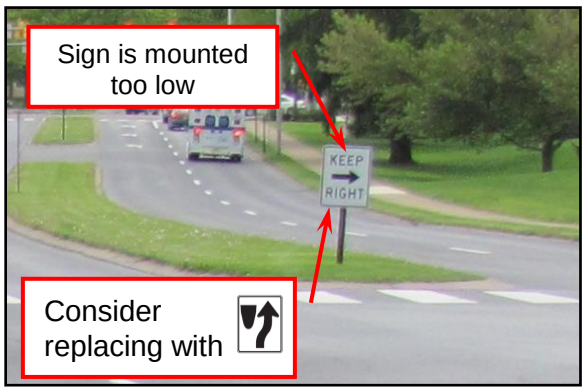
1. Spot-Speed Study: Conduct a vehicular spot-speed study in accordance with PennDOT Publication 212's Appendix to determine the 85th percentile speed along University Drive near the intersection with Briarcrest Drive (See Appendix A-1). If necessary, LTAP can assist the Township in performing the study. The results of the spot-speed study will quantify the existing speeds along University Drive and allow the Township to make well informed decisions related to law enforcement and what improvements to implement.

2. Gap Study: Motorists attempting to enter or cross University Drive may not be able to find and/or judge an adequate gap in the traffic to safely enter. Normally inadequate gaps are caused by high volume traffic flows that are evenly dispersed. A motorist's gap acceptance, the minimum distance between approaching vehicles where he or she feels it is safe to enter, decreases the longer he or she waits. After waiting for a significant period of time, the motorist might become frustrated and attempt to enter prematurely. To determine if there is a gap acceptance issue, consider completing a gap study to determine if there are adequate gaps in the University Drive traffic. These studies should be completed during peak traffic conditions because these time periods are typically when gap acceptance issues are most evident.

3. Evaluate Existing Roadway Conditions: Since four (4) of the crashes at the intersection occurred when the road surface was wet, consider documenting the Skid Resistance Level (SRL) of the course aggregates in the pavement surface wearing course of the study intersection to determine if there are any deficiencies in the existing pavement. Also consider examining the roadway drainage to determine if there is any ponding or sheeting of water that may affect safety.

Short-term Solutions – depending on the results of the studies listed above, consider providing the following short-term improvements in advance of and/or at the intersection:

1. Basic Treatments:
    a. Regulatory Signs:
        i. Consider signing enhancements on the minor street approaches, such as oversized STOP signs (R1-1, 36"x36") and retroreflective material in the channel posts (See Appendix A-5).
        ii. Consider installing LANE USE CONTROL (LS-SR) (R3-8A) signs along each approach of University Drive, one in advance of and one at the intersection (See Appendix A-5).
        iii. Consider replacing or removing the KEEP RIGHT signs with the horizontal arrow that are mounted on the median islands of University Drive. The existing signs are mounted too low. If replaced, consider using the KEEP RIGHT (R4-7) signs with an OJECT MARKER (OM1-3) mounted below the signs (See Appendix A-5).



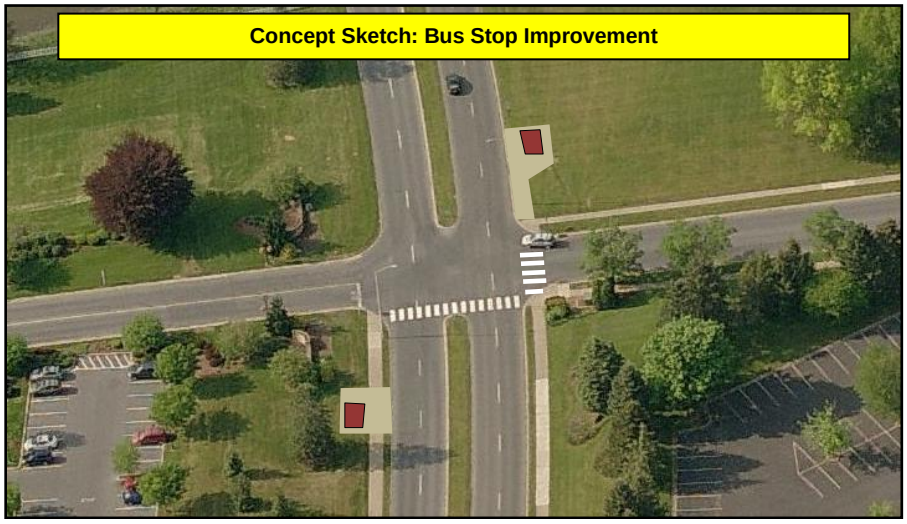
b. Guide Signs:
   i. Consider installing DOUBLE-LINE ADVANCE STREET NAME signs (D3-3) (See Appendix A-6) on the approaches of University Drive in advance of the intersection with Briarcrest Drive.
   ii. Consider using larger letter sizes (8") on the STREET NAME signs (D3-1) (See Appendix A-6) to help emphasize the intersection.
c. Retroreflectivity: Use high intensity retroreflective material (ASTM Type III) or better for all signs (See Appendix A-7).
d. Pavement Markings:
   i. Consider adding double yellow centerline pavement markings and white edge line pavement markings to the Briarcrest Drive approach, as appropriate (See Appendix A-8).
   ii. Consider supplementing the STOP sign (R1-1) on Briarcrest Drive with a stop bar to guide driver's to the point that maximizes their sight distance (See Appendix A-8).
   iii. Consider adding single yellow pavement markings along the median island and dashing the markings through the intersection in accordance with Pub 111M, TC-8600 (See Appendix A-8). The length and spacing between each dash should be similar to the "Dotted Extension Line".

2. Pedestrian Facilities / Bus Facilities:
   a. ADA Ramps: Consider upgrading the curb ramps to meet current ADA standards. PennDOT's specific requirements for ADA compliant curb ramps can be found in PennDOT Publication 72M, Standards for Roadway Construction, Standard Drawing Number RC-67M. RC-67M provides numerous curb ramp details for numerous variations of sidewalk/intersection designs. PennDOT Publication 13M Chapters 6.6 and 6.7, Design Manual 2: Highway Design, also address the design of curb ramps at intersections. While the standards described in RC-67M only apply to new and alteration construction projects, the Township should take a proactive approach to update and reconstruct curb ramps to meet the new standards due to the higher probability of pedestrian crossings generated by the nearby facilities.
   b. Pedestrian paths and sidewalks: Consider improving access to the CAT bus stops by providing connections to the surrounding local sidewalk network.
   c. Crosswalks: Consider providing a crosswalk across Briarcrest Drive. For consistency, use the same type of pavement markings currently being used across University Drive (See Appendix A-8).
   d. Pedestrian Warning Signs: Consider providing fluorescent yellow-green PEDESTRIAN (W11-2) warning signs in advance of and at the marked crossing on University Drive to warn of the unexpected hazard of pedestrians entering, sharing the use of, or crossing the roadway. The advance signs should be supplemented with the AHEAD PLAQUE (W16-9P) or (_) FEET PLAQUE (W16-2). The PEDESTRIAN (W11-2) signs used at the crossings must be supplemented with a DIAGONAL

DOWNWARD POINTING ARROW PLAQUE (W16-7P) showing the location of the crossing. These additional plaques must be placed below the warning sign and must be the same color as the warning sign. Refer to Appendix A-14 for additional information on pedestrian warning signs. Also consider using matching retroreflective material in the channel posts of the signs for added visibility.

e. Bus stops:
   i. There is currently a bus stop located just to the north of the Hershey Lodge Access along the southbound approach of University Drive. Consider relocating the bus stop to the south side of the intersection. There is currently a sidewalk in this area which could be improved to include a landing pad. This location would also eliminate bus blockages which should improve pedestrian visibility and the sight line for motorists. All facilities should be designed in accordance with *ADA Accessibility Guidelines* and any proposed revisions should be coordinated with CAT.
   ii. Depending on the pedestrian volume/demand in the area, consider improving the bus stop areas by making boarding and exiting easier and safer for passengers of all abilities. Things to consider include route and schedule information signing, shelters (some agencies use 50 daily passenger boardings as the threshold), benches, trash cans, bicycle racks, lighting, and access to the local sidewalk network. These items will help to improve a passenger's experience and may help increase ridership and are normally selected based on the number of passenger boarding. All facilities should be designed in accordance with *ADA Accessibility Guidelines* and any proposed improvements should be coordinated with CAT.
   iii. For more information related to pedestrian safety near bus stops, please see Appendix A-15. Another valuable resource, *Pedestrian Safety Guide for Transit Agencies*, produced by the Federal Highway Administration, can be found by clicking on the link below:

   http://safety.fhwa.dot.gov/ped_bike/ped_transit/ped_transguide/transit_guide.pdf



3. Maintenance Treatments:
    a. Signing and Pavement Markings: Continually restripe faded pavement markings and replace faded and/or damaged signs. Establish a schedule for inspection, cleaning, and replacement. In accordance with Section 2A.08 of the 2009 MUTCD (See Appendix A-7), an assessment or management method that is designed to maintain sign retroreflectivity shall be used. A FREE sample management tool can be found on LTAP's website by clicking on the following link:

       LTAP Website: https://www.dot7.state.pa.us/LTAP/

       Click on "New Items" and under "LTAP News / Events" the Township will find information related to the FREE sign inventory and management tool. If the Township has questions about the tool, please contact LTAP.

4. Other Treatments:
    a. Enforcement: Consider using law enforcement to enforce speed regulations, especially along the University Drive approaches to Briarcrest Drive.
    b. Skid-Resistive Overlays: Consider applying skid-resistive overlays on the intersection approaches to increase the skid resistance of the driving surface if after the roadway evaluation it is determined that the skid resistance of the roadway surfaces are deficient. The most significant material property that affects a roadway's surface friction is the polishing resistance of the course aggregate. Overlays of open-graded asphalt friction courses are quite effective because of their frictional and hydraulic properties. Section 5.6 of PennDOT Publication 242, Pavement Policy Manual, provides specific information on determining the appropriate Skid Resistance Level based on the existing ADT (See Appendix A-16).
    c. Signal retiming: If the gap study indicates that there are inadequate gaps or issues assessing an adequate gap, consider retiming the signals at the

adjacent up and downstream intersections to create additional gaps in the through traffic at the intersection.

Mid-term Solutions – if safety concerns still exist after the implementation of the short-term solutions, consider providing the following improvements in advance of and/or at the intersection:

1. Other Treatments:
    a. Innovative signs and pavement markings: If the gap study indicates that there are inadequate gaps or issues assessing an adequate gap, a potential solution includes providing pavement markings at a fixed distance from the intersection to physically show an adequate gap. The motorists on Briarcrest Drive must be informed not to enter the intersection if approaching vehicles are closer than the pavement markings. Since the pavement markings are used to guide vehicles from side street approaches as to a suitable available gap for making turning or crossing maneuvers, ensure the pavement markings are placed such that there is suitable available gap between the pavement markings and the intersection for motorists on Briarcrest Drive to safely proceed (See Appendix A-12).

Long-term Solutions – if safety concerns still exist after the implementation of the short-term and mid-term solutions, consider providing the following improvements in advance of and/or at the intersection:

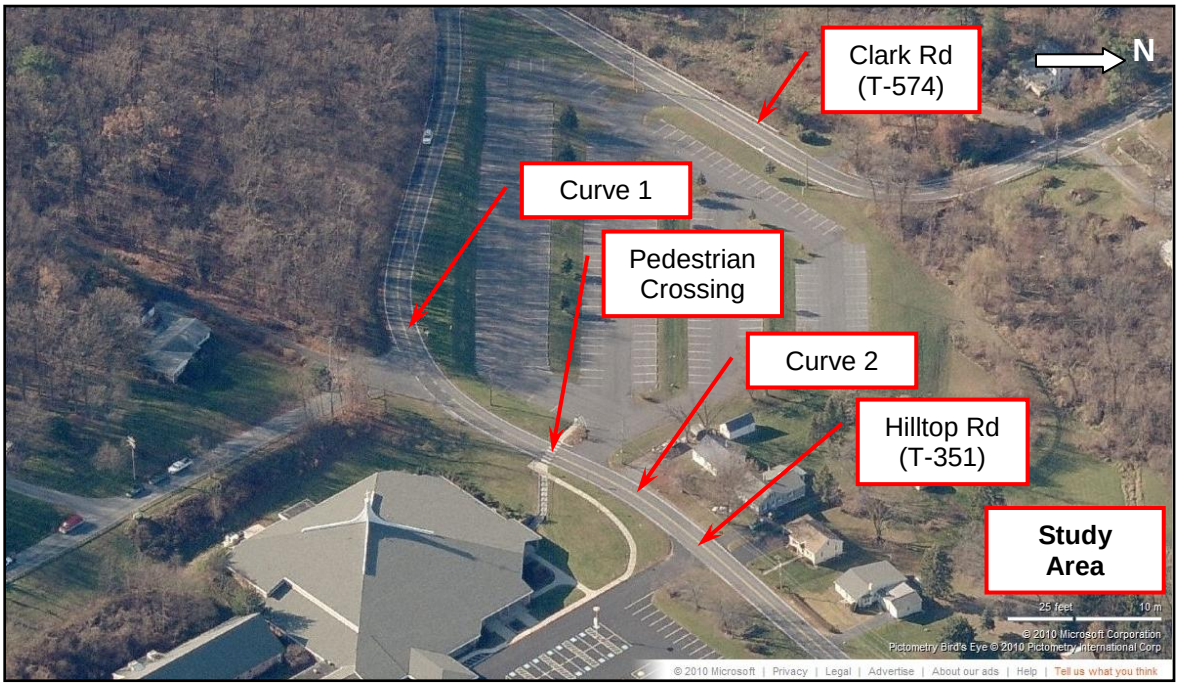
1. Pedestrian Facilities:
    a. Raised Crosswalk: Investigate the feasibility of constructing a raised crosswalk across University Drive to further improve pedestrian visibility and decrease speeds through the study area. This will require a study and approval process (See Appendix A-17).
    b. Median Island: Consider revising the median island on University Drive to include a protected refuge area for pedestrians. If constructed, angle the crosswalk so that pedestrians will be looking at approaching traffic.


Example Angled Median Crosswalk

2. Other Treatments: Consider providing one of the following improvements in advance of or at the intersection:
    a. Intersection Control Beacons: Consider installing intersection control beacons above the intersection with flashing yellow beacon(s) for the University Drive approaches. Chapter 4K of the MUTCD provides specific guidance on intersection control beacons (See Appendix A-11).
    b. Roundabout: If warranted and justified based on engineering and traffic studies, consider constructing a roundabout at the intersection (See Appendix A-18). This solution may require extensive roadway widening, utility relocation, ROW acquisitions, and pavement marking/signing enhancements.
    c. Median Closure: If warranted and justified based on engineering and traffic studies, consider closing the median on University Drive. This solution should only be considered if it will not adversely affect safety and/or operations at this intersection or adjacent intersections.

Location 5: Horizontal Curves on Hilltop Road (T-351) just east of the intersection with Clark Road (T-574)

Issue: Derry Township is concerned about the safety of vehicles traversing the horizontal curves along Hilltop Road (T-351), particularly the curves just east of the Clark Road (T-574) intersection and adjacent to the Evangelical Free Church of Hershey.



Crash Evaluation: The following crash evaluation stems from reportable crash data obtained from PennDOT. The crash data covered the most recent five years of available crash data as of the time this report was written (2005-2009).

PennDOT's reportable crash data only gives specifics as to the location of each crash if the crash occurred on a state route. For township roads, such as Hilltop Road, PennDOT's crash data can only be specifically located if the crash occurred near a known intersection. For locations such as the curves along Hilltop Road, PennDOT expresses these crashes as midblock crashes making it difficult to determine exactly where the crashes occurred. Thus, the following crash data evaluation includes all crashes along Hilltop Road that occurred within a horizontal curve.

According to the crash data, eighteen (18) reportable crashes occurred within horizontal curves along Hilltop Road. The crash types consisted of the following:

- Hit Fixed Objects – 16 crashes (89%)
- Angle – 1 crash (5.5%)
- Non-collision – 1 crash (5.5%)

The cited reasons for these crashes consisted of the following:

- Driving too fast for conditions and/or speeding – 11 crashes (61%)
- No contributing action – 3 crashes (17%)
- Over/under compensation at curve – 2 crashes (11%)
- Driver was distracted – 1 crash (5.5%)
- Driver was inexperienced – 1 crash (5.5%)

Some other notable information from the PennDOT crash history data are as follows:

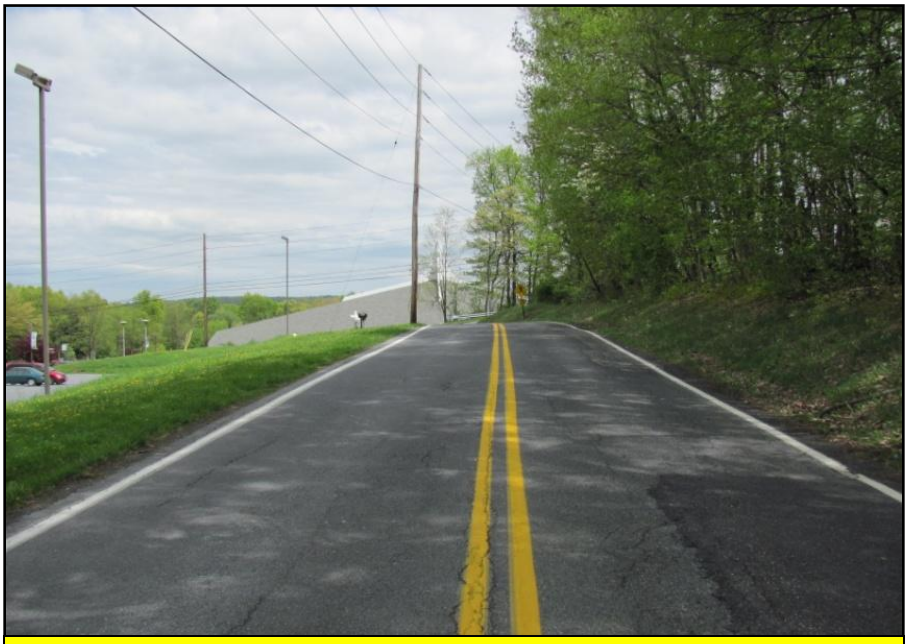
- Thirteen (13) of the eighteen (18) crashes (72%) occurred when the roadway surface was wet (9), snow covered (3), or icy (1).
- Ten (10) of the eighteen (18) crashes (56%) occurred during daylight conditions. The other eight (8) of the eighteen (18) crashes (44%) occurred during dark (7) or dusk (1) conditions.

Based on the crash data, there appears to be a crash trend involving motorists leaving the roadway because they are driving too fast through the curves along Hilltop Road, particularly under poor roadway surface conditions.

Field View Data:

Hilltop Road (T-351)

- Roadway Type: Township Road
- Average Daily Traffic (ADT): Unknown
- 25 MPH posted speed limit
- East/west oriented two-lane, two-way, and uncurbed
- Free flowing (no traffic control) near curves
- Double yellow centerline and white edge lines
- No paved shoulders
- Numerous obstructions (e.g. embankments, trees, shrubs, utility poles, and mailboxes) located adjacent to the roadway
- Driveway access point located within Curve 1
- Dashed double yellow centerline and dashed white edge line pavement markings provided through the driveway intersection
- Large church with a parking lot on the opposite side of the road located on the eastern side of the curves
- Marked pedestrian crosswalk provided across the road from the church to the parking lot
- PEDESTRIAN (W11-2) signs and ADVISORY SPEED (15) (W13-1) plaques provided in advance of the crosswalk and curves in both directions
- IN STREET PEDESTRIAN CROSSING (R1-6) signs provided in advance of the crosswalk in both directions



Eastbound Hilltop Road Approaching Curve 1

Westbound Hilltop Road Approaching Curve 1

Eastbound Hilltop Road Approaching Curve 2

Westbound Hilltop Road Approaching Curve 2

Probable Causes: The most probable causes for the safety concerns along the curves are vehicular speeds, inadequate curve warning and delineation, and slippery roadway surfaces during inclement weather conditions.

Potential Solutions:

Studies – perform the following studies in order to obtain existing information for the approach roadways and curves:

1. Spot-Speed Study: Conduct a vehicular spot-speed study in accordance with PennDOT Publication 212's Appendix to determine the 85th percentile speed along Hilltop Road in both directions (See Appendix A-1). If necessary, LTAP can assist the Township in performing the study. The results of the spot-speed study will quantify the existing speeds along Hilltop Road near the curves and allow the Township to determine if in fact a speeding issue is present. Depending on the findings of the spot-speed study, address any speeding concerns with local law enforcement and focus the improvements on reducing speeds approaching and through the curves.

2. Curve Speed Study: Conduct curve speed studies in accordance with PennDOT Publication 212's Appendix in order to determine the appropriate advisory speed for the curves (See Appendix A-1). A curve speed study should be conducted in both directions through the curves because the resulting advisory speeds may vary due to the differences in approach roadway geometry. If necessary, LTAP can assist the Township with performing these studies.

3. Sign Inventory: Inventory existing warning signs and determine if they are properly maintained and placed in accordance with Chapter 2C of the MUTCD (See Appendix A-3). Section 2.5 of PennDOT Publication 46 provides additional information about the placement of warning signs (See Appendix A-3).

4. Evaluate Existing Roadway Conditions: Document the existing roadway conditions of Hilltop Road within the study area by either obtaining the information from construction drawings or by taking measurements. Key conditions to document include the curve radius, approaching grades, cross slopes of the roadway before, through and after the curve, the rate of superelevation of the curve, the side friction factor of the curve, and the Skid Resistance Level (SRL) of the course aggregates in the pavement surface wearing course. The purpose of acquiring this information is to identify any deficiencies in the geometrics or pavement of the existing roadway. Also examine roadway drainage, and determine if there is any ponding or sheeting of water that may affect safety.

5. Clear Zone Determination: Determine what the appropriate clear zone widths are along Hilltop Road based on Chapter 12 of PennDOT Publication 13M, Design Manual 2 Highway Design (See Appendix A-19). Clear zone is defined as the total roadside border area, starting at the edge of traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The width of the clear zone is influenced by the traffic volume, the design speed, and embankment slope. Ensure that the calculated clear zone widths account for the changes in horizontal alignment.

Short-term Solutions – consider providing the following short-term improvements in advance of and/or through the curves:

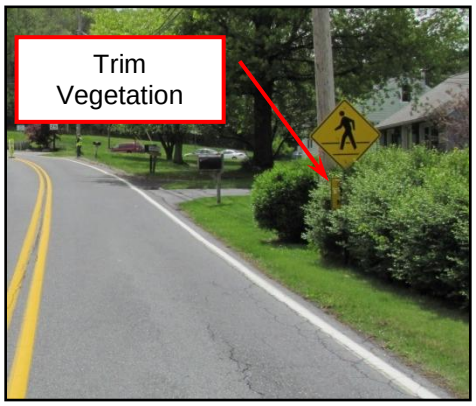
1. Basic Treatments:
    a. Regulatory Signs: Ensure that the SPEED LIMIT (25 MPH) (R2-1) sign that is currently located in advance of the curves in the westbound direction is not located too close to the curves. Placing SPEED LIMIT (25 MPH) (R2-1) signs near the curves may confuse motorists if the recommended speed through the curves is determined to be less than the posted speed limit. The sign should be relocated to a distance adequate enough to allow motorists enough time to react to the speed limit change and advisory speed prior to entering the curves. PennDOT Publication 46 recommends that SPEED LIMIT signs should not be placed in advance of curves that have an advisory speed posted on warning signs, so as to not confuse motorists (See Appendix A-20).
    b. Horizontal Alignment Signs: Based on the results of the curve speed studies, determine the type of advanced curve warning sign that should be installed in advance of the curve(s) in both directions. One of the following signing options may be appropriate depending on the results of the curve speed studies:
        i. To emphasize a curve in which the advisory speed is less than or equal to 30 MPH:
            1. Install TURN (W1-1 series) warning signs.
            2. Supplement the TURN (W1-1 series) warning signs with ADVISORY SPEED (W13-1) plaques, noting the advisory curve speed (determined through the curve speed study). The ADVISORY SPEED (W13-1) plaques should only be used if the advisory speed is less than the posted speed limit (25 MPH).
        ii. To emphasize a curve in which the advisory speed is greater than 30 MPH:
            1. Install CURVE (W1-2 series) warning signs.
            2. Since the posted speed limit is 25 MPH, do not supplement the CURVE (W1-2 series) warning signs with ADVISORY SPEED (W13-1) plaques because they will be greater than the posted speed limit.
        iii. To emphasize reverse curves (i.e. curves separated by a tangent distance less than 600-feet) and if the lowest advisory curve speed between the two curves is less than or equal to 30 MPH:
            1. Install REVERSE TURN (W1-3 series) warning signs.
            2. Supplement the REVERSE TURN (W1-3 series) warning signs with ADVISORY SPEED (W13-1) plaques, noting the lowest advisory curve speed (determined through the curve speed study). The ADVISORY SPEED (W13-1) plaques should only be used if the advisory speed is less than the posted speed limit (25 MPH).

iv. To emphasize reverse curves (i.e. curves separated by a tangent distance less than 600-feet) and if the lowest advisory curve speed between the two curves is greater than 30 MPH:
    1. Install REVERSE CURVE (W1-4 series) warning signs.
    2. Since the posted speed limit is 25 MPH, do not supplement the REVERSE CURVE (W1-4 series) warning signs with ADVISORY SPEED (W13-1) plaques because they will be greater than the posted speed limit.

For additional information on the use of and placement of advanced curve warning signs and their supplemental plaques, please see Appendix A-21.

c. Large Single Arrows: Consider installing LARGE SINGLE ARROW (W1-6) signs on the outside of Curve 1 in line with and at right angles to approaching traffic (See Appendix A-22). According to PennDOT Publication 46, these signs are appropriate for curves up to about 300-feet or 350-feet in length.
d. Chevrons: Consider installing CHEVRON ALIGNMENT (W1-8) signs to supplement the proposed LARGE SINGLE ARROW (W1-6) signs, as described in PennDOT Publication 236M and Section 2C.10 of the MUTCD, along the outside of the curves to increase curve visibility (See Appendix A-22).
e. Pedestrian Warning Signs:
    i. Remove the existing PEDESTRIAN (W11-2) signs and ADVISORY SPEED (15) (W13-1) plaques provided in advance of the crosswalk and curves in both directions.
    ii. Consider providing fluorescent yellow-green PEDESTRIAN (W11-2) warning signs in advance of and at the marked crossing on Hilltop Road to warn of the unexpected hazard of pedestrians entering, or sharing the use of, or crossing the roadway. The advance signs should be supplemented with the AHEAD PLAQUE (W16-9P) or (_) FEET PLAQUE (W16-2). To avoid confusion, the placement of the advance signs should be closely coordinated with the curve warning signs, if installed. The PEDESTRIAN (W11-2) signs used at the crossings must be supplemented with a DIAGONAL DOWNWARD POINTING ARROW PLAQUE (W16-7P) showing the location of the crossing. These additional plaques must be placed below the warning sign and must be the same color as the warning sign. Refer to Appendix A-14 for additional information on pedestrian warning signs. Also consider using matching retroreflective material in the channel posts of the signs for added visibility.
f. Retroreflectivity: Use high intensity retroreflective material (ASTM Type III) or better for all signs (See Appendix A-7).
g. Raised Pavement Markers: Consider installing snowplowable raised pavement markers in advance of and through the curves in accordance with PennDOT Publication 111M, TC-8600 Series (See Appendix A-23). This solution is intended to increase alignment visibility, especially during low light inclement weather conditions.

2. Maintenance Treatments:
    a. Sight Lines: Cut/trim/remove any vegetation and other obstructions that may be obstructing sight lines throughout the curves or obstructing the view of traffic control devices. PA Motor Vehicle Code Section 6112 and PennDOT Publication 212 (Section 212.6) provide local municipalities with the authority to require property owners to remove obstructing objects (See Appendix A-9). Continually monitor and cut/trim/remove any vegetation that may be limiting sight distance or obstructing traffic control devices.



    b. Drainage: Observe the roadway surface and existing drainage features during heavy precipitation. Document where the water is going. Look for sheeting and ponding water. Also look to see if the drainage features are functioning properly (i.e. meeting the hydraulic demand). Note any deficiencies and make improvements as needed. Adequate drainage is imperative within horizontal curves to ensure optimal tire to road contact.
    c. Signing and Pavement Markings: Continually restripe faded pavement markings and replace faded and/or damaged signs. Establish a schedule for inspection, cleaning, and replacement. In accordance with Section 2A.08 of the 2009 MUTCD (See Appendix A-7), an assessment or management method that is designed to maintain sign retroreflectivity shall be used. A FREE sample management tool can be found on LTAP's website by clicking on the following link:

        LTAP Website: https://www.dot7.state.pa.us/LTAP/

        Click on "New Items" and under "LTAP News / Events" the Township will find information related to the FREE sign inventory and management tool. If the Township has questions about the tool, please contact LTAP.
    d. Winter Maintenance: Continually ensure that the study area is clear of snow/ice and that it is salted during the winter months.
    e. Shoulder Drop-off Elimination: According to the American Association of State Highway and Transportation Officials (AASHTO) 2" drop-offs or greater can create an unsafe condition and should be repaired immediately. Drop-offs adjacent to the roadway should be filled and compacted to eliminate them (See Appendix A-13).

3. Other Treatments:
    a. Object Removal or Relocation: As for objects such as utility poles, vegetation, and signs along the edge of the curves that may be posing a safety risk for run-off-the-road vehicles, consider completing the following steps:
        i. Determine what the appropriate clear zone width is through the curves based on Chapter 12 of PennDOT Publication 13M, Design Manual 2 Highway Design (See Appendix A-19).
        ii. Identify what objects are within the clear zone and prioritize these objects for removal/relocation based on the crash history (frequency and severity) and the potential for future conflicts.
        iii. Coordinate with property owners and utility companies to have these objects removed or relocated starting with the most high-risk objects.
    b. Skid-Resistive Overlays: Consider applying either skid-resistive overlays or pavement grooving throughout the curves to increase the skid resistance of the driving surface if after the roadway evaluation it is determined that the skid resistance of the roadway surface is deficient. The most significant material property that affects a roadway's surface friction is the polishing resistance of the course aggregate. Overlays of open-graded asphalt friction courses are quite effective because of their frictional and hydraulic properties. Section 5.6 of PennDOT Publication 242, Pavement Policy Manual, provides specific information on determining the appropriate Skid Resistance Level based on the existing ADT. The Federal Highway Administration (FHWA) also provides guidance on skid-resistive pavement surface treatments in a technical document titled "Low-Cost Treatments for Horizontal Curve Safety" (See Appendix A-16).
    c. Speed Trailers: Consider utilizing speed trailers that provide visual feedback to motorists on how fast they are traveling.
    d. Enforcement: Consider using law enforcement to enforce speed regulations, especially on the approaches to the curves.

Mid-term Solutions – if safety concerns still exist after the implementation of the short-term solutions, consider providing the following improvements in advance of and/or through the curves:

1. Basic Treatments:
    a. Delineators: Consider installing roadside delineators to supplement the CHEVRON ALIGNMENT (W1-8) signs in accordance with Chapter 3D of the MUTCD and PennDOT Publication 212 (Section 212.203) along the outside of the curves if it has been determined that the curves need additional delineation due to continued run-off-the-road crashes (See Appendix A-22).

2. Enhanced Basic Treatments:
    a. Horizontal Alignment Signs: Based on the results of the curve speed studies, consider installing a second, identical set of oversized TURN (W1-1 series), CURVE (W1-2 series), REVERSE TURN (W1-3 series), or REVERSE CURVE (W1-4 series) signs on the left side of the roadway along with their appropriate advisory placard, if necessary (See Appendix A-21).
    b. Edge Lines: If the lane widths are greater than 10-feet, consider using a wider white edge line (6 inches or more) through the curves to emphasize the roadway section.
    c. Pavement Markings: Consider using one or more of the following pavement marking enhancements to warn and/or slow the traffic approaching the curves.
        i. Double thick thermoplastic transverse pavement markings: Transverse pavement markings can be implemented quickly and effectively, and are not as costly or noisy as rumble strips. For more information, refer to page 63 of PennDOT Publication 383, Pennsylvania's Traffic Calming Handbook (See Appendix A-24).
        ii. Advanced Curve Warning Treatment: Consider installing pavement marking enhancements to the roadway to warn motorists of the upcoming curves (See Appendix A-24). Also, consider using hot thermoplastic pavement markings instead of paint and beads when applying these treatments.

3. Roadway Improvements:
    a. Shoulder Widening: Consider providing paved shoulders on both sides of the curves. Shoulders are safety features because they provide space that allows motorists a recovery area and room to get out of the travel lane and avoid crashes. This is particularly important in horizontal curves where vehicles use more of the travel lane. This solution may require extensive roadway widening, utility relocation, ROW acquisitions, and pavement marking/signing enhancements along Hilltop Road.
    b. Superelevation: Based on the speed and curve radii, ensure that the proper superelevation rate is provided through the curves and that the correct superelevation transitions are provided. Refer to Chapter 2 of PennDOT Publication 13M, Design Manual, Part 2 for more information on superelevation.

Long-term Solutions – if safety concerns still exist after the implementation of the short-term and mid-term solutions, consider providing the following improvements in advance of and/or through the curve:

1. Roadway Improvements:
    a. Realignment: In conjunction with plans for new developments in the area, consider realigning the roadway through this section to eliminate the curves.

2. Other Treatments:
    a. Rumble Strips:
        i. Centerline: Consider installing milled centerline rumble strips along Hilltop Road to alert motorists from driving into the opposing lane and thereby reduce head-on and sideswipe-opposite direction crashes. Since this treatment is typically used on higher speed (>50 MPH) roadways and the curves are located near some houses, this treatment may require public approval since rumble strips will lead to increased noise (See Appendix A-25).
        ii. Edge line: If shoulder widening is completed, consider installing milled edge line rumble strips along Hilltop Drive to alert motorists from driving off of the road and thereby avoid hitting fixed objects. Please note that edge line rumble strips should not be installed on the inside of moderate to sharp curves because vehicular paths often times pass through the inside of these curves. Since the curves are located near some houses, this treatment may require public approval since rumble strips will lead to increased noise (See Appendix A-25).

b. Overhead Lighting: Consider installing overhead street lighting at the crosswalk (if needed) and near the minor side road intersection located within the curve. It appears that there may be some utility poles nearby that the luminaries could be mounted to. Consider using L.E.D. lighting to reduce energy costs. Before implementing this potential solution, the Township should consider the negative effects of light pollution and diminished rural quality that is associated with the installation of lighting.

Roadway Safety Improvement Plan

A Roadway Safety Improvement Plan (RSIP) is most valuable when used as a dynamic and evolving tool that is regularly and consistently updated; whether annually, when improvements are implemented, or when new data is available. An up-to-date RSIP is an effective tool for managing and evaluating safety on your roadway network and planning future improvements. The steps below offer guidance toward developing a RSIP and keeping it updated. An updated and current RSIP is also an effective tool when applying for funding when implementing future safety improvements. A well defined RSIP can assist your municipality with planning for low-cost as well as more intensive safety improvements clearly and efficiently.

Several resources are available for assisting with the formulation of a roadway safety improvement plan. First, LTAP offers a course on Roadway Safety Improvement Plans, which covers in detail the steps necessary to create the plan. Second, NCHRP Report 321, Roadway Safety Tools for Local Agencies, also discusses the process and tools for developing a roadway safety improvement plan.

The basic format of a RSIP involves the following steps:

1. Identifying Safety Issues
2. Identifying Possible Solutions
3. Selecting and Implementing Solutions
4. Evaluating the Effectiveness of a Solution
5. Developing/Maintaining Written Records

Each of these steps is briefly described below.

Identifying Safety Issues

Safety issues can be identified reactively through crash analysis, or proactively through observation and road safety audits, or a combination of both. Using crash data, the preparation of a crash spot/cluster map is the simplest tool to develop and maintain. The map should be updated annually. More about proactive and reactive techniques is presented in the LTAP RSIP class.

Typically, municipalities monitor the number of crashes at intersections and along roadway segments, using a threshold of six crashes per year to identify locations for study/improvement. Based upon MUTCD and NCHRP guidance, a threshold of five crashes per year may be more appropriate.

From the crash map, a list of intersections/roadway segments that have five or more crashes per year should be generated. The list can be prioritized based on several factors, the simplest being the total number of

crashes along with the severity of the crashes.

Identifying Possible Solutions

Using the prioritized list, the top crash locations may be analyzed in further detail to identify the causal factors of the crashes. Methods and charts to identify the causal factors are contained in both the LTAP RSIP class and NCHRP Report 321.

Based upon the causal factors, solutions to mitigate crash potential can be identified from the charts and studies. Countermeasure charts are available from the LTAP RSIP class and also from NCRHP Report 321. Studies, such as speed studies for curves, corner sight distance studies and others are defined in the MUTCD and PennDOT Publication 212.

After countermeasures have been identified they can be subdivided into Short Term and Long Term solutions, based upon resources and costs.

Selecting and Implementing Solutions

Solutions should focus primarily on crash areas with the more severe and numerous crashes. Consideration should also be given to those low-cost solutions that can be effectively implemented quickly using existing resources. Further, solutions that can be implemented in conjunction with other ongoing or planned projects can also save resources and time.

Information on funding safety improvements can be obtained from discussions with the PennDOT District Municipal Services Representative and the Regional Planning Organization.

Evaluating the Effectiveness of a Solution

After improvements have been made, the effectiveness of those modifications should be closely monitored. This can be accomplished by periodically observing motorist behavior in the vicinity of the improvements, and also through discussions with local residents, police officers, and others that drive through the modified area. Any unintended or unexpected negative consequences of the countermeasures should be quickly remedied.

After a period of six months, crash data should be collected and the effectiveness of the countermeasures assessed.

Developing/Maintaining Written Records

Written records and documentation are vital not only to a safety improvement program, but are also vital to managing a municipality's exposure to liability. The RSIP itself should be written and documented. For each safety improvement, the studies/data collected, the potential solutions considered, and the countermeasures implemented should be documented and filed.

According to state law, safety studies are non-discoverable, meaning that except for special circumstances, they are generally held as confidential, and may not be used as evidence. More information can be obtained from the LTAP class on risk management and tort liability.

Additional Resources

Traffic control devices are required to meet the standards established by the Manual on Uniform Traffic Control Devices (MUTCD), PennDOT Publication 212 (Pub 212), and PennDOT Publication 236M, *Handbook of Approved Signs*. Traffic study elements are required to meet the standards established in the Appendix of Pub 212, as well as guideline/warrant requirements in the MUTCD and Pub 212.

The MUTCD 2003 Edition is available online at:

http://mutcd.fhwa.dot.gov/kno_2003r1r2.htm

The MUTCD 2009 Edition is available online at:

http://mutcd.fhwa.dot.gov/kno_2009.htm

The most current versions (PDFs) of all PennDOT Publications referenced in this report can be found within PennDOT's Sale Store:

ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%2012.pdf

Sample ordinances for traffic regulations are available from PSATS website:

http://www.psats.org/searchord.cfm?ordinanceid=241

Additional resources for identifying countermeasures are available from NCHRP Report 321, Roadway Safety Tools for Local Agencies:

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_321.pdf

LTAP also offers a series of classes that provide additional information, including:

- Traffic Signs Class
- Engineering and Traffic Studies Class
- Roadway Safety Improvement Program Class
- Risk Management and Tort Liability Class

Further, LTAP can offer site specific technical assistance in the field. Information on LTAP classes and technical assists can be found at https://www.dot7.state.pa.us/LTAP/ or by calling 1-800-FOR-LTAP.

Appendix Materials

This appendix contains supplemental information to help assist the community with implementing the suggested safety improvements.

A-1

Traffic and Engineering Study: Speed Data
(PennDOT Publication 212, Appendix 17)

Spot-Speed Study Worksheet and Example

Table B - Minimum Stopping Sight Distance (feet)

85th Percentile Speed (mph)	*Coefficient of Friction*	*Grade = -10%*	*Grade = -5%*	*Grade = 0%*	*Grade = +5%*	*Grade = +10%*
25	0.38	166	155	147	140	135
30	0.35	230	210	196	185	177
35	0.34	299	269	249	233	221
40	0.32	389	345	314	291	274
45	0.31	487	425	383	353	330
50	0.30	600	517	462	422	392
55	0.30	706	605	538	490	454
60	0.29	852	721	634	573	528

- The stopping sight distance is computed from the following formula:

$$SSD = 1.47VT + V^2 / 30(f \pm g)$$

Where:
SSD = Stopping Sight Distance (feet).
V = 85th Percentile Speed (miles per hour).
T = Perception Time of driver (2.5 seconds).
f = Coefficient of Friction for Wet Pavements.
g = Percent of Grade of Roadway divided by 100.

(17) ***Speed data.***

(i) *Speed limit.* The maximum speed limit as provided in 75 Pa.C.S. § § 3362 and 3363 (relating to maximum speed limits; and alteration of maximum limits) and posted in accordance with Chapter 212 (relating to official traffic control devices).

(ii) *Spot speed.* The instantaneous measure of travel speeds at a specific location by an electronic or electrical device such as radar, or a calculated average speed over a relatively short section of roadway.

- The following guidelines shall be established for taking spot-speed samples:
    - In urban districts, studies should be taken at about .5 mile intervals or at locations where traffic or roadway features change. In rural areas, studies should be made at intervals up to about 2 miles apart if traffic or roadway features are consistent.
    - The study sites should be located on tangent or midblock sections of roadways in order that the speed distribution is not influenced by stop signs, traffic signals, curves and other traffic flow interruptions.
    - Samples should consist of at least 100 observations, except 50 observations is acceptable on low volume highways. Samples should be composed of randomly selected vehicles to ensure a reliable speed distribution. The percentage of trucks in the sample should be approximately the same as the percentage of trucks in the traffic stream.
- The following statistical values may be determined from an adequate size sample of spot speeds in accordance with the *Manual of Traffic Engineering Studies*, *Institute of Transportation Engineers*, current edition:
    - Average speed.
    - The 85th percentile speed.

(iii) *Safe-running speed.* The safe-running speed for a portion of a highway is determined by making a minimum of five test runs in each direction and periodically recording the running speed at different locations while driving at a speed which is reasonable and prudent considering the spacing of intersections, roadside development, sight distance, and so forth. The safe-running speed for a section of highway is the average test run speed.

(iv) *Recommended speed for curves*. The recommended speed for curves may be determined by making several trial runs through the curve in a car equipped with a ball-bank indicator in accordance with the following guidelines:

- The ball-bank indicator should be transversely mounted in the car and positioned so as to give a ‘‘zero reading’’ when the car is level.

- The speed of the first trial run should be a multiple of 5 miles per hour and should be selected to provide a ball-bank indicator reading less than the following appropriate value from *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials, current edition:

Table C

Posted Speed Limit (mph)	*Ball-bank indicator (degrees)*
20 or less	14
25 and 30	12
35 or more	10

- Succeeding observations should be made at increasing 5-mile-per-hour increments until the reading on the ball-bank indicator equals or exceeds the indicated degree in Table C. The recommended speed for the curve is the highest speed which did not exceed the indicated degree in Table C.

(v) *Design speed.* The speed used in designing the roadway which controls the minimum radius of curves, superelevation, length of vertical curves, sight distance, cross section, and so forth. It is the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of the highway govern. The design speed may be derived by considering the elements listed in this subparagraph with reference to *A Policy on Geometric Design of Highways and Streets*, *American Association of State Highway and Transportation Officials*, current edition, or the Department's Design Manual, Part 2.

(vi) *Travel time and delay.*

- Travel time varies inversely with travel speed and is a good indicator of the average speed and level of service that is being provided on a given route. The difference between travel times over a route during low traffic volumes and during high traffic volumes is operational delay. This delay consists of such items as time consumed at a stop sign waiting for cross traffic to clear; time consumed at an uncontrolled intersection awaiting the right-of-way; and time losses resulting from congestion, interference with parked vehicles, parking maneuvers and waiting for turning traffic.

Speed Distribution Study

County _____ Date _____

SR _____ Seg/Offset _____

Speed Limit _____ No. of Lanes _____

Pavement Type _____

Roadway Width _____

Direction of Traffic _____

Time Start _____ Time End _____

Weather _____

Conditions: Excellent Good Fair Poor

Modal Speed _____

Pace _____ MPH to _____ MPH

% Vehicles Above Pace _____%

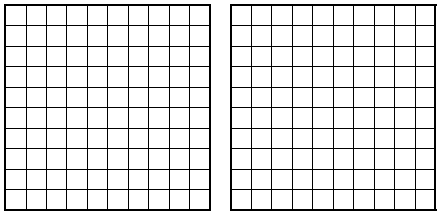
% Vehicles Below Pace _____%

% Vehicles in Pace _____%

85TH Percentile Speed _____ MPH

Total Vehicles _____ OBSERVER _____

Running Total



County _____ Date _____

SR _____ Seg/Offset _____

Speed Limit _____ No. of Lanes _____

Pavement Type _____

Roadway Width _____

Direction of Traffic _____

Time Start _____ Time End _____

Weather _____

Conditions: Excellent Good Fair Poor

Modal Speed _____

Pace _____ MPH to _____ MPH

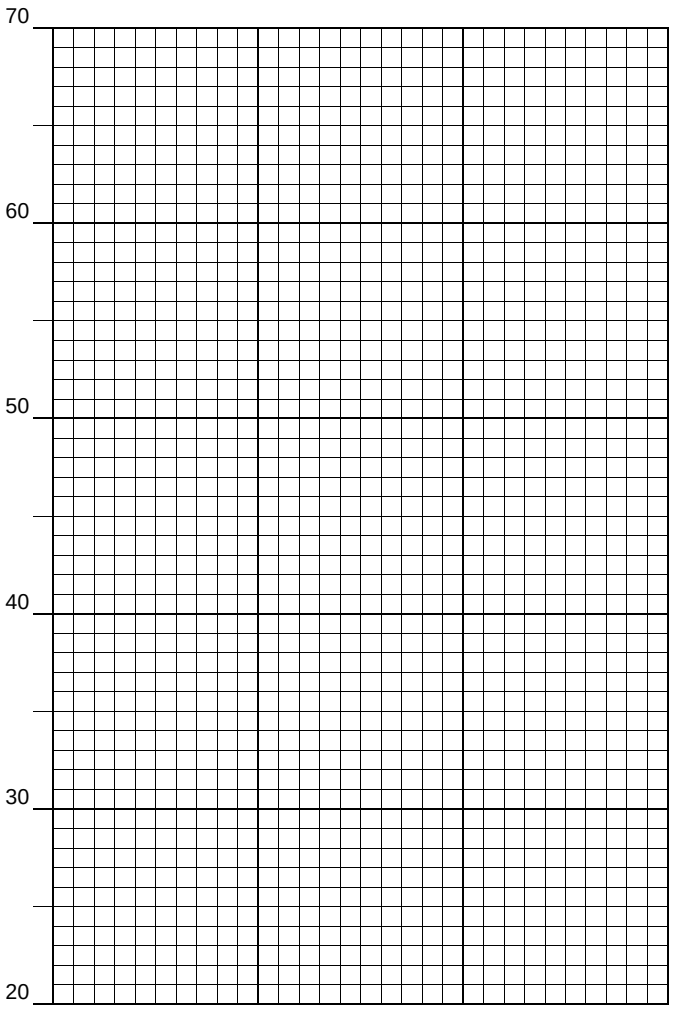
% Vehicles Above Pace _____%

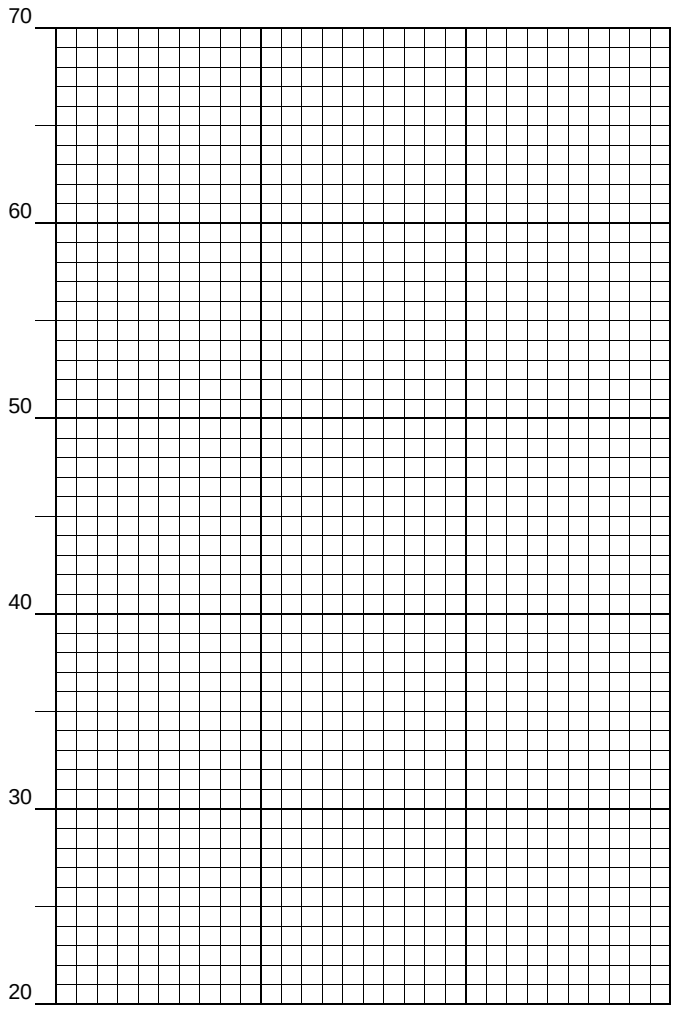
% Vehicles Below Pace _____%

% Vehicles in Pace _____%

85TH Percentile Speed _____ MPH

Total Vehicles _____ OBSERVER _____





Speed Distribution Study

County Apple Date 1/1/2008

SR 1234 Seg/Offset 01/1046

Speed Limit 55 No. of Lanes 2

Pavement Type Bituminous

Roadway Width 20'

Direction of Traffic Westbound

Time Start 10:00 AM Time End 12:00 PM

Weather Sunny, warm

Conditions: Excellent **Good** Fair Poor

Modal Speed 50

Pace - MPH to - MPH

% Vehicles Above Pace - %

% Vehicles Below Pace - %

% Vehicles in Pace - %

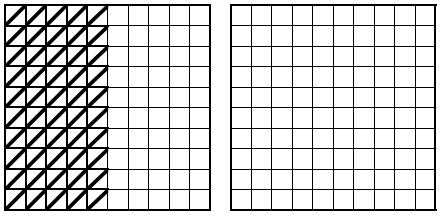
85TH Percentile Speed 57 MPH

Total Vehicles 100 OBSERVER TT

Legend

CAR	●
TRUCK	✕

Running Total



County Date

SR Seg/Offset

Speed Limit No. of Lanes

Pavement Type

Roadway Width

Direction of Traffic

Time Start Time End

Weather

Conditions: Excellent Good Fair Poor

Modal Speed

Pace MPH to MPH

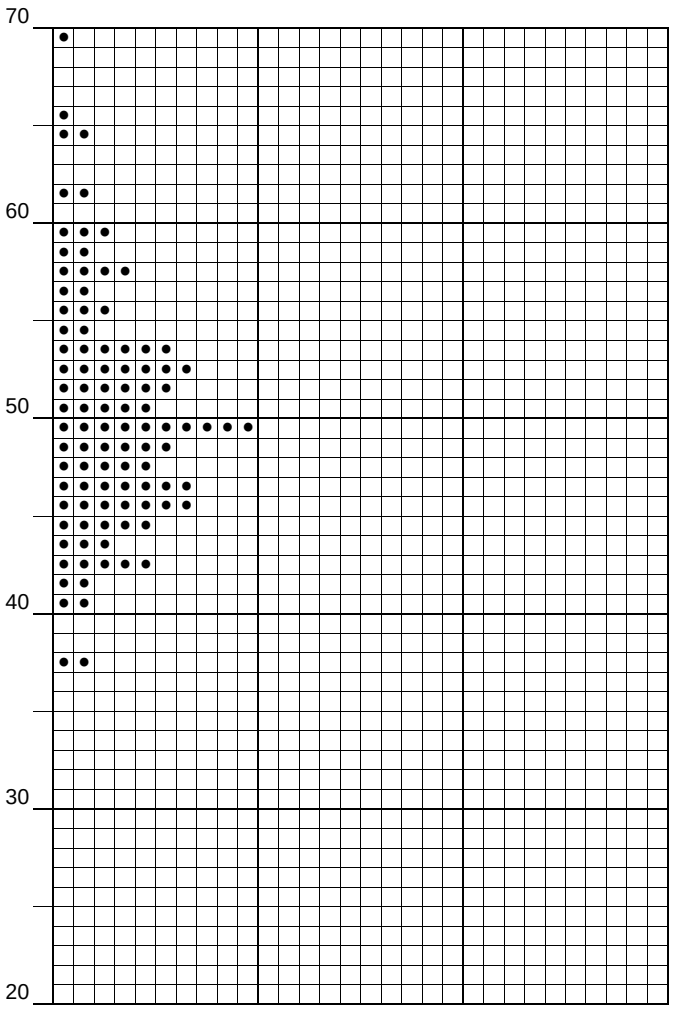
% Vehicles Above Pace %

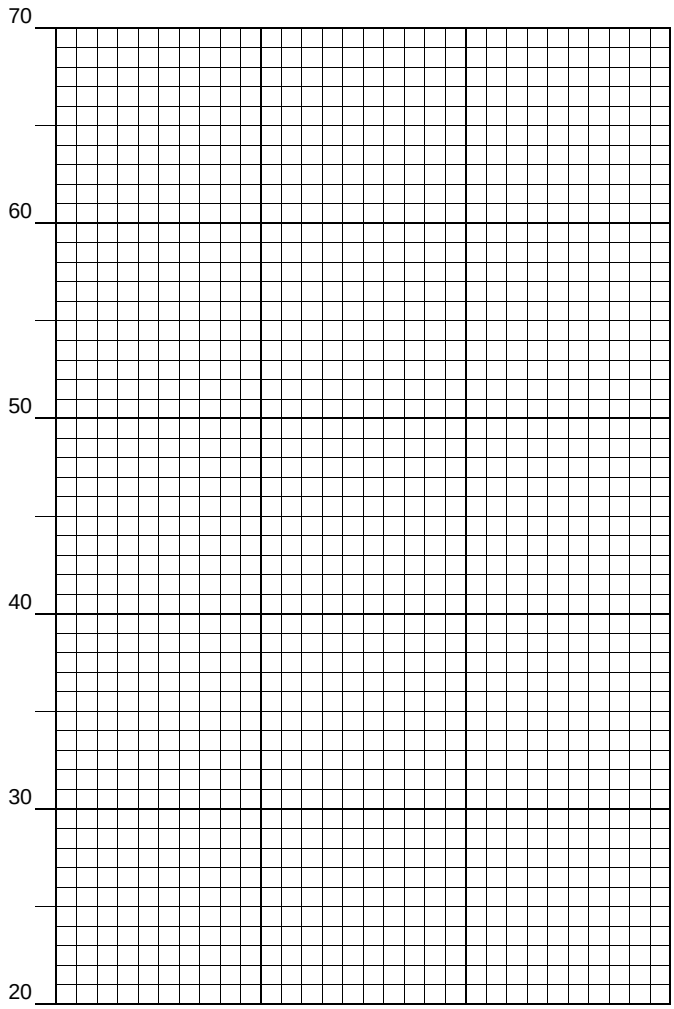
% Vehicles Below Pace %

% Vehicles in Pace %

85TH Percentile Speed MPH

Total Vehicles OBSERVER





A-2

Traffic and Engineering Study: Sight Distance
(PennDOT Publication 212, Appendix 16)

Sight Distance Worksheet
(PennDOT Form M-950S)

(ii) A further classification of pedestrian volume is often beneficial especially for traffic signal studies. Typical classifications are: children less than 12 years old and adults; school children and nonschool children; handicapped or elderly people.

(iii) Pedestrian studies should be conducted in accordance with the methods described in the Institute of Transportation Engineers' *Manual of Traffic Engineering Studies, current edition*.

(13) ***Roadside development.*** An orderly review of the number, type and size of businesses, residences or other developments along the highway which generate traffic having the right of access onto the highway. Interference resulting from traffic turning into or out of driveways to the roadside development typically results in lower capacity on the highway and an increase in crashes.

(14) ***Roadside obstructions.*** An orderly review of the roadside environment which either decreases the drivers' sight distance, restricts lateral movement on the roadway or generates potential hazards if the vehicle leaves the highway surface.

(15) ***School route plan.*** A school route plan is a drawing showing the recommended travel paths of school children. This plan should be developed by the school and municipal officials responsible for school pedestrian safety and consist of a simple map showing the streets, the school, existing traffic controls and established school routes and crossings. The school routes should be planned to take full advantage of the protection afforded by existing traffic controls and intersections with sufficient gaps in the traffic to safely permit student usage. The planning may make it necessary for children to walk a nondirect, longer distance to an established school crossing located where there is existing traffic control, and to avoid the use of a potentially hazardous crossing where there is no existing control. Reference: *Manual on Uniform Traffic Control Devices*, Federal Highway Administration, current edition.

(16) ***Sight distance.***

(i) *General.* Sight distance, in general, refers to the maximum distance that a driver can see objects such as traffic signs, pavement markings, fixed objects, vehicles and pedestrians. Particular types of sight distance are further clarified in subparagraphs (ii)—(iv).

(ii) *Corner sight distance.* Corner sight distance refers to the maximum length of highway along which a driver stopped at an intersection or driveway can continuously see another vehicle approaching on another roadway or driveway. For the purpose of measuring the available corner sight distance, the height of both the driver's eye and the approaching vehicle should be assumed to be 3.50 feet above the road surface. In addition, the driver's eye should be assumed to be 10 feet from the near edge of the intersecting roadway or driveway or the near edge of the closest travel lane in the event there is parking permitted on the intersecting roadway or driveway.

(iii) *Passing sight distance.* Passing sight distance is the length of highway upon which a driver can at all times see an approaching vehicle. For the purpose of measuring the available passing sight distance, the eye height of the driver and the height of the approaching vehicle are assumed to be 3.50 feet above the road surface. Minimum passing sight distance values which will allow a vehicle to complete a pass before meeting an opposing vehicle—which might appear after the pass began—shall be as follows:

85th percentile speed (mph)	*Minimum passing sight distance (feet)*
30	500
35	550
40	600
45	700
50	800
55	900
60	1000

(iv) *Stopping sight distance.* Stopping sight distance is the length of highway over which an object is visible to the driver at all times.

- For the purpose of measuring the available stopping sight distance at a particular location, the driver's eye height is assumed to be 3.50 feet above the roadway surface and the object height is assumed to be 2.0 feet above the roadway surface.

- Minimum acceptable stopping sight distance values, using typical friction factors for wet pavements, from, *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials, current edition, are indicated in the following table:

Table B - Minimum Stopping Sight Distance (feet)

85th Percentile Speed (mph)	*Coefficient of Friction*	*Grade = -10%*	*Grade = -5%*	*Grade = 0%*	*Grade = +5%*	*Grade = +10%*
25	0.38	166	155	147	140	135
30	0.35	230	210	196	185	177
35	0.34	299	269	249	233	221
40	0.32	389	345	314	291	274
45	0.31	487	425	383	353	330
50	0.30	600	517	462	422	392
55	0.30	706	605	538	490	454
60	0.29	852	721	634	573	528

- The stopping sight distance is computed from the following formula:

$$SSD = 1.47VT + V^2 / 30(f \pm g)$$

Where:
SSD = Stopping Sight Distance (feet).
V = 85th Percentile Speed (miles per hour).
T = Perception Time of driver (2.5 seconds).
f = Coefficient of Friction for Wet Pavements.
g = Percent of Grade of Roadway divided by 100.

(17) ***Speed data.***

(i) *Speed limit.* The maximum speed limit as provided in 75 Pa.C.S. § § 3362 and 3363 (relating to maximum speed limits; and alteration of maximum limits) and posted in accordance with Chapter 212 (relating to official traffic control devices).

(ii) *Spot speed.* The instantaneous measure of travel speeds at a specific location by an electronic or electrical device such as radar, or a calculated average speed over a relatively short section of roadway.

M-950S (3-04)
PENNDOT

DRIVEWAY SIGHT DISTANCE MEASUREMENTS

(FOR LOCAL ROADS, USE PENNDOT PUB 70)

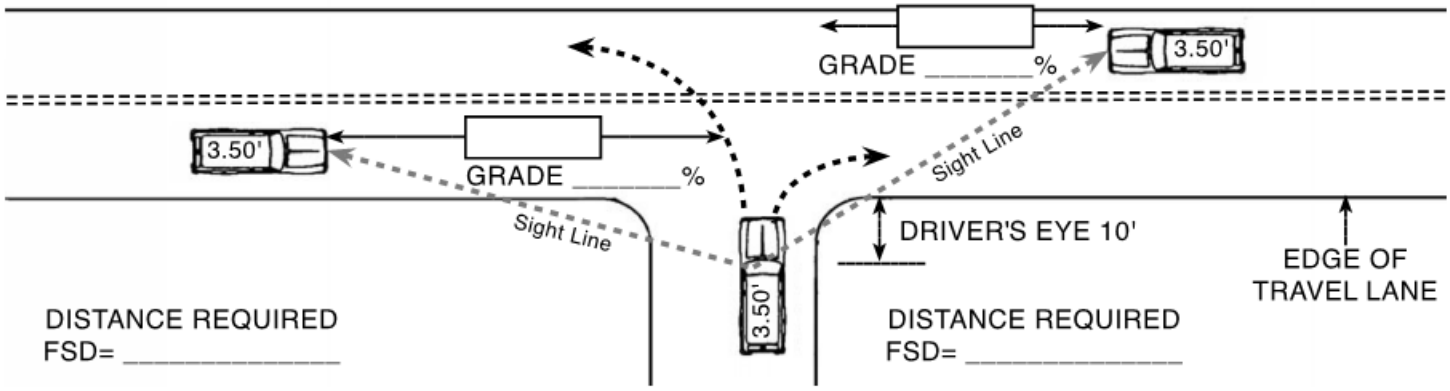
APPLICANT_____ APPLICATION NO._____ ___

S.R._____SEG._____OFFSET_____ LEGAL SPEED LIMIT_____

MEASURED BY_____ DATE _____

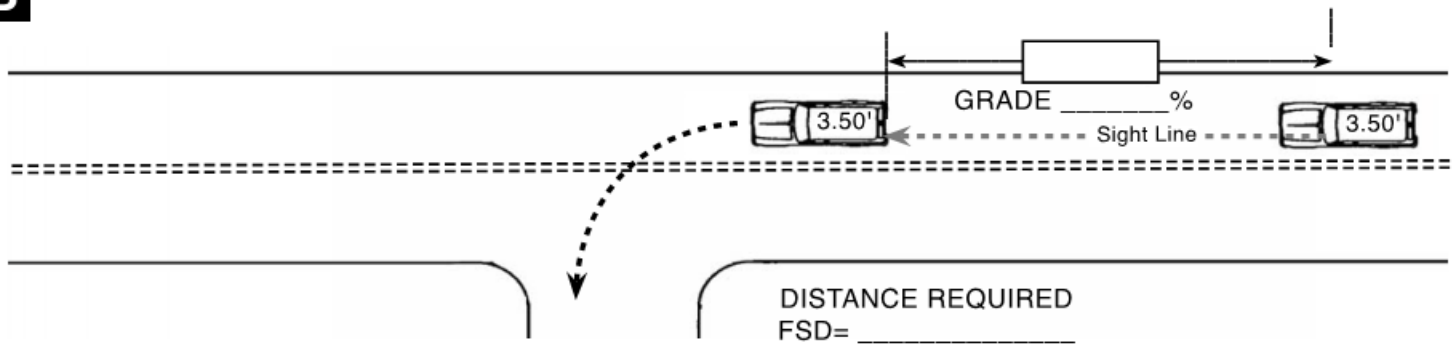
FOR DEPARTMENT USE ONLY: Safe-Running Speed _____ 85th Percentile Speed _____

A



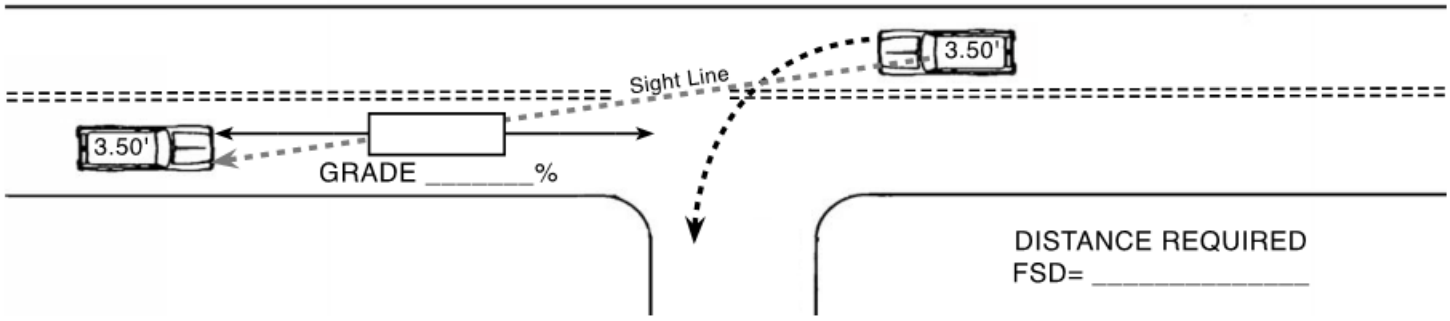
THE MAXIMUM LENGTH OF ROADWAY ALONG WHICH A DRIVER AT A DRIVEWAY LOCATION CAN CONTINUOUSLY SEE ANOTHER VEHICLE APPROACHING ON THE ROADWAY.

B



THE MAXIMUM LENGTH OF ROADWAY ALONG WHICH A DRIVER ON THE ROADWAY CAN CONTINUOUSLY SEE THE REAR OF A VEHICLE WHICH IS LOCATED IN THE DRIVER'S TRAVEL LANE AND WHICH IS POSITIONED TO MAKE A LEFT TURN INTO A DRIVEWAY.

C



THE MAXIMUM LENGTH OF ROADWAY ALONG WHICH A DRIVER OF A VEHICLE INTENDING TO MAKE A LEFT TURN INTO A DRIVEWAY CAN CONTINUOUSLY SEE A VEHICLE APPROACHING FROM THE OPPOSITE DIRECTION.

FORMULA SIGHT DISTANCE TABLE

Speed (V) (Miles Per Hour)	Average Grade (G) (Percent)										
	Use plus grades when approaching vehicle is travelling upgrade.										
	0.0	+1.0	+2.0	+3.0	+4.0	+5.0	+6.0	+7.0	+8.0	+9.0	+10.0
25	147	145	144	143	142	140	139	138	137	136	135
30	196	194	191	189	187	185	183	182	180	178	177
35	249	245	242	239	236	233	231	228	226	224	221
40	314	309	304	299	295	291	287	284	280	277	274
45	383	376	370	364	358	353	348	343	339	334	330
50	462	453	444	436	429	422	415	409	403	397	392
55	538	527	517	508	499	490	482	475	468	461	454
	Use negative grades when approaching vehicle is travelling downgrade.										
	0.0	-1.0	-2.0	-3.0	-4.0	-5.0	-6.0	-7.0	-8.0	-9.0	-10.0
25	147	148	150	151	153	155	157	159	161	164	166
30	196	199	201	204	207	210	214	217	221	226	230
35	249	252	256	260	265	269	275	280	286	292	299
40	314	319	325	331	338	345	352	360	369	379	389
45	383	390	398	406	415	425	435	447	459	472	487
50	462	471	481	492	504	517	531	546	563	581	600
55	538	550	562	576	590	606	622	641	661	682	706

A-3

Warning Signs
(Manual on Uniform Traffic Control Devices, Chapter 2C)

Warning Signs
(PennDOT Publication 46, Section 2.5)

CHAPTER 2C. WARNING SIGNS

Section 2C.01 Function of Warning Signs

Support:

Warning signs call attention to unexpected conditions on or adjacent to a highway or street and to situations that might not be readily apparent to road users. Warning signs alert road users to conditions that might call for a reduction of speed or an action in the interest of safety and efficient traffic operations.

Section 2C.02 Application of Warning Signs

Standard:

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

Guidance:

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 covered when the condition or activity does not exist.

Support:

The categories of warning signs are shown in Table 2C-1.

Warning signs specified herein cover most of the conditions that are likely to be encountered. Additional warning signs for low-volume roads (as defined in Section 5A.01), temporary traffic control zones, school areas, highway-rail grade crossings, bicycle facilities, and highway-light rail transit grade crossings are discussed in Parts 5 through 10, respectively.

Option:

Word message warning signs other than those specified in this Manual may be developed and installed by State and local highway agencies.

Section 2C.03 Design of Warning Signs

Standard:

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 (see Section 1A.11).

Option:

Warning signs regarding conditions associated with pedestrians, bicyclists, playgrounds, school buses, and schools may have a black legend and border on a yellow background or a black legend and border on a fluorescent yellow-green background.

Section 2C.04 Size of Warning Signs

Standard:

The sizes for warning signs shall be as shown in Table 2C-2.

Guidance:

The Conventional Road size should be used on conventional roads.

The Freeway and Expressway sizes should be used for higher-speed applications to provide larger signs for increased visibility and recognition.

Option:

The Minimum size may be used on low-speed roadways where the reduced legend size would be adequate for the warning or where physical conditions preclude the use of the other sizes.

Oversized signs and larger sizes may be used for those special applications where speed, volume, or other factors result in conditions where increased emphasis, improved recognition, or increased legibility would be desirable.

Standard:

The minimum size for supplemental warning plaques shall be as shown in Table 2C-3.

Option:

Signs larger than those shown in Tables 2C-2 and 2C-3 may be used (see Section 2A.12).

Table 2C-1. Categories of Warning Signs

Category	Group	Section	Signs	MUTCD Codes
Roadway Related	Changes in Horizontal Alignment	2C.06	Turn, Curve, Reverse Turn, Reverse Curve, Winding Road, Hairpin Curve, 270-Degree Curve	W1-1 through W1-5, W1-11, W1-15
		2C.07	Combination Horizontal Alignment/Advisory Speed	W1-1a, W1-2a
		2C.08	Combination Horizontal Alignment/Intersection	W1-10
		2C.09	Large Arrow (one direction)	W1-6
		2C.10	Chevron Alignment	W1-8
		2C.11	Truck Rollover	W1-13
	Vertical Alignment	2C.12	Hill	W7-1, W7-1a, W7-1b
		2C.13	Truck Escape Ramp	W7-4, W7-4a
		2C.14	Hill Blocks View	W7-6
	Cross Section	2C.15	Road Narrows	W5-1
		2C.16-17	Narrow Bridge, One Lane Bridge	W5-2, W5-3
		2C.18-20	Divided Road, Divided Road Ends, Double Arrow	W6-1, W6-2, W12-1
		2C.21	Dead End, No Outlet	W14-1, W14-1a, W14-2, W14-2a
		2C.22	Low Clearance	W12-2, W12-2p
	Roadway Surface Condition	2C.23-24	Bump, Dip, Speed Hump	W8-1, W8-2, W17-1
		2C.25	Pavement Ends	W8-3
		2C.26	Shoulder	W8-4, W8-9, W8-9a
		2C.27	Slippery When Wet	W8-5
		2C.28	Bridge Ices Before Road	W8-13
Traffic Related	Advance Traffic Control	2C.29-30	Stop Ahead, Yield Ahead, Signal Ahead, Be Prepared To Stop, Speed Reduction	W3-1, W3-2, W3-3, W3-4, W3-5, W3-5a
	Traffic Flow	2C.31-35	Merge, Lane Ends, Added Lane, Two-Way Traffic, Right Lane Ends, Lane Ends Merge Left, No Passing Zone	W4-1, W4-2, W4-3, W4-5, W4-6, W6-3, W9-1, W9-2, W14-3
	Change in Speed	2C.36	Advisory Speed	W13-2, W13-3, W13-5
	Intersections	2C.37	Cross Road, Side Road, T, Y, and Circular Intersection	W2-1 through W2-6
		2C.38	Large Arrow (two directions)	W1-7
		2C.39	Oncoming Extended Green	W25-1, W25-2
	Vehicular Traffic	2C.40	Truck Crossing, Truck (symbol), Emergency Vehicle, Tractor, Bicycle, Golf Cart, Horse-Drawn Vehicle	W8-6, W11-1, W11-5, W11-5a, W11-8, W11-10, W11-11, W11-12p, W11-14
	Nonvehicular	2C.41-42	Pedestrian, Deer, Cattle, Snowmobile, Horse, Wheelchair, Playground	W11-2, W11-3, W11-4, W11-6, W11-7, W11-9, W15-1
Supplemental Plaques	Distance	2C.45	XX Feet, XX Miles, Next XX Feet, Next XX MI	W16-2, W16-3, W16-4, W7-3a
	Speed	2C.46	Advisory Speed	W13-1
	Arrow	2C.47	Advance Arrow, Directional Arrow, Diagonal Arrow	W16-5p, W16-6p, W16-7p
	Hill-Related	2C.48	Trucks Use Low Gear, X% Grade	W7-2, W7-3
	Street Name Plaque	2C.49	Advance Street Name	W16-8
	Intersection	2C.50	Cross Traffic Does Not Stop	W4-4p
	Share The Road	2C.51	Share The Road	W16-1
	HOV	2C.52	High-Occupancy Vehicle	W16-11
	Photo Enforced	2C.53	Photo Enforced	W16-10
	Traffic Circle	2C.37	Traffic Circle	W16-12p

Table 2C-2. Warning Sign Sizes

Description		Conventional Road	Express-way	Freeway	Minimum	Oversized
Shape	Sign Series					
Diamond	W1, W2, W7, W8, W9, W11, W14, W15-1, W17-1	750 x 750 (30 x 30)	900 x 900 (36 x 36)	1200 x 1200 (48 x 48)	600 x 600 (24 x 24)	———
	W1 Combination, W3, W4, W5, W6, W8-3, W10, W12	900 x 900 (36 x 36)	1200 x 1200 (48 x 48)	1200 x 1200 (48 x 48)	750 x 750 (30 x 30)	———
Rectangular	W1 - Arrows	1200 x 600 (48 x 24)	———	———	900 x 450 (36 x 18)	1500 x 750 (60 x 30)
	W1 - Chevron	450 x 600 (18 x 24)	750 x 900 (30 x 36)	900 x1200 (36 x 48)	300 x 450 (12 x 18)	———
	W7-4	1950 x 1200 (78 x 48)	1950 x 1200 (78 x 48)	1950 x 1200 (78 x 48)	———	———
	W7-4b, 4c	1950 x 1500 (78 x 60)	1950 x 1500 (78 x 60)	1950 x 1500 (78 x 60)	———	———
	W10-9, 10	600 x 450 (24 x 18)	———	———	———	———
	W12-2p	2100 x 600 (84 x 24)	2100 x 600 (84 x 24)	2100 x 600 (84 x 24)	———	———
	W13-2, 3, 5, W25	600 x 750 (24 x 30)	900 x1200 (36 x 48)	1200 x 1500 (48 x 60)	600 x 750 (24 x 30)	1200 x 1500 (48 x 60)
Pennant	W14-3	900 x 1200 x 1200 (36 x 48 x 48)	———	———	750 x 1000 x 1000 (30 x 40 x 40)	1200 x 1600 x 1600 (48 x 64 x 64)
Circular	W10-1	900 (36) Dia.	1200 (48) Dia.	———	750 (30) Dia.	1200 (48) Dia.

Notes: 1. Larger signs may be used when appropriate
2. Dimensions are shown in millimeters followed by inches in parentheses and are shown as width x height

Section 2C.05 Placement of Warning Signs

Support:

For information on placement of warning signs, see Sections 2A.16 to 2A.21.

The total time needed to perceive and complete a reaction to a sign is the sum of the times necessary for Perception, Identification (understanding), Emotion (decision making), and Volition (execution of decision), and is called the PIEV time. The PIEV time can vary from several seconds for general warning signs to 6 seconds or more for warning signs requiring high road user judgment.

Table 2C-4 lists suggested sign placement distances for two conditions. This table is provided as an aid for determining warning sign location.

Table 2C-3. Minimum Size of Supplemental Warning Plaques

Size of Warning Sign	Size of Supplemental Plaque			
	Rectangular			Square
	1 Line	2 Lines	Arrow	
600 x 600 (24 x 24) 750 x 750 (30 x 30)	600 x 300 (24 x 12)	600 x 450 (24 x 18)	600 x 300 (24 x 12)	450 x 450 (18 x 18)
900 x 900 (36 x 36) 1200 x 1200 (48 x 48)	750 x 450 (30 x 18)	750 x 600 (30 x 24)	750 x 450 (30 x 18)	600 x 600 (24 x 24)

Notes: 1. Larger supplemental plaques may be used when appropriate
2. Dimensions are shown in millimeters followed by inches in parentheses and are shown as width x height

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Guidance:

Warning signs should be placed so that they provide adequate PIEV time. The distances contained in Table 2C-4 are for guidance purposes and should be applied with engineering judgment. Warning signs should not be placed too far in advance of the condition, such 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.

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

Option:

Warning signs that advise road users about conditions that are not related to a specific location, such as Deer Crossing or SOFT SHOULDER, may be installed in an appropriate location, based on engineering judgment, since they are not covered in Table 2C-4.

Table 2C-4. Guidelines for Advance Placement of Warning Signs
(Metric Units)

Posted or 85th-Percentile Speed (km/h)	Advance Placement Distance [1]											
	Condition A: Speed Reduction and Lane Changing in Heavy Traffic[2]	Condition B: Deceleration to the listed advisory speed (km/h) for the condition[4]										
		0[3]	10	20	30	40	50	60	70	80	90	100	110
30	60 m	N/A[5]	N/A[5]	N/A[5]	—	—	—	—	—	—	—	—	—
40	100 m	N/A[5]	N/A[5]	N/A[5]	N/A[5]	—	—	—	—	—	—	—	—
50	150 m	N/A[5]	N/A[5]	N/A[5]	N/A[5]	N/A[5]	—	—	—	—	—	—	—
60	180 m	30 m	N/A[5]	N/A[5]	N/A[5]	N/A[5]	N/A[5]	—	—	—	—	—	—
70	220 m	50 m	40 m	30 m	N/A[5]	N/A[5]	N/A[5]	N/A[5]	—	—	—	—	—
80	260 m	80 m	60 m	55 m	50 m	40 m	30 m	N/A[5]	N/A[5]	—	—	—	—
90	310 m	110 m	90 m	80 m	70 m	60 m	40 m	N/A[5]	N/A[5]	N/A[5]	—	—	—
100	350 m	130 m	120 m	115m	110 m	100 m	90 m	70 m	60 m	40 m	N/A[5]	—	—
110	380 m	170 m	160 m	150 m	140 m	130 m	120 m	110 m	90 m	70 m	50 m	N/A[5]	—
120	420 m	200 m	190 m	185 m	180 m	170 m	160 m	140 m	130 m	110 m	90 m	60 m	40 m
130	460 m	230 m	230 m	230 m	220 m	210 m	200 m	180 m	170 m	150 m	120 m	100 m	70 m

Notes:

[1] The distances are adjusted for a sign legibility distance of 50 m for Condition A. The distances for Condition B have been adjusted for a sign legibility distance of 75 m, 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 and 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 50 m 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 PIEV time of 2.5 seconds, a deceleration rate of 3.4 m/second^2, minus the sign legibility distance of 50 m.

[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 3 m/second^2, minus the sign legibility distance of 75 m.

[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 for the driver.

Table 2C-4. Guidelines for Advance Placement of Warning Signs

(English Units)

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 and 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 PIEV 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 for the driver.

2.5 Warning Signs

2.5.1 General

Guidelines for installing warning signs are included in Sections 2C.10 of the *MUTCD*.

Consider the installation of oversize warning signs if one or more of the following exists:

(a) The condition is properly signed and/or delineated, but crashes or incidents related to the condition addressed by the warning sign continue to occur.

(b) Inadequate contrast exists between the sign and the environment when a standard size sign is used.

(c) The location is on a high-speed (45 mph or higher) highway with four or more lanes.

2.5.2 Advance Placement of Warning Signs

Since the primary purpose of warning signs is to gain attention of the unfamiliar motorist, the placement of warning signs is important. The placement must allow these drivers sufficient time to see the warning sign, understand the intent, identify the potential hazard, decide what action must be taken, and then to perform any necessary maneuver.

Table 2C-4 in the *MUTCD* (see Exhibit 2.5-A) provides the recommended advance sign placement distances. However, it is important to note that Condition A is only for those situations where motorists may have to change lanes in heavy traffic. Examples of applicable signs include:

- Merge (W4-1).
- Lane Reduction Transition (W4-2L, W4-2R).
- Entering Roadway Merge (W4-5).
- RIGHT LANE ENDS (W9-1).

Condition B is for all other advance placement distances and these values are typically much smaller than the values historically used by traffic engineers. The reason for the change is that FHWA has reconciled their advance distances to match the stopping sight distances in Table 3-1 of AASHTO's *A Policy on Geometric Design of Highways and Streets*, using a 2.5-second reaction time and a deceleration rate of 10 feet/second^2. Moreover, Engineering Districts should keep in mind that these are minimum distances and they may want to use larger values for the following reasons:

- The advance distances assume that drivers will always use their brakes to decelerate to a posted advisory speed, thereby wasting energy.

- The lower advance posting distances may violate drivers' expectations, especially if at the same time more realistic advisory speeds are used as suggested in Section 2.5.3.2.

Also, Districts should base the minimum advance distance on the "0 mph" advisory speed for the Stop Ahead, Yield Ahead, Signal Ahead, Advance Railroad Crossing, and Intersection Warning signs because a driver may wish to turn at an intersection or may need to stop due to other turning traffic.

A few warning signs are not placed in advance of the situation, but instead rely on the visibility of the sign from a distance. Examples include:

- Chevron Alignment (W1-8) sign.

- NO PASSING ZONE (W14-3) pennant.

- Pedestrian Crossing (W11-2) and School Advance Warning (S1-1) signs, when physically placed at the crosswalks with a Diagonal Arrow (W16-7p) sign.

- Double Arrow (W12-1) sign, i.e., as used on the approach end of an island where traffic can pass on both sides.

Exhibit 2.5-A Guidelines for Advance Placement of Warning Signs

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 and 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 PIEV 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 for the driver.

2.5.3 Signing Curves and Turns

2.5.3.1 Curve and Turn Signs

The legal speed limit of the highway should be used when evaluating the need for advance Turn (W1-1) or Curve (W1-2) signs. All curves and turns with a recommended safe speed less than the legal speed for the highway should normally be signed with an appropriate curve or turn sign. An exception to the installation of a curve or turn sign may be a ramp to or from a freeway or expressway where an advisory exit speed or ramp speed sign exists and flexible delineator posts or Chevron Alignment (W1-8) signs exist.

Curve or turn signs should normally be installed a minimum distance in advance of the curve or turn equal to the appropriate values in Condition B in Exhibit 2.5-A. To use this table, you need to know the legal or 85th percentile speed, plus the recommended advisory speed around the curve or turn.

2.5.3.2 Advisory Speed Signs

An Advisory Speed (W13-1) plaque may be installed below a Curve or Turn sign if the recommended safe speed for the curve or turn is less than the legal speed for the highway.

The safe speed on curves may be determined by making several trial runs through the curve in a car equipped with a ball-bank indicator in accordance with the following guidelines:

(a) Mount the ball-bank indicator transversely in the car at an orientation to give a "zero reading" when the car is level.

(b) For the first trial run, drive the car in the center of the lane at a speed that is a multiple of 5 mph that provides a maximum ball-bank indicator reading less than the appropriate value in Exhibit 2.5-B.

(c) If necessary, make succeeding observations at higher 5 mph increments until the reading on the ball-bank indicator equals or exceeds the appropriate value in Exhibit 2.5-B. The safe speed on the curve is the highest speed that does not exceed the appropriate value in Exhibit 2.5-B while consistently driving in the center of the travel lane.

(d) On two-way roadways, conduct test runs in each direction of travel since the safe speed may be different for the different directions of travel.

Exhibit 2.5-B Maximum Ball-Bank Indicator Readings

Posted Speed Limit (mph)	Ball–Bank Indicator (degrees)
20 or less	16
25 and 30	14
35 or more	12

2.5.3.3 Additional Signing and Delineation at Curves and Turns

In addition to the advance Curve or Turn sign discussed in Section 2.5.3.1 and Section 2.5.3.2, additional signing and/or delineation of curves and turns should be considered if one or more of the following exists:

(a) Crash lists indicate that there are "run-off-the road," "hit-fixed-object," or other curve-related crashes.

(b) There is physical evidence of errant vehicles leaving the road in the form of shoulder rutting, guide rail damage, scars on adjacent trees, or other markings on the shoulder that appear to be made by vehicles.

(c) The curve or turn is "hidden" from drivers and the roadway alignment is not evident such as a combination horizontal and an over-vertical curve, an overhead utility line that diverges from the highway, or other features that could mislead drivers.

(d) Day or night test drives of the highway indicate that additional signing and/or delineation is required to adequately indicate the travel path for drivers.

The additional signing and/or delineation could consist of the Large Single Arrow (W1-6) sign, Chevron Alignment (W1-8) sign, or Flexible Delineator Posts. These devices also provide day and night target value, especially the Large Single Arrow and the Chevron Alignment signs. However, these devices should not generally be installed at a curve or turn unless an advance Curve or Turn sign exists. Exceptions are:

1. On a ramp where an Advisory Exit Speed (W13-2) or Ramp Speed (W13-3) sign exists.

2. On a ramp, freeway, or expressway where delineators are required in accordance with the Sign Foreman's Manual (Publication 108) and the *MUTCD*.

3. At locations identified in Paragraph (a) above, but the recommended safe speed for the curve or turn as determined by ball-bank readings is equal to or higher than the legal speed limit for the highway.

If it is determined that the installation of one or more of these devices is desirable, consider the following guidelines:

A. Large Single Arrow (W1-6) Sign. This sign should be considered for use on curves and turns that are relatively short in length. Normally curves and turns up to about 300 or 350 feet in length can be satisfactorily signed with one W1-6 sign in each direction. It is also possible to sign longer curves with a single W1-6 sign, but engineering judgment based on field conditions must be used in making this decision.

   You may also consider the W1-6 sign for use on compound curves, reverse curves and turns, winding roads, and other locations where a severe change in alignment occurs.

B. Chevron Alignment (W1-8) Sign. Based on the results of a study in Virginia, "Evaluation of Curve Delineation Signs," published in Transportation Research Record 1010, consider this sign for curves or turns that are greater than 7 degrees. In addition, consider the W1-8 sign when:

   - Standard delineation is in place, but there is still a high incidence of daytime and/or nighttime "run-off-the-road" crashes.

   - Standard delineation does not, or would not, show the roadway alignment; e.g., combination horizontal and over vertical curve.

   Do not use the W1-8 sign if a turn has inadequate length for proper spacing of the W1-8 sign.

   When used, a minimum of two signs should always be visible. Do not install the first W1-8 sign before the P.C. and the last sign beyond the P.T. When applicable, W1-8 signs may be installed on back-to-back installations as described in the Sign Foreman's Manual (Publication 108).

When W1-8 signs are used, Exhibit 2.5-C shows recommended spacing based on three different methods in accordance with TTI Report FHWA/TX 04/0 4052 1, entitled *Simplifying Delineator and Chevron Applications for Horizontal Curves*.

Exhibit 2.5-C Suggested Spacing for W1-8 Signs

Method 1	Method 2	Method 3	Chevron Spacing (feet)
Curve Radius (feet)	Degree-of-Curve*	Curve Advisory Speed (mph)*	
< 200	> 28.6	≤ 15	40
200 - 400	14.3 -28.6	20 - 30	80
401 - 700	8.2 – 14.2	35 - 45	120
701 – 1250	4.6 – 8.1	50 - 60	160
> 1250	< 4.6	> 60	200

* "Degree-of-Curve" (D) is the measurement, in degrees, of the change in alignment over a 100-foot section of roadway. The degree-of-curve can be calculated by the formula D=5729.6/radius.

C. Flexible Delineator Posts. Based on the results of the study in Virginia, these devices should be considered for use on curves that are less than or equal to 7 degrees. They may be considered for use on curves or turns which are greater than 7 degrees, when it has been determined that the W1-8 sign should not be used.

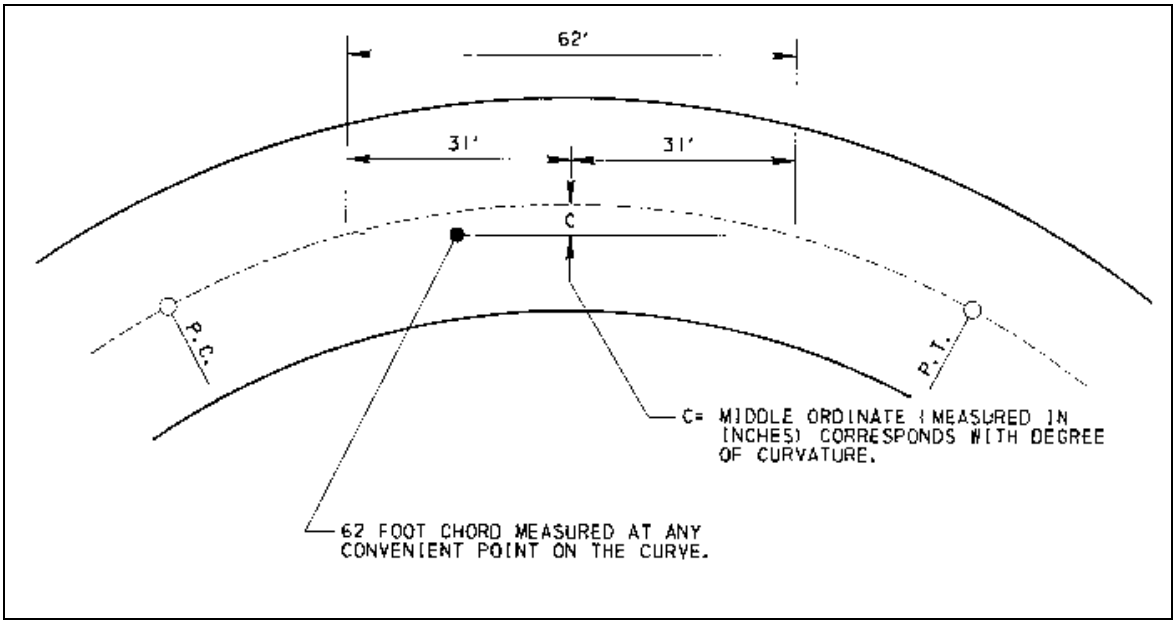
D. Combination of Signs and/or Delineation Devices. A combination of devices discussed above may be used to delineate a curve or turn (or combination of curves or turns), if a field review indicates the need for a combination of devices to adequately advise drivers of the roadway alignment.

2.5.3.4 Degree-of-Curve

If you do not know the degree-of-curve or the radius of a curve, you can estimate the degree-of-curve by two methods. First, you can take the total change in direction of the curve and divide by the length of the curve in hundreds of feet to calculate the degree-of-curve. For example, if you have a right angle (90 degree) curve that measures 1,000 feet from the beginning of the curve (P.C.) to the end of the curve (P.T.), the curve would be a 9-degree curve (i.e., 90/10 = 9). A compass that includes degrees and a distance-measuring instrument (DMI) are of value.

Although labor intensive, the second method involves stretching a 62-foot string between two points along the roadway's centerline or an edge line, and measuring the distance from the center of the string to the line. This distance is the middle ordinate, and when measured in inches, it very closely approximates the "degree-of-curve" for curves with a degree-of-curve up to approximately a 45-degree curve (e.g., a 10-inch middle ordinate equals a 10-degree curve, a 20-inch middle ordinate equals a 20-degree curve, etc.). Exhibit 2.5-D illustrates this method.

Exhibit 2.5-D. Estimating the Degree of Curve



2.5.4 Stop Ahead Signs

Stop Ahead (W3-1) signs should be installed in advance of STOP (R1-1) signs when one or more of the following exists:

(a) Because of physical conditions, the R1-1 sign is not continuously visible for the required distance specified for the W3-1 sign in Publication 236.

(b) Although the R1-1 sign is visible for the minimum distance in Publication 236, one of the following exists:

- A "running-the-stop-sign" crash experience exists.
- The view of the R1-1 sign is occasionally blocked by moving or stopped vehicles.

- The highway has a multi-lane, high-speed (45 mph or higher) approach to the R1-1 sign. (Note, if a divided highway and the median is wide enough, the STOP Sign and/or the Stop Ahead Signs should be installed on both sides of the roadway.)

- There is extensive environmental interference.

When used, install the Stop Ahead (W3-1) sign in advance of the R1-1 sign in accordance with the distance indicated in Condition B in Exhibit 2.5-A.

2.5.5 Share the Road Sign

The Share-the-Road Sign (W16-1) is available for installation on appropriate State highways throughout the Commonwealth. The purpose of the sign is to promote cooperation, understanding, and mutual safety between motorists and bicyclists on roadways where sharing roadway space is required.

Requests for the W16-1 sign may come from any legitimate source, including the following internal or external sources:

(a) Department designers or consultants may independently suggest the installation of the signs as part of the project development process. In addition, Department personnel may suggest locations for the signs as a stand-alone project.

(b) Non-department personnel may suggest locations for installation without solicitation from the Department. These suggestions may be included as part of a larger project or as a stand-alone project. Forums for this input may be District Bicycle/Pedestrian Advisory Committees, MPO/LDD Bicycle/Pedestrian Advisory Committees, or other sources. However, it is important to note that the Department will not provide signs to local municipalities for installation on local roads.

All requests for W16-1 signs on State highways should go to the District Bicycle/Pedestrian Coordinator for review. The criteria for road selection should include roads that possess any or all of the following:

- Highways promoted as a cycling route by a local or state agency, or that demonstrate a need based on the traveling patterns of local cyclists or a car-bike crash history.

- Prior to bottlenecks such as narrow bridges or underpasses, and short stretches of roads that lack paved shoulders.

- On sections of highway that have numerous commercial driveways, such as in a cluster of suburban strip malls.

- Sections of highway where lanes are greater than 14 feet wide and motorists may be tempted to travel two abreast and crowd cyclists off the road.

- On narrow highways where cyclists can only proceed safely if, they use the full lane width.

If the Bicycle/Pedestrian Coordinator determines that a request is justified, counties may order W16-1 signs from the Sign Shop. If installed by the Department, the Department is responsible for maintenance of the signs.

2.5.6 Advance Street Name Signs

On multilane roads and roads with a speed limit greater than 35 mph, Districts are encouraged to use either the Single-Line Advance Street Name (W16-8) or Double-Line Advance Street Name (W16-8A) sign, with appropriate arrows, as necessary, below any of the following advance warning signs:

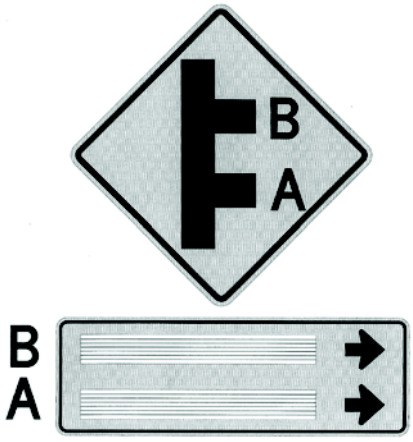
- Any W1-series sign with a side road.
- Cross Road (W2-1) sign.
- Offset Side Road (W2-1-1L, W2-1-1R) sign.
- Side Road (W2-2) sign.
- Double Side Road (W2-2D).
- 45º Side Road (W2-3L, W2-3R) sign.
- Curve – Side Road (W2-3-1L, W2-3-1R) sign.
- "T" Symbol (W2-4) sign.
- "Y" Symbol (W2-5) sign.
- "Y" Symbol Secondary (W2-5-1L, W2-5-1R) sign.
- Stop Ahead (W3-1) sign.
- Signal Ahead (W3-3) sign.

Note: The decision to erect the above-listed warning signs should be based on their justification in Publication 236, and not solely to facilitate the installation of Advance Street Name Signs. As an alternate, you may install the Single-Line Advance Street Name (D3-2) sign or the Double-Line Advance Street Name (D3-3) sign in lieu of the W16-8 or W16-8A sign.

If a Double-Line Advance Street Name (W16-8A) sign is installed below a Double Side Road (W2-2D) sign, the consensus is that the order of destinations on the W16-8A sign should correspond to the warning sign graphic as illustrated in Exhibit 2.5-E.

Therefore, the first destination on the W16-8A sign is the second side road as approached by the driver, and the second destination on the W16-8A sign is the first side road as approached by the driver.

Exhibit 2.5-E Order of Destinations for Double Side Road Sign



Using a W16-8A sign below a W2-2D sign is a challenge. The problem is created by a conflict in how drivers read signs, i.e., we read intersection and alignment signs from the bottom to the top, whereas we read legend signs from the top to the bottom.

Therefore, if you observe problems, it may be best not to install this combination of signs.

A-4

Large Double Arrow Sign
(PennDOT Publication 236M, W1-7)

Left Curve Right Side Road Sign
(PennDOT Publication 236M, W1-10L)

Right Curve Left Side Road Sign
(PennDOT Publication 236M, W1-10R)

Cross Road Sign
(PennDOT Publication 236M, W2-1)

Offset Side Road Sign
(PennDOT Publication 236M, W2-1-1R)

Side Road Sign
(PennDOT Publication 236M, W2-2)

Double Arrow Sign
(PennDOT Publication 236M, W12-1)

Advisory Speed Plaque
(PennDOT Publication 236M, W13-1)

(__) Feet Plaque
(PennDOT Publication 236M, W16-2)

Single-Line Advance Street Name Sign
(PennDOT Publication 236M, W16-8)

A-4 (Continued)

Double-Line Advance Street Name Sign
(PennDOT Publication 236M, W16-8A)

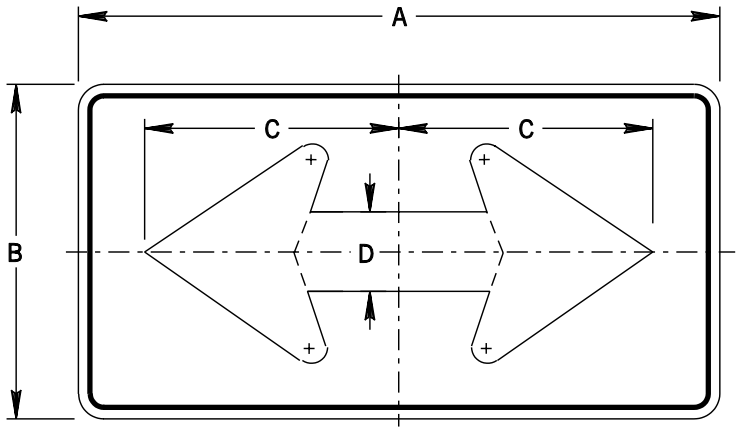
Ahead Plaque
(PennDOT Publication 236M, W16-9P)

W1–7

LARGE DOUBLE ARROW SIGN

(a) Justification. The Large Double Arrow Sign (W1–7) shall be authorized for use on the far side of a "T" intersection, in line with, and at right angles to, approaching traffic. This sign shall not be used to mark the ends of median strips, center piers, and so forth, when there is no change in the direction of traffic.

(b) Size. The standard size of the W1–7 shall be 1200 mm by 600 mm (48" x 24").



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)					
SIGN SIZE A x B	C	D	MAR–GIN	BOR–DER	BLANK STD.
1200 x 600 (48" x 24")	515 (20.6)	165 (6.6)	15 (0.6)	20 (0.8)	B5–1200600 (B5–4824)
2400 x 1200 (96" x 48")	1025 (41)	325 (13)	20 (0.8)	30 (1.2)	———
3000 x 1500 (120" x 60")	1270 (50.8)	400 (16)	25 (1)	30 (1.2)	———

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

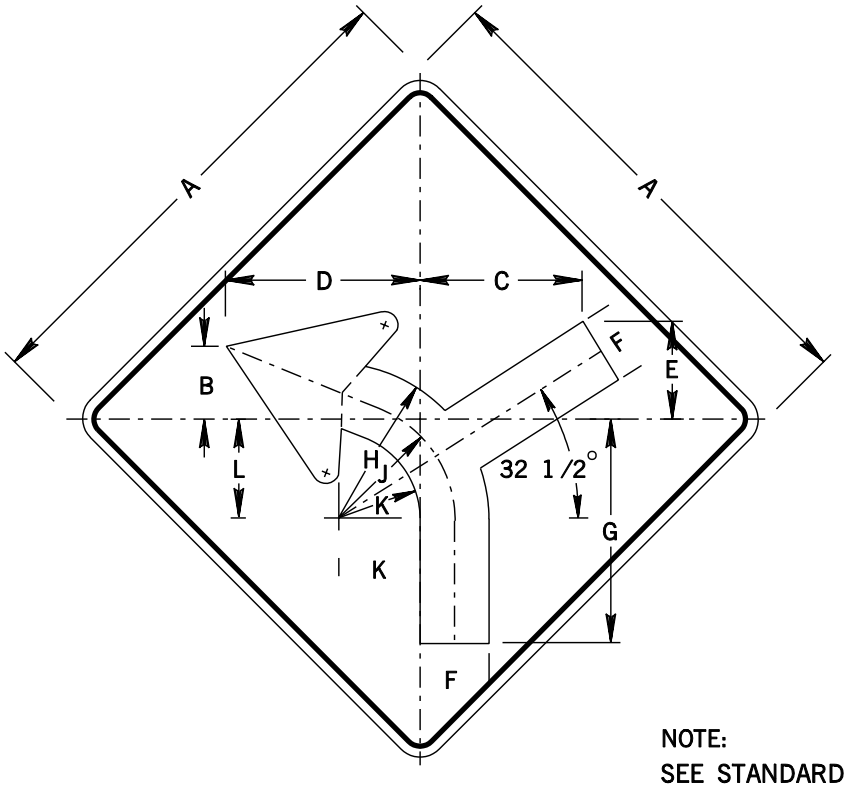
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–10L

LEFT CURVE RIGHT SIDE ROAD SIGN

The Left Curve Right Side Road Sign (W1–10L) may be used in advance of a curve to the left where the recommended speed on the curve is greater than 50 km/h (30 MPH) but less than or equal to the legal speed limit, and where a side road to the right exists on the curve.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)													
SIGN SIZE A x A	B	C	D	E	F	G	H	J	K	L	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	135 (5.4)	250 (10)	315 (12.6)	155 (6.2)	110 (4.4)	345 (13.8)	250 (10)	195 (7.8)	140 (5.6)	160 (6.4)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	242 (9.7)	400 (16)	500 (20)	240 (9.6)	176 (7)	550 (22)	401 (16)	313 (12.5)	225 (9)	260 (10.4)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

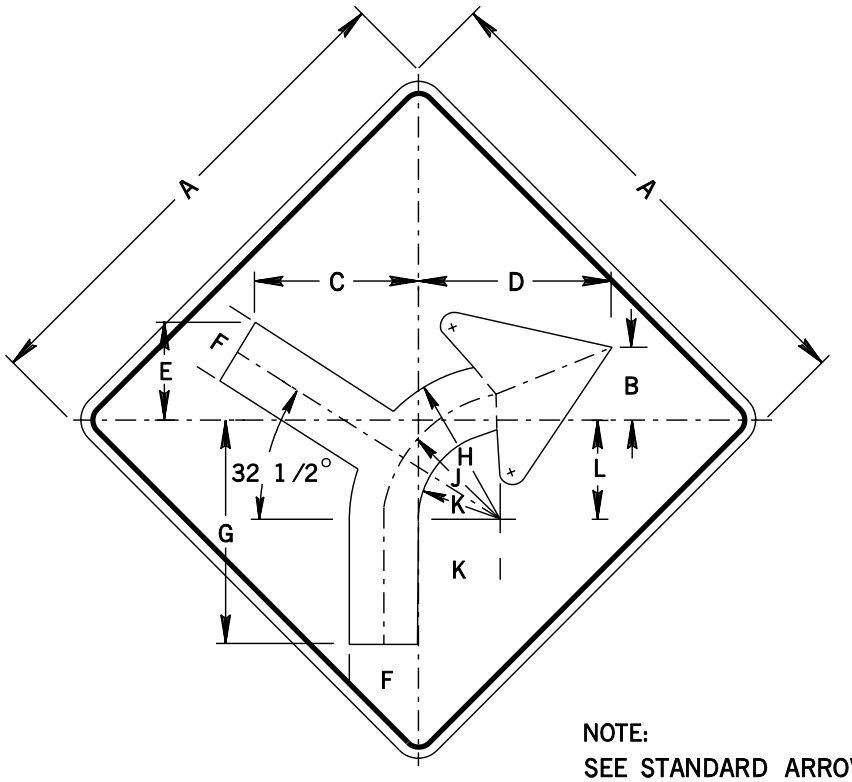
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–10R

RIGHT CURVE LEFT SIDE ROAD SIGN

The Right Curve Left Side Road Sign (W1–10R) may be used in advance of a curve to the right where the recommended speed on the curve is greater than 50 km/h (30 MPH) but less than or equal to the legal speed limit, and where a side road to the left exists on the curve.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)													
SIGN SIZE A x A	B	C	D	E	F	G	H	J	K	L	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	135 (5.4)	250 (10)	315 (12.6)	155 (6.2)	110 (4.4)	345 (13.8)	250 (10)	195 (7.8)	140 (5.6)	160 (6.4)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	242 (9.7)	400 (16)	500 (20)	240 (9.6)	176 (7)	550 (22)	401 (16)	313 (12.5)	225 (9)	260 (10.4)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

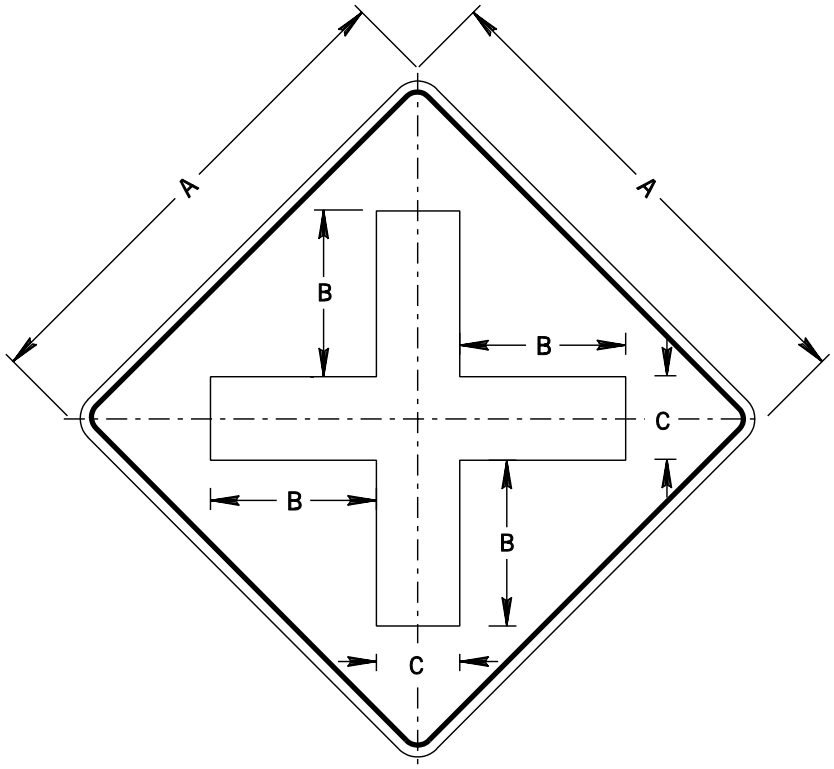
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W2–1

CROSS ROAD SIGN

The Cross Road Sign (W2–1) shall be authorized for use on a through highway to indicate the presence of a cross road. Its use should be restricted to intersections with roads that are improved to such an extent that there is likely to be a fairly large volume of traffic entering or crossing the through route and where poor sight distance or obscured entrances make it advisable that the intersection be called to the motorists' attention.

Too frequent use should be avoided. This sign may be used as advance warning of two side roads which are offset from each other by not more than 15 m (50').



DIMENSIONS – mm (IN)					
SIGN SIZE A x A	B	C	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	250 (10)	125 (5)	15 (0.6)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	400 (16)	200 (8)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

SYMBOL AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

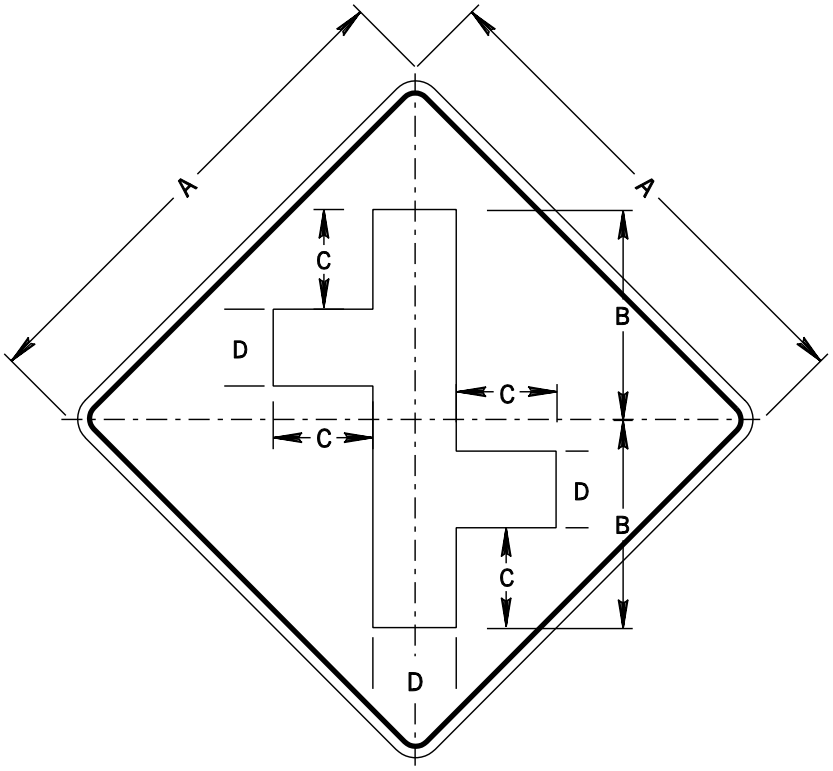
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W2–1–1R

OFFSET SIDE ROAD RIGHT SIGN

The Offset Side Road Right Sign (W2–1–1R) may be used on a through highway to indicate the presence of two offset side roads, the first of which is to the right and the second to the left, and which are separated by a distance greater than 15 m (50') but less than 150 m (500'). Its use should be restricted to those intersections having a high volume of traffic entering from the side roads and where poor sight distance or obscured entrances make it advisable that the intersections be called to the drivers' attention.

The (W2–1–1R) sign may also be used on the two side roads of the depicted intersection if both side roads have the same local road name or traffic route number and they are separated by a distance greater than 15 m (50') but less than 150 m (500'). In such cases, the W2–1–1R sign should be rotated 90 degrees.



DIMENSIONS – mm (IN)						
SIGN SIZE A x A	B	C	D	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	340 (13.6)	150 (6)	115 (4.6)	15 (0.6)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	540 (21.6)	250 (10)	190 (7.6)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

SYMBOL AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

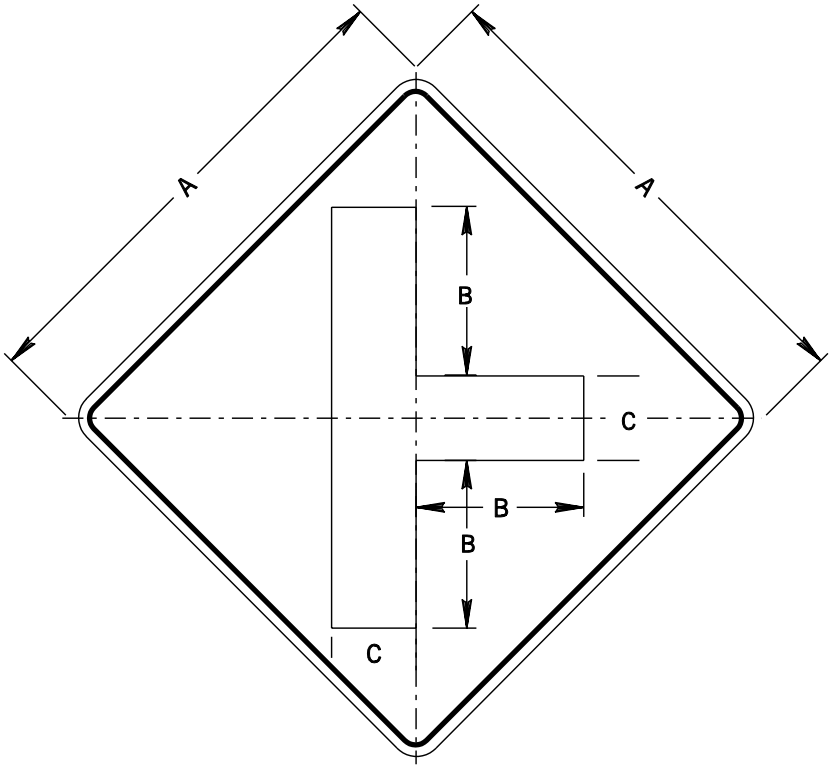
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W2–2

SIDE ROAD SIGN

The Side Road Sign (W2–2) shall be authorized for use in advance of a side road intersection. Its use should be restricted to intersections with roads that are improved to such an extent that there is likely to be a fairly large volume of traffic entering the through route and where poor sight distance or obscured entrances make it advisable that the intersection be called to the motorists' attention.

Too frequent use should be avoided. When an offset of two intersecting roads is more than 15 m (50'), two side road signs should be used.



DIMENSIONS – mm (IN)					
SIGN SIZE A x A	B	C	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	250 (10)	125 (5)	15 (0.6)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	400 (16)	200 (8)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

SYMBOL AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

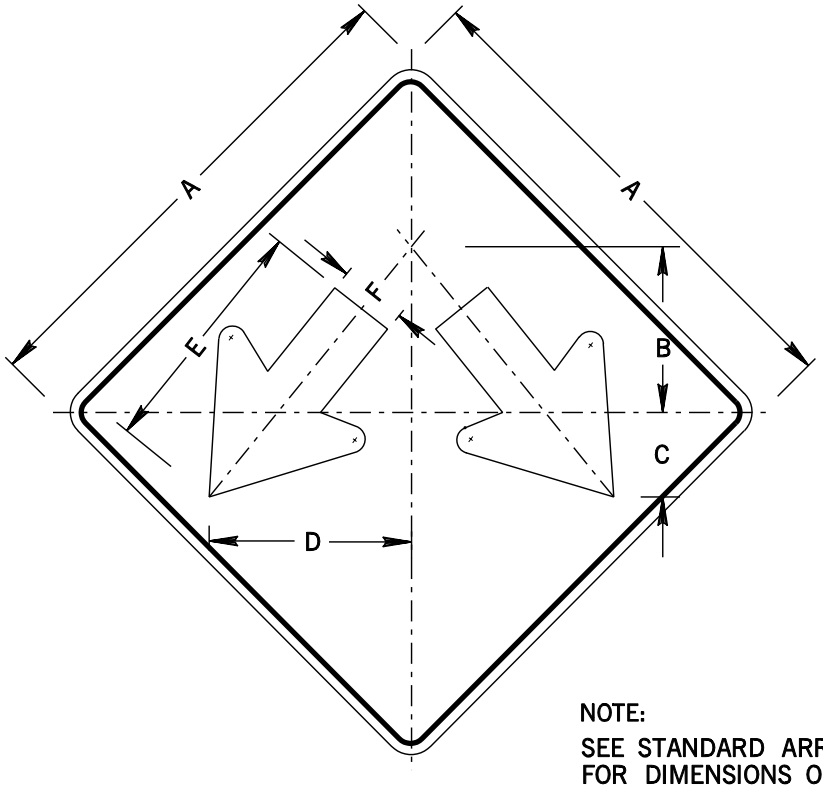
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W12–1

DOUBLE ARROW SIGN

The Double Arrow Sign (W12–1) may be used at loading and refuge islands, traffic islands, and other obstructions in the roadway, when traffic is permitted to pass on either side of the island or obstruction. It should normally be mounted at a height of 2.1 m (7') to the bottom of the sign in order that it will be visible over preceding vehicles.

If white striping is used on the obstruction, it should be discontinued in the vicinity of the sign to leave a minimum of 75 mm (3") around the outside of the sign.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)								
SIGN SIZE A x A	B	C	D	E	F	MAR–GIN	BOR–DER	BLANK STD.
900 x 900 (36" x 36")	305 (12)	157 (6.1)	372 (14.6)	443 (17.5)	120 (4.8)	15 (0.6)	25 (1)	B3–900 (B3–36)

COLOR:

ARROWS AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

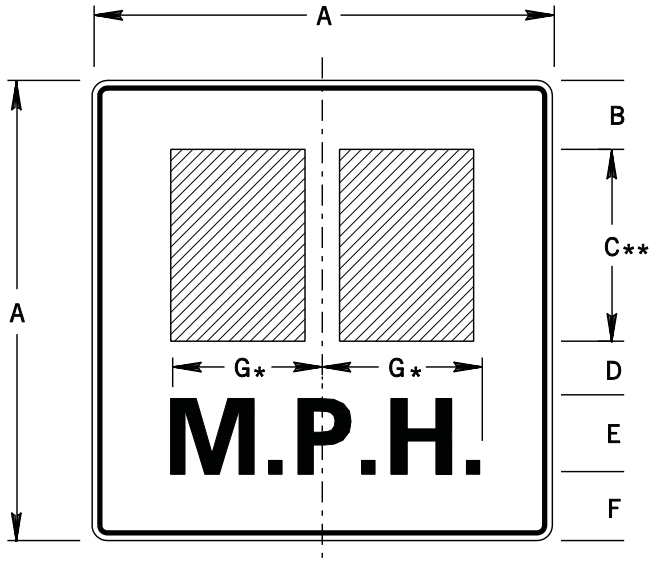
W13–1

ADVISORY SPEED PLAQUE

(a) Justification. The Advisory Speed Plaque (W13–1) shall be authorized for use in conjunction with any standard warning sign to indicate the maximum safe speed. It shall not be used in conjunction with any sign other than a warning sign, nor shall it be used alone. It shall be mounted below the warning sign.

The speed shown shall be a multiple of 5 MPH (10 km/h), to be determined by accepted traffic engineering procedures.

(b) Size. The 450 mm by 450 mm (18" x 18") size should be used with a warning sign of 750 mm by 750 mm (30" x 30"), the 600 mm by 600 mm (24" x 24") with 900 mm by 900 mm (36" x 36") sign, the 750 mm by 750 mm (30" x 30") size with 1200 mm by 1200 mm (48" x 48") signs.



DIMENSIONS – mm (IN)									
SIGN SIZE A x A	B	C	D	E	F	G	MAR–GIN	BOR–DER	BLANK STD.
450 x 450 (18" x 18")	63 (2.5)	200E (8E)	50 (2)	75E (3E)	62 (2.5)	135 (5.3)	10 (0.4)	10 (0.4)	B3–450 (B3–18)
600 x 600 (24" x 24")	90 (3.6)	250E (10E)	70 (2.8)	100E (4E)	90 (3.6)	180 (7.1)	10 (0.4)	15 (0.6)	B3–600 (B3–24)
750 x 750 (30" x 30")	105 (4.2)	300E (12E)	90 (3.6)	150E (6E)	105 (4.2)	269 (10.7)	15 (0.6)	20 (0.8)	B3–750 (B3–30)

* INCREASE SPACING 100%

** OPTICALLY SPACE NUMERALS ABOUT VERTICAL ℄

COLOR:

LEGEND AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

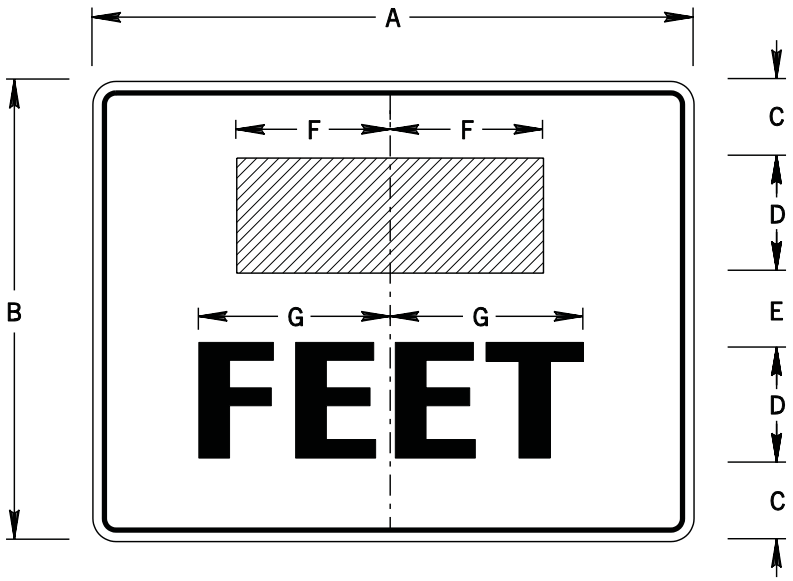
W13_1.DGN

W16–2

(__) FEET PLAQUE

(a) Justification. The (__) Feet Plaque (W16–2) may be used below a standard warning sign to indicate the distance to the condition cited by the warning sign. Normally distances used should be in an increment of 150 m (500'). This plaque shall only be fluorescent yellow–green, when used beneath another fluorescent yellow–green sign.

(b) Size. The 750 mm by 600 mm (30" x 24") size should be used with 1200 mm by 1200 mm (48" x 48") and larger warning signs.



DIMENSIONS – mm (IN)								
SIGN SIZE A x B	C	D	E	F	G	MAR–GIN	BOR–DER	BLANK STD.
600 x 450 (24" x 18")	75 (3)	125D (5D)	50 (2)	VAR.	186 (7.4)	10 (0.4)	15 (0.6)	B5–600450 (B5–2418)
750 x 600 (30" x 24")	110 (4.4)	150D (6D)	80 (3.2)	VAR.	224 (8.9)	15 (0.6)	20 (0.8)	B5–750600 (B5–3024)

COLOR:

LEGEND AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW OR FLUORESCENT YELLOW–GREEN (REFLECTORIZED)

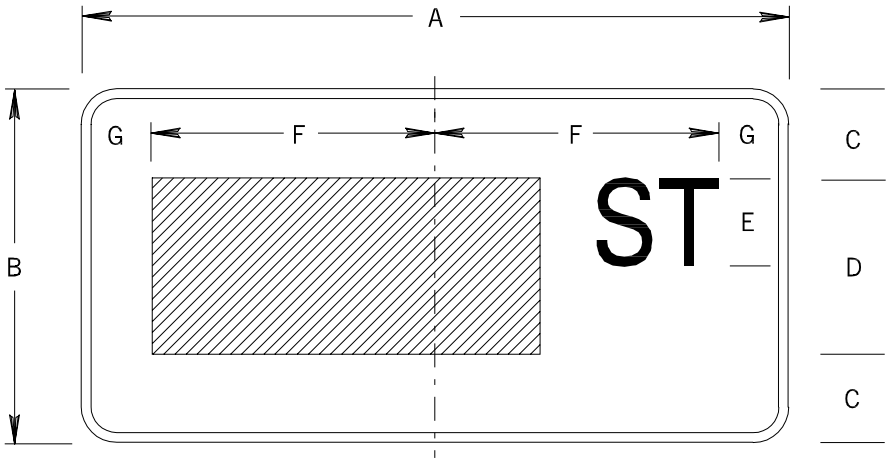
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W16–8

SINGLE–LINE ADVANCE STREET NAME SIGN

The Single–Line Advance Street Sign (W16–8) may be used beneath any intersection warning sign (W2 series) or advance traffic control sign (W3 series) to identify the name of the intersecting street. If the street name to the left is different than the one to the right, the Double–Line Advance Street Name Sign (W16–8A) should be used. The abbreviation "ST" may be changed to "RD", "LN", "CT", etc. as applicable.



DIMENSIONS – mm (IN)								
SIGN SIZE A x B	C	D *	E	F	G **	MAR–GIN	BOR–DER	BLANK STD.
VAR x 200 (VAR x 8")	50 (2)	100 (4)	50B (2B)	VAR.	50 (2)	10 (0.4)	10 (0.4)	—
VAR x 300 (VAR x 12")	75 (3)	150 (6)	100B (4B)	VAR.	75 (3)	10 (0.4)	15 (0.6)	—

** CHOOSE UPPER/LOWER CASE ClearviewHwy FONT FOR BEST FIT

* MINIMUM SPACE

COLOR:

LEGEND AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 06–30–08

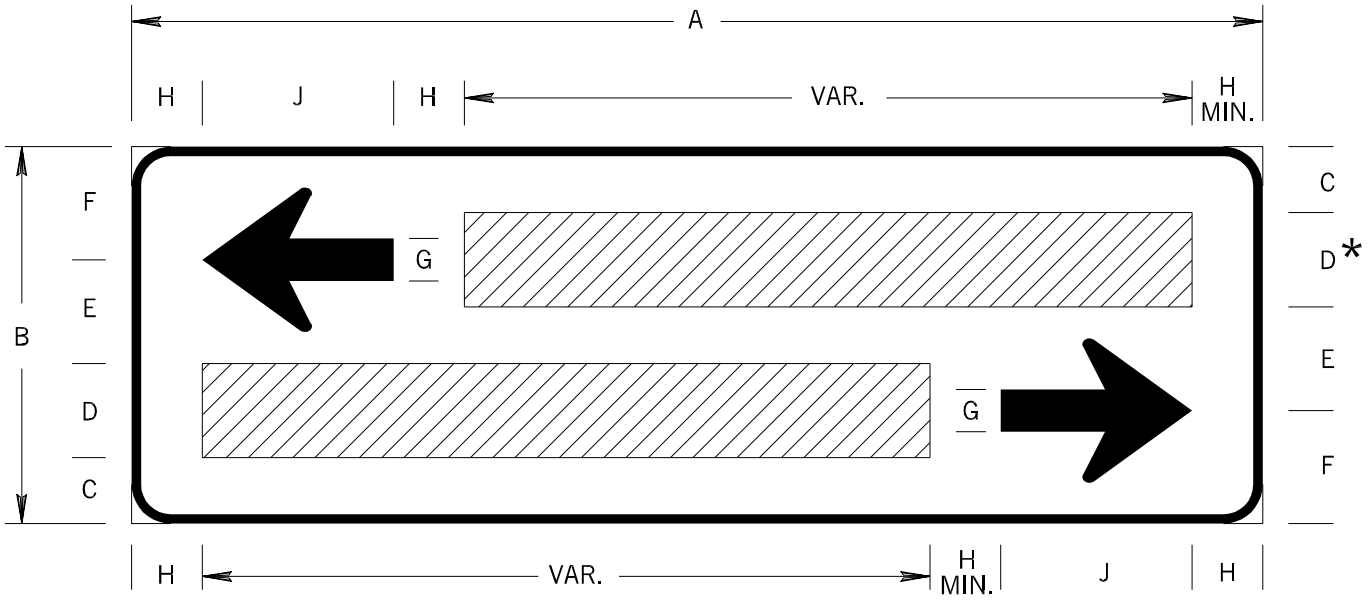
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W16_8.DGN

W16–8A

DOUBLE–LINE ADVANCE STREET NAME SIGN

The Double–Line Advance Street Name Sign (W16–8A) may be used beneath any intersection warning sign (W2 series) or advance traffic control sign (W3 series) to identify the name of the intersecting street when the street name to the left is different than the one to the right. The street name of the road to the left should be above the street name of the road to the right.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD.

DIMENSIONS – mm (IN)										
SIGN SIZE A x B	C	D*	E	F	G	H	J	K	BOR–DER	BLANK STD.
1200 x 400 (48" x 16")	70 (2.8)	100 (4)	110 (4.4)	120 (4.8)	45 (1.8)	75 (3)	135 (5.4)	10 (0.4)	10 (0.4)	___
1800 x 600 (72" x 24")	110 (4.4)	150 (6)	155 (6.2)	185 (7.4)	70 (2.8)	100 (4)	205 (8.2)	20 (0.8)	15 (0.6)	___

* CHOOSE UPPER/LOWER CASE ClearviewHwy FONT FOR BEST FIT

COLOR:

ARROWS, LEGEND AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

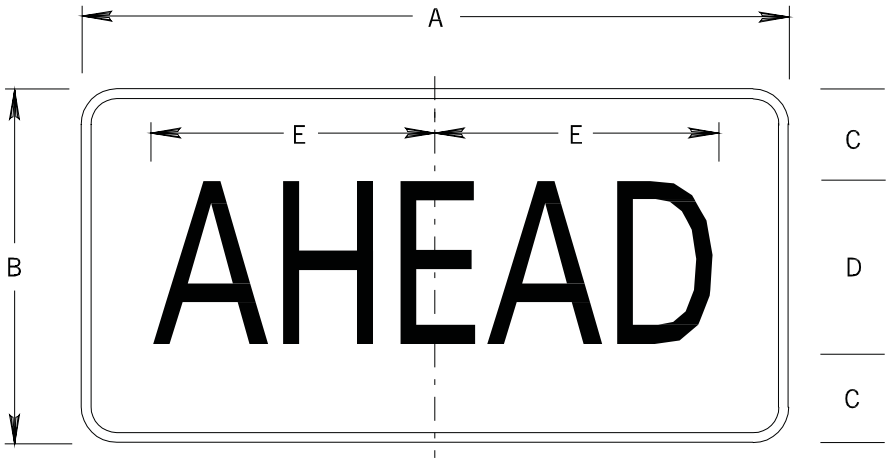
By : Glen C Rowe Date : 06–30–08
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

w16_8a.dgn

W16–9P

AHEAD PLAQUE

The Ahead Plaque (W16–9P) may be used to supplement a variety of warning signs such as Two–Way Traffic Sign (W6–3), School Advance Warning Sign (S1–1), and variety of crossings signs.



DIMENSIONS – mm (IN)						
SIGN SIZE A x B	C	D	E	MAR–GIN	BOR–DER	BLANK STD.
600 x 300 (24" x 12")	100 (4)	100D (4D)	222 (8.7)	10 (0.4)	15 (0.6)	B5–600300 (B5–2412)
900 x 600 (36" x 24")	212.5 (8.5)	175D (7D)	388 (15.3)	15 (0.6)	25 (1)	B5–900600 (B5–3624)
1200 x 750 (48" x 30")	262.5 (10.5)	225D (9D)	499 (19.7)	20 (0.8)	30 (1.2)	B5–1200750 (B5–4830)

COLOR:

LEGEND AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW OR FLUORESCENT YELLOW GREEN (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 06–30–08
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

A-5

Standardization of Location
(Manual on Uniform Traffic Control Devices, Section 2A.16)

Posts and Mountings
(Manual on Uniform Traffic Control Devices, Section 2A.21)

Stop Sign
(PennDOT Publication 236M, R1-1)

Lane Use Control (Two Lanes) Sign
(PennDOT Publication 236M, R3-8A)

Keep Right Sign
(PennDOT Publication 236M, R4-7)

Object Marker
(PennDOT Publication 236M, OM1-3)

Option:

State and/or local highway agencies may conduct research studies to determine road user comprehension, sign conspicuity, and sign legibility.

Educational plaques may be left in place as long as they are in serviceable condition.

Although most standard symbols are oriented facing left, mirror images of these symbols may be used where the reverse orientation might better convey to road users a direction of movement.

Section 2A.14 Word Messages

Standard:

Except as noted in Section 2A.06, all word messages shall use standard wording and letters as shown in this Manual and in the "Standard Highway Signs" book (see Section 1A.11).

Guidance:

Word messages should be as brief as possible and the lettering should be large enough to provide the necessary legibility distance. A minimum specific ratio, such as 25 mm (1 in) of letter height per 12 m (40 ft) of legibility distance, should be used.

Support:

Some research indicates that a ratio of 25 mm (1 in) of letter height per 10 m (33 ft) of legibility distance could be beneficial.

Guidance:

Abbreviations (see Section 1A.14) should be kept to a minimum, and should include only those that are commonly recognized and understood, such as AVE (for Avenue), BLVD (for Boulevard), N (for North), or JCT (for Junction).

Standard:

All sign lettering shall be in capital letters as provided in the "Standard Highway Signs" book, except as indicated in the Option below.

Option:

Word messages on street name signs and destinations on guide signs may be composed of a combination of lower-case letters with initial upper-case letters.

Section 2A.15 Sign Borders

Standard:

Unless specifically stated otherwise, each sign illustrated herein shall have a border of the same color as the legend, at or just inside the edge.

The corners of all sign borders shall be rounded, except for STOP signs.

Guidance:

A dark border on a light background should be set in from the edge, while a light border on a dark background should extend to the edge of the panel. A border for 750 mm (30 in) signs with a light background should be from 13 to 19 mm (0.5 to 0.75 in) in width, 13 mm (0.5 in) from the edge. For similar signs with a light border, a width of 25 mm (1 in) should be used. For other sizes, the border width should be of similar proportions, but should not exceed the stroke-width of the major lettering of the sign. On signs exceeding 1800 x 3000 mm (72 x 120 in) in size, the border should be 50 mm (2 in) wide, or on larger signs, 75 mm (3 in) wide. Except for STOP signs and as otherwise provided in Section 2E.15, the corners of the sign should be rounded to fit the border.

Section 2A.16 Standardization of Location

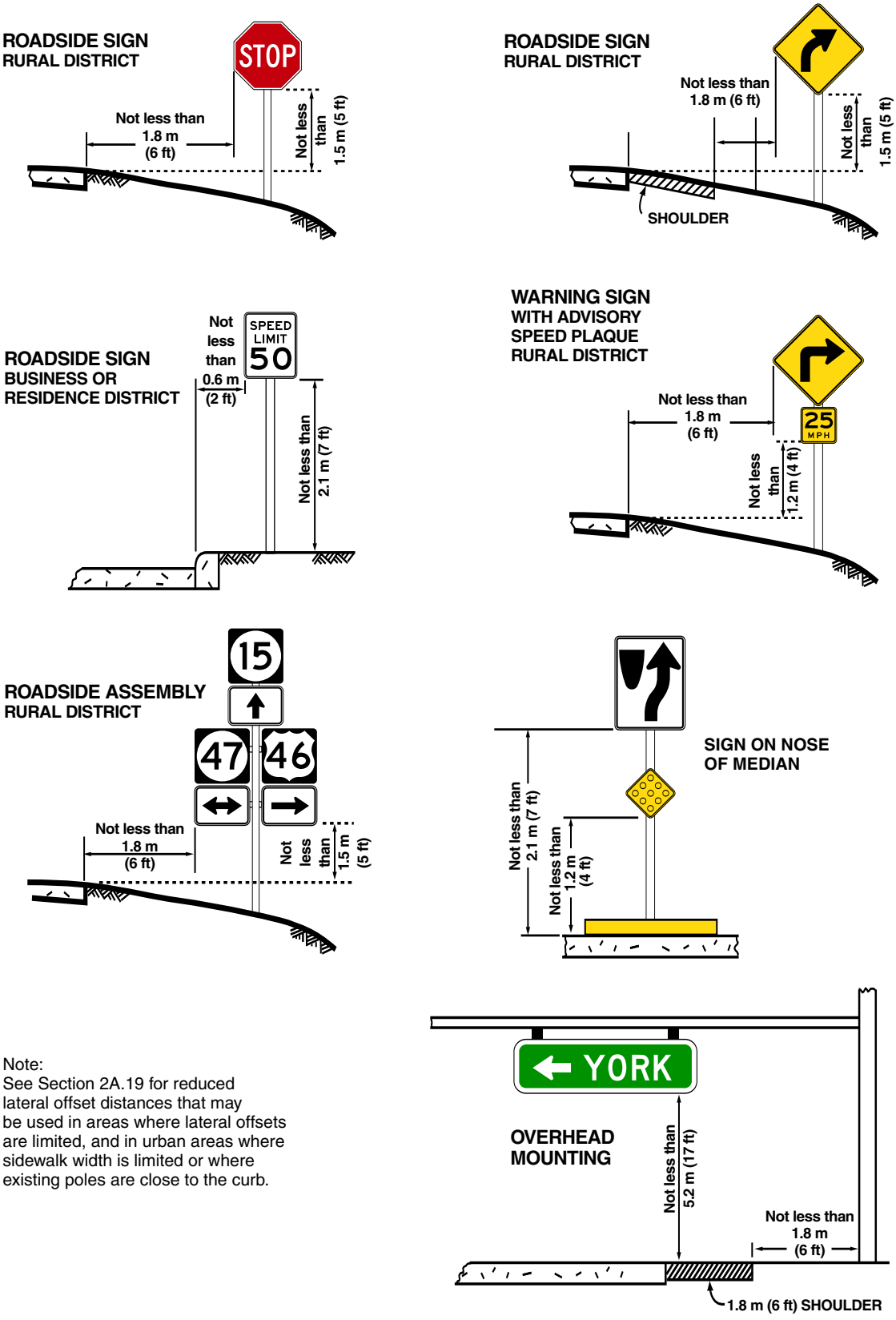
Support:

Standardization of position cannot always be attained in practice. Examples of heights and lateral locations of signs for typical installations are illustrated in Figure 2A-1, and examples of locations for some typical signs at intersections are illustrated in Figure 2A-2.

Standard:

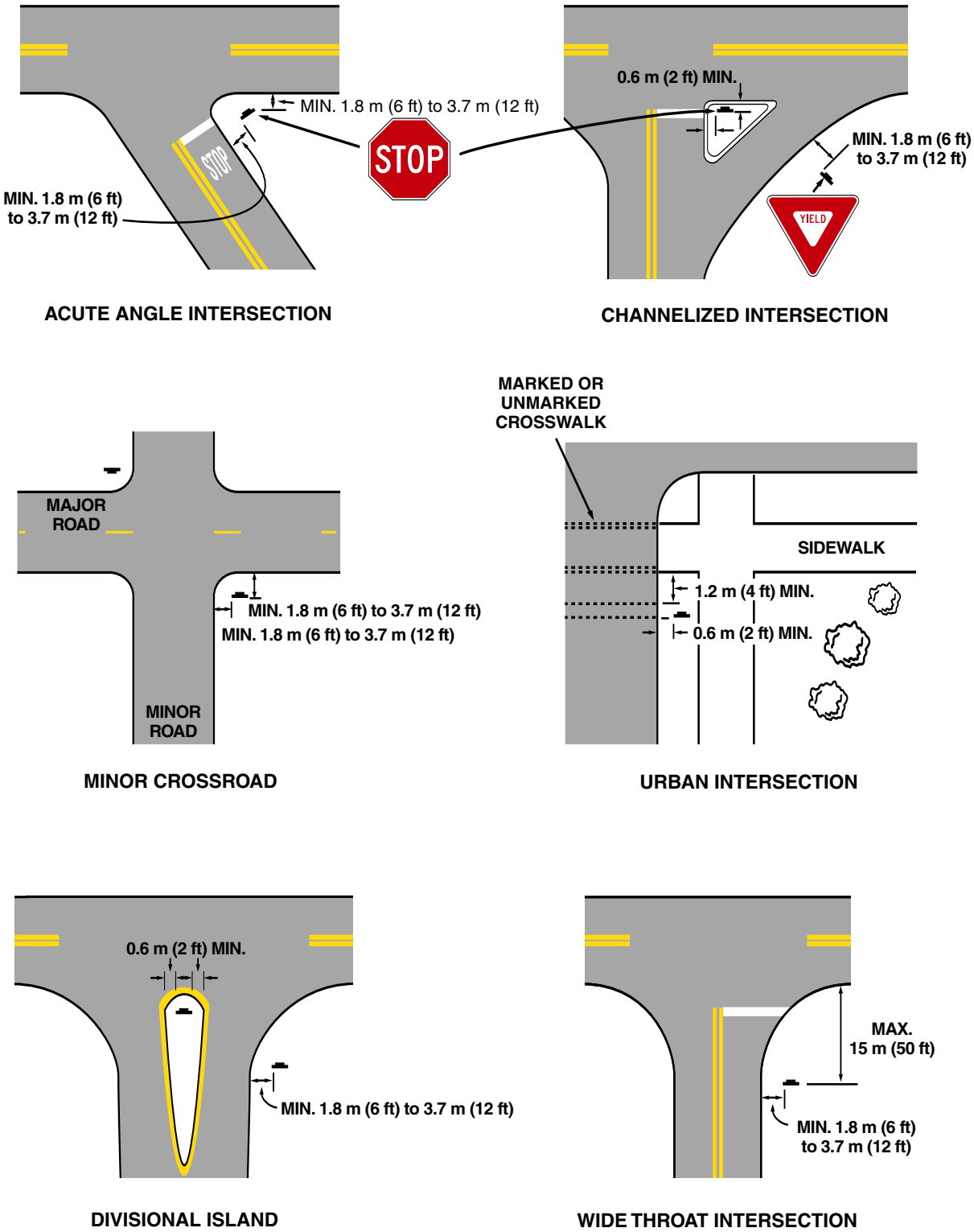
Signs requiring different decisions by the road user shall be spaced sufficiently far apart for the required decisions to be made reasonably safely. One of the factors considered when determining the appropriate spacing shall be the posted or 85th-percentile speed.

Figure 2A-1. Examples of Heights and Lateral Locations of Signs for Typical Installations



Note:
See Section 2A.19 for reduced lateral offset distances that may be used in areas where lateral offsets are limited, and in urban areas where sidewalk width is limited or where existing poles are close to the curb.

Figure 2A-2. Examples of Locations for Some Typical Signs at Intersections



Note: Lateral offset is a minimum of 1.8 m (6 ft) measured from the edge of the shoulder, or 3.7 m (12 ft) measured from the edge of the traveled way. See Section 2A.19 for lower minimums that may be used in urban areas, or where lateral offset space is limited.

Guidance:

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 (see Section 2A.19);
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.

Support:

The clear zone is the total roadside border area, starting at the edge of the traveled way, available for use by errant vehicles. The width of the clear zone is dependent upon traffic volumes, speeds, and roadside geometry. Additional information can be found in the "AASHTO Roadside Design Guide" (see Page i for AASHTO's address).

Guidance:

With the increase in traffic volumes and the desire to provide road users regulatory, warning, and guidance information, an order of priority for sign installation should be established.

Support:

An order of priority is especially critical where space is limited for sign installation and there is a demand for several different types of signs. Overloading road users with too much information is not desirable.

Guidance:

Because regulatory and warning information is more critical to the road user than guidance information, regulatory and warning signing whose location is critical 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.

Option:

Under some circumstances, such as on curves to the right, signs may be placed on median islands or on the left side of the road. A supplementary sign located on the left of the roadway may be used on a multi-lane road where traffic in the right lane might obstruct the view to the right.

Guidance:

In urban areas where crosswalks exist, signs should not be placed within 1.2 m (4 ft) in advance of the crosswalk.

Section 2A.17 Overhead Sign Installations

Guidance:

Overhead signs should be used on freeways and expressways, at locations where some degree of lane-use control is desirable, and at locations where space is not available at the roadside.

Support:

The operational requirements of the present highway system are such that overhead signs have value at many locations. The factors to be considered for the installation of overhead sign displays are not definable in specific numerical terms.

Option:

The following conditions (not in priority order) may be considered in an engineering study to determine if overhead signs would be beneficial:

A. Traffic volume at or near capacity;
B. Complex interchange design;
C. Three or more lanes in each direction;
D. Restricted sight distance;

Section 2A.19 Lateral Offset

Standard:

For overhead sign supports, 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 overhead sign supports (cantilever or sign bridges) shall be 1.8 m (6 ft). Overhead sign supports shall have a barrier or crash cushion to shield them if they are within the clear zone.

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

Guidance:

For ground-mounted signs, the minimum lateral offset should be 3.7 m (12 ft) from the edge of the traveled way. If a shoulder wider than 1.8 m (6 ft) exists, the minimum lateral offset for ground-mounted signs should be 1.8 m (6 ft) from the edge of the shoulder.

Support:

The minimum lateral offset is intended to keep trucks and cars that use the shoulders from striking the signs or supports.

Guidance:

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.

Option:

Where permitted, signs may be placed on existing supports used for other purposes, such as highway traffic signal supports, highway lighting supports, and utility poles.

Standard:

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

Option:

Lesser lateral offsets may be used on connecting roadways or ramps at interchanges, but not less than 1.8 m (6 ft) from the edge of the traveled way.

In areas where lateral offsets are limited, a minimum lateral offset of 0.6 m (2 ft) may be used.

A minimum offset of 0.3 m (1 ft) from the face of the curb may be used in urban areas where sidewalk width is limited or where existing poles are close to the curb.

Support:

Figures 2A-1 and 2A-2 illustrate some examples of the lateral offset requirements contained in this Section.

Section 2A.20 Orientation

Guidance:

Unless otherwise stated in this Manual, 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 9 m (30 ft) or more from the pavement edge 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.

Option:

On grades, sign faces may be tilted forward or back from the vertical position to improve the viewing angle.

Section 2A.21 Posts and Mountings

Standard:

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.

Support:

The latest edition of AASHTO's "Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" contains additional information regarding posts and mounting (see Page i for AASHTO's address).

Option:

Where engineering judgment indicates a need to draw attention to the sign during nighttime conditions, a strip of retroreflective material may be used on regulatory and warning sign supports.

Standard:

If a strip of retroreflective material is used on the sign support, it shall be at least 50 mm (2 in) in width, it shall be placed for the full length of the support from the sign to within 0.6 m (2 ft) above the edge of the roadway, and its color shall match the background color of the sign, except that the color of the strip for the YIELD and DO NOT ENTER signs shall be red.

Section 2A.22 Maintenance

Guidance:

Maintenance activities should consider proper position, cleanliness, legibility, and daytime and nighttime visibility (see Section 2A.09). Damaged or deteriorated signs should be replaced. Rev. 2

To assure adequate maintenance, a schedule for inspecting (both day and night), cleaning, and replacing signs should be established. Employees of highway, law enforcement, 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.

A regular schedule of replacement of lighting elements for illuminated signs should be maintained.

Section 2A.23 Median Opening Treatments for Divided Highways with Wide Medians

Guidance:

Where divided highways are separated by median widths at the median opening itself of 9 m (30 ft) or more, median openings should be signed as two separate intersections.

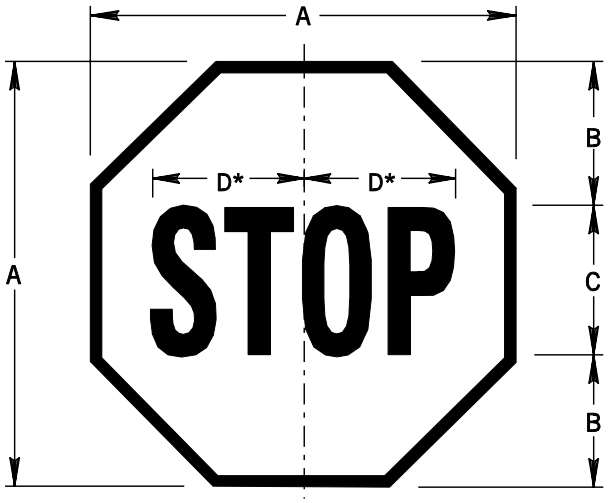
R1–1

STOP SIGN

(a) Justification. The Stop Sign (R1–1) is authorized for use on those streets or highways which intersect with a through highway or at a stop intersection so designated by the Department with reference to State–designated highways or local authorities with reference to highways under their jurisdiction. The R1–1 sign is also authorized for use in work zones involving one–lane, two–way roadways. At intersections where all approaches are controlled by an R1–1 sign, a supplemental plaque (R1–3 or R1–4) shall be mounted below each R1–1 sign.

(b) Authorization. Before local authorities designate any highway as a through highway or stop intersection which will intersect or affect a State–designated highway, approval of such designation shall first be obtained from the Department. Approval to install R1–1 signs in work areas shall not require the approval of the Department or local authorities when the conditions stipulated in Publication 203M (relating to work zone traffic control) are satisfied.

(c) Size. The standard size R1–1 sign shall be 750 mm by 750 mm (30" x 30"); however, on low–speed minor roads and secondary streets, a 600 mm by 600 mm (24" x 24") sign may be used.



DIMENSIONS – mm (IN)					
SIGN SIZE A x A	B	C	D	BOR–DER	BLANK STD.
600 x 600 (24" x 24")	200 (8)	200C (8C)	254 (10)	15 (0.6)	B1–600 (B1–24)
750 x 750 (30" x 30")	250 (10)	250C (10C)	318 (12.6)	20 (0.8)	B1–750 (B1–30)
900 x 900 (36" x 36")	300 (12)	300C (12C)	381 (15)	20 (0.8)	B1–900 (B1–36)
1200 x 1200 (48" x 48")	400 (16)	400C (16C)	508 (20)	30 (1.2)	B1–1200 (B1–48)

* REDUCE SPACING 40%

COLOR:

LEGEND AND BORDER:
WHITE (REFLECTORIZED)

BACKGROUND:
RED (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

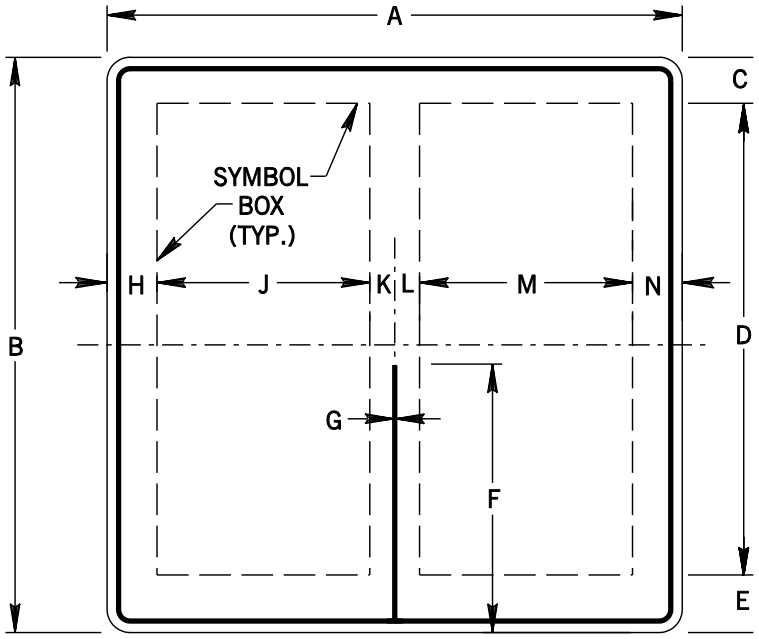
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

R3–8A

LANE USE CONTROL (TWO LANES) SIGN

The Lane Use Control (Two Lanes) Sign (R3–8A) may be used on a two–lane approach to an intersection. The R3–8A sign can be designed using appropriate lane use symbols to depict actual site conditions. Symbol combinations which are not listed below are also acceptable.

When used, the R3–8A sign should be mounted an adequate distance in advance of the intersection to allow the motorist time to select the appropriate lane before reaching the intersection. The R3–8A sign may also be placed at the intersection or as a supplement to other lane use control signs.



DIMENSIONS – mm (IN)														
SIGN SIZE A x B (SYM. COMB.)	C	D	E	F	G	H	J	K	L	M	N	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30") (L–S, S–R, L–R)	60 (2.4)	615 (24.6)	75 (3)	350 (14)	20 (0.8)	65 (2.6)	278 (10.9)	32 (1.5)	32 (1.5)	278 (10.9)	65 (2.6)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
750 x 750 (30" x 30") (L–LS, L–SR, S–SR)	60 (2.4)	615 (24.6)	75 (3)	350 (14)	20 (0.8)	47 (2.1)	278 (10.9)	20 (0.8)	0 (0)	370 (14.8)	35 (1.4)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
750 x 750 (30" x 30") (LS–R, SR–R)	60 (2.4)	615 (24.6)	75 (3)	350 (14)	20 (0.8)	35 (1.4)	370 (14.8)	0 (0)	20 (0.8)	278 (10.9)	47 (2.1)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
900 x 750 (36" x 30") (UL–L)	60 (2.4)	615 (24.6)	75 (3)	350 (14)	20 (0.8)	70 (2.8)	370 (14.8)	55 (2.2)	55 (2.2)	278 (10.9)	72 (3.1)	10 (0.4)	20 (0.8)	B5–900750 (B5–3630)
900 x 750 (36" x 30") (L–LSR)	60 (2.4)	615 (24.6)	75 (3)	350 (14)	20 (0.8)	65 (2.6)	278 (10.9)	42 (1.9)	0 (0)	450 (18)	65 (2.6)	10 (0.4)	20 (0.8)	B5–900750 (B5–3630)

COLOR:

LEGEND, ARROWS AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
WHITE (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

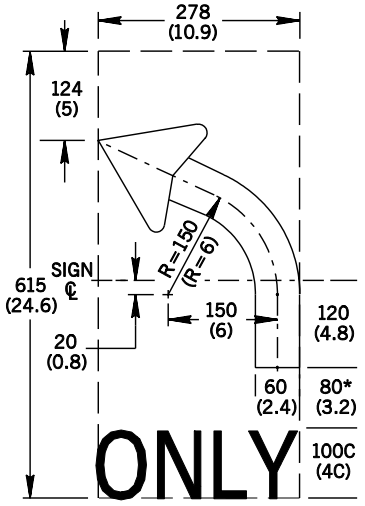
By : Glen C Rowe Date : 01–03–06

Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

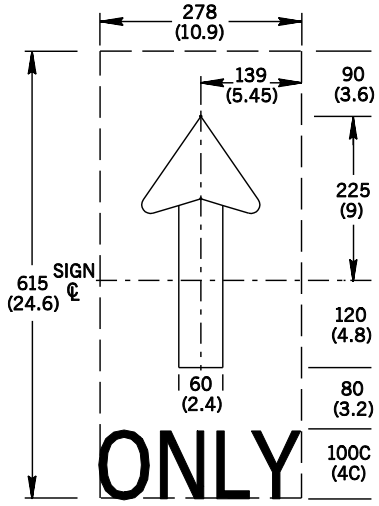
R3_8A.DGN

R3–8A

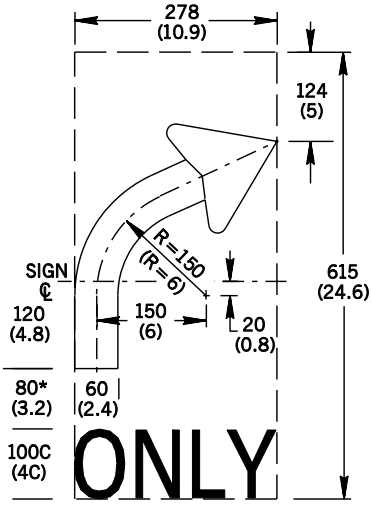
LANE USE CONTROL (TWO LANES) SIGN



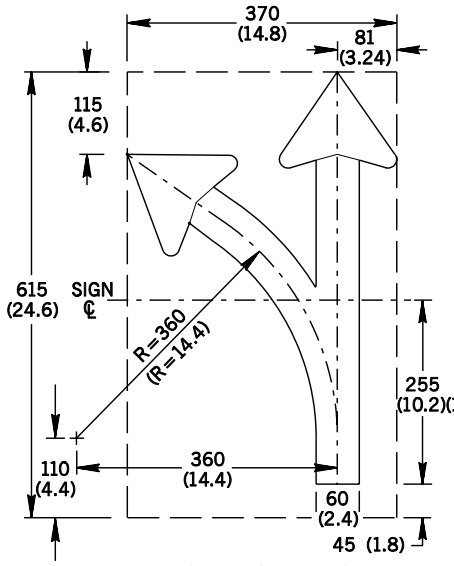
SYMBOL – L



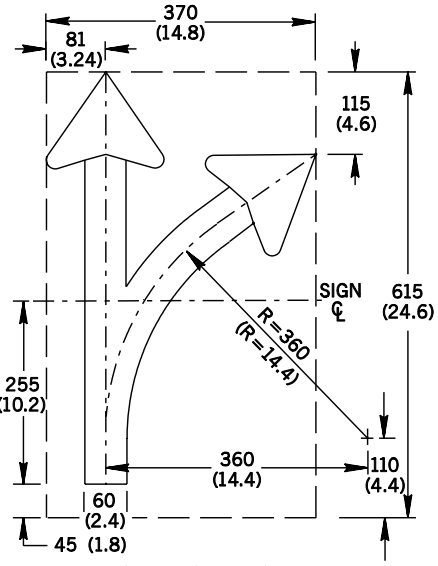
SYMBOL – S



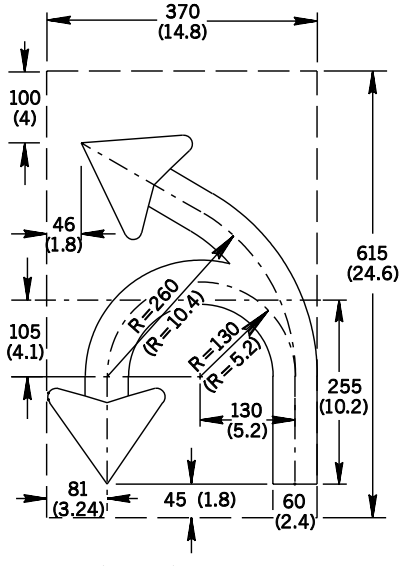
SYMBOL – R



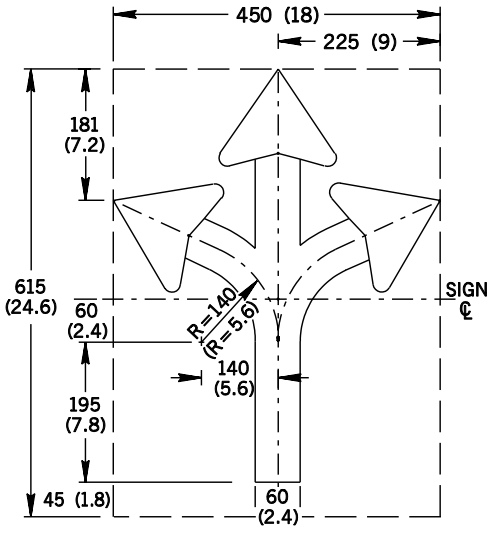
SYMBOL – LS



SYMBOL – SR



SYMBOL – UL



SYMBOL – LSR

* LOCATE ARROW 30 mm (1.2") ABOVE LEGEND "ONLY" WHEN SYMBOL–L OR SYMBOL–R IS USED WITH SYMBOL–LSR

NOTES:

1. ALL DIMENSIONS ARE IN mm (IN).
2. SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD.

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

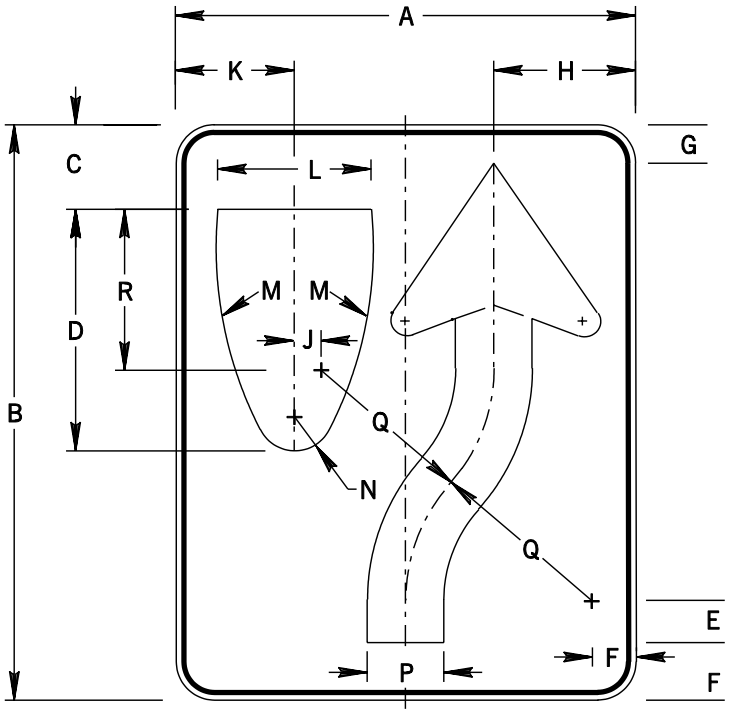
R3_8A.DGN

R4–7

KEEP RIGHT SIGN

The Keep Right Sign (R4–7) may be used at the ends of medians, parkways, loading islands, and refuge islands, at traffic islands and at underpass piers, where traffic is required to keep to the right of such obstructions. The R4–7 sign may not always be necessary at intermediate ends of divisional islands and medians and should not be used with other signs that obviously mark locations where motorists know they must pass on the right.

The standard size of the R4–7 sign is 600 mm by 750 mm (24" x 30"), except on expressways the standard size is 900 mm by 1200 mm (36" x 48"). It may also be desirable to install a Object Marker (OM1–3) on the same sign post with the top of the marker at an appropriate 1.2 m (4') height.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)			
SIGN SIZE A x B	MAR–GIN	BOR–DER	BLANK STD.
600 x 750 (24" x 30")	10 (0.4)	15 (0.6)	B5–750600 (B5–3024)
900 x 1200 (36" x 48")	15 (0.6)	20 (0.8)	B5–1200900 (B5–4836)
1200 x 1500 (48" x 60")	20 (0.8)	25 (1)	B5–15001200 (B5–6048)

DIMENSIONS – mm (IN)														
SIGN SIZE A x B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R
600 x 750 (24" x 30")	110 (4.4)	315 (12.6)	55 (2.2)	75 (3)	50 (2)	185 (7.4)	35 (1.4)	155 (6.2)	200 (8)	750 (30)	50 (2)	100 (4)	225 (9)	210 (8.4)
900 x 1200 (36" x 48")	170 (6.8)	470 (18.8)	125 (5)	110 (4.4)	70 (2.8)	280 (11.2)	45 (1.8)	235 (9.4)	300 (12)	1125 (45)	75 (3)	150 (6)	340 (13.6)	345 (13.8)
1200 x 1500 (48" x 60")	225 (9)	625 (25)	115 (4.6)	150 (6)	95 (3.8)	370 (14.8)	70 (2.8)	310 (12.4)	400 (16)	1500 (60)	100 (4)	200 (8)	450 (18)	409 (16.4)

COLOR:

LEGEND, ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
WHITE (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

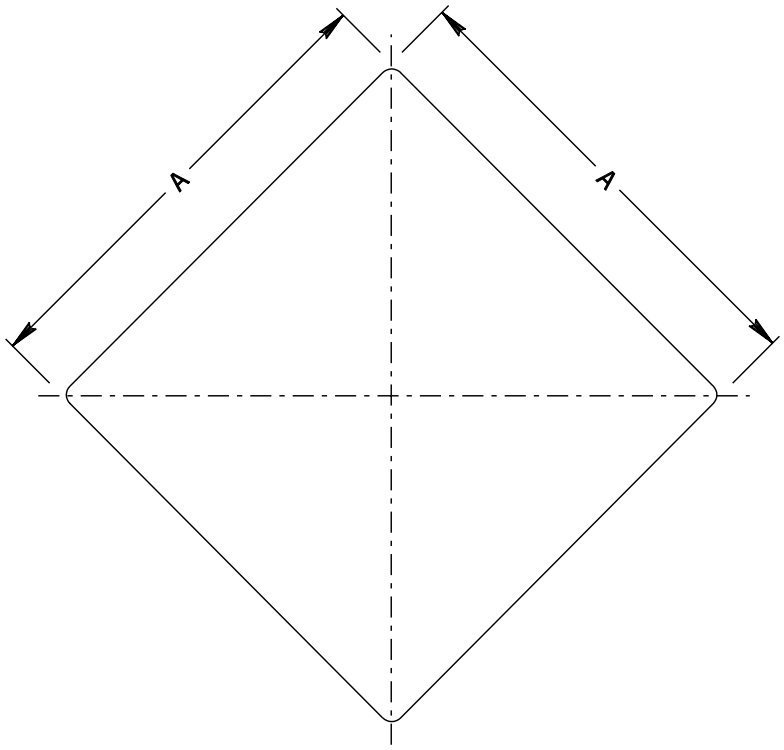
R4_7.DGN

OM1–3

OBJECT MARKER

The Object Marker (OM1–3) shall be authorized for use to mark obstructions located within the roadway such as bridge piers, and the approach end of islands. This marker may be posted with other signs where appropriate.

The OM1–3 marker is a 450 mm by 450 mm (18" x 18") yellow reflectorized blank.



DIMENSIONS – mm (IN)	
SIGN SIZE A x A	BLANK STD.
450 x 450 (18" x 18")	B3–450 (B3–18)

COLOR:

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

OM1_3.DGN

A-6

Street Name Sign
(PennDOT Publication 236M, D3-1)

Single-Line Advance Street Name Sign
(PennDOT Publication 236M, D3-2)

Double-Line Advance Street Name Sign
(PennDOT Publication 236M, D3-3)

D3–1

STREET NAME SIGN

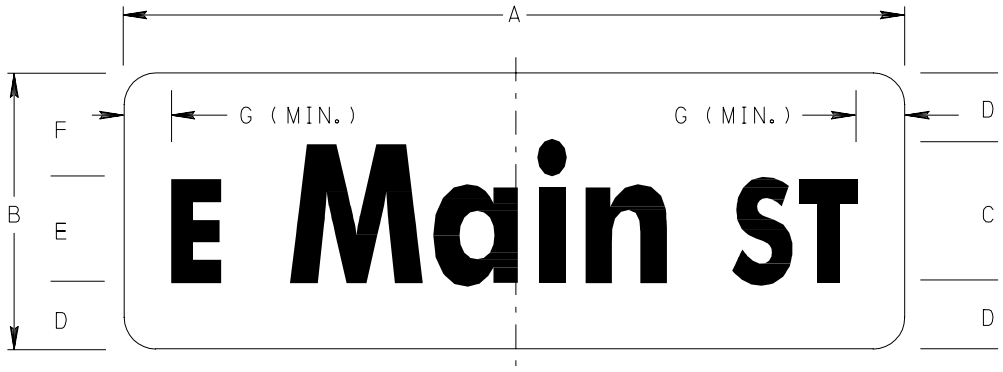
The Street Name Sign (D3–1) shall be authorized for use as a post–mounted sign to identify names of streets for motorists and pedestrians. The D3–1 sign, or other official type of street name sign, should be placed at all street intersections regardless of other route marking that may be present.

When the D3–1 signs are used in business districts, they should be placed at least on the diagonally opposite corners so that they will be on the far right–hand side of the intersection for traffic on the more important street. Signs naming both streets should be erected at each location. They should be mounted with their faces parallel to the streets they name, as close to the corner as practical with the nearest part of the each sign not less than 0.3 m (1'), and preferably 0.6 m (2'), back from both curb lines.

In residential districts, D3–1 signs should be mounted as in business districts, but a single location at each intersection shall ordinarily suffice on all but the most important thoroughfares.

The standard for street name lettering shall be 150 mm (6") high upper/lower–case letters. The overall width of the sign is variable. Except when necessary to avoid confusion, suffixes such as "ST", "DR", and "RD", or sections of the city such as "NW" should not be used. When used, this supplemental lettering may be in smaller lettering, at least 100 mm (4") high. For roads functionally classified as local with speed limits of 40km/h (25mph) or less, the lettering may be 100 mm (4") high upper and lower case letters.

The street name sign should be reflectorized or illuminated and should have a white legend on a green background or other contrasting colors as approved by the Department.



DIMENSIONS – mm (IN)					
SIGN SIZE A x B	C	D	E	F	G
VAR. x 150 (VAR. x 6")	100* (4*)	25 (1)	75* (3*)	50 (2)	25 (1)
VAR. x 200 (VAR. x 8")	150* (6*)	25 (1)	100* (4*)	75 (3)	35 (1.4)

* CHOOSE UPPER / LOWER CASE CLEARVIEWHWY FONT FOR BEST FIT

NOTE:
WHEN DESCENDING LOWER–CASE LEGEND (e.g., g, j, p, q AND y) CANNOT BE ACCOMMODATED ON A STANDARD SIZE 6" OR 8" SIGN BLANK; THE HEIGHT OF THE BLANK SHOULD BE INCREASED BY 2" TO ACCOMMODATE THESE LETTERS.

COLOR:

LEGEND:
WHITE (REFLECTORIZED)

BACKGROUND:
GREEN (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 06–30–08
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

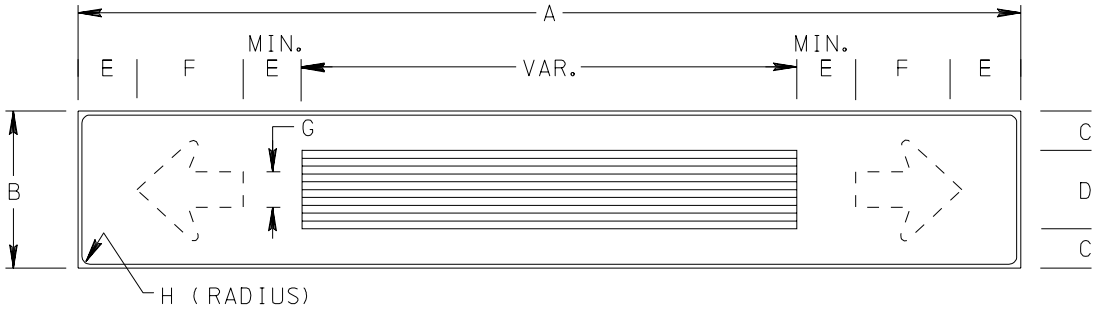
D3_1.DGN

D3–2

SINGLE–LINE ADVANCE STREET NAME SIGN

(a) Justification. The Single–Line Advance Street Name Sign (D3–2) shall be authorized for use in advance of an intersection to identify the name of the intersecting street. A single arrow may be used if the name only applies in one direction.

(b) Size. The standard size of D3–2 sign shall be 1200 mm by 200 mm (48" x 8").



NOTE:

SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)								
SIGN SIZE A x B	C	D	E	F	G	H	BOR–DER	BLANK STD.
1200 x 200 (48" x 8")	50 (2)	100* (4)	75 (3)	135 (5.4)	45 (1.8)	10 (0.4)	12 (0.5)	___
1800 x 300 (72" x 12")	75 (3)	150* (6)	100 (4)	205 (8.2)	70* (2.8)	20 (0.8)	15 (0.6)	___

*CHOOSE UPPER/LOWER CASE ClearviewHwy FONT FOR BEST FIT

COLOR:

LEGEND AND BORDER:
WHITE (REFLECTORIZED)

BACKGROUND:
GREEN (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

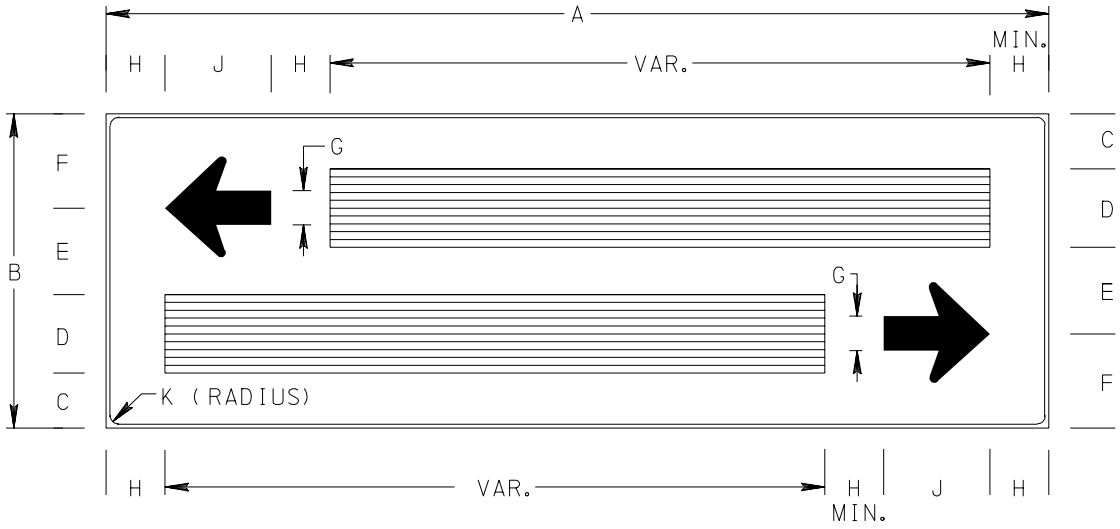
By : Glen C Rowe Date : 06–30–08
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

D3–3

DOUBLE–LINE ADVANCE STREET NAME SIGN

(a) Justification. The Double–Line Advance Street Name Sign (D3–3) shall be authorized for use in advance of an intersection to identify the names of the intersecting streets.

(b) Size. The standard size of D3–3 sign shall be 1200 mm by 400 mm (48" x 16").



NOTE:

SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)										
SIGN SIZE A x B	C	D	E	F	G	H	J	K	BOR–DER	BLANK STD.
1200 x 400 (48" x 16")	70 (2.8)	100* (4)	110 (4.4)	120 (4.8)	45 (1.8)	75 (3)	135 (5.4)	10 (0.4)	10 (0.4)	___
1800 x 600 (72" x 24")	110 (4.4)	150* (6)	155 (6.2)	185 (7.4)	70 (2.8)	100 (4)	205 (8.2)	20 (0.8)	15 (0.6)	___

* CHOOSE UPPER/LOWER CASE ClearviewHwy FONT FOR BEST FIT

COLOR:

LEGEND AND BORDER:
WHITE (REFLECTORIZED)

BACKGROUND:
GREEN (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 06–30–08
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

A-7

Retroreflectivity
(PennDOT Publication 46, Section 2.1)

Retroreflectivity and Illumination
(2009 Manual on Uniform Traffic Control Devices, Sections 2A.07 and 2A.08)

New MUTCD Sign Retroreflectivity Requirements
(Federal Highway Administration, FHWA-SA-07-020)

Retroreflectorization
(PennDOT Publication 212, Section 212.104)

Sign Nomenclature

The *MUTCD* assigns a unique nomenclature to all common types of traffic signs. PennDOT uses the nomenclature in the *MUTCD*, but like other states, PennDOT also has some additional traffic signs that they have approved for unique applications, and for which they have assigned their own nomenclature. The first letter in sign nomenclature conforms to the following:

- Regulatory signs – R.
- Warning signs – W, except school signs start with the letter S.
- Guide signs – a variety of letters, but most commonly D, G, I, or M.

Sign names used in this manual may look awkward because some are in all capital letters while others are in title case. This mix of styles is common because the *MUTCD* and most other sign manuals generally use the following practice:

1. Uppercase legends (capitals) for sign names when the sign name and the sign legend message are the same (e.g., STOP, YIELD, and DO NOT ENTER signs).

2. Title case for symbol signs and whenever the sign name and sign message are not the same (e.g., Speed Limit, Turn, and Intersection signs).

What is Retroreflectivity?

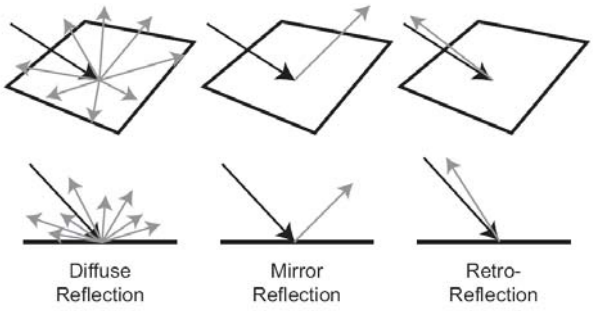
The *MUTCD* requires traffic signs to be either retroreflective or illuminated to show the same shape and color both day and night. Since it is more cost effective to make signs retroreflective than it is to illuminate them, PennDOT requires retroreflective sheeting material on all signs.

Most objects reflect light. The most common type of reflection is “diffuse reflection” where light scatters after striking rough surfaces such as trees, clothing and carpet. Only a very small amount of the diffused light reflects back toward the light source.

Another type of reflection is “mirror reflection” that occurs when light strikes smooth or glossy surfaces, and the light reflects off the surface at an equal but opposite angle. Mirror reflection frequently occurs at night on wet roads when the headlights of approaching vehicles create extensive glare. Sign faces also produce some mirror reflection due to their glossy surfaces, and for this reason; it is a good practice to rotate signs away from the driver.

In contrast, “retroreflection” (see Exhibit 2.1-A) is the unique ability of a surface to reflect light back toward the light source, and “retroreflectivity” is the measurable property of a material to redirect light back to its source.

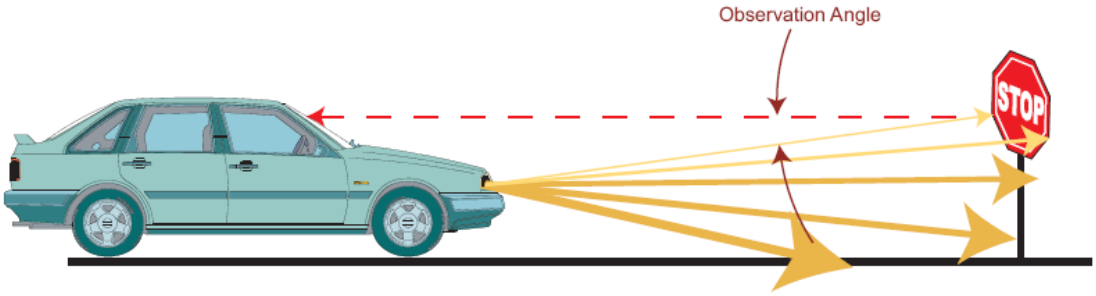
Exhibit 2.1-A Types of Retroreflection



Retroreflective Sheeting Materials

To make signs retroreflective, sign manufacturers apply retroreflective sheeting, which contains either microscopic glass beads or cube corner reflectors, to the face of each sign. If the sheeting manufacturers could make all glass beads and cube corner reflectors perfectly shaped, all reflected light would return directly to the light source (headlights). Although retroreflective sheeting does not have perfectly shaped lenses, drivers do see more reflected light the closer their eyes are to the headlights. As illustrated in Exhibit 2.1-B, the angle formed between the headlights, the sign and the driver's eyes is the observation angle, and the smaller the angle the higher the retroreflectivity.

Exhibit 2.1-B Graphic Illustration of the Observation Angle



Retroreflective materials are also more efficient when the light source is approximately perpendicular to the sign face; therefore, it is important to have signs oriented to face approaching traffic.

The ability to see traffic signs at night is a function of the following:

- Driver's night vision.
- Intensity and light distribution of the headlights.

- Distance, mounting height, and orientation of the sign in relation to the vehicle's headlights.
- Location of driver's eyes with respect to the headlights.
- Type, color and age of the retroreflective material.

Why is Retroreflectivity Important?

The nighttime visibility of signs and pavement markings is essential for highway safety. National studies show that 50 percent or more of all fatal crashes occur at night despite lower travel volumes. In fact, the average fatality rate (fatalities per 100 million vehicle-miles of travel) is about three times higher during the night than during the day.

Some of the factors that contribute to higher nighttime crash rates include:

- After age 20, the human eye needs about twice as much light approximately every 13 years in order to read. For example, compared to a 20-year old driver, a 33-year old driver needs twice as much light, a 46-year old driver needs four times as much light, a 59-year old driver needs eight times as much light, and a 72-year old driver needs 16 times as much light.
- The number of visual clues that delineate the roadway alignment are reduced at night.
- Glare from opposing traffic further reduces the number of visual clues.
- Rain, snow, fog, dew and frost reduce visibility distances.
- There are more intoxicated and sleepy drivers.

Some traffic signs may look almost new during the day but are completely ineffective at night. This nighttime visibility problem is usually a function of the type and age of the retroreflective material.

Initially, only one type of retroreflective sheeting material was available, but as technology developed, brighter and more durable materials became available. Exhibit 2.1-C shows eight types of retroreflective materials currently manufactured for permanent-type signs, and new more-efficient types are rapidly evolving. Please note that Types V and VI sheeting are not included because they are not for permanent signs (Type V sheeting is for delineation and Type VI sheeting is for temporary roll-up signs).

Exhibit 2.1-C Retroreflective Materials for Permanent Signs

Type Retroreflective Material*	Common Name	Life Expectancy (years)	General Comments
I	Engineering Grade	7	These two types of materials are no longer approved for use
II	Super-Engineering Grade	7-10	
III	High-Intensity Grade	10+	Encapsulated lens or microprismatic materials
IV	High-Performance Grade	10+	Microprismatic materials
VII, VIII, IX & X	Super-High Intensity or Very High Intensity Grades	12+	Microprismatic materials

When is Sign Lighting Required?

In 1993, PennDOT started using Type III or higher type retroreflective sheeting for all new traffic signs. Because the Department has elected to use higher types of retroreflective sheeting materials, the need for sign lighting should be minimal. In general, consider sign lighting only for overhead freeway signs as discussed in Section 2.12.8.

2.1.4 Minimum Retroreflectivity

In 1993, Congress directed the U.S. Secretary of Transportation to include minimum retroreflectivity values for traffic signs in the *MUTCD*. Following extensive research and public input, FHWA adopted minimum retroreflectivity values for most traffic signs on December 21, 2007, and incorporated them into the *MUTCD* (Revision 2 of the 2003 Edition). Specifically, Section 2A-09 and Table 2A-1 of the *MUTCD* contain the new criteria. Table 2A-1 is included herein as Exhibit 2.1-D.

The Department discontinued using Type I (Engineering Grade) and Type II (Super Engineering Grade) materials in 1993, but most local authorities continued using these materials. However, in 2004, the Department canceled the approvals of all Type I and Type II materials because: (1) the Department was aware of the on-going research; and (2) the fact that the higher grade materials were more cost effective then the cheaper materials. Therefore, no one should be using Type I or Type II materials on any public highway within the Commonwealth.

Exhibit 2.1-D Minimum Maintained Retroreflectivity Levels

Sign Color	Sheeting Type (ASTM D4956-04)				Additional Criteria
	Beaded Sheeting			Prismatic Sheeting	
	I	II	III	III, IV, VI, VII, VIII, IX, X	
White on Green	W*; G ≥ 7	W*; G ≥ 15	W*; G ≥ 25	W ≥ 250; G ≥ 25	Overhead
	W*; G ≥ 7	W ≥ 120; G ≥ 15			Ground-mounted
Black on Yellow or Black on Orange	Y*; O*	Y ≥ 50; O ≥ 50			②
	Y*; O*	Y ≥ 75; O ≥ 75			③
White on Red	W ≥ 35; R ≥ 7				④
Black on White	W ≥ 50				–

① The minimum maintained retroreflectivity levels shown in this table are in units of cd/lx/m² measured at an observation angle of 0.2° and an entrance angle of -4.0°.
② For text and fine symbol signs measuring at least 1200 mm (48 in) and for all sizes of bold symbol signs
③ For text and fine symbol signs measuring less than 1200 mm (48 in)
④ Minimum Sign Contrast Ratio ≥ 3:1 (white retroreflectivity ÷ red retroreflectivity)
* This sheeting type should not be used for this color for this application.

Bold Symbol Signs

- W1-1, -2 – Turn and Curve
- W1-3, -4 – Reverse Turn and Curve
- W1-5 – Winding Road
- W1-6, -7 – Large Arrow
- W1-8 – Chevron
- W1-10 – Intersection in Curve
- W1-11 – Hairpin Curve
- W1-15 – 270 Degree Loop
- W2-1 – Cross Road
- W2-2, -3 – Side Road
- W2-4, -5 – T and Y Intersection
- W2-6 – Circular Intersection
- W3-1 – Stop Ahead
- W3-2 – Yield Ahead
- W3-3 – Signal Ahead
- W4-1 – Merge
- W4-2 – Lane Ends
- W4-3 – Added Lane
- W4-5 – Entering Roadway Merge
- W4-6 – Entering Roadway Added Lane
- W6-1, -2 – Divided Highway Begins and Ends
- W6-3 – Two-Way Traffic
- W10-1, -2, -3, -4, -11, -12 – Highway-Railroad Advance Warning
- W11-2 – Pedestrian Crossing
- W11-3 – Deer Crossing
- W11-4 – Cattle Crossing
- W11-5 – Farm Equipment
- W11-6 – Snowmobile Crossing
- W11-7 – Equestrian Crossing
- W11-8 – Fire Station
- W11-10 – Truck Crossing
- W12-1 – Double Arrow
- W16-5p, -6p, -7p – Pointing Arrow Plaques
- W20-7a – Flagger
- W21-1a – Worker

Fine Symbol Signs – Symbol signs not listed as Bold Symbol Signs.

Special Cases

- W3-1 – Stop Ahead: Red retroreflectivity ≥ 7
- W3-2 – Yield Ahead: Red retroreflectivity ≥ 7; White retroreflectivity ≥ 35
- W3-3 – Signal Ahead: Red retroreflectivity ≥ 7; Green retroreflectivity ≥ 7
- W3-5 – Speed Reduction: White retroreflectivity ≥ 50
- For non-diamond shaped signs such W14-3 (No Passing Zone), W4-4p (Cross Traffic Does Not Stop), or W13-1, -2, -3, -5 (Speed Advisory Plaques), use largest sign dimension to determine proper minimum retroreflectivity level.

NOTE: Type I and II materials both have a uniform appearance similar to metallic paint, whereas all Type III, IV, VII, VIII, IX and X materials have a pattern of hexagons, diamonds or circular shapes measuring about one-eighth inch across. Therefore, it is easy to recognize the inferior Type I and Type II materials. FHWA's Retroreflective Sheeting Identification Guide – September 2005 (available at http://safety.fhwa.dot.gov/roadway_dept/retro/sign/retrore_sheet_id.htm), is a handy tool to help determine the grade and manufacturer of most sheeting materials.

2.1.5 Recouping Costs Incurred from Crashes

Sign maintenance is frequently required because of highway crashes. Therefore, if the responsibility party is identified, record the vehicle information and provide it to the Reimbursable Activities Unit in the Bureau of Maintenance and Operations so that the Department can receive reimbursement from the individual or their insurance carrier.

If a logo sign is damaged, the Department should contact the Logo Signing Trust at 717-232-8880 (fax 717-232-8948).

2.1.6 Laws, Regulations, and Other Publications

Adopt-A-Highway Operational Manual. A PennDOT manual defining the procedures and types of signs available for the Adopt-A-Highway Program.

Approved Construction Materials – Bulletin 15 (Publication 35). A listing of approved materials and manufacturers, including sign materials and sign manufacturers.

Maintenance Manual (Publication 23). A manual prescribing the planning, scheduling, equipment, materials, and labor required to accomplish the Department's highway maintenance program.

Manual on Uniform Traffic Control Devices (*MUTCD*). A manual adopted by the Federal Highway Administration, and which establishes national guidelines for traffic-control devices, including signs. Specifically, Part 2 addresses traffic signs, and is available at http://mutcd.fhwa.dot.gov/pdfs/2003r1r2/pdf_index.htm.

Official Traffic-Control Devices (Publication 212). Regulations published as Chapter 212 of Title 67 of the PA Code. This regulation adopts the Federal Highway Administration's Manual on Uniform Traffic Control Devices (*MUTCD*) and establishes additional study requirements, warrants, principles and guidelines not included in the *MUTCD*. The purpose of Publication 212 is to establish greater uniformity for the design, location and operation of all official traffic signs, signals, markings, and other traffic-control devices within this Commonwealth.

Standard:

14 **Except as provided in Paragraph 16 and except for the Carpool Information (D12-2) sign (see Section 2I.11), Internet addresses and e-mail addresses, including domain names and uniform resource locators (URL), shall not be displayed on any sign, supplemental plaque, sign panel (including logo sign panels on Specific Service signs), or changeable message sign.**

Guidance:

15 *Unless otherwise provided in this Manual for a specific sign, and except as provided in Paragraph 16, telephone numbers of more than four characters should not be displayed on any sign, supplemental plaque, sign panel (including logo sign panels on Specific Service signs), or changeable message sign.*

Option:

16 Internet addresses, e-mail addresses, or telephone numbers with more than four characters may be displayed on signs, supplemental plaques, sign panels, and changeable message signs that are intended for viewing only by pedestrians, bicyclists, occupants of parked vehicles, or drivers of vehicles on low-speed roadways where engineering judgment indicates that an area is available for drivers to stop out of the traffic flow to read the message.

Standard:

17 **Pictographs (see definition in Section 1A.13) shall not be displayed on signs except as specifically provided in this Manual. Pictographs shall be simple, dignified, and devoid of any advertising. When used to represent a political jurisdiction (such as a State, county, or municipal corporation) the pictograph shall be the official designation adopted by the jurisdiction. When used to represent a college or university, the pictograph shall be the official seal adopted by the institution. Pictorial representations of university or college programs shall not be permitted to be displayed on a sign.**

Section 2A.07 Retroreflectivity and Illumination

Support:

01 There are many materials currently available for retroreflection and various methods currently available for the illumination of signs and object markers. New materials and methods continue to emerge. New materials and methods can be used as long as the signs and object markers meet the standard requirements for color, both by day and by night.

Standard:

02 **Regulatory, warning, and guide signs and object markers shall be retroreflective (see Section 2A.08) or illuminated to show the same shape and similar color by both day and night, unless otherwise provided in the text discussion in this Manual for a particular sign or group of signs.**

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

Option:

04 Sign elements may be illuminated by the means shown in Table 2A-1.

05 Retroreflection of sign elements may be accomplished by the means shown in Table 2A-2.

06 Light Emitting Diode (LED) units may be used individually within the legend or symbol of a sign and in the border of a sign, except for changeable message signs, to improve the conspicuity, increase the legibility of sign legends and borders, or provide a changeable message.

Table 2A-1. Illumination of Sign Elements

Means of Illumination	Sign Element to be Illuminated
Light behind the sign face	• Symbol or word message • Background • Symbol, word message, and background (through a translucent material)
Attached or independently mounted light source designed to direct essentially uniform illumination onto the sign face	• Entire sign face
Light emitting diodes (LEDs)	• Symbol or word message • Portions of the sign border
Other devices, or treatments that highlight the sign shape, color, or message: Luminous tubing Fiber optics Incandescent light bulbs Luminescent panels	• Symbol or word message • Entire sign face

Table 2A-2. Retroreflection of Sign Elements

Means of Retroreflection	Sign Element
Reflector “buttons” or similar units	Symbol Word message Border
A material that has a smooth, sealed outer surface over a microstructure that reflects light	Symbol Word message Border Background

Standard:

07 **Except as provided in Paragraphs 11 and 12, neither individual LEDs nor groups of LEDs shall be placed within the background area of a sign.**

08 **If used, the LEDs shall have a maximum diameter of 1/4 inch and shall be the following colors based on the type of sign:**

- **A. White or red, if used with STOP or YIELD signs.**
- **B. White, if used with regulatory signs other than STOP or YIELD signs.**
- **C. White or yellow, if used with warning signs.**
- **D. White, if used with guide signs.**
- **E. White, yellow, or orange, if used with temporary traffic control signs.**
- **F. White or yellow, if used with school area signs.**

09 **If flashed, all LED units shall flash simultaneously at a rate of more than 50 and less than 60 times per minute.**

10 **The uniformity of the sign design shall be maintained without any decrease in visibility, legibility, or driver comprehension during either daytime or nighttime conditions.**

Option:

11 For STOP and YIELD signs, LEDs may be placed within the border or within one border width within the background of the sign.

12 For STOP/SLOW paddles (see Section 6E.03) used by flaggers and the STOP paddles (see Section 7D.05) used by adult crossing guards, individual LEDs or groups of LEDs may be used.

Support:

13 Other methods of enhancing the conspicuity of standard signs are described in Section 2A.15.

14 Information regarding the use of retroreflective material on the sign support is contained in Section 2A.21.

Section 2A.08 Maintaining Minimum Retroreflectivity

Support:

01 Retroreflectivity is one of several factors associated with maintaining nighttime sign visibility (see Section 2A.22).

Standard:

02 **Public agencies or officials having jurisdiction shall use an assessment or management method that is designed to maintain sign retroreflectivity at or above the minimum levels in Table 2A-3.**

Support:

03 Compliance with the Standard in Paragraph 2 is achieved by having a method in place and using the method to maintain the minimum levels established in Table 2A-3. Provided that an assessment or management method is being used, an agency or official having jurisdiction would be in compliance with the Standard in Paragraph 2 even if there are some individual signs that do not meet the minimum retroreflectivity levels at a particular point in time.

Guidance:

04 *Except for those signs specifically identified in Paragraph 6, one or more of the following assessment or management methods should be used to maintain sign retroreflectivity:*

- *A. Visual Nighttime Inspection—The retroreflectivity of an existing sign is assessed by a trained sign inspector conducting a visual inspection from a moving vehicle during nighttime conditions. Signs that are visually identified by the inspector to have retroreflectivity below the minimum levels should be replaced.*
- *B. Measured Sign Retroreflectivity—Sign retroreflectivity is measured using a retroreflectometer. Signs with retroreflectivity below the minimum levels should be replaced.*
- *C. Expected Sign Life—When signs are installed, the installation date is labeled or recorded so that the age of a sign is known. The age of the sign is compared to the expected sign life. The expected sign life is based on the experience of sign retroreflectivity degradation in a geographic area compared to the minimum levels. Signs older than the expected life should be replaced.*
- *D. Blanket Replacement—All signs in an area/corridor, or of a given type, should be replaced at specified intervals. This eliminates the need to assess retroreflectivity or track the life of individual signs. The replacement interval is based on the expected sign life, compared to the minimum levels, for the shortest-life material used on the affected signs.*

Table 2A-3. Minimum Maintained Retroreflectivity Levels[1]

Sign Color	Sheeting Type (ASTM D4956-04)				Additional Criteria
	Beaded Sheeting			Prismatic Sheeting	
	I	II	III	III, IV, VI, VII, VIII, IX, X	
White on Green	W*; G ≥ 7	W*; G ≥ 15	W*; G ≥ 25	W ≥ 250; G ≥ 25	Overhead
	W*; G ≥ 7	W ≥ 120; G ≥ 15			Post-mounted
Black on Yellow or Black on Orange	Y*; O*	Y ≥ 50; O ≥ 50			[2]
	Y*; O*	Y ≥ 75; O ≥ 75			[3]
White on Red	W ≥ 35; R ≥ 7				[4]
Black on White	W ≥ 50				–

[1] The minimum maintained retroreflectivity levels shown in this table are in units of cd/lx/m^2 measured at an observation angle of 0.2° and an entrance angle of -4.0°.
[2] For text and fine symbol signs measuring at least 48 inches and for all sizes of bold symbol signs
[3] For text and fine symbol signs measuring less than 48 inches
[4] Minimum sign contrast ratio ≥ 3:1 (white retroreflectivity ÷ red retroreflectivity)
* This sheeting type shall not be used for this color for this application.

Bold Symbol Signs

• W1-1,2 – Turn and Curve • W1-3,4 – Reverse Turn and Curve • W1-5 – Winding Road • W1-6,7 – Large Arrow • W1-8 – Chevron • W1-10 – Intersection in Curve • W1-11 – Hairpin Curve • W1-15 – 270 Degree Loop • W2-1 – Cross Road • W2-2,3 – Side Road • W2-4,5 – T and Y Intersection • W2-6 – Circular Intersection • W2-7,8 – Double Side Roads	• W3-1 – Stop Ahead • W3-2 – Yield Ahead • W3-3 – Signal Ahead • W4-1 – Merge • W4-2 – Lane Ends • W4-3 – Added Lane • W4-5 – Entering Roadway Merge • W4-6 – Entering Roadway Added Lane • W6-1,2 – Divided Highway Begins and Ends • W6-3 – Two-Way Traffic • W10-1,2,3,4,11,12 – Grade Crossing Advance Warning	• W11-2 – Pedestrian Crossing • W11-3,4,16-22 – Large Animals • W11-5 – Farm Equipment • W11-6 – Snowmobile Crossing • W11-7 – Equestrian Crossing • W11-8 – Fire Station • W11-10 – Truck Crossing • W12-1 – Double Arrow • W16-5P,6P,7P – Pointing Arrow Plaques • W20-7 – Flagger • W21-1 – Worker

Fine Symbol Signs (symbol signs not listed as bold symbol signs)

Special Cases

- W3-1 – Stop Ahead: Red retroreflectivity ≥ 7
- W3-2 – Yield Ahead: Red retroreflectivity ≥ 7; White retroreflectivity ≥ 35
- W3-3 – Signal Ahead: Red retroreflectivity ≥ 7; Green retroreflectivity ≥ 7
- W3-5 – Speed Reduction: White retroreflectivity ≥ 50
- For non-diamond shaped signs, such as W14-3 (No Passing Zone), W4-4P (Cross Traffic Does Not Stop), or W13-1P,2,3,6,7 (Speed Advisory Plaques), use the largest sign dimension to determine the proper minimum retroreflectivity level.

E. Control Signs—Replacement of signs in the field is based on the performance of a sample of control signs. The control signs might be a small sample located in a maintenance yard or a sample of signs in the field. The control signs are monitored to determine the end of retroreflective life for the associated signs. All field signs represented by the control sample should be replaced before the retroreflectivity levels of the control sample reach the minimum levels.

F. Other Methods—Other methods developed based on engineering studies can be used.

Support:

05 Additional information about these methods is contained in the 2007 Edition of FHWA's "Maintaining Traffic Sign Retroreflectivity" (see Section 1A.11).

Option:

06 Highway agencies may exclude the following signs from the retroreflectivity maintenance guidelines described in this Section:

A. Parking, Standing, and Stopping signs (R7 and R8 series)
B. Walking/Hitchhiking/Crossing signs (R9 series, R10-1 through R10-4b)
C. Acknowledgment signs
D. All signs with blue or brown backgrounds
E. Bikeway signs that are intended for exclusive use by bicyclists or pedestrians

NEW MUTCD SIGN RETROREFLECTIVITY REQUIREMENTS

U.S. Department of Transportation
Federal Highway Administration

Maintaining Traffic Sign Retroreflectivity *FHWA-SA-07-020*

Traffic signs provide important information to drivers at all times, both day and night. To be effective, their visibility must be maintained. The 2003 *Manual on Uniform Traffic Control Devices* (MUTCD) addresses sign visibility in several places, including Sections 1A.03, 1A.04, 1A.05, 2A.06, 2A.08, and 2A.22. These sections address factors such as uniformity, design, placement, operation, and maintenance. Previously, the MUTCD did not specify minimum retroreflectivity levels.

The second revision of the 2003 MUTCD introduces new language establishing minimum retroreflectivity levels that must be maintained for traffic signs. **Agencies have until January 2012, to establish and implement a sign assessment or management method to maintain minimum levels of sign retroreflectivity.** The compliance date for regulatory, warning, and ground-mounted guide signs is January 2015. For overhead guide signs and street name signs, the compliance date is January 2018. The new MUTCD language is shown on page 2 and 3 of this document.

The new standard in Section 2A.09 requires that agencies maintain traffic signs to a minimum level of retroreflectivity outlined in Table 2A-3 of the MUTCD. The Federal Highway Administration (FHWA) believes that this proposed change will promote safety while providing sufficient flexibility for agencies to choose a maintenance method that best matches their specific conditions.

Including Table 2A-3 in the MUTCD does not imply that an agency must measure the retroreflectivity of every sign. Rather, the new MUTCD language describes five methods that agencies can use to maintain traffic sign retroreflectivity at or above the minimum levels. Agencies can choose from these methods or combine them. Agencies are allowed to develop other appropriate methods based on engineering studies. However, agencies should adopt a consistent method that produces results that correspond to the values in Table 2A-3.

The new MUTCD language recognizes that there may be some individual signs that do not meet the minimum retroreflectivity levels at a particular point in time. As long as the agency with jurisdiction is maintaining signs in accordance with Section 2A.09 of the MUTCD, the agency will be considered to be in compliance. This document describes methods that can be used to maintain sign retroreflectivity at or above the MUTCD's minimum maintained retroreflectivity levels.

RETROREFLECTIVITY MAINTENANCE

The MUTCD describes two basic types of methods that agencies can use to maintain sign retroreflectivity at or above the MUTCD minimum maintained retroreflectivity levels — assessment methods and management methods. The FHWA has identified and listed assessment and management methods for maintaining sign retroreflectivity in accordance with Section 2A.09. These methods are described on page four. A full report on these methods can be found at *www.fhwa.dot.gov/retro*.

New MUTCD Minimum Retroreflectivity Compliance Periods

- Four years for implementation and continued use of an assessment or management method that is designed to maintain traffic sign retroreflectivity at or above the established minimum levels;
- Seven years for replacement of regulatory, warning, and ground-mounted guide (except street name) signs that are identified using the assessment or management methods as failing to meet the established minimum levels; and
- Ten years for replacement of street name signs and overhead guide signs that are identified using the assessment or management method as failing to meet the established minimum levels.

New MUTCD Section 2A.09 Maintaining Minimum Retroreflectivity

Support:
Retroreflectivity is one of several factors associated with maintaining nighttime sign visibility (see Section 2A.22).

Standard:
Public agencies or officials having jurisdiction shall use an assessment or management method that is designed to maintain sign retroreflectivity at or above the minimum levels in Table 2A-3.

Support:
Compliance with the above Standard is achieved by having a method in place and using the method to maintain the minimum levels established in Table 2A-3. Provided that an assessment or management method is being used, an agency or official having jurisdiction would be in compliance with the above Standard even if there are some individual signs that do not meet the minimum retroreflectivity levels at a particular point in time.

Guidance:
Except for those signs specifically identified in the Option portion of this Section, one or more of the following assessment or management methods should be used to maintain sign retroreflectivity:

A. **Visual Nighttime Inspection** – The retroreflectivity of an existing sign is assessed by a trained sign inspector conducting a visual inspection from a moving vehicle during nighttime conditions. Signs that are visually identified by the inspector to have retroreflectivity below the minimum levels should be replaced.

B. **Measured Sign Retroreflectivity** – Retroreflectivity is measured using a retroreflectometer. Signs with retroreflectivity below the minimum levels should be replaced.

C. **Expected Sign Life** – When signs are installed, the installation date is labeled or recorded so that the age of a sign is known. The age of the sign is compared to the expected sign life. The expected sign life is based on the experience of sign retroreflectivity degradation in a geographic area compared to the minimum levels. Signs older than the expected life should be replaced.

D. **Blanket Replacement** – All signs in an area/corridor, or of a given type, should be replaced at specified intervals. This eliminates the need to assess retroreflectivity or track the life of individual signs. The replacement interval is based on the expected sign life, compared to the minimum levels, for the shortest-life material used on the affected signs.

E. **Control Signs** – Replacement of signs in the field is based on the performance of a sample of control signs. The control signs might be a small sample located in a maintenance yard or a sample of signs in the field. The control signs are monitored to determine the end of retroreflective life for the associated signs. All field signs represented by the control sample should be replaced before the retroreflectivity levels of the control sample reach the minimum levels.

F. **Other Methods** – Other methods developed based on engineering studies can be used.

Support:
Additional information about these methods is contained in the 2007 Edition of FHWA's *"Maintaining Traffic Sign Retroreflectivity"* (see Section 1A.11).

Option:
Highway agencies may exclude the following signs from the retroreflectivity maintenance guidelines described in this Section:

A. Parking, Standing, and Stopping signs (R7 and R8 series)
B. Walking/Hitchhiking/Crossing signs (R9 series, R10-1 through R10-4b)
C. Adopt-A-Highway signs
D. All signs with blue or brown backgrounds
E. Bikeway signs that are intended for exclusive use by bicyclists or pedestrians

New MUTCD Table 2A-3. Minimum Maintained Retroreflectivity Levels ①

SIGN COLOR	SHEETING TYPE (ASTM D4956-04)				ADDITIONAL CRITERIA
	Beaded Sheeting			Prismatic Sheeting	
	I	II	III	III, IV, VI, VII, VIII, IX, X	
White on Green	W*; G ≥ 7	W*; G ≥ 15	W*; G ≥ 25	W ≥ 250; G ≥ 25	Overhead
	W*; G ≥ 7	W ≥ 120; G ≥ 15			Ground-mounted
Black on Yellow or Black on Orange	Y*; O*	Y ≥ 50; O ≥ 50			②
	Y*; O*	Y ≥ 75; O ≥ 75			③
White on Red	W ≥ 35; R ≥ 7				④
Black on White	W ≥ 50				—

① The minimum maintained retroreflectivity levels shown in this table are in units of cd/lx/m^2 measured at an observation angle of 0.2° and an entrance angle of -4.0°.
② For text and fine symbol signs measuring at least 1200 mm (48 in) and for all sizes of bold symbol signs
③ For text and fine symbol signs measuring less than 1200 mm (48 in)
④ Minimum Sign Contrast Ratio ≥ 3:1 (white retroreflectivity ÷ red retroreflectivity)
* This sheeting type should not be used for this color for this application.

BOLD SYMBOL SIGNS

- W1-1, -2 – Turn and Curve
- W1-3, -4 – Reverse Turn and Curve
- W1-5 – Winding Road
- W1-6, -7 – Large Arrow
- W1-8 – Chevron
- W1-10 – Intersection in Curve
- W1-15 – 270 Degree Loop
- W2-1 – Cross Road
- W2-2, -3 – Side Road
- W2-4, -5 – T and Y Intersection
- W2-6 – Circular Intersection
- W3-1 – Stop Ahead
- W3-2 – Yield Ahead
- W3-3 – Signal Ahead
- W4-1 – Merge
- W4-2 – Lane Ends
- W4-3 – Added Lane
- W4-6 – Entering Roadway Added Lane
- W6-1, -2 – Divided Highway Begins and Ends
- W6-3 – Two-Way Traffic
- W10-1, -2, -3, -4, -11, -12 – Highway-Railroad Advance Warning
- W11-2 – Pedestrian Crossing
- W11-3 – Deer Crossing
- W11-4 – Cattle Crossing
- W11-5 – Farm Equipment
- W11-6 – Snowmobile Crossing
- W11-7 – Equestrian Crossing
- W11-8 – Fire Station
- W11-10 – Truck Crossing
- W12-1 – Double Arrow
- W16-5p, -6p, -7p – Pointing Arrow Plaques
- W20-7a – Flagger
- W21-1a – Worker

FINE SYMBOL SIGNS – Symbol Signs Not Listed As Bold Symbol Signs

SPECIAL CASES

- W3-1 – Stop Ahead: Red retroreflectivity ≥ 7
- W3-2 – Yield Ahead: Red retroreflectivity ≥ 7; White retroreflectivity ≥ 35
- W3-3 – Signal Ahead: Red retroreflectivity ≥ 7; Green retroreflectivity ≥ 7
- W3-5 – Speed Reduction: White retroreflectivity ≥ 50
- For non-diamond shaped signs such W14-3 (No Passing Zone), W4-4p (Cross Traffic Does Not Stop), or W13-1, -2, -3, -5 (Speed Advisory Plaques), use largest sign dimension to determine proper minimum retroreflectivity level.

ASSESSMENT METHODS

Assessment methods require evaluation of individual signs within an agency's jurisdiction. There are two basic assessment methods — visual assessment and measured sign retroreflectivity.

1. VISUAL ASSESSMENT

Nighttime Inspection

In the visual nighttime inspection method, on-the-fly assessments of retroreflectivity are made by an inspector during nighttime conditions. The following recommendations provide general guidance for the inspections:

- Develop guidelines and procedures for inspectors to use in conducting the nighttime inspections and train inspectors in the use of these procedures.
- Conduct inspections at normal speed from the travel lane(s).
- Conduct inspections using low-beam headlights while minimizing interior vehicle lighting.
- Evaluate signs at typical viewing distances so that adequate time is available for an appropriate driving response.

One or more of the following procedures should be used to support visual inspections.

Calibration Signs Procedure

In this procedure, an inspector views a "calibration sign" prior to conducting the nighttime inspection described above. Calibration signs have known retroreflectivity levels at or above minimum levels. These signs are set up where the inspector can view the calibration signs in a manner similar to nighttime field inspections. The inspector uses the visual appearance of the calibration sign to establish the evaluation threshold for that night's inspection activities. The following factors provide additional information on the use of this procedure:

- Calibration signs are needed for each color of sign in Table 2A-3.
- Calibration signs are viewed at typical viewing distances using the inspection vehicle.
- Calibration signs need to be properly stored between inspections so that their retroreflectivity does not deteriorate over time.
- Calibration sign retroreflectivity should be verified periodically.

Comparison Panels Procedure

Comparison panels are used to assess signs that have marginal retroreflectivity. The comparison panels are fabricated at retroreflectivity levels at or above the minimum levels. When the visual inspection identifies the retroreflectivity of a sign as marginal, a comparison panel is attached to the sign and the sign/panel combination is viewed and compared by the inspector.

Consistent Parameters Procedure

Nighttime inspections are conducted under similar factors that were used in the research to develop the minimum retroreflectivity levels. These factors include:

- Using a sport utility vehicle or pick-up truck to conduct the inspection.
- Using a model year 2000 or newer vehicle for the inspection.
- Using an inspector who is at least 60 years old.

2. MEASURED SIGN RETROREFLECTIVITY

In this method the retroreflectivity of a sign is measured and directly compared to the minimum level appropriate for that sign. ASTM E1709, Standard Test Method for Measurement of Retroreflective Signs Using a Portable Retroreflectometer, provides a standard method for measuring sign retroreflectivity.

An agency can choose to use either an assessment method or a management method, or a combination of the two. Agencies may develop other methods as long as they are documented in an engineering study and correspond to the values in Table 2A.3.

MANAGEMENT METHODS

Management methods provide an agency with the ability to maintain sign retroreflectivity without having to assess individual signs. There are three basic management methods — sign replacement based on expected sign life, blanket replacement of large numbers of signs at appropriate intervals, and use of control signs.

1. EXPECTED SIGN LIFE

In this method, individual signs are replaced before they reach the end of their expected service life, which is the time anticipated for the retroreflective material to degrade to the appropriate minimum level. Expected service life can be based on sign sheeting warranties, weathering deck results, measurements of field signs, or other criteria.

This method requires a system for tracking sign age. A common approach for identifying the age of individual signs uses a label on the sign to mark the year of fabrication or installation. Sign management systems can also be used to track the age of individual signs.

2. BLANKET REPLACEMENT

With this method, an agency replaces all signs in an area, or of a given type, at specified time intervals based on the relevant expected sign life. This method typically requires that all of the designated signs within a replacement area, or of the particular sign type, be replaced even if a sign was recently installed.

3. CONTROL SIGNS

In this method, a control sample of signs is used to represent all of an agency's signs. The retroreflectivity of the control signs is monitored and sign replacement is based on the performance of the control signs.

- Agencies should develop a sampling plan to determine the appropriate number and type of control signs needed to represent the agency's signs.
- Control signs may be actual signs in the field or signs in a maintenance yard (for convenience).
- The retroreflectivity of the control signs should be monitored using an assessment method.

§ 212.104. Retroreflectorization.

Retroreflective sheeting or other approved retroreflective materials must be used on all signs that do not have sign illumination, unless the sign standard as included in the *Pennsylvania Handbook of Approved Signs* (Department Publication 236M) indicates that the sign does not need to be retroreflective. Type III or higher type retroreflective sheeting is encouraged to improve nighttime visibility of signs, especially for older drivers.

§ 212.105. Sign posts and mountings.

Unless physically protected by guide rail or a barrier, or installed beyond the clear zone as defined in the Department's *Design Manual, Part 2 (Department Publication 13M)*, all sign posts must be of a Department-approved breakaway design as listed in the *Approved Construction Materials* (Department Publication 35), and in accordance with the *Signing and Marking Standards* (Department Publication 111M).

§ 212.106. Additional warrants for Stop Signs (R1-1) and Yield Signs (R1-2).

(a) *Through highways*. The Department and local authorities may designate highways as through highways to permit more continuous movement and less delay to the major flow of traffic.

(1) Stop Signs (R1-1) or Yield Signs (R1-2) may be installed at all approaches to the through highway to provide preferential right-of-way at intersections.

(2) The designation of a highway as a through highway does not prevent modification of the right-of-way assignment at intersections of the through highway.

(3) The justification for the modification at a particular intersection will be based on the warrants in the MUTCD and the additional warrants in subsection (b), (c) or (d).

(b) *Stop Signs (R1-1) at intersections*. In addition to the warrants for stop signs in the MUTCD (relating to stop sign applications), a Stop Sign (R1-1) may be installed on a channelized right-turn roadway at a signalized intersection where the traffic-control signals are not readily visible, and the right-turn roadway does not have separate signals, and a Yield Sign (R1-2) is not appropriate.

A-8

Pavement Markings – Conventional
(PennDOT Publication 111M, TC-8600)

NOTES:

LANE, EDGE AND CENTERLINES

1. MAKE ALL LANE LINES, EITHER SOLID OR BROKEN WHITE, 100 mm (4") MINIMUM WIDE ON TWO-LANE, TWO-WAY HIGHWAYS AND 150 mm (6") WIDE ON MULTI-LANE HIGHWAYS.
2. LANE LINES ON AN APPROACH TO A SIGNALIZED INTERSECTION SHALL BE SOLID WHITE FOR A DISTANCE OF 45 m (150') MEASURED FROM THE STOP BAR.
3. LANE LINES THAT DELINEATE THE EDGE OF A TURNING LANE ARE TO BE SOLID WHITE LINES WITH A LENGTH EQUAL 2X/3, BUT NOT LESS THAN 1/3 THE LENGTH OF THE TURN LANE, MEASURED FROM THE STOP BAR.
4. MAKE EDGE LINES SOLID WHITE LINES 100 mm (4") WIDE, EXCEPT USE SOLID YELLOW LINES WHEN ADJACENT TO A MEDIAN WHICH SEPARATES OPPOSING DIRECTIONS OF VEHICULAR TRAFFIC FLOW.
5. ON TWO-LANE, TWO-WAY HIGHWAYS, THE CENTER LINES ARE YELLOW, 100 mm (4") WIDE EITHER SOLID, BROKEN OR A COMBINATION THEREOF. A SOLID BARRIER LINE SHALL PRECEDE ALL CONTROLLED INTERSECTIONS BY THE MINIMUM DISTANCE NOTED IN TABLE A.
6. ON FOUR OR MORE LANE UNDIVIDED HIGHWAYS, FOR CENTER LINES USE THE TWO-WAY BARRIER LINES.
7. "CENTER LANE LEFT TURN ONLY" MARKINGS ARE TWO (2) SETS OF ONE-WAY BARRIER LINES WITH BROKEN YELLOW LINES INSIDE OF THE SOLID YELLOW LINES.
8. EXTEND THE LANE LINES, EDGE LINES AND/OR CENTER LINES A DISTANCE OF 45 m (150') FROM THE STOP BAR ON MINOR APPROACHES, WHERE CONDITIONS PERMIT.

STOP LINE

9. STOP LINES ARE SOLID WHITE LINES THAT COMPLETELY TRAVERSE EACH TRAFFIC LANE. AT AN INTERSECTION WITH A STOP SIGN, THE STOP LINE SHOULD BE PLACED AT A LOCATION NO LESS THAN 1.2 m (4'), OR MORE THAN 9 m (30') FROM THE NEAREST EDGE OF THE INTERSECTING ROADWAY TO ENSURE MAXIMUM SIGHT DISTANCE TO VEHICLES ON THE CROSSING ROUTE. WHEN USED ON MULTI-LANE APPROACH TO A SIGNALIZED INTERSECTION, THE STOP LINE MAY BE STAGGERED TO ASSIST TURNING VEHICLES AND TO IMPROVE SIGHT DISTANCE FOR MOTORIST DESIRING TO MAKE A TURN ON RED.
10. LOCATE STOP LINES AT A MINIMUM OF 1.2 m (4') IN ADVANCE OF AND PARALLEL TO THE CROSSWALK LINES UNLESS OTHERWISE NOTED.

YIELD LINE (FOR DETAILS SEE SHEET 5 OF 8)

11. YIELD LINES ARE TO CONSIST OF A ROW OF SOLID WHITE ISOSCELES TRIANGLES POINTING TOWARD APPROACHING VEHICLES EXTENDING ACROSS APPROACH LANES TO INDICATE THE POINT AT WHICH THE YIELD IS INTENDED OR REQUIRED TO BE MADE.

MEDIAN MARKINGS

12. TRANSVERSE MEDIAN MARKINGS ARE 600 mm (24") WIDE YELLOW LINES SPACED AS INDICATED ON SHEET 4, WITHIN TWO (2) SETS OF TWO-WAY BARRIER LINES. USE TRANSVERSE LINES ONLY WHEN REQUIRED TO PROVIDE EMPHASIS IF THE SIGHT DISTANCE OR VISIBILITY IS RESTRICTED.

GORE MARKINGS

13. EDGE LINES ARE 100 mm (4") SOLID WHITE LINES. USE TRANSVERSE OR DIAGONAL LINES ONLY WHEN REQUIRED TO PROVIDE ADDITIONAL EMPHASIS IF THE SIGHT DISTANCE OR VISIBILITY OF GORE IS RESTRICTED.

PAVEMENT LEGENDS

14. WORD AND SYMBOL MARKINGS SHOULD NOT EXCEED THREE LINES OF INFORMATION. IF A PAVEMENT MARKING WORD MESSAGE CONSISTS OF MORE THAN ONE LINE OF INFORMATION, IT SHOULD READ IN THE DIRECTION OF TRAVEL. THE FIRST WORD OF THE MESSAGE SHOULD BE NEAREST TO THE ROAD USER. THE LONGITUDINAL SPACE BETWEEN WORD OR SYMBOL MESSAGE MARKINGS, INCLUDING ARROW MARKINGS, SHOULD BE AT LEAST FOUR TIMES THE HEIGHT OF THE CHARACTERS FOR LOW-SPEED ROADS, BUT NOT MORE THAN TEN TIMES THE HEIGHT OF THE CHARACTERS UNDER ANY CONDITIONS. ON ALL APPROACHES, CENTER THE LEGENDS WITHIN THE LANE.
15. ALIGN THE LEGENDS TRANSVERSELY ACROSS EACH PAVEMENT. THE MINIMUM DISTANCE BETWEEN THE ARROW SYMBOL AND STOP BAR IS 6 m (20').

DOTTED EXTENSION LINES

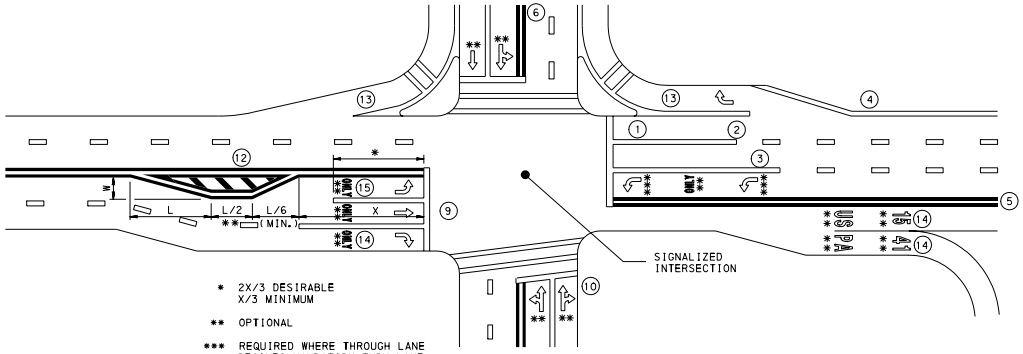
16. DOTTED EXTENSION LINES MAY BE USED TO DELINEATE TRAVEL PATHS FOR TURNING TRAFFIC MOVEMENTS AT OFFSET, SKEWED OR COMPLEX INTERSECTIONS AND FOR MULTIPLE TURN LANES.

LANE REDUCTION ARROW (LRA)

17. FOR DETAILS SEE SHEET 10.

GENERAL

18. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
19. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.



PLAN

METRIC UNITS

$L = \frac{WS^2}{155}$	FOR CONVENTIONAL ROADWAYS WHERE THE 85TH PERCENTILE SPEED IS 65 km/h OR LESS
$L = \frac{WS}{1.6}$	FOR CONVENTIONAL ROADWAYS WHERE THE 85TH PERCENTILE SPEED IS 70 km/h OR GREATER AND FOR ALL FREEWAYS AND EXPRESSWAYS
WHERE:	S = 85TH PERCENTILE SPEED (KMH) W = OFFSET

X = 7.5 m PER 30 TURNING V.P.H. THE MINIMUM IS 22.5 m

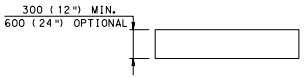
ENGLISH UNITS

$L = \frac{WS^2}{60}$	FOR CONVENTIONAL ROADWAYS WHERE THE 85TH PERCENTILE SPEED IS 40 MPH OR LESS
L = WS	FOR CONVENTIONAL ROADWAYS WHERE THE 85TH PERCENTILE SPEED IS 45 MPH OR GREATER AND FOR ALL FREEWAYS AND EXPRESSWAYS
WHERE:	S = 85TH PERCENTILE SPEED (MPH) W = OFFSET

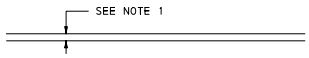
X = 25' PER 30 TURNING V.P.H. THE MINIMUM IS 75'

SPEED LIMIT OR 85TH PERCENTILE SPEED km/h (MPH)	DISTANCE m (FT)
60 (35) OR LESS	90 (300)
65 (40)	105 (350)
70 (45)	120 (400)
80 (50)	135 (450)
90 (55)	150 (500)

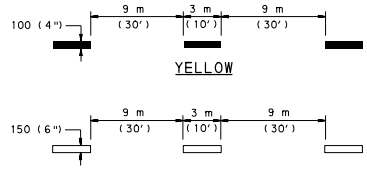
TABLE A
(SEE NOTE 5)



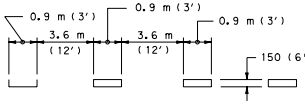
STOP LINE



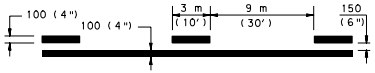
SOLID LANE LINE



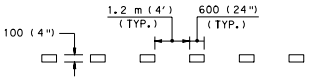
BROKEN LANE LINE



AUXILIARY LANE LINE



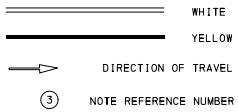
ONE-WAY BARRIER LINES
(SEE NOTE 5)



DOTTED EXTENSION LINE

TWO-WAY BARRIER LINES
(SEE NOTE 5)

LEGEND



COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

PAVEMENT MARKINGS

CONVENTIONAL

RECOMMENDED JUN. 23, 2009
CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION

RECOMMENDED JUN. 23, 2009
ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

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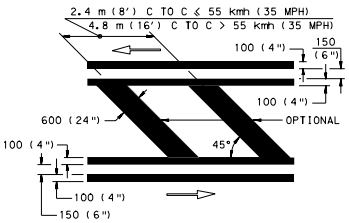
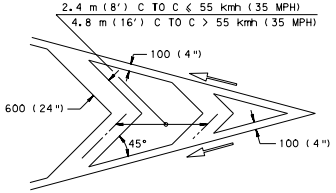
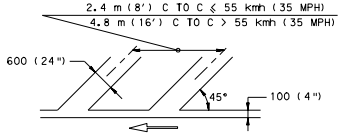


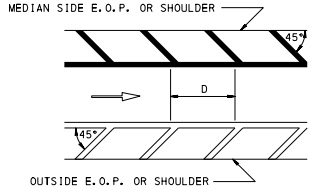
TRANSVERSE MEDIAN MARKING



CHEVRON GORE MARKING
(OPTIONAL)

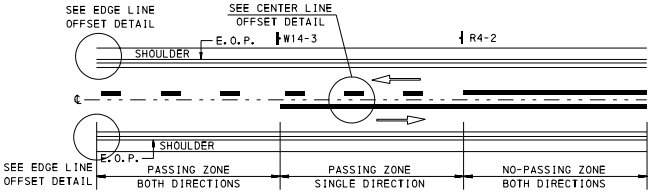


ONE-WAY BARRIER GORE MARKING
(OPTIONAL)

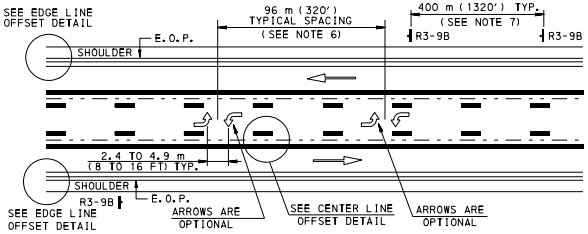


D = SPACING OF DIAGONAL LINES (TYPICALLY EQUAL IN FEET TO THE POSTED SPEED LIMIT). INCREASE SPACING OF DIAGONALS TO 60 m (200') OR MORE ON INTERSTATE ROADWAYS.

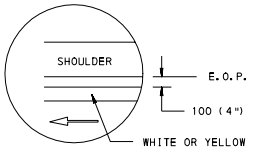
EDGE OF PAVEMENT OR SHOULDER ISLAND



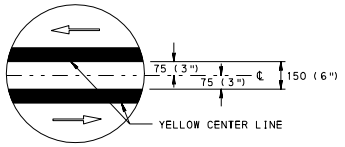
TWO-LANE, TWO-WAY UNDIVIDED ROADWAY



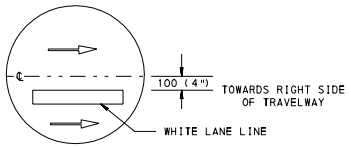
TWO-LANE, TWO-WAY UNDIVIDED ROADWAY WITH TWO-WAY LEFT TURN LANE



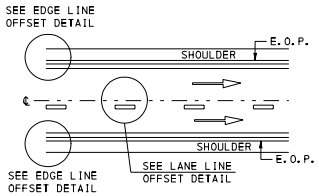
EDGE LINE OFFSET DETAIL



CENTER LINE OFFSET DETAIL



LANE LINE OFFSET DETAIL



MULTI-LANE ROADWAY

NOTES:

1. OFFSET PAVEMENT MARKING LINES 100 mm (4") FROM LONGITUDINAL PAVEMENT CONSTRUCTION JOINTS, AS DETERMINED BY THE ENGINEER OR AS INDICATED BELOW:
   - YELLOW SKIP LINES ON TWO-LANE, TWO-WAY ROADWAYS (WHERE PASSING IS ALLOWED IN BOTH DIRECTIONS) CAN BE OFFSET 75 mm (3") FROM THE CENTER LINE TO ALLOW FOR FUTURE REPAINTING OF THE LINES WITH COMPATIBLE DEPARTMENT EQUIPMENT.
   - OFFSET DOUBLE YELLOW CENTER LINES 75 mm (3") ON EACH SIDE OF THE CENTER LINE TO ALLOW FOR PLACEMENT OF PAVEMENT MARKERS (PRESENT OR FUTURE PLACEMENT).
2. PASSING - NO PASSING ZONES WILL BE DETERMINED BY THE ENGINEER.
3. EDGE LINES ARE NOT REQUIRED ALONG CURB AND GUTTER LOCATIONS.
4. DO NOT CONTINUE EDGE LINES THRU INTERSECTIONS, AND DO NOT BREAK EDGE LINES AT DRIVEWAYS.
5. PLACE EDGE LINES AT RAISED ISLAND LOCATIONS, OUTLINING THE SHAPE OF THE RAISED ISLAND.
6. 96 m (320') TYPICAL SPACING BETWEEN SETS OF ARROW SYMBOLS CAN BE INCREASED OR DECREASED AS DETERMINED BY THE ENGINEER.
7. 400 m (1320') TYPICAL DISTANCE BETWEEN CENTER LANE - LEFT TURN ONLY SIGNS (R3-9B) CAN BE INCREASED OR DECREASED AS DETERMINED BY THE ENGINEER.
8. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
9. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.

LEGEND

WHITE

YELLOW

DIRECTION OF TRAVEL

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
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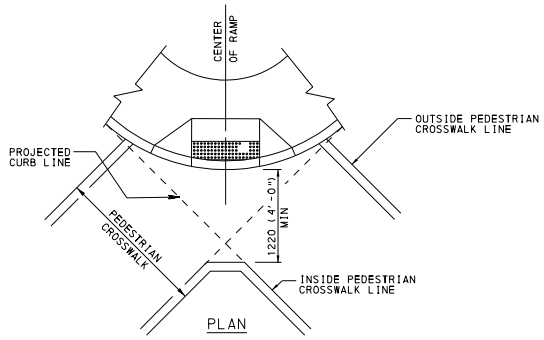
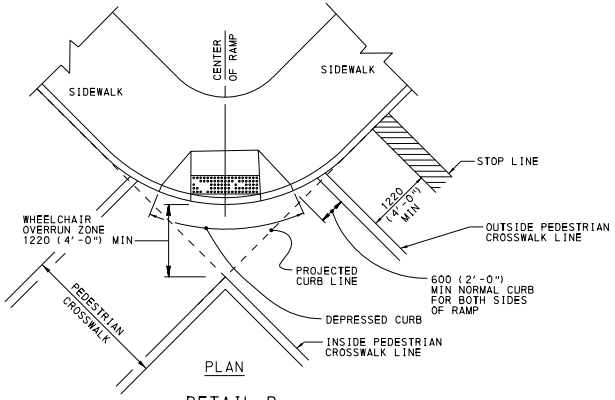


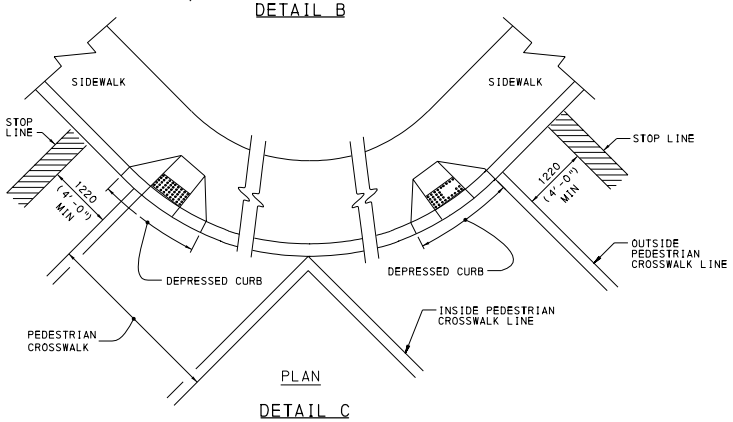
PLAN

DETAIL A



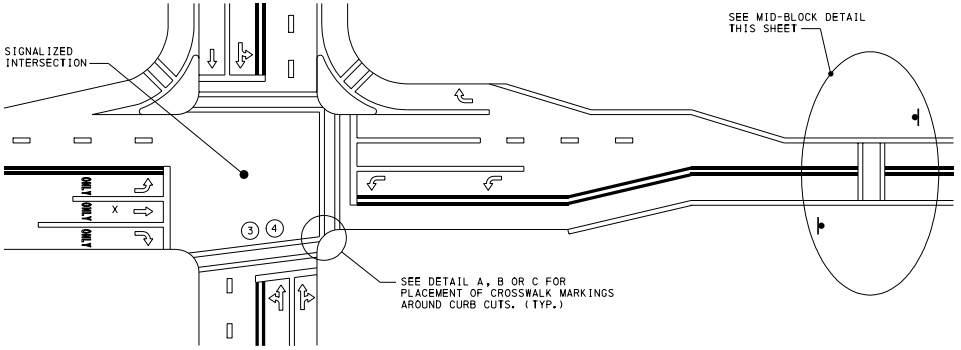
PLAN

DETAIL B

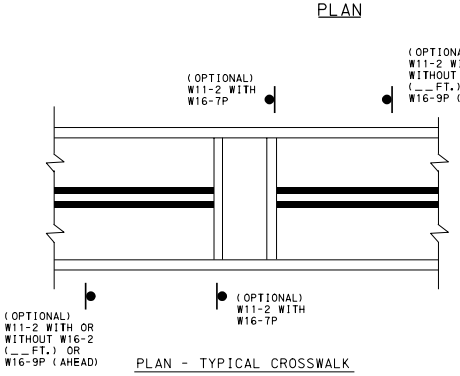


PLAN

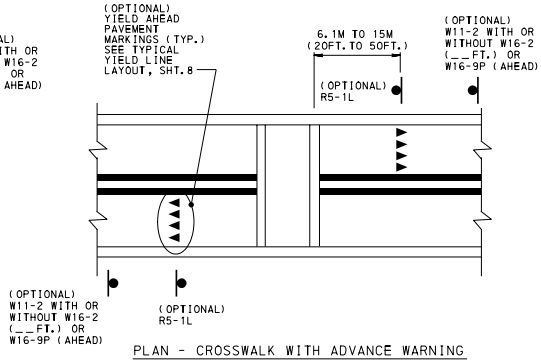
DETAIL C



PLAN



PLAN - TYPICAL CROSSWALK



PLAN - CROSSWALK WITH ADVANCE WARNING PAVEMENT MARKINGS

MID-BLOCK CROSSWALK DETAIL

REFER TO PUBLICATION 46 CHAPTER 11.9 AND MUTCD PART 3B.17 FOR MORE DETAILS.

LEGEND

WHITE

YELLOW

DIRECTION OF TRAVEL

NOTES:

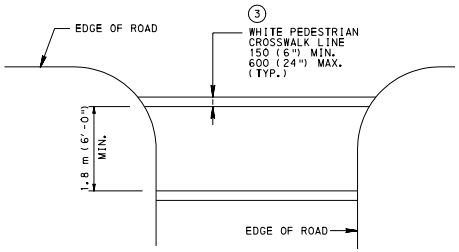
1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
2. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.
3. THE MINIMUM WIDTH OF CROSSWALKS SHALL BE 1.8 m (6') AND MAKE THE CROSSWALK LINES SOLID WHITE NOT LESS THAN 150 mm (6") WIDE, THE LINES FORMING A CROSSWALK SHALL BE PARALLEL TO EACH OTHER AND EXTEND ACROSS THE ROADWAY FROM FACE OF CURB TO FACE OF CURB OR EDGE OF SHOULDER AS APPLICABLE.
4. FOR STANDARD CROSSWALK MARKINGS AND APPROVED DECORATIVE CROSSWALK PATTERN CONFIGURATION AND COLORS SEE SHEET 6.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

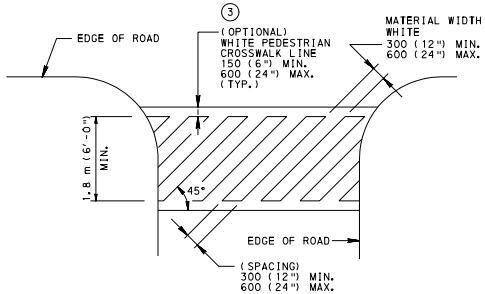
PAVEMENT MARKINGS

CROSSWALKS

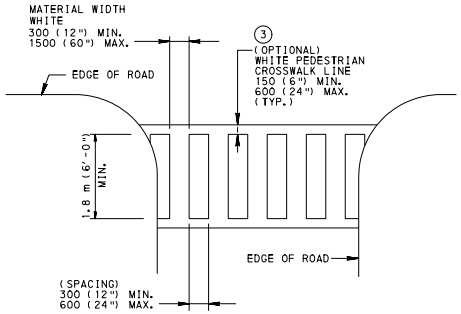
RECOMMENDED JUN. 23, 2009 CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION	RECOMMENDED JUN. 23, 2009 ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING	SHT. 5 OF 11 TC-8600



TYPE A - PARALLEL



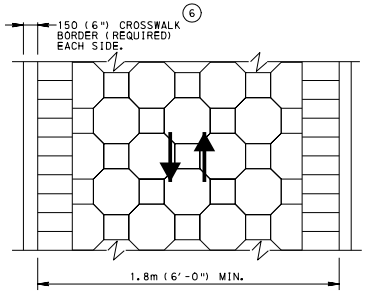
TYPE B - DIAGONAL



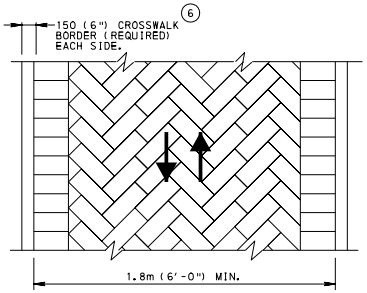
TYPE C - PERPENDICULAR

STANDARD CROSSWALK MARKINGS

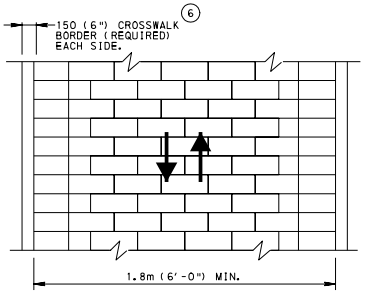
DECORATIVE CROSSWALK



TYPE D - COURTYARD



TYPE E - HERRINGBONE



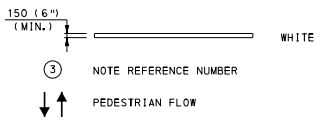
TYPE F - OFFSET BRICK

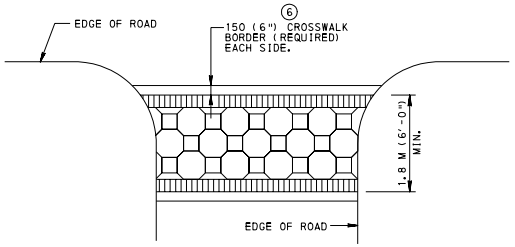
APPROVED NON-REFLECTIVE COLORS: WHITE, BLACK, BROWN, SILVER-GRAY AND MAROON

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
2. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.
3. MAKE THE CROSSWALK LINES SOLID WHITE, NOT LESS THAN 150 (6") WIDE.
4. EXTEND THE CROSSWALK ACROSS THE ROADWAY FROM FACE OF CURB TO FACE OF CURB OR EDGE OF SHOULDER AS APPLICABLE.
5. THE MINIMUM WIDTH OF CROSSWALKS SHALL BE 1.8 m (6').
6. A WHITE BORDER, 150 (6") WIDE, IS REQUIRED ALONG EACH SIDE OF THE DECORATIVE CROSSWALK, THE BORDERS ARE TO BE PARALLEL USING A PENNDOT APPROVED PAVEMENT MARKING MATERIAL AND EXTENDS FROM FACE OF CURB TO FACE OF CURB OR SHOULDER.

LEGEND





PLAN - CROSSWALK WITH DECORACTIVE PATTERN

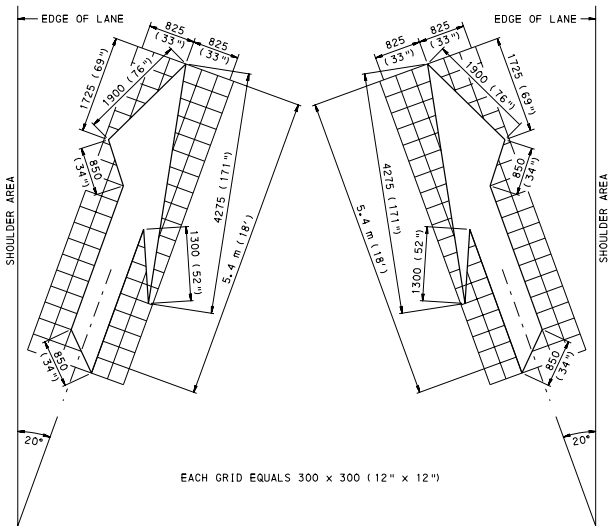
SEE DECORATIVE CROSSWALK PATTERNS.
(DECORACTIVE CROSSWALK PATTERN MUST BE CONTAINED WITHIN THE 150 (6") WHITE PEDESTRIAN CROSSWALK BORDERS FORMING THE CROSSWALK)

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

PAVEMENT MARKINGS

CROSSWALKS

RECOMMENDED JUN. 23, 2009	RECOMMENDED JUN. 23, 2009	SHT. 6 OF 11
CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION	ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING	TC-8600

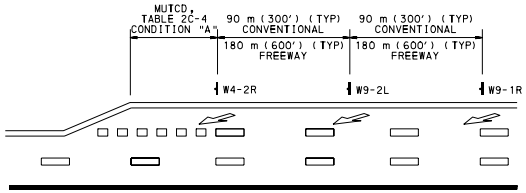


EACH GRID EQUALS 300 x 300 (12" x 12")

LEFT LANE
(MERGE RIGHT)

RIGHT LANE
(MERGE LEFT)

LANE REDUCTION TRANSITION ARROW



1. LOCATE LRA IN CENTER OF LANE.
2. PLACE LRAS IN GROUPS OF THREE WHEN CONDITIONS PERMIT.
3. FOLLOW MUTCD - TABLE 2C-4 (CONDITION A) FOR PLACEMENT OF FIRST LANE REDUCTION ARROW IN ADVANCE OF TAPER.

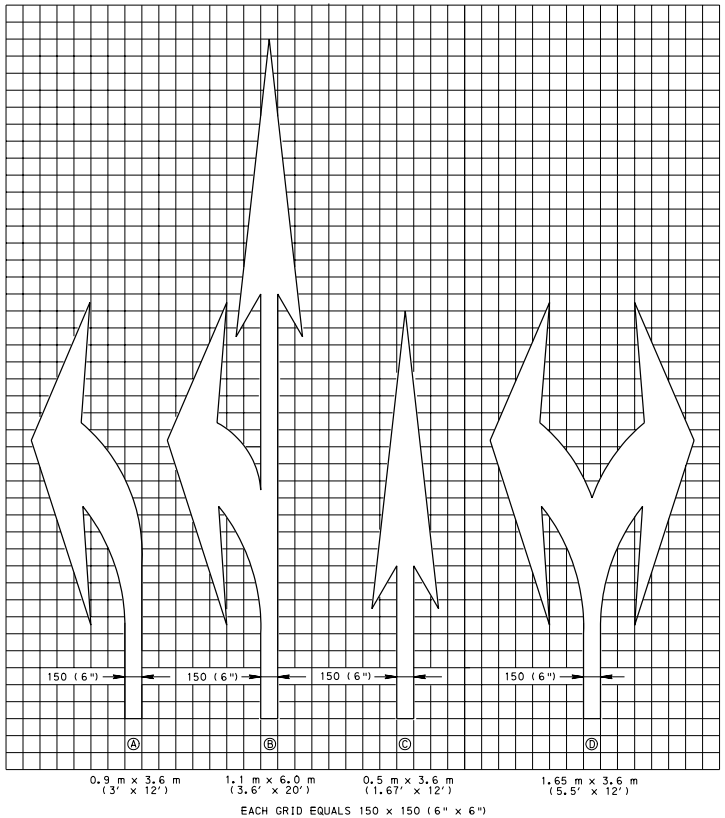
   INTERSTATE - EXPRESSWAY/FREEWAY

4. PLACE ADDITIONAL LANE REDUCTION ARROWS AT 180 m (600') INTERVALS.

   CONVENTIONAL ROADWAYS

5. PLACE ADDITIONAL LANE REDUCTION ARROWS AT 90 m (300') INTERVALS.

LANE REDUCTION ARROW PLACEMENT



EACH GRID EQUALS 150 x 150 (6" x 6")

ARROW	QUANTITY FOR PAVEMENT MARKING REMOVAL
Ⓐ	1.11 m² (20 FT²)
Ⓑ	2.04 m² (32 FT²)
Ⓒ	0.84 m² (13 FT²)
Ⓓ	1.95 m² (32 FT²)

MARKING ARROWS

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
2. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

PAVEMENT MARKINGS

LEGENDS AND SYMBOLS

RECOMMENDED JUN. 23, 2009
CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION

RECOMMENDED JUN. 23, 2009
ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

SHT. 10 OF 11

TC-8600

A-9

Removal of Traffic Hazards by Property Owner
(The Vehicle Code, Title 75 §6112)

Removal of Traffic Hazards
(PennDOT Publication 212, Section 212.6)

Removal of Traffic Hazards Engineering and Traffic Study
(PennDOT Form TE-119)

1992 Amendment. Act 31 amended subsec. (b)(2).
1981 Amendment. Act 86 amended subsec. (b).

§ 6111. Regulation of traffic on bridges under authority of interstate commissions.

(a) General rule.--The provisions of this title apply to any bridge under the supervision and control of the Delaware River Joint Toll Bridge Commission, the Delaware River Port Authority and the New York-Pennsylvania Joint Commission on Bridges over the Delaware River unless specifically modified by rules and regulations which shall become effective only upon publication in accordance with law. Rules and regulations, so long as they are effective, shall be posted at all entrances to the bridges.

(b) Penalty.--Any person violating any of the rules and regulations of the Delaware River Joint Toll Bridge Commission, the Delaware River Port Authority or the New York-Pennsylvania Joint Commission on Bridges over the Delaware River for which no penalty has otherwise been provided by statute is guilty of a summary offense and shall, upon conviction, be sentenced to pay a fine of $25.

§ 6112. Removal of traffic hazards by property owner.

(a) General rule.--It is the duty of the owner of real property to remove from the property any tree, plant, shrub or other similar obstruction, or part thereof, which by obstructing the view of any driver constitutes a traffic hazard.

(b) Notice of hazard.--When the department or any local authority determines on the basis of an engineering and traffic investigation that a traffic hazard exists, it shall notify the owner and order the hazard removed within ten days.

(c) Penalty.--The failure of the owner to remove the traffic hazard within ten days after notice under subsection (b) is a summary offense and every day the owner fails to remove it shall be a separate and distinct offense. The offense is punishable by a fine of $10.

§ 6113. Control of public travel on private property by owner.

(a) General rule.--Nothing in this title shall be construed to prevent the owner of real property used by the public for purposes of vehicular travel by permission of the owner, and not as a matter of right, from prohibiting such use, or from requiring other or different or additional conditions than those specified in this title, or otherwise regulating such use as may seem best to such owner.

(b) Enforcement.--The owner of real property which is ten contiguous acres or more in size may request the local authority to enforce the observance of speed limits and traffic-control devices on his property, providing the property has been posted in accordance with departmental regulations.

(June 30, 1984, P.L.473, No.99, eff. imd.)

§ 6114. Limitation on sale, publication and disclosure of records.

(a) Offenses defined.--It is unlawful for:

(1) Any police officer, or any officer, employee or agent of any Commonwealth agency or local authority which makes or receives records or reports required to be filed under this title to sell, publish or disclose or offer to sell, publish or disclose records or reports which relate to

(4) The Department may take appropriate action if it deems it necessary to carry out the maintenance responsibility of a local authority or permittee because of failure or inability to act in a timely manner.

(5) Local authorities are responsible to determine the need for any Stop Ahead Signs (W3-1) and Yield Ahead Signs (W3-2) on local highway approaches to State-designated highways, and for installing and maintaining any warranted signs.

(e) *Police authority*. Police officers may install temporary traffic-control devices on any highway without approval from the Department or the local authorities. These traffic-control devices may be used to close highways during emergencies, to weigh or inspect vehicles, to establish sobriety checkpoints or to conduct other enforcement programs or activities.

§ 212.6. Removal of traffic hazards.

(a) *Interfering signs, lights or markings*. The Secretary and local authorities, under their respective jurisdictions, have the authority to cause the removal of all colored or flashing lighted signs or other lights, signs or markings so located as to interfere with traffic or to be confused with or to obstruct the view or effectiveness of traffic-control devices.

(b) *Trees, plants, shrubs or other obstructions*. The Department on State-designated highways, and local authorities on any highway within their boundaries, may require a property owner to remove or trim a tree, plant, shrub or other obstruction or part thereof which constitutes a traffic hazard. The following are examples of traffic hazards:

(1) The obstruction restricts the stopping sight distance for drivers of through vehicles or the available corner sight distance for drivers entering from side roads or driveways to distances less than the appropriate minimum stopping sight distance or minimum corner sight distance values.

(2) The obstruction critically restricts the sight distance to a traffic-control device.

(3) Vehicle crash records indicate that a crash has involved the obstruction or that the obstruction contributed to one or more of the vehicle crashes.

TE-119 (7-09)

REMOVAL OF TRAFFIC HAZARDS ENGINEERING AND TRAFFIC STUDY

PLEASE TYPE OR PRINT ALL INFORMATION IN BLUE OR BLACK INK

pennsylvania
DEPARTMENT OF TRANSPORTATION
www.dot.state.pa.us

A - LOCATION INFORMATION

COUNTY	MUNICIPALITY
STREET NAME	TOWNSHIP ROAD #
SR#	SEGMENT

RESTRICTED BETWEEN: Segment: Offset: To Segment: Offset:

Location: to Location:

B - REFERENCE INFORMATION

REFERENCE	SECTION(S)
Chapter 212	212.6
Vehicle Code Title 75 Pa. C.S.	§6112

C - STUDY ELEMENTS

FROM PUB 212 APPENDIX:

- ☐ Crash Analysis (1)
- ☐ Geometric Review (8)
- ☐ Sight Distance (16)
- ☐ Speed Data (17)
- ☐ Traffic Volumes (20)
- ☐ Other: _____

D - ATTACHMENTS LISTING

Check those that apply and attach to this form in the order listed below:

- ☐ 1. 10-Day Response Letter
- ☐ 2. Letter or Memo Requesting Study
- ☐ 3. Location Map
- ☐ 4. Straight Line Diagram
- ☐ 5. Photographs
- ☐ 6. Field View Drawing or Condition Diagram
- ☐ 7. Crash Extract
- ☐ 8. Crash Rate
- ☐ 9. Collision Diagram Plot
- ☐ 10. Speed Study
- ☐ 11. Warrant Analysis
- ☐ 12. Multi-Way Stop or Truck Restriction Worksheet
- ☐ 13. Traffic/Pedestrian Volumes
- ☐ 14. STAMPP Identification Data
- ☐ 15. Speed Limit
- ☐ 16. Traffic Signal Permit Plan
- ☐ 17. Other _____

E - SITE OBSERVATION CHECKLIST

Operational Checklist:

1. Do obstructions block a driver's view of pedestrians or approaching vehicles? ☐ YES ☐ NO ☐ N/A
2. Do drivers respond correctly to signals, signs, or other traffic control devices? ☐ YES ☐ NO ☐ N/A
3. Is there evidence of crashes (skid marks, property damage, tree/bush damage, broken glass/vehicle parts, etc.)? ☐ YES ☐ NO ☐ N/A
4. Are there violations of parking or other traffic regulations? ☐ YES ☐ NO ☐ N/A
5. Do drivers appear confused about routes, street names, or other guidance information? ☐ YES ☐ NO ☐ N/A
6. Have you observed the location during peak hours for volume, crashes, and traffic operations? ☐ YES ☐ NO ☐ N/A
7. Are there traffic flow deficiencies or traffic conflict patterns associated with turning movements? ☐ YES ☐ NO ☐ N/A
8. Are there significant delays and/or congestion? ☐ YES ☐ NO ☐ N/A
9. Are there vehicle/pedestrians conflicts? ☐ YES ☐ NO ☐ N/A
10. Are there other traffic flow deficiencies or traffic conflict patterns? ☐ YES ☐ NO ☐ N/A

Physical Checklist:

1. Can sight obstructions be removed or lessened? ☐ YES ☐ NO ☐ N/A
2. Do the street alignments or widths adequately accommodate the type of traffic using the roadway? ☐ YES ☐ NO ☐ N/A
3. Are curb radii adequate for turning vehicles? ☐ YES ☐ NO ☐ N/A
4. Are pedestrian crosswalks properly located? ☐ YES ☐ NO ☐ N/A
5. Are signs adequate as to usefulness, message, size, conformity, and placement? ☐ YES ☐ NO ☐ N/A
6. Are traffic signals adequate as to placement, visibility, glare, conformity, number of signal heads, and timing? ☐ YES ☐ NO ☐ N/A
7. Are pavement markings adequate as to their conformance to standards and location? ☐ YES ☐ NO ☐ N/A
8. Is channelization (islands or pavement markings) adequate for reducing conflict areas, separating traffic flows, and defining movements? ☐ YES ☐ NO ☐ N/A
9. Does the existing legal parking layout affect sight distance for through or turning vehicles? ☐ YES ☐ NO ☐ N/A
10. Is the pavement condition free of potholes, washboard, slick surface, etc.? ☐ YES ☐ NO ☐ N/A

F - SITE DATA

DATE DATA COLLECTED	PERSON CONDUCTING STUDY	TITLE

1. Type or nature of the hazard to be removed: _____

   _____

2. Describe how the hazard affects safety: (Provide sketch of location)

3. Indicate the stopping sight distance and/or the corner sight distance from side roads affected by the hazard. Estimate the appropriate sight distance with the hazard removed.

F - SITE DATA (CONTINUED)

4. Does the obstruction critically restrict the sight distance to a traffic control device? ☐ Yes ☐ No

   A. What is the device _____

   B. What is the existing sight distance: _____ feet.

   C. Estimate the sight distance with the obstruction removed: _____ feet

   D. Could the control device be easily relocated? ☐ Yes ☐ No
      Explain.

5. Is the hazard a colored or flashing lighted sign or other light so located as to interfere with traffic or to be confused with or obstruct the view of effectiveness of traffic control device? ☐ Yes ☐ No

G - REMARKS

H - ENGINEERING JUDGEMENT

I - APPROVALS

Comments:

Reviewed and Approved by Signature	Name/Title	Date
Reviewed and Approved by Signature	Name/Title	Date

A-10

Turn Restriction Warrants
(PennDOT Publication 212, Section 212.111)

Turn Prohibition Signs
(Manual on Uniform Traffic Control Devices, Section 2B.19)

No Left Turn Sign
(PennDOT Publication 236M, R3-2)

Turn Restrictions Engineering and Traffic Study
(PennDOT Form TE-110)

(2) A Trucks Over (____) Lbs. Speed Sign (R2-2-1), or other sign as applicable, shall be erected at the beginning of the hazardous grade speed zone and at intervals not greater than 1/4 mile throughout the zone.

(3) A Trucks Over (____) Lbs. Speed Sign (R2-2-1), or other sign as applicable, with an End Sign (R2-10) mounted above the Trucks Over (____) Lbs. Speed Sign (R2-2-1) or other sign, shall be installed at the end of the hazardous grade speed limit.

§ 212.111. Turn restriction warrants.

A straight-through or turning movement may be restricted if the movement can be made at an alternate location, and if one or more of the following conditions are present:

(1) A review of vehicle crashes shows that ten crashes have occurred during the previous 3 years, or five crashes have occurred during any 12-month period in the previous 3 years that can be attributed to vehicles making or attempting to make the movement.

(2) When a capacity analysis or field review of the intersection indicates that turning or crossing vehicles are causing unreasonable delays or creating a potential crash situation for through vehicles.

(3) When a field review of the intersection indicates that significant conflicts occur between vehicles making or attempting to make a particular movement and other vehicular or pedestrian movements.

(4) When a field review of the intersection indicates that a turn or straight-through movement delays the platoon of vehicles through a progressive signal system.

(5) When a field review of the intersection indicates that the geometric design or the available corner sight distance does not adequately provide for the movement or the movement frequently cannot be safely executed.

(6) A study shows that the turning movement is frequently being made by through traffic onto a residential street to avoid downstream congestion.

B. A supplemental plaque WHEN CHILDREN (WORKERS) ARE PRESENT; or
C. A supplemental plaque WHEN FLASHING (similar to the S4-4 plaque shown in Figure 7B-1) if used in conjunction with a yellow flashing beacon.

The legend FINES HIGHER may be replaced by multiple values such as FINES DOUBLE or FINES TRIPLE, or by a specific value such as $150 FINE.

Standard:

The FINES HIGHER plaque shall be a rectangle with a black legend and border on a white background.

All supplemental plaques mounted below the FINES HIGHER plaque shall be rectangles with black legends and borders on white backgrounds.

The FINES HIGHER plaque shall include a SCHOOL, WORK ZONE, or other applicable designated zone plaque mounted above the applicable regulatory or warning sign. The SCHOOL supplemental plaque shall be rectangular in shape with a black legend and border on a yellow or fluorescent yellow-green background (same as the S4-3 plaque). The WORK ZONE supplemental plaque shall be rectangular in shape with a black legend and border on an orange background.

Guidance:

If used, the FINES HIGHER plaque should be located at the beginning of the temporary traffic control zone, school zone, or other applicable designated zone and just beyond any interchanges, major intersections, or other major traffic generators.

Agencies should limit the use of the FINES HIGHER plaque to locations where work is actually underway, or to locations where the roadway, shoulder, or other conditions, including the presence of a school, require a speed reduction or extra caution on the part of the road user.

Section 2B.18 Location of Speed Limit Signs

Standard:

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.

Section 2B.19 Turn Prohibition Signs (R3-1 through R3-4, and R3-18)

Standard:

Except as noted in the Option, where turns are prohibited, Turn Prohibition signs shall be installed.

Guidance:

Turn Prohibition signs should be placed where they will be most easily seen by road users who might be intending to turn.

If No Right Turn (R3-1) signs (see Figure 2B-3) are used, at least one should be placed either over the roadway or at a right corner of the intersection.

If No Left Turn (R3-2) signs (see Figure 2B-3) are used, at least one should be placed either over the roadway, at the far left corner of the intersection, on a median, or in conjunction with the STOP sign or YIELD sign located on the near right corner.

Except as noted in the Option, if NO TURNS (R3-3) signs (see Figure 2B-3) are used, two signs should be used, one at a location specified for a No Right Turn sign and one at a location specified for a No Left Turn sign.

If No U-Turn (R3-4) signs (see Figure 2B-3) are used, at least one should be used at a location specified for No Left Turn signs.

If combination No U-Turn/No Left Turn (R3-18) signs (see Figure 2B-3) are used, at least one should be used at a location specified for No Left Turn signs.

Option:

If signals are present:

A. The No Right Turn sign may be installed adjacent to a signal face viewed by road users in the right lane.
B. The No Left Turn (or No U-Turn or combination No U-Turn/No Left Turn) sign may be installed adjacent to a signal face viewed by road users in the left lane.

C. A NO TURNS sign may be placed adjacent to a signal face viewed by all road users on that approach, or two signs may be used.

If signals are present, an additional Turn Prohibition sign may be ground mounted to supplement the sign mounted overhead.

Where ONE WAY signs are used (see Section 2B.32), Turn Prohibition signs may be omitted.

When the movement restriction applies during certain time periods only, the following Turn Prohibition signing alternatives may be used and are listed in order of preference:

A. Changeable message signs, especially at signalized intersections.
B. Permanently mounted signs incorporating a supplementary legend showing the hours and days during which the prohibition is applicable.
C. Portable signs, installed by proper authority, located off the roadway at each corner of the intersection. The portable signs are only to be used during the time that the turn prohibition is applicable.

Turn Prohibition signs may be omitted at a ramp entrance to an expressway or a channelized intersection where the design is such as to indicate clearly the one-way traffic movement on the ramp or turning lane.

If both left turns and U-turns are prohibited, the R3-18 sign may be used instead of separate R3-2 and R3-4 signs.

Section 2B.20 Intersection Lane Control Signs (R3-5 through R3-8)

Standard:

Intersection Lane Control signs, if used, shall require road users in certain lanes to turn, shall permit turns from a lane where such turns would otherwise not be permitted, shall require a road user to stay in the same lane and proceed straight through an intersection, or shall indicate permitted movements from a lane.

Intersection Lane Control signs (see Figure 2B-4) shall have three applications:

A. Mandatory Movement Lane Control (R3-5, R3-5a, and R3-7) signs;
B. Optional Movement Lane Control (R3-6) sign; and
C. Advance Intersection Lane Control (R3-8 series) signs.

Guidance:

When Intersection Lane Control signs are mounted overhead, each sign should be placed over the lane or a projection of the lane to which it applies.

Standard:

Use of an overhead sign for one approach lane shall not require installation of overhead signs for the other lanes of that approach.

Option:

Where the number of through lanes on an approach is two or less, the Intersection Lane Control signs (R3-5, R3-6, or R3-8) may be overhead or ground mounted.

Intersection Lane Control signs may be omitted where:

A. Turning bays have been provided by physical construction or pavement markings, and
B. Only the road users using such turning bays are permitted to make a similar turn.

Section 2B.21 Mandatory Movement Lane Control Signs (R3-5, R3-5a, and R3-7)

Standard:

If used, Mandatory Movement Lane Control (R3-5, R3-5a, and R3-7) signs (see Figure 2B-4) shall indicate only those vehicle movements that are required from each lane and shall be located where the regulation applies. When the mandatory movement applies to lanes exclusively designated for HOV traffic, the R3-5c supplemental plaque shall be used. When the mandatory movement applies to lanes that are not HOV facilities, but are lanes exclusively designated for buses and/or taxis, the word message R3-5d and/or R3-5g supplemental plaques shall be used. The R3-7 word message sign shall be for ground mounting only.

If the R3-5 sign is ground mounted on a multi-lane approach, a supplemental plaque (see Figure 2B-4), such as LEFT LANE (R3-5b), HOV 2+ (R3-5c), TAXI LANE (R3-5d), CENTER LANE (R3-5e), RIGHT LANE (R3-5f), BUS LANE (R3-5g), or LEFT 2 LANES, indicating the lane with the appropriate movement shall be added below.

The Mandatory Movement Lane Control (R3-7) sign shall include the legend RIGHT (LEFT) LANE MUST TURN RIGHT (LEFT). The Mandatory Movement Lane Control symbol signs (R3-5 and R3-5a) shall include the legend ONLY.

R3–2

NO LEFT TURN SIGN

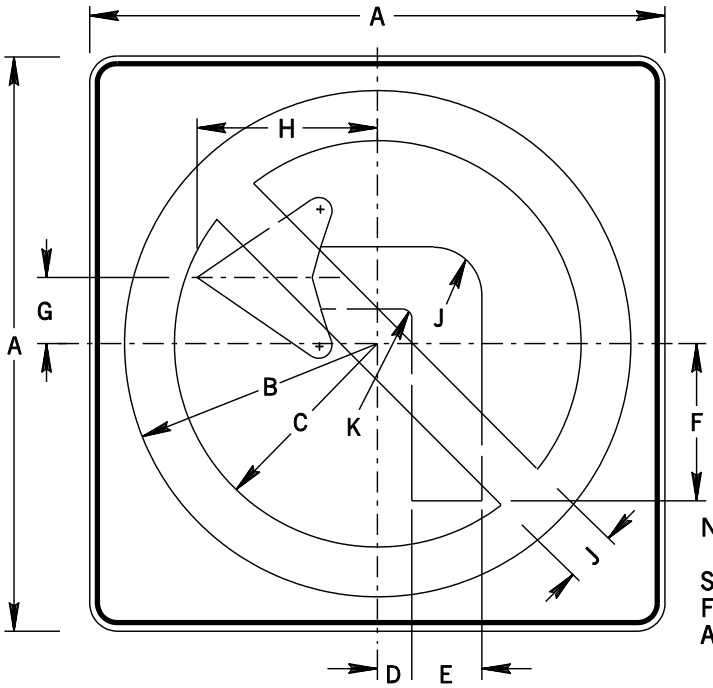
(a) Justification. The No Left Turn Sign (R3–2) shall be authorized for use to prohibit left turns.

(b) Placement.

(1) When the No Left Turn Sign (R3–2) is used on undivided streets, one sign should be placed at the near right–hand corner and one at the far left–hand corner. An exception is made when there are overhead traffic signals, in that case the sign on the near right–hand corner shall be eliminated and a sign shall be installed over the roadway near the traffic signal.

(2) On divided streets or highways this sign should be placed on both the near side and the far side ends of the medians unless the median width is insufficient to permit the installation of the signs; the signs should then be installed as indicated for undivided streets. When there are overhead traffic signals, the sign on the far side median should be eliminated and a R3–2 sign placed over the roadway near the traffic signal. An auxiliary sign with the same message may be used in advance of the intersection.

(c) Size. The standard size of the R3–2 sign shall be 600 mm by 600 mm (24" x 24") for post–mounted signs and 750 mm by 750 mm (30" x 30") for overhead installations. The standard size for expressways shall be 900 mm by 900 mm (36" x 36").



NOTE:

SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)												
SIGN SIZE A x A	B	C	D	E	F	G	H	J	K	MAR–GIN	BOR–DER	BLANK STD.
600 x 600 (24" x 24")	262 (10.5)	212 (8.5)	38 (1.5)	64 (2.6)	160 (6.4)	70 (2.8)	185 (7.4)	50 (2)	10 (0.4)	10 (0.4)	15 (0.6)	B3–600 (B3–24)
750 x 750 (30" x 30")	330 (13.2)	265 (10.6)	45 (1.8)	80 (3.2)	205 (8.2)	85 (3.4)	235 (9.4)	65 (2.6)	15 (0.6)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
900 x 900 (36" x 36")	395 (15.8)	320 (12.8)	55 (2.2)	94 (3.8)	240 (9.6)	102 (4.1)	280 (11.2)	75 (3)	20 (0.8)	15 (0.6)	25 (1)	B3–900 (B3–36)
1200 x 1200 (48" x 48")	525 (21)	425 (17)	75 (3)	126 (5)	325 (13)	138 (5.5)	375 (15)	100 (4)	25 (1)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

CIRCLE AND DIAGONAL:
RED (REFLECTORIZED)

BACKGROUND:
WHITE (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

R3_2.DGN

TE-110 (7-09)

TURN RESTRICTIONS ENGINEERING AND TRAFFIC STUDY

PLEASE TYPE OR PRINT IN BLUE OR BLACK INK ALL INFORMATION

pennsylvania
DEPARTMENT OF TRANSPORTATION
www.dot.state.pa.us

A - LOCATION INFORMATION

COUNTY	MUNICIPALITY

MAJOR STREET INFORMATION

SR#	TOWNSHIP ROAD #	STREET NAME

STATION	LOCATION

MINOR STREET INFORMATION

SR#	TOWNSHIP ROAD #	STREET NAME

SEGMENT/OFFSET	LOCATION

B - REFERENCE INFORMATION

REFERENCE	SECTION(S)
Chapter 212	212.111
MUTCD	2B.19
Vehicle Code Title 75 Pa. C.S.	§3331, 3332 and 6109(a)(7)(9)(13)

C - STUDY ELEMENTS

FROM PUB 212 APPENDIX:

- ☐ Crash Analysis (1)
- ☐ Capacity Analysis (6)
- ☐ Pedestrian Volumes (12)
- ☐ Sight Distance (16)
- ☐ Speed Data (17)
- ☐ Traffic Volumes (20)
- ☐ Other _____

D - ATTACHMENTS LISTING

Check those that apply and attach to this form in the order listed below:

- ☐ 1. 10-Day Response Letter
- ☐ 2. Letter or Memo Requesting Study
- ☐ 3. Location Map
- ☐ 4. Straight Line Diagram
- ☐ 5. Photographs
- ☐ 6. Field View Drawing or Condition Diagram
- ☐ 7. Crash Extract
- ☐ 8. Crash Rate
- ☐ 9. Collision Diagram Plot
- ☐ 10. Speed Study
- ☐ 11. Warrant Analysis
- ☐ 12. Multi-Way Stop or Truck Restriction Worksheet
- ☐ 13. Traffic/Pedestrian Volumes
- ☐ 14. STAMPP Identification Data
- ☐ 15. Speed Limit
- ☐ 16. Traffic Signal Permit Plan
- ☐ 17. Other _____

E - SITE OBSERVATION CHECKLIST

Operational Checklist:

1. Do obstructions block a driver's view of pedestrians or approaching vehicles? ☐ YES ☐ NO ☐ N/A
2. Do drivers respond correctly to signals, signs, or other traffic control devices? ☐ YES ☐ NO ☐ N/A
3. Is there evidence of crashes *(skid marks, property damage, tree/bush damage, broken glass/vehicle parts, etc.)*? ☐ YES ☐ NO ☐ N/A
4. Are there violations of parking or other traffic regulations? ☐ YES ☐ NO ☐ N/A
5. Do drivers appear confused about routes, street names, or other guidance information? ☐ YES ☐ NO ☐ N/A
6. Have you observed the location during peak hours for volume, crashes, and traffic operations? ☐ YES ☐ NO ☐ N/A
7. Are there traffic flow deficiencies or traffic conflict patterns associated with turning movements? ☐ YES ☐ NO ☐ N/A
8. Are there significant delays and/or congestion? ☐ YES ☐ NO ☐ N/A
9. Are there vehicle/pedestrians conflicts? ☐ YES ☐ NO ☐ N/A
10. Are there other traffic flow deficiencies or traffic conflict patterns? ☐ YES ☐ NO ☐ N/A

Physical Checklist:

1. Can sight obstructions be removed or lessened? ☐ YES ☐ NO ☐ N/A
2. Do the street alignments or widths adequately accommodate the type of traffic using the roadway? ☐ YES ☐ NO ☐ N/A
3. Are curb radii adequate for turning vehicles? ☐ YES ☐ NO ☐ N/A
4. Are pedestrian crosswalks properly located? ☐ YES ☐ NO ☐ N/A
5. Are signs adequate as to usefulness, message, size, conformity, and placement? ☐ YES ☐ NO ☐ N/A
6. Are traffic signals adequate as to placement, visibility, glare, conformity, number of signal heads, and timing? ☐ YES ☐ NO ☐ N/A
7. Are pavement markings adequate as to their conformance to standards and location? ☐ YES ☐ NO ☐ N/A
8. Is channelization (islands or pavement markings) adequate for reducing conflict areas, separating traffic flows, and defining movements? ☐ YES ☐ NO ☐ N/A
9. Does the existing legal parking layout affect sight distance for through or turning vehicles? ☐ YES ☐ NO ☐ N/A
10. Is the pavement condition free of potholes, washboard, slick surface, etc.? ☐ YES ☐ NO ☐ N/A

F - STUDY AND DATA SHEETS

DATE DATA COLLECTED	PERSON CONDUCTING STUDY	TITLE

TURN RESTRICTIONS

1. Posted speed limit _____MPH
2. Have there been 10 or more crashes during any 12 month period in the last three years attributed to turning movements? ☐ YES ☐ NO
3. Have there been 5 or more crahes during any 12 month period in the last three years attributed to turning movements? ☐ YES ☐ NO
4. Are turning behicles causing unreasonable delays? ☐ YES ☐ NO
5. Are turning or straight-through movements delaying vehicles through a progressive signal system? ☐ YES ☐ NO
6. Are turning vehicles creating potential crashes for through vehicles? ☐ YES ☐ NO
7. Is there a significant conflict between turning vehicles and pedestrian movements? ☐ YES ☐ NO
8. Is there adequate corner sight distance to safely ececute movements? ☐ YES ☐ NO
9. Is there adequate sight distance for turning vehicles on potential through vehicles? ☐ YES ☐ NO
10. Is the turning movement frequently being made by through traffic onto a residential street to avoid downstream congestion? ☐ YES ☐ NO

G - REMARKS

H - ENGINEERING JUDGEMENT

I - APPROVALS

Reviewed and Approved by Signature	Name/Title	Date
Reviewed and Approved by Signature	Name/Title	Date

A-11

Flashing Beacons
(Manual on Uniform Traffic Control Devices, Chapter 4K)

Flashing Warning Device
(PennDOT Publication 149)

CHAPTER 4K. FLASHING BEACONS

Section 4K.01 General Design and Operation of Flashing Beacons

Support:

A Flashing Beacon is a highway traffic signal with one or more signal sections that operates in a flashing mode. It can provide traffic control when used as an intersection control beacon or warning in alternative uses.

Standard:

Flashing Beacon units and their mountings shall follow the provisions of Chapter 4D, except as specified herein.

Beacons shall be flashed at a rate of not less than 50 nor more than 60 times per minute. The illuminated period of each flash shall not be less than one-half and not more than two-thirds of the total cycle.

Guidance:

If used to supplement a warning or regulatory sign, the edge of the beacon signal housing should normally be located no closer than 300 mm (12 in) outside of the nearest edge of the sign.

Option:

An automatic dimming device may be used to reduce the brilliance of flashing yellow signal indications during night operation.

Section 4K.02 Intersection Control Beacon

Standard:

An Intersection Control Beacon shall consist of one or more signal faces directed toward each approach to an intersection. Each signal face shall consist of one or more signal sections of a standard traffic signal face, with flashing CIRCULAR YELLOW or CIRCULAR RED signal indications in each signal face. They shall be installed and used only at an intersection to control two or more directions of travel.

Application of Intersection Control Beacon signal indications shall be limited to the following:

A. Yellow on one route (normally the major street) and red for the remaining approaches; and
B. Red for all approaches (if the warrant for a multiway stop is satisfied).

Flashing yellow signal indications shall not face conflicting vehicular approaches.

A STOP sign shall be used on approaches to which a flashing red signal indication is shown on an Intersection Control Beacon (see Section 2B.04).

Guidance:

An Intersection Control Beacon should not be mounted on a pedestal in the roadway unless the pedestal is within the confines of a traffic or pedestrian island.

Option:

Supplemental signal indications may be used on one or more approaches in order to provide adequate visibility to approaching road users.

Intersection Control Beacons may be used at intersections where traffic or physical conditions do not justify conventional traffic control signals but crash rates indicate the possibility of a special need.

An Intersection Control Beacon is generally located over the center of an intersection; however, it may be used at other suitable locations.

Section 4K.03 Warning Beacon

Support:

Typical applications of Warning Beacons include the following:

A. At obstructions in or immediately adjacent to the roadway;
B. As supplemental emphasis to warning signs;
C. As emphasis for midblock crosswalks;
D. On approaches to intersections where additional warning is required, or where special conditions exist; and
E. As supplemental emphasis to regulatory signs, except STOP, YIELD, DO NOT ENTER, and SPEED LIMIT signs.

Standard:

A Warning Beacon shall consist of one or more signal sections of a standard traffic signal face with a flashing CIRCULAR YELLOW signal indication in each signal section.

A Warning Beacon shall be used only to supplement an appropriate warning or regulatory sign or marker. The beacon shall not be included within the border of the sign except for SCHOOL SPEED LIMIT sign beacons.

Warning Beacons, if used at intersections, shall not face conflicting vehicular approaches.

If a Warning Beacon is suspended over the roadway, the clearance above the pavement shall be at least 4.6 m (15 ft) but not more than 5.8 m (19 ft).

Guidance:

The condition or regulation justifying Warning Beacons should largely govern their location with respect to the roadway.

If an obstruction is in or adjacent to the roadway, illumination of the lower portion or the beginning of the obstruction or a sign on or in front of the obstruction, in addition to the beacon, should be considered.

Warning Beacons should be operated only during those hours when the condition or regulation exists.

Option:

If Warning Beacons have more than one signal section, they may be flashed either alternately or simultaneously.

A flashing yellow beacon interconnected with a traffic signal controller assembly may be used with a traffic signal warning sign (see Section 2C.29).

Section 4K.04 Speed Limit Sign Beacon

Standard:

A Speed Limit Sign Beacon shall be used only to supplement a Speed Limit sign.

A Speed Limit Sign Beacon shall consist of one or more signal sections of a standard traffic control signal face, with a flashing CIRCULAR YELLOW signal indication in each signal section. The signal lenses shall have a nominal diameter of not less than 200 mm (8 in). If two lenses are used, they shall be vertically aligned, except that they may be horizontally aligned if the Speed Limit (R2-1) sign is longer horizontally than vertically. If two lenses are used, they shall be alternately flashed.

Option:

A Speed Limit Sign Beacon may be used with a fixed or variable Speed Limit sign. If applicable, a flashing Speed Limit Sign Beacon (with an appropriate accompanying sign) may be used to indicate that the speed limit shown is in effect.

Support:

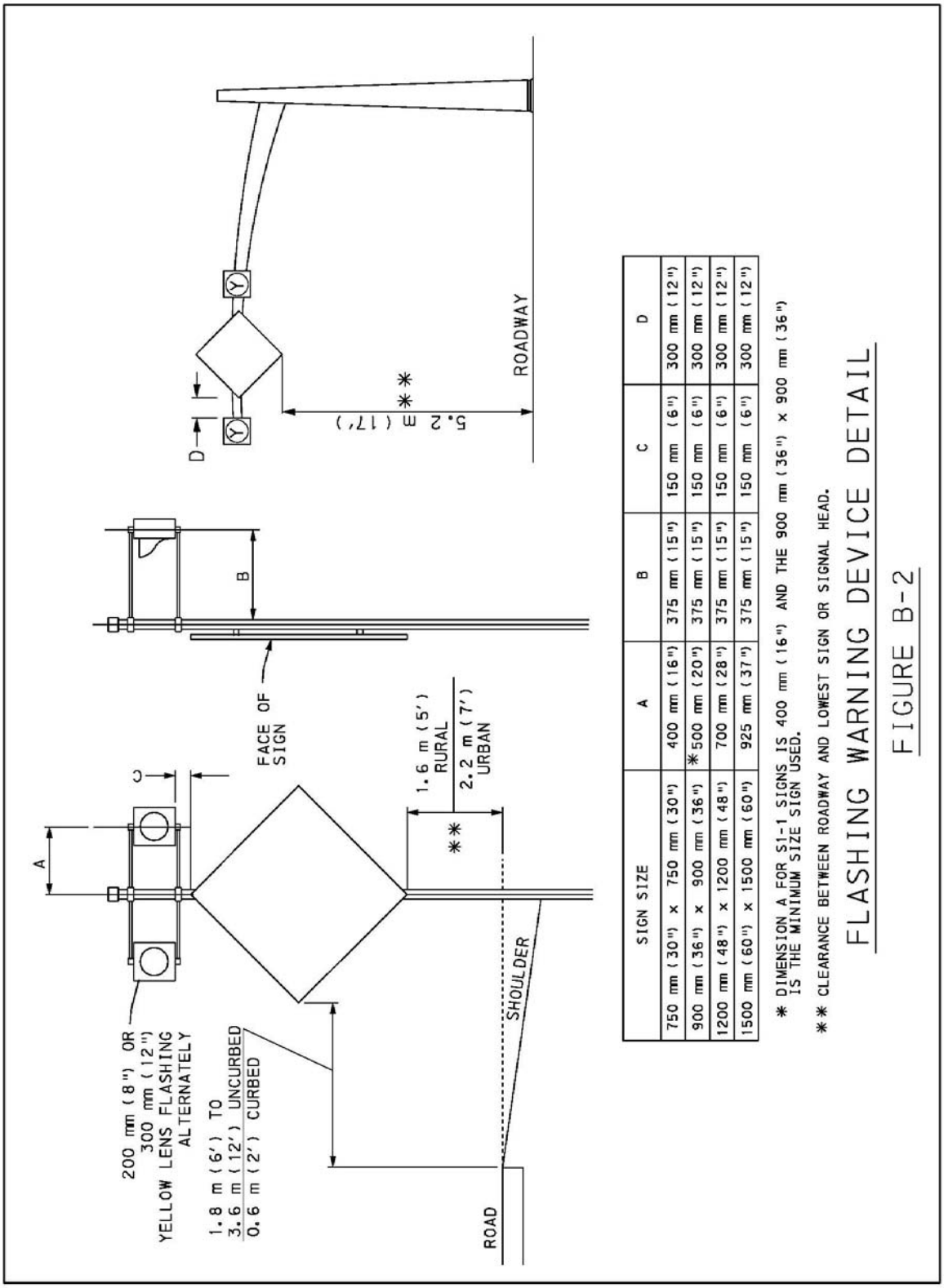
Section 7B.11 contains additional Options for the use of Speed Limit Sign Beacons with SCHOOL SPEED LIMIT signs.

Section 4K.05 Stop Beacon

Standard:

A Stop Beacon shall consist of one or more signal sections of a standard traffic signal face with a flashing CIRCULAR RED signal indication in each signal section. If two horizontally aligned signal lenses are used, they shall be flashed simultaneously to avoid being confused with a highway-rail grade crossing flashing- light signals. If two vertically aligned signal lenses are used, they shall be flashed alternately.

The bottom of the signal housing of a Stop Beacon shall be not less than 300 mm (12 in) nor more than 600 mm (24 in) above the top of a STOP sign (see Section 2B.04).



SIGN SIZE	A	B	C	D
750 mm (30") x 750 mm (30")	400 mm (16")	375 mm (15")	150 mm (6")	300 mm (12")
900 mm (36") x 900 mm (36")	*500 mm (20")	375 mm (15")	150 mm (6")	300 mm (12")
1200 mm (48") x 1200 mm (48")	700 mm (28")	375 mm (15")	150 mm (6")	300 mm (12")
1500 mm (60") x 1500 mm (60")	925 mm (37")	375 mm (15")	150 mm (6")	300 mm (12")

* DIMENSION A FOR S1-1 SIGNS IS 400 mm (16") AND THE 900 mm (36") x 900 mm (36") IS THE MINIMUM SIZE SIGN USED.

** CLEARANCE BETWEEN ROADWAY AND LOWEST SIGN OR SIGNAL HEAD.

FLASHING WARNING DEVICE DETAIL

FIGURE B-2

A-12

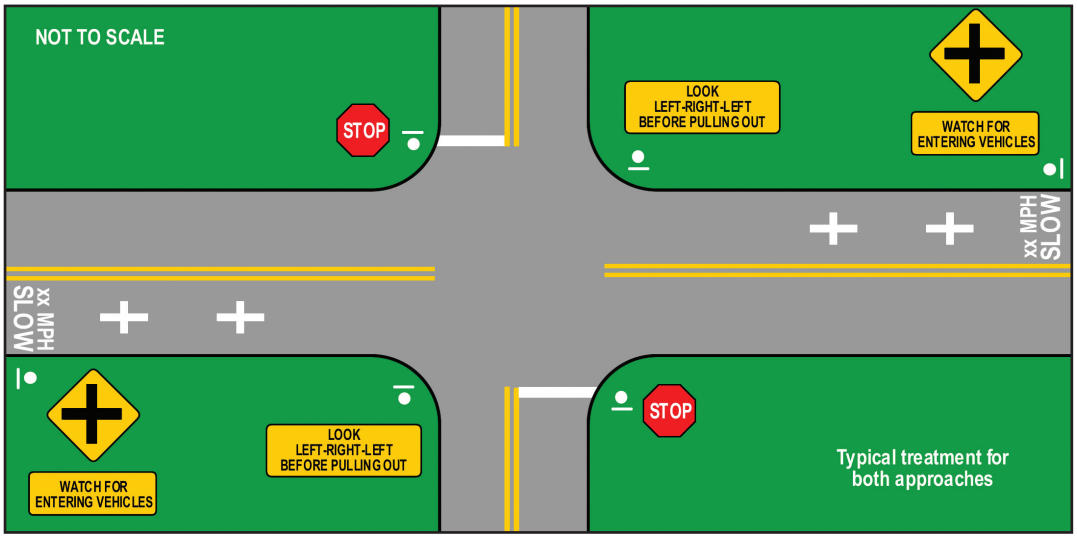
Provide Innovative Signs and Markings to Assist Drivers in Judging the Suitability of Available Gaps for Making Turning and Crossing Maneuvers *(FHWA Unsignalized Intersection Safety Strategies Fact Sheet)*

U.S.Department of Transportation
Federal Highway Administration

Provide Innovative Signs and Markings to Assist Drivers in Judging the Suitability of Available Gaps for Making Turning and Crossing Maneuvers

WHERE TO USE

Unsignalized intersections where crash data shows a high occurrence of crashes where vehicles on secondary roadways intersecting at grade misjudge the gap between approaching vehicles.



This diagram represents one example of how such a system of pavement markings and signs may be used.

DETAILS

The lack of adequate sight distance at unsignalized intersections may reduce the ability of drivers to see an approaching vehicle and/or judge the suitable available gap for making turning and crossing maneuvers. Even where sight distance is adequate, drivers may ignore traffic control devices such as stop or yield signs and may misjudge available gaps in traffic. Thus, intersection crashes may occur because drivers are unable to judge adequately the distance and time to an approaching vehicle. This strategy involves the use of innovative signing and passive markings to assist drivers in deciding when to accept a gap. The markings could take the form of pavement markings placed in the field of view of a driver observing the approaching traffic stream. Drivers would need to be told, by signing or through a public education campaign, not to proceed when an approaching vehicle is closer to the intersection than the pavement marker.

In the illustration above, the entire treatment consists of the following components:

1. Placement of legend SLOW, MPH recommendation, and the cross-style markers on the primary roadway.
2. Placement of appropriate signs outlined below on the secondary roadway.

KEY TO SUCCESS

It is very important that a driver on the secondary road, while stopped to make the decision whether to enter the intersection, can clearly view the "Look Left-Right-Left Before Pulling Out" warning sign. If the warning sign is not easily viewed from the decision point on the secondary road, it should be shifted to a more visible location.

ISSUES

This strategy is considered experimental. If an agency desires to pursue its application, it is recommended that the agency proceed with caution, conducting pilot tests in conjunction with a carefully planned evaluation.

TIME FRAME ●●○

Time frame for implementation can generally be short if right-of-way is available.

COSTS ●○○○

Costs are generally low for a simple system but will increase for more complex systems.

EFFECTIVENESS

EXPERIMENTAL: This strategy has been experimented with in few locations with no conclusive results. Pennsylvania has experimented with a similar type of countermeasure.

COMPATIBILITY

This strategy can be used in conjunction with most other strategies for improving safety at unsignalized intersections.

SUPPLEMENTAL INFORMATION

The information in this fact sheet differs from that presented in the *NCHRP Report 500 Volume 5*. The countermeasure discussed in the report was found to not increase safety and therefore is not recommended.

For more details on this and other countermeasures: http://safety.transportation.org

For more information contact:

FHWA Office of Safety Design
E71, 1200 New Jersey Avenue SE
Washington, D.C. 20590
(202) 366-9064
http://safety.fhwa.dot.gov

FHWA Resource Center - Safety and Design Team
19900 Governor's Drive, Suite 301
Olympia Fields, IL 60461
(708) 283-3545
http://www.fhwa.dot.gov/resourcecenter

U.S.Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives

2/08

A-13

Pavement Edge Maintenance
(LTAP Technical Information Sheet #127)

The Safety Edge
(FHWA Publication Number FHWA-SA-09-023)

The Pennsylvania Local Roads Program

Pavement Edge Maintenance

Diane Purdy, Penn State

LTAP TECHNICAL INFORMATION SHEET # 127
Winter 2005-2006

The Transportation Research Board of the National Research Council considers pavement edge shoulder drop-offs among the top crash related pavement disturbances and a common source of tort claims against roadway agencies. A pavement edge drop is created by a difference in elevation between two adjacent surfaces of the roadway. This condition frequently occurs on narrow pavement or roads without paved shoulders, where the wheels of vehicles frequently traverse off the pavement.

Edge drop-off on narrow roadway (from TxDOT Project 0-4396).

Several recent studies have concluded that the proper maintenance of pavement shoulders and edges can facilitate safe roadway reentry by vehicles that stray onto the shoulder, to prevent run-off-the-road crashes, improve motorist safety, and reduce tort liability claims. This tech sheet will address edge maintenance and edge repair techniques associated with a paved traveled way and an unpaved shoulder.

CAUSES OF PAVEMENT EDGE DROP-OFF

Pavement edge drop-offs are generally caused by erosion from wind, rain or other environmental conditions and by vehicular traffic on an unpaved shoulder. If the shoulder areas are not compacted properly, they erode easily. When shoulder slopes are too steep, surface runoff will flow too fast while crossing the shoulder and create significant erosion. Edge drop-offs can also occur during pavement overlay construction as we learned in the Fall 2005 Technical Information Sheet # 123, *Remedy for Pavement Edge Drop-Offs from Resurfacing Projects*.

Areas that are more susceptible to pavement edge drop-off are: the inside of horizontal curves, the turning radius of intersections with other roads or driveways, and at approaches to uphill or vertical curve areas. Other common locations are mail box turnouts and school bus stops. Snow plowing operations also cause pavement edge drop-off, because the operators often drive on the edge and the plowing can score the pavement surface, which creates raveled and damaged edges.

With a mission to help Pennsylvania's municipalities solve road and bridge management problems, LTAP is sponsored by the Pennsylvania Department of Transportation, the Federal Highway Administration and The Pennsylvania State University in partnership with the Governor's Center for Local Government Services. For information about LTAP services across the state that include Roads Scholar courses, on-site training (road shows), technical assistance and publications, write or call:

LTAP
The Pennsylvania
Local Roads Program
Penn State University
201 Trans. Research Bldg.
University Park, PA
16802-4710

800-FOR-LTAP
https://www,ltap.state.pa.us

PAVEMENT EDGE MAGNITUDE

There are no accepted standards that represent an acceptable risk with regard to pavement edge drop-offs. However, the U.S. DOT suggests that a drop-off of 3 inches or more of vertical differential is unsafe, and the American Association of State Highway and Transportation Officials suggests that no vertical differential greater than 2 inches occur between lanes. Agencies can use a technique that involves placing a straight edge or level on the pavement to measure the depth of the drop-off using a ruler or tape measure. If a drop-off greater than 2 inches exists, the shoulder should be scheduled for maintenance and repaired immediately.

MAINTENANCE PRACTICES

Maintenance personnel identify or become aware of pavement edge problems in various ways, but the most common method is a frequent windshield survey of their roads. It is important to remember that the assessment of severity associated with edge damage is subjective so, when in doubt, get out of the vehicle and observe the conditions. Since edge drops tend to occur in particular locations, maintenance personnel will become aware of these locations. Complaints from road users and other agency employees are also sources of information for edge drop-offs. A majority of these reports may relate to construction zone edge drop-offs or driveways and mailbox turnouts.

An effective edge maintenance strategy is not only important in achieving good roads, without good edge maintenance an agency cannot achieve good roads. An effective edge maintenance strategy is the key element of a successful road maintenance program.

PREVENTIVE EDGE MAINTENANCE

Preventive edge maintenance can be defined as a group of activities performed to protect the pavement and decrease the rate of deterioration of the pavement edge. Asphalt roadway surfaces tend to deteriorate over time as the elements of nature cause the asphalt to become brittle. This often occurs in the form of raveling (loss of aggregate) or surface cracks. Application of a seal coat can restore the resilient properties of the asphalt surface and prevent further deterioration. Seal coats commonly used for pavement maintenance are fog seals, scrub seals, slurry seals and chip seals. Our discussion will be limited to the use of fog seals and chip seals in preventive edge maintenance operations.

Fog seal applied along the edge of pavement
(from TxDOT Project 0-4396).

Fog Seal

A fog seal is a light application of a diluted, slow-setting asphalt emulsion, similar to a tack coat, to the roadway surface. It is used to renew old asphalt surfaces that have become dry and brittle with age and to seal small cracks and surface voids. Typically fog seals are used to seal shoulders, dig outs and patches.

Using a fog seal as a preventive edge maintenance activity involves spraying asphalt emulsion along the pavement edge to cover 1 or 2 feet of the edge. A thin layer of fine-grained soils (e.g., blow sand) can be applied over the sprayed edges with a motor grader to eliminate stickiness, especially if excessive asphalt has been applied.

In Texas, this practice is known as raw edging and is generally performed after pavement edge repair or shoulder reshaping as a preventive measure. It offers some degree of stabilization against wind or light rain erosion. The emulsion also helps seal the pavement to retard moisture infiltration.

Chip Seal

A chip seal can be used where light to moderate cracking or raveling is occurring. This surface treatment provides skid resistance and improves ride quality, as well as seals the roadway. Chip seals generally involve applying asphalt emulsions or liquid asphalts, covering them with aggregate and then rolling them.

An edge or strip seal (chip seal) can be used as a preventive edge maintenance activity. It involves the spray application of a single layer of asphalt followed immediately by application of a thin aggregate cover, which is rolled. The operation is similar to a seal coat treatment, but the edge seal is typically done for a 1- to 2-foot strip instead of the full width. The edge or strip seal serves some of the same purposes as the fog seal: sealing hairline cracks on the surface and rejuvenating oxidized asphalt. This technique can be used to help maintain cracked or broken edges.

In Texas, this practice is generally performed as a preventive measure after pavement edge repair or shoulder reshaping. Some districts report that edge sealing helps other repairs last longer. One concern about using an edge seal is creating a build-up of fine aggregate at the pavement edge after repeated application.

Edge seal at pavement edge
(from TxDOT Project 0-4396).

EDGE REPAIR TECHNIQUES

Standard repair techniques include pavement edge repair, reshaping (pulling up) the shoulder, cutting high edges, and replenishing the shoulder with select materials.

Pavement Edge Repair

Edge repairs are needed when the pavement has failed along the edge due to the action of traffic and the loss of edge support. The repair of localized edge damage is similar to pothole patching and is among the most simple of repair techniques because it involves hand patching. Different types of repair materials are used, including hot mix asphalt and cold mix asphalt. The basic procedure to repair the pavement edge can be defined as follows: Clean, Tack, Place and Compact.

- Clean the edge drop area.
- Apply a tack coat to exposed surfaces. [1]
- Place patching material to fill the drop.
- Compact materials using compaction equipment.

Pavement edge failure (from TxDOT Project 0-4396).

Reshaping (Pulling) Shoulders and Replenishing Shoulders

The purpose of both these techniques is to reestablish the slope and shape of the shoulder, to ensure proper drainage from the surface of the pavement, to eliminate any edge drop between the pavement and shoulder, and to provide side support to the pavement.

Reshaping is done when there is very little erosion and when there is enough material in place to allow reestablishing the correct shape. On the other hand, replenishing is a similar operation but is done when there is more than a 2-inch drop-off

and where there are not enough materials in place on the shoulder to restore it to its original shape and slope.

Both of these operations may also involve cleaning and reshaping of the adjacent ditches. The best time to perform these operations is when the shoulder surface is moist; otherwise a water truck will be needed to dampen the surface.

A basic procedure to reshape earth and gravel shoulders involves the following:

- Remove debris from the shoulder and ditch.
- Blade the shoulder and spread the material using a motor grader.
- Compact the shoulder using compaction equipment after achieving proper cross-slope.
- Remove excess material and sweep pavement surface.

Replenishing pavement edges with select materials is an operation similar to reshaping the shoulder, with a few additional steps, as described below:

- Place and spread additional select material over the compacted shoulder surface.
- Compact additional select material.
- Apply a seal coat to stabilized shoulders.
- Remove excess material and sweep pavement surface.

Since replenishing involves the use of selected materials, this repair technique may be preferred at locations with recurring problems, such as the inside of horizontal curves, turning radii at intersections, erosion-prone areas and locations of pull-offs. If pavement edge drop-offs continue to be a problem, the local agency may want to consider paving the shoulder at these locations.

Replenishing repair in progress at inside of horizontal curve (from TxDOT Project 0-4386).

Cutting High Edges

Another problem at the pavement-shoulder junction is build-up of material. This occurs as a result of not cleaning the shoulders after winter operations. Anti-skid material gets shoved to the side of the road by traffic action and catches dust and dirt. Vegetation then begins to grow in this excess material. Accumulated debris, excess materials, and vegetation along the edge of the pavement must be bladed off periodically to facilitate proper drainage. Shaved-off materials from the high edges are frequently used to fill low spots elsewhere. Cutting high edges is often scheduled during spring maintenance operations to avoid exposing soils to erosion when there is no vegetation.

NOTES

[1] PennDOT does not require the use of a tack coat when placing a cold mix.

SOURCES

Lawson, W.D., and Hossain, M.S. *Best Practices for Pavement Edge Maintenance*. Report No. 0-4396-1. Texas Department of Transportation. May 2004.

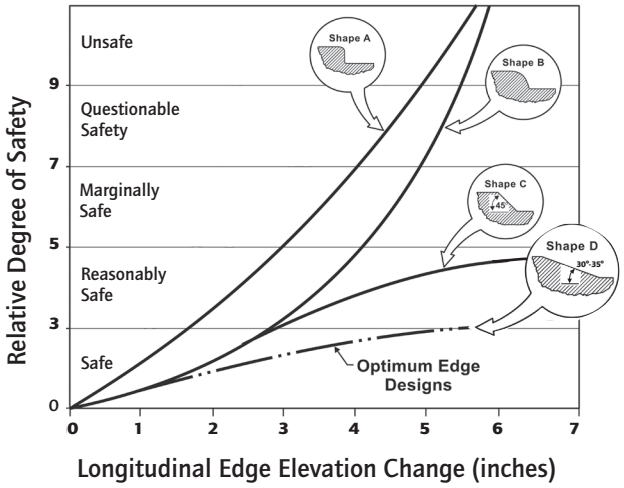
Shoulder Maintenance. LTAP Technical Information Sheet # 62. The Pennsylvania Local Roads Program. Summer 1995.

Pavement Maintenance Manual. Nebraska Department of Roads, www.nebraskatransportation.org/docs/pavement/pdf.

Call 1-800-FOR-LTAP for more information on pavement edge maintenance.

Relative Safety of Various Edge Elevations and Shapes

The chart below shows how various edge shapes relate to safety at speeds of up to 55 mph.



Graphic Source: Zimmer and Ivey, Texas Transportation Institute

The Safety Wedge Shoe is a special edging device that asphalt paving contractors can install on new or existing resurfacing equipment to shape the Safety Edge.

Contact the FHWA for More Information about the Safety Edge and other Roadway Departure Crash Countermeasures

For more information about Roadway Departure issues and effective countermeasures to prevent Roadway Departure crashes, go to the FHWA Office of Safety's Web site at **http://safety.fhwa.dot.gov/** and click on "Roadway Departure." FHWA contacts for technical assistance with the Safety Edge are listed below.

CONTACTS

Frank Julian
FHWA Resource Center
Safety and Design Team
(404) 562-3689
Frank.Julian@dot.gov

Chris Wagner
FHWA Resource Center
Pavement and Materials Team
(404) 562-3693
Christopher.Wagner@dot.gov

Cathy Satterfield
FHWA Office of Safety
Roadway Departure Team
(708) 283-3552
Cathy.Satterfield@dot.gov

1. Hallmark et. al: *Safety Impacts of Pavement Edge Drop-Offs,* AAA Foundation for Highway Safety, Washington, DC, September 2006.

U.S. Department of Transportation
Federal Highway Administration

Publication Number FHWA-SA-09-023

YOU CAN REDUCE PAVEMENT EDGE DROP-OFFS WITH THE SAFETY EDGE PAVEMENT EDGE TREATMENT

- ***Saves Lives***
- ***Reduces Tort Liability***
- ***Reduces Maintenance Expense***
- ***Costs Less than 1 Percent of Pavement Resurfacing Budget***

Safe Roads for a Safer Future
Investment in roadway safety saves lives

Pavement Edges Can Pose Serious Safety Risks

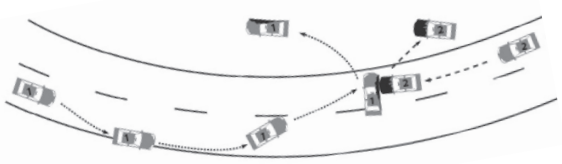
Roadway departures account for 53 percent of fatal crashes. While national data documenting the role of pavement edge configuration in the sequence of events leading to crashes are not available, some State-level studies point to the life-saving potential of safety edges. For example, researchers studying crashes in Iowa during 2002-2004 reported that pavement edges may have been a contributing factor in as many as 18 percent of rural run-off-road crashes on paved roadways with unpaved shoulders. This type of crash was four times more likely to include a fatality than rural crashes overall on similar roads.[1]

How Pavement Edges Affect Crash Severity

When a tire drops off a paved surface, sometimes just inches from the travel lane, a driver can have difficulty re-entering the roadway if the pavement edge is nearly vertical—especially if the height difference is significantly more than 2 inches. When a driver drifts off the pavement and tries to steer back on, the nearly vertical edge can create a "tire scrubbing" condition that may result in over-steering. If drivers over-steer to return to the paved surface without reducing speed, they are likely to lose control of the vehicle. The vehicle may veer into the adjacent lane, where it may collide with, or sideswipe oncoming cars; overturn; or run off the opposite side of the roadway and crash.

Photo Source: FHWA

Sharp, steep pavement edge drop-offs can contribute to crashes.



This is a typical diagram for a crash caused by tire scrubbing. The vehicle at left scrubbed the edge of the pavement, and when it returned, the driver overcorrected, lost control, crossed into the adjacent lane, and struck an oncoming vehicle.

Graphic Source: AAA Foundation for Highway Safety

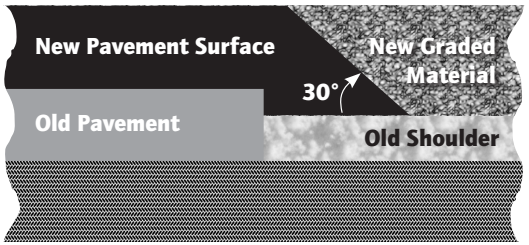
Increase Roadway Safety at No or Low Cost by Specifying the Safety Edge

A simple and cost-effective way to promote pavement edge safety is to adopt a standard specification for all resurfacing projects that requires a 30° - 35° angle "Safety Edge." After paving, the adjacent material is graded flush with the top of the pavement.

Solutions to the Pavement Edge Drop-off Risk

- Require a 30° - 35° angle asphalt wedge "Safety Edge" at the graded material interface in asphalt resurfacing projects.
- Routinely resurface shoulders when roadways are resurfaced, and add the Safety Edge.
- Maintain edge drop-off depths at 2 inches or less on high-speed highways.

The asphalt wedge provides a safer roadway edge, and a stronger interface between the pavement and the graded material. The additional cost of the asphalt wedge is minimal when included as part of resurfacing projects. Benefits include the avoided economic and social impacts of fatalities, injuries, and property damage.



The placement of the asphalt wedge during resurfacing operations mitigates the risk posed by edge drop-offs as soon as the paving machine lays down the asphalt mat, allowing the highway agency reasonable time to restore the shoulder or other adjacent graded material.

A-14

Pedestrian Sign
(PennDOT Publication 236M, W11-2)

(_) Feet Plaque
(PennDOT Publication 236M, W16-2)

Diagonal Downward Pointing Arrow
(PennDOT Publication 236M, W16-7P)

Ahead Plaque
(PennDOT Publication 236M, W16-9P)

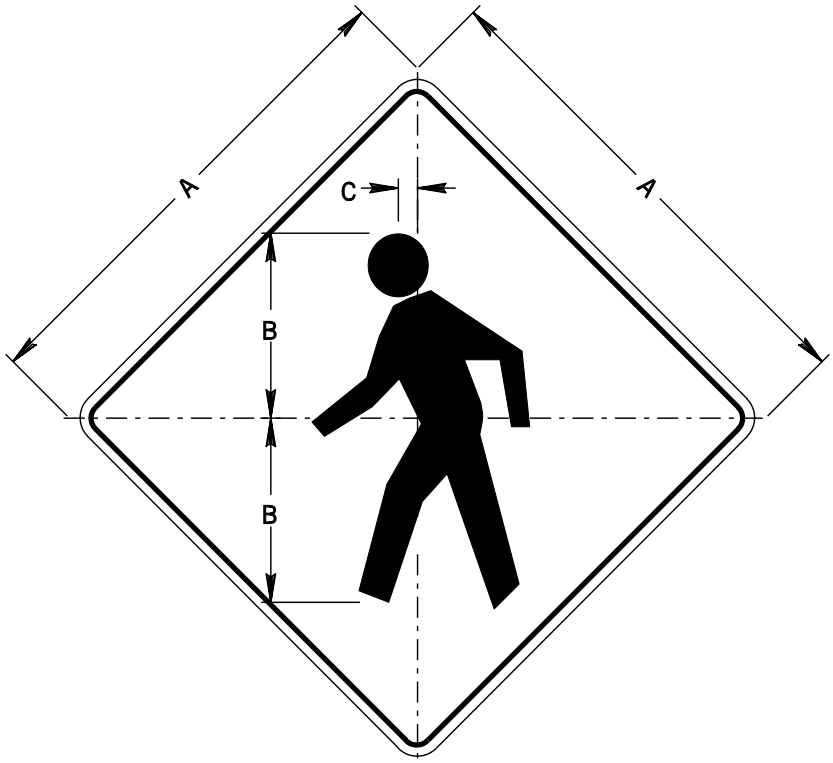
W11–2

PEDESTRIAN SIGN

The Pedestrian Sign (W11–2) may be used to warn of the unexpected hazard of pedestrians entering, or sharing the use of, or crossing the roadway. The W11–2 sign may be installed in advance of the crossing, in which case it may be supplemented with the (__) Feet Plaque (W16–2) or the Ahead Plaque (W16–9P).

If the sign is used at the crossing, the W11–2 sign shall be supplemented with a Diagonal Downward Pointing Arrow Plaque (W16–7P) showing the location of the crossing, which may or may not have crosswalk marking.

Fluorescent yellow–green background may be used for the W11–2 Sign, in which case all associated plaques shall be the same color.



DIMENSIONS – mm (IN)					
SIGN SIZE A x A	B	C	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	340 (13.6)	38 (1.5)	10 (0.4)	20 (0.8)	B3–750 (B3–30)

COLOR:

SYMBOL AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW OR FLUORESCENT YELLOW GREEN (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

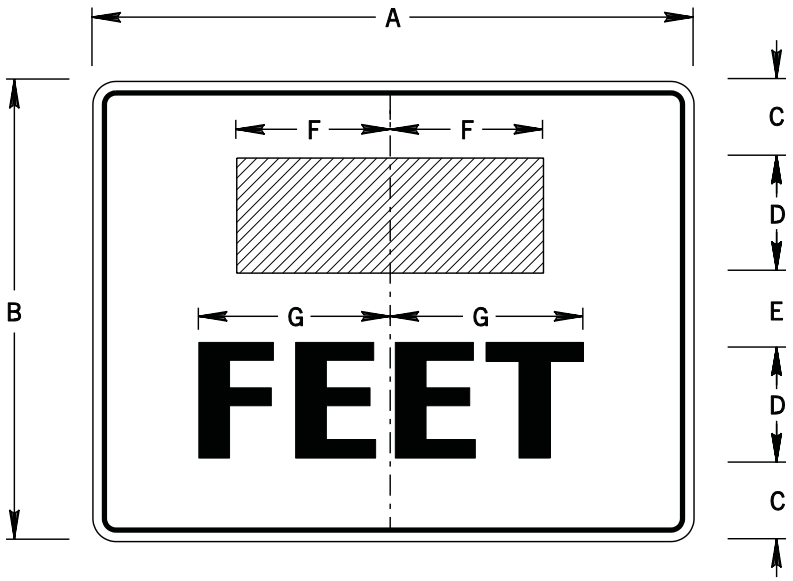
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W16–2

(__) FEET PLAQUE

(a) Justification. The (__) Feet Plaque (W16–2) may be used below a standard warning sign to indicate the distance to the condition cited by the warning sign. Normally distances used should be in an increment of 150 m (500'). This plaque shall only be fluorescent yellow–green, when used beneath another fluorescent yellow–green sign.

(b) Size. The 750 mm by 600 mm (30" x 24") size should be used with 1200 mm by 1200 mm (48" x 48") and larger warning signs.



DIMENSIONS – mm (IN)								
SIGN SIZE A x B	C	D	E	F	G	MAR–GIN	BOR–DER	BLANK STD.
600 x 450 (24" x 18")	75 (3)	125D (5D)	50 (2)	VAR.	186 (7.4)	10 (0.4)	15 (0.6)	B5–600450 (B5–2418)
750 x 600 (30" x 24")	110 (4.4)	150D (6D)	80 (3.2)	VAR.	224 (8.9)	15 (0.6)	20 (0.8)	B5–750600 (B5–3024)

COLOR:

LEGEND AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW OR FLUORESCENT YELLOW–GREEN (REFLECTORIZED)

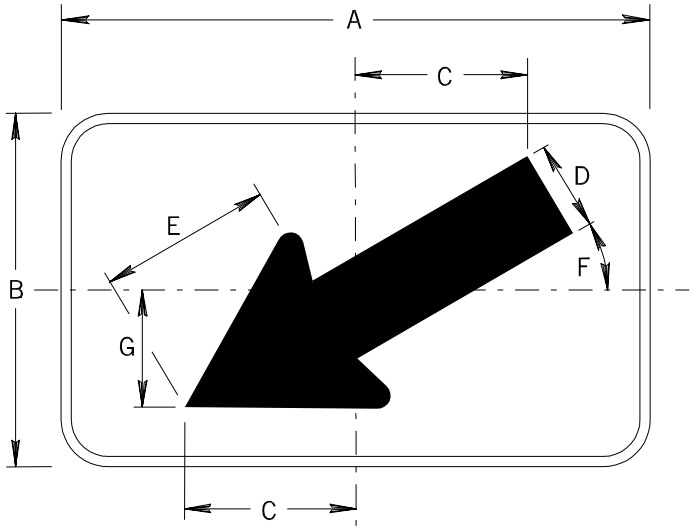
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W16–7P

DIAGONAL DOWNWARD POINTING ARROW

The Diagonal Downward Pointing Arrow Plaque (W16–7P) may be used below the Pedestrian Sign (W11–2), the School Sign (S1–1) and other crossing signs when the crossing sign is installed at the crossing location.



DIMENSIONS – mm (IN)								
SIGN SIZE A x B	C	D	E	F	G	MAR–GIN	BOR–DER	BLANK STD.
600 x 300 (24" x 12")	146 (5.8)	75 (3)	147 (5.9)	30°	99 (3.9)	10 (0.4)	15 (0.6)	B5–600300 (B5–2412)
750 x 450 (30" x 18")	219 (8.7)	113 (4.5)	221 (8.8)	30°	149 (5.9)	15 (0.6)	20 (0.8)	B5–750450 (B5–3018)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW OR FLUORESCENT
YELLOW GREEN (REFLECTORIZED)

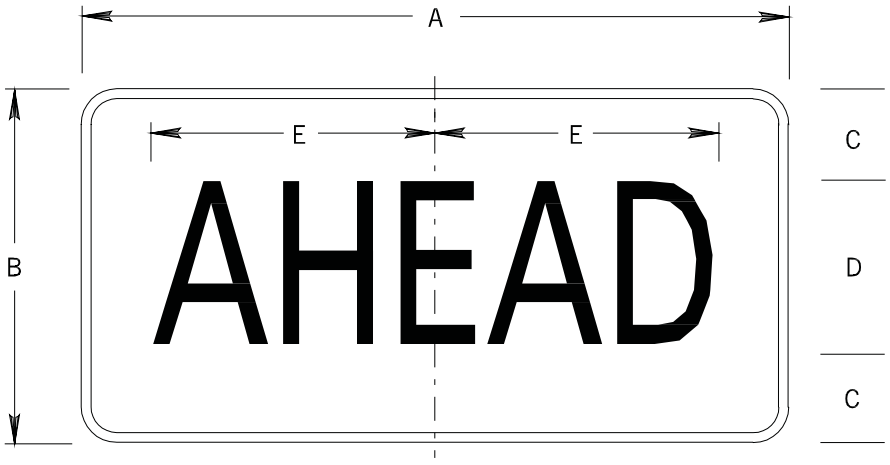
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 06–30–08
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W16–9P

AHEAD PLAQUE

The Ahead Plaque (W16–9P) may be used to supplement a variety of warning signs such as Two–Way Traffic Sign (W6–3), School Advance Warning Sign (S1–1), and variety of crossings signs.



DIMENSIONS – mm (IN)						
SIGN SIZE A x B	C	D	E	MAR–GIN	BOR–DER	BLANK STD.
600 x 300 (24" x 12")	100 (4)	100D (4D)	222 (8.7)	10 (0.4)	15 (0.6)	B5–600300 (B5–2412)
900 x 600 (36" x 24")	212.5 (8.5)	175D (7D)	388 (15.3)	15 (0.6)	25 (1)	B5–900600 (B5–3624)
1200 x 750 (48" x 30")	262.5 (10.5)	225D (9D)	499 (19.7)	20 (0.8)	30 (1.2)	B5–1200750 (B5–4830)

COLOR:

LEGEND AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW OR FLUORESCENT YELLOW GREEN (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 06–30–08
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

A-15

Improving Transit Stop/Station Access
(walkinginfo.org)

walkinginfo.org
Pedestrian and Bicycle Information Center

Improving Transit Stop/Station Access

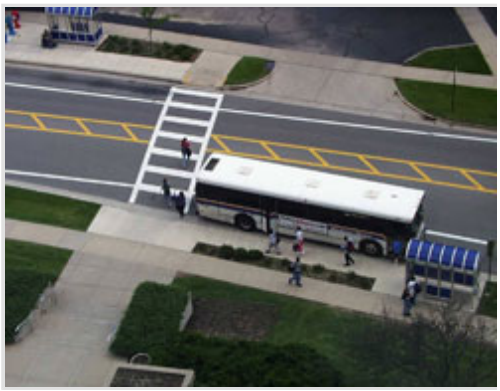
Riders need safe and convenient routes to get to and from transit. Riders will typically walk one-fourth to one-half mile (about a 5 to 10-minute walk for most people) to and from transit. Riders typically walk to a transit stop, board the bus or train, get off, and then walk to their final destination. Thus, the riders' needs as pedestrians extend beyond the bus stop to and from the surrounding neighborhood. However, transit agencies usually assume responsibility only for their stops, stations, and parking lots, and not for sidewalks, crossings, or other pedestrian elements on nearby streets. As a result, pedestrians must often cross busy streets and cut through parking lots to get to the bus stop or train station.

Transit agencies need to cooperate with local transportation agencies to improve pedestrian access to transit. Building sidewalks will make bus stops and train stations more accessible. Safe and convenient crossings are also essential, especially for midblock bus stops. New stops and stations can be placed with pedestrian (and bicycle) access in mind.

Access to transit stops located on surface streets

Choosing transit stops for buses, light rail, and bus rapid transit (BRT) is a complicated task, as each location must take into account three factors:

1. Passengers (stops must be near places where there's an expectation of riders)
2. Access (if a stop can't be located right where riders are, they must be able to get to the stop conveniently)
3. Traffic characteristics (buses can't always stop where riders want to be because of complex traffic patterns, especially at intersections)



Therefore, access to transit also involves selecting the right location for stops, especially for bus stops located on surface streets. The Transportation Research Board (TRB)'s Transit Cooperative Research Program (TCRP) Report 19: Guidelines for the Location and Design of Bus Stops provides information on locating and designing bus stops in various operating environments.

Since there is an element of risk in crossing busy streets, safety improvements must be made at transit stops. The safety of pedestrians can also be enhanced using a variety of transit operation improvements (such as consolidating, relocating or eliminating stops) usually implemented by the transit agency in cooperation with the road authority. Convenient access by passengers must remain at the forefront of all transit stop planning: simply eliminating stops because they are perceived as unsafe will not be satisfactory to riders who cannot walk very far.

When a transit stop is located midblock, a single crossing should be provided to serve both directions of bus travel. If a crosswalk is marked midblock, it should be behind the bus stop for several reasons:

- Pedestrians cross behind the bus, where they can see oncoming traffic (crossing in front of a bus blocks visibility).
- The bus driver can accelerate as soon as passengers have left the bus.
- The bus driver won't accidentally hit a pedestrian crossing in front of the bus, out of the driver's cone of vision.

At intersections, farside stops are usually preferred for a variety of safety and operational reasons. One safety advantage is that pedestrians cross in back of the bus. Operationally, a far side stop often improves intersection capacity by allowing motor vehicles to make right turns even when the bus in loading and unloading. However, transit operators often must place stops nearside, for reasons such as a concentration of users at a nearside corner, or because the bus route makes a right turn at that intersection. In all cases, the safety and convenience of pedestrians must be a high priority.

Access to light rail and BRT on dedicated rights-of-way

Transit agencies often build park-and-ride lots at rail and BRT stations for riders who live far from the station. Once these riders park their cars, they become pedestrians as they walk through the parking lot to the station itself. These parking lots can present challenges for pedestrians walking to the station. Pedestrians can be at risk of being struck by motorists looking for, driving into, and backing out of parking spaces; they must also dodge cars and buses on access roads and passenger drop-off areas.

Park-and-ride lots can be designed to reduce these risks to pedestrians. For example, sidewalks can be built between rows of facing cars so that pedestrians don't have to walk in the aisles. Pedestrian routes should cross access roads where drivers will expect and see them. Bus loading areas should be positioned so that pedestrians don't have to cross between parked buses. Because hundreds of people may get off a train at once, there must be enough sidewalk space adjacent to the station entrance so that no one is forced to walk along the roadway.

Access to BRT on surface streets

Bus rapid transit often operates in a hybrid mode; it can run on dedicated rights-of-way on special tracks and also act like a bus on streets. Often the special tracks are laid in the median of a wide thoroughfare or boulevard. Stations are typically far apart to improve operational efficiency. This creates situations where stops will attract a large number of riders within a busy street environment, with multiple challenges:

- Providing enough waiting area for passengers
- Providing safe and convenient street crossings
- Ensuring that waiting, crossing, boarding, and de-boarding passengers don't interfere with the flow of pedestrians just walking by

Transit stop/station design

Providing a few amenities can make waiting for the bus or train a much more pleasant experience. Shelters with seating can offer protection from rain, snow, wind, and sun. Many transit agencies provide shelters at frequently-used bus stops and at outdoor rail stations. The shelters should be positioned so riders in wheelchairs have enough room to enter and exit the shelter. The sidewalk behind the shelter should be wide enough for two wheelchair users to pass each other and to handle the expected levels of pedestrian activity, including those who are just walking by. The best location for bus shelters is in the furniture zone, away from the walking zone.

Schedules and route maps should be placed at bus stops or in train stations to orient riders. Current technology makes it easy to have video monitors with bus arrival times in real time, displaying the number of minutes until the next bus or train and its destination.

Nighttime lighting is important for passenger safety and security. Lighting makes it easier for riders to watch their step so they don't trip on station escalators or while boarding the bus. With lighting, drivers are more likely to see riders crossing the street. Riders are more secure while they're waiting because they can see their surroundings and watch for suspicious activity.

Transit must be made accessible to riders with disabilities, who often don't have other travel options. Federal regulations require design treatments such as station elevators and tactile strips along platform edges (to allow visually-impaired riders who use canes to detect the edge of a platform). Adequate room should exist to operate wheelchair lifts (minimum ADA Accessibility Guidelines for

Buildings and Facilities [ADAAG] requirement is 8 ft). Many transit agencies also provide large-print maps, make audio announcements of upcoming stations and bus stops, designate wheelchair-boarding areas, and operate low-floor buses.

This site is funded by the U.S. Department of Transportation Federal Highway Administration and maintained by the Pedestrian and Bicycle Information Center within the University of North Carolina Highway Safety Research Center. Please read our Usage Guidelines

A-16

Providing Friction in Bituminous Wearing Courses *(PennDOT Publication 242, Section 5.6)*

Skid-Resistive Pavement Surface Treatment

McGee, Hugh W. and Fred R. Hanscom., *Low Cost Treatments for Horizontal Curve Safety*. FHWA-SA-07-002. Washington, DC: Federal Highway Administration, December 2006.

5.5 LONGITUDINAL JOINTS

During the proposal preparation stage of a project, consideration shall be given to specifying construction procedures that would provide for the best possible bituminous pavement in the area around the longitudinal joint. For those pavements where the District requires special construction procedures, a provision must be included requiring full-width paving, dual pavers or another system that would accomplish the desired result. Also, include appropriate provisions in the M&PT special provision to coordinate the paving method with traffic protection and/or detour operations. Refer to Publication 203, Work Zone Traffic Control for M&P setup requirements.

5.6 PROVIDING FRICTION IN BITUMINOUS WEARING COURSES

The pavement surface of a highway should have an adequate level of friction throughout its life to insure safe driving conditions. From a safety standpoint, a desirable surface:

- develops an adequate amount of friction between the tire and pavement
- has sufficient surface texture (i.e., low-speed gradient) to prevent build-up of water pressure at the tire/pavement interface at the posted speed limit
- is capable of retaining these properties under traffic and environmental conditions throughout the life of the surface.

Studies of bituminous pavement surfaces during their normal service life indicate that material properties, mix design and construction techniques are all criteria in the development of a surface with good friction values. The most significant material property affecting the surface friction is the polishing resistance of the coarse aggregate. In 1975, PENNDOT adopted a system of rating aggregates for friction.

The rating system was developed from a comprehensive test strip research program. It was determined that friction values go through an annual cycle in Pennsylvania roughly approximating a sine curve. Low values usually occur in late summer and fall with the amplitude depending on coarse aggregate characteristics and traffic volume. Initial friction measurements were nearly all adequate and not indicative of future performance. Coarse aggregate properties have the major effect, and the petrographic properties of a particular source can be related to its friction value.

Each of the approved sources of coarse aggregate listed in Bulletin 14, Approved Aggregate Producers, are assigned a Skid Resistance Level (SRL) designation based on the particular aggregate properties. The SRL designation for an aggregate is based on performance in properly designed and produced dense-graded bituminous surfaces. Friction test results determined by PENNDOT, using AASHTO-T242 Test Method, are used in reevaluating SRL designations.

When planning all new construction, overlays and resurfacing work, use the guidelines in Table 5.4 to determine the appropriate SRL designation for the coarse aggregate used in bituminous wearing course or the fine aggregate in FJ-1 wearing course. Determine the SRL designation by the anticipated initial ADT on new facilities or the current ADT for resurfacing. Exceptions to this may be made on a project-by-project basis.

Whenever a bituminous wearing course will be used, the SRL designation shall be indicated on pavement design approval forms, on typical sections and in the contract proposal. A contractor is given the option of providing an aggregate with that SRL or better or an equivalent blend of aggregates. ***The use of inappropriately high SRL designations on non-wearing courses, leveling courses, shoulders and short duration temporary roadways will be prohibited.***

Table 5.4 SRL Criteria

Initial or Current Two-Way ADT*	SRL Designation
Above 20,000	E
5,001 - 20,000	H; Blend of E and M; Blend of E and G
3,001 - 5,000	G; Blend of H and M; Blend of E and L
1,001 - 3,000	M; Blend of H and L; Blend of G and L; Blend of E and L;
0 - 1,000	L

*When all traffic for an SR travels in one direction, divide the ADT values shown above by 2 to determine the required SRL.

5.7 SUPERPAVE HOT-MIX ASPHALT PAVING COURSES

5.7.1 General

Superpave was one of the results from the Strategic Highway Research Program (SHRP) conducted between 1989 and 1993. Superpave provides a system for designing hot-mix asphalt paving courses to resist the climatic and traffic conditions for a specific project location. The full Superpave Asphalt Mixture Design System includes a volumetric asphalt mixture design procedure and additional mixture analysis. The volumetric asphalt mixture design procedure is complete and ready for use. The additional mixture analysis is still undergoing research refinements and is not ready for use. The Superpave volumetric asphalt mixture design procedure is a basic mixture design procedure that will replace the Marshall method of asphalt mixture design. The additional mixture analysis is based on advanced performance testing and performance prediction models that will predict the performance of mixtures under the specific climatic and traffic conditions of a project.

Effectiveness

The table below lists estimated reductions in related crashes resulting from widening paved or unpaved shoulders. Related crashes, i.e., those affected by shoulder widenings, include single vehicle run-off-road and multiple vehicle head-on and sideswipe crashes. For example, widening an unpaved shoulder by 4ft (e.g., from 2 ft to 6 ft) would reduce related crashes by an estimated 25 percent. Adding 8-ft paved shoulders to a road with no shoulders would reduce related crashes by an estimated 49 percent. These estimated reductions in related crashes apply only when roadside characteristics (side slope and clear zone) are rebuilt to the condition existing before the shoulder was widened. Although the table below was developed for rural two-lane roads, and not limited to horizontal curves, it is reasonable to expect the major benefit from shoulder widening can also be realized for horizontal curves.

Crash Reductions Related to Shoulder Widening.

Shoulder Widening per Side, (ft)	Reduction in Related Crash Types (%)	
	Paved	Unpaved
2	16	13
4	29	25
6	40	35
8	49	43

SKID-RESISTIVE PAVEMENT SURFACE TREATMENT

Description

Agencies should maintain pavements to ensure adequate friction necessary for vehicle braking and maneuvering under both dry and wet conditions. A vehicle will skid during braking and maneuvering when frictional demand exceeds the friction force that can be developed between the tire and the road surface. Horizontal curves are particularly prone to these types of crashes, especially under wet conditions. On road segments where skidding crashes are known to occur, consider applying remedial treatments, including specific asphalt mixtures (type and gradation of aggregate as well as asphalt content), pavement overlays on both concrete or asphalt pavements, and pavement grooving.

Application of skid-resistive pavement surface in curve.

Application Guidelines

Target locations where skidding is a recognized problem and apply either skid-resistive overlays or pavement grooving treatment. Specifically, select sites where vehicle crashes directly result from skidding during wet pavement conditions.

Pavement Surface Overlay Design

Using aggregate that lacks specific particle gradations creates voids on the surface, which promotes better drainage and improves skid resistance. Engineers recommend applying a 1-in, open-graded asphalt concrete to reduce wet pavement crashes. The 1-in maximum gradation improves drainage and skid resistance because it has substantially more voids than the ⅜-in or ½-in maximum open-graded asphalt concrete standard mix.

An agency's first step is to repair major surface defects (cracks, ruts, etc.) and apply dense-graded asphalt concrete. Next, apply a tack coat to the existing surface before placing the open-graded material. Alternatively, apply a slurry seal using nonpolishing aggregate. A 0.15-ft-thick blanket of the 1-in maximum open-graded asphalt concrete should be sufficient to remove water, increase traction, and ultimately reduce the number of crashes.

Pavement Grooving Design

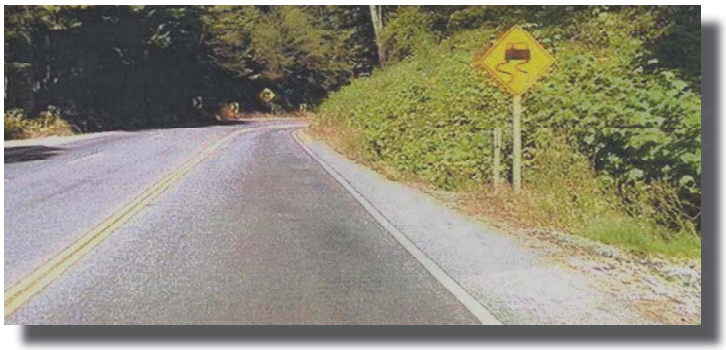
Pavement grooves increase skid resistance by improving drainage characteristics and creating a rougher pavement surface. Pavement grooving is a technique for installing longitudinal or transverse cuts on the surface to increase skid resistance and reduce the number of wet-weather crashes. Grooves cut in the longitudinal direction have proved most effective in increasing directional control of the vehicle, while transverse grooving is most effective at locations where vehicles make frequent stops. Therefore, applying longitudinal grooving is the commonsense choice for improving safety on horizontal curves.

Because asphalt concrete's uniform aggregate composition is not conducive to drainage, grooved pavement application is primarily intended for rigid concrete. Agencies can expect a greater accident-reduction result with application at 50 mi/h curves than at 30 or 40 mi/h curves because the major benefit of grooving is to reduce hydroplaning. An accepted application technique is to use a portable grooving machine equipped with carbide-tipped flails to install grooves 3/16 in to 3/8 in wide and 5/32 in to 5/16 in deep, with 8 grooves/ft on a random spacing.

Skid-Resistive Overlay Effectiveness

The rural two-lane curve shown in the figure on the following page was treated with 1-in graded asphalt concrete to improve skid resistance. The appropriate warning sign also was

installed. The result was an immediate reduced crash rate—from 16 wet pavement-related crashes in the 13-month period before treatment to two during the first six months following the treatment. Before treatment, 60 percent of crashes along a 2-mile section of treated pavement were wet-pavement related. After the treatment, wet-pavement accidents accounted for only 26 percent.



Rural curve treated with skid-resistive graded asphalt concrete, warning signs, and chevrons.

The New York State DOT (NYSDOT) implemented a program to identify sites statewide with a low skid resistance and treat them with overlays as part of the maintenance program. A site is eligible for treatment if its 2-year wet accident proportion is 50 percent higher than the average wet crash proportion for roads in the same county. Between 1995 and 1997, NYSDOT treated 36 sites on Long Island, which reduced the annually recurring wet road crashes by more than 800. These results, and others throughout the State, support earlier findings that treating wet-road crash locations can reduce this type of crash by 50 percent and reduce total crashes by 20 percent.

The Florida DOT (FDOT) treated a curved freeway ramp with Tyregrip®, a high-friction material illustrated below. This system consists of a highly modified exothermic epoxy resin two-part binder top dressed with a calcinated bauxite with a Polish Stone Value of 70 percent plus. The treatment proved effective at increasing the skid resistance value from 35 to 104. While the FDOT application was to a freeway ramp, the material may be applicable to a higher volume curve with a higher than normal number of wet pavement crashes.

Application of Tyregrip® friction material on a curved ramp.

Pavement Grooving Effectiveness

As indicated, grooved pavements can reduce wet-weather crashes. One study of a California two-lane road with sharp curves found a 72 percent reduction in wet-pavement accidents, but only 7 percent reduction in dry-pavement accidents. There is concern that grooving accelerates pavement wear, but it has not been shown to affect either ride quality or drainage performance.

Cost

Moderate costs are involved in the application of skid-resistive surface treatments. For example a 2-mi section of asphalt overlay cost the California DOT $200,000 in 1996.

Further Information

Technical Advisory T 5040.36 *Surface Texture for Asphalt and Concrete Pavements*, Federal Highway Administration, Washington, DC, June 17, 2005.

Florida DOT's experience with Tyregrip, high-friction material for Interstate ramp installation, Charles Holzschuher, phone (352) 955-6341.

A-17

Raised Crosswalks
(PennDOT Publication 383, Pages 46-47)

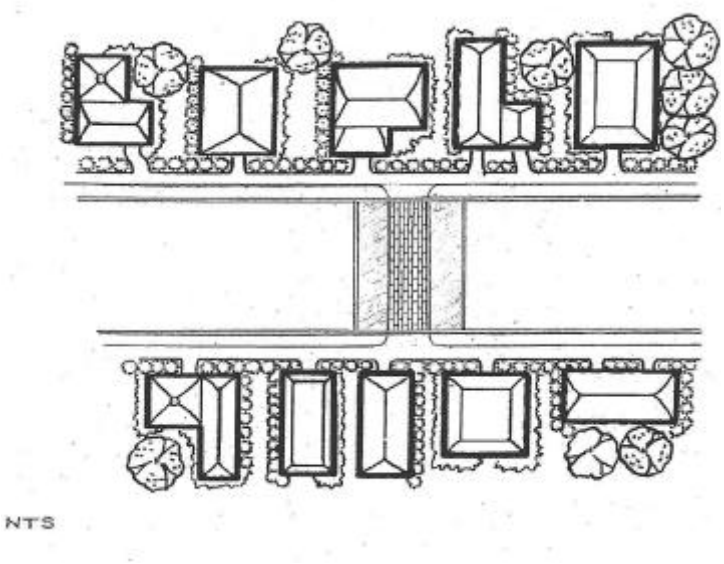
RAISED CROSSWALKS

Description:
Raised crosswalks are marked and elevated pedestrian areas that are an extension of the sidewalk at mid-block locations or intersections. Raised crosswalks are typically 3 to 6 inches above street level. In many jurisdictions, raised crosswalks are level with the curb, about 6 inches above the street. They often have the same profile as the Seminole County speed hump.

Appropriate Locations:
- They are appropriate on local streets and minor collectors, with volumes less than 10,000 vehicles per day.

Typical Uses:
- Reduce speeds and improve visibility of the pedestrians by defining crossings.

Speed/Volume Reductions:
- Raised crosswalks reduce speeds an average of 6 mph.
- Volumes are reduced an average of 12%.
- Due to their long flat tops and gently sloped ramps, raised crosswalks actually slow vehicles less than the Watts speed humps (12 feet in length; 3 inches in height) despite being as much as three inches higher.



Approximate Cost:
- Cost of a raised crosswalk is approximately $2,000 to $10,000 each. If drainage is an issue, costs could increase considerably.

Signing and Markings:
- It is recommended that the "Raised Pedestrian Crossing Warning Sign" (W11A-3) be used with each raised pedestrian crossing.

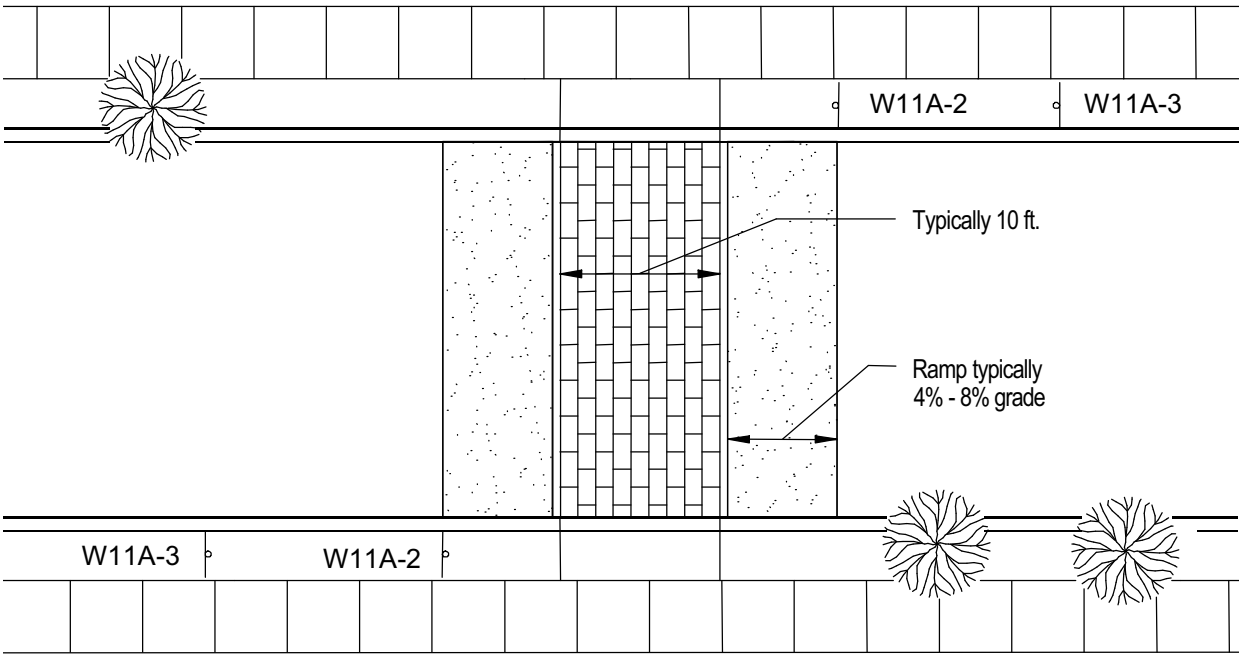
W11A-3

Other Considerations:
- If the raised pedestrian crossing is the same height as the curb, the edge of the raised crosswalk should be differentiated with a tactile measure to warn visually impaired people.
- Most appropriately used at areas with significant pedestrian crossing activity.
- Effectiveness of the measure is increased when used with textured crosswalks or curb extensions.
- Primary emergency access routes should be avoided, unless acceptable to emergency service providers.
- A catch basin should be installed for drainage on the uphill side of the raised crosswalk.
- All ADA requirements must be met.
- In areas with snow removal problems, a measure such as a flexible delineator post may be needed at each hump to alert snowplow operators to lift their blades.

Advantages:	Disadvantages:
❑ Reduce speeds. ❑ Improves visibility for pedestrians. ❑ Improves the visibility of pedestrians. ❑ May reduce volumes.	❑ Slows emergency vehicles by 4 to 6 seconds, on average. ❑ May generate noise and additional emissions from vehicle deceleration and acceleration. ❑ Require more maintenance than traditional crosswalks. ❑ Icing can be a problem If snow is not properly removed.

Raised Crosswalk

For typical profile, see drawings of Seminole County speed table or the Gwinnett County speed table in the "Speed Humps" section.



W11A-2

W11A-3

A-18

Roundabouts: A Proven Safety Solution that Reduces the Number and Severity of Intersection Crashes *(Federal Highway Administration, FHWA-SA-10-005)*

14 ISSUE BRIEFS

Roundabouts: A Proven Safety Solution that Reduces the Number and Severity of Intersection Crashes

What is a Modern Roundabout?

A modern roundabout is a circular intersection with specific design and traffic control features that distinguish it from other types of circular intersections. These features include a counterclockwise traffic flow around a central island, yield control for entering traffic, channelized approaches, and appropriate geometric curvature and features to induce desirable vehicular speeds. These features have been proven to reduce the number and severity of intersection crashes.[1]

History of Roundabouts

The "modern roundabout" is commonly confused with older-style traffic circles and rotaries. Traffic circles have been around for over a century, with one of the earliest documented being built in 1905 on the southwest corner of Central Park in New York City and named after Christopher Columbus. From the start, traffic circles provided the ability for a city to tie a number of intersecting streets together and make a landscaped central circle that had aesthetic value to the community. Many large circles or rotaries were built in the United States until the 1950s when they fell out of favor. The older-style rotaries enabled high-speed merging and weaving of vehicles that led to a high crash experience.

The modern roundabout evolved from studies in the United Kingdom of various features to rectify problems associated with older traffic circles. In 1966, the United Kingdom adopted a rule requiring entering traffic to "give way," or yield, to circulating traffic at all circular intersections. This rule prevented circular intersections from locking up by not allowing vehicles to enter the intersection until there were sufficient gaps in circulating traffic.

Since the modern roundabout is significantly different from the older-style traffic circles in both design and operation, they have been used successfully around the world. It is estimated that there are tens of thousands worldwide and more than a thousand installations in the United States to date.

What Users Do Roundabouts Serve?

Roundabouts must be designed to meet the needs of all users—drivers, pedestrians, and bicyclists—each of whom may have varying abilities. Proper site selection and the design of appropriate geometric features and traffic control devices are essential to making roundabouts accessible to all users. Roundabouts can also be designed for trucks and larger vehicles and in geographic areas where significant snowfall is the norm during the winter.

The needs of pedestrians with visual disabilities require particular attention in design. Most pedestrians who cross streets at roundabouts use their vision to identify a crossable gap between vehicles or to detect that a driver has yielded to them. Blind pedestrians rely primarily on auditory information to make judgments when crossing a street.

1. Robinson, B. W., L. Rodegerdts, W. Scarbrough, W. Kittelson, R. Troutbeck, W. Brilon, L. Bondzio, K. Courage, M. Kyte, J. Mason, A. Flannery, E. Myers, J. Bunker, and G. Jacquemart. *Roundabouts: An Informational Guide*. Report FHWA-RD-00-067. FHWA, U.S. Department of Transportation, June 2000. (This document is being updated, with publication likely in 2010.)

U.S.Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives

FHWA-SA-10-005

Recent research suggests that some roundabouts can present significant accessibility challenges and risks to the blind user, both in judging acceptable gaps in traffic and in detecting that a driver has yielded. The U.S. Access Board has published a bulletin[2] that describes strategies that may improve the accessibility of roundabouts to blind pedestrians.

Features of Modern Roundabouts

The design and traffic control features of roundabouts, shown in Figure 1, are as follows:

- Yield control is used on all entries.
- Circulating vehicles have the right of way. All vehicles circulate counterclockwise around a central island.
- Pedestrian access is allowed only across the legs of the roundabout, behind the yield line to the circulatory roadway. Pedestrian crossings are typically located at least one vehicle length upstream of the yield point.
- The splitter island is a raised or painted area on an approach used to separate entering from exiting traffic, deflect and slow entering traffic, and provide storage space for pedestrians crossing the road in two stages.
- Landscaping buffers may be provided to improve the aesthetics of the intersection, better separate vehicular and pedestrian traffic, and encourage pedestrians to cross only at the designated crossing locations.
- All intersections that include pedestrian facilities must comply with accessibility standards as required by the Americans with Disabilities Act (ADA). Accessibility features at roundabouts include sidewalks and crosswalks that meet surface, slope, and clearance requirements; ramps connecting sidewalks and crosswalks; and detectable edge treatments at ramp/roadway boundaries. In situations where there are few crossable gaps, or, at crossings with multiple lanes, some form of pedestrian signalization may be appropriate.

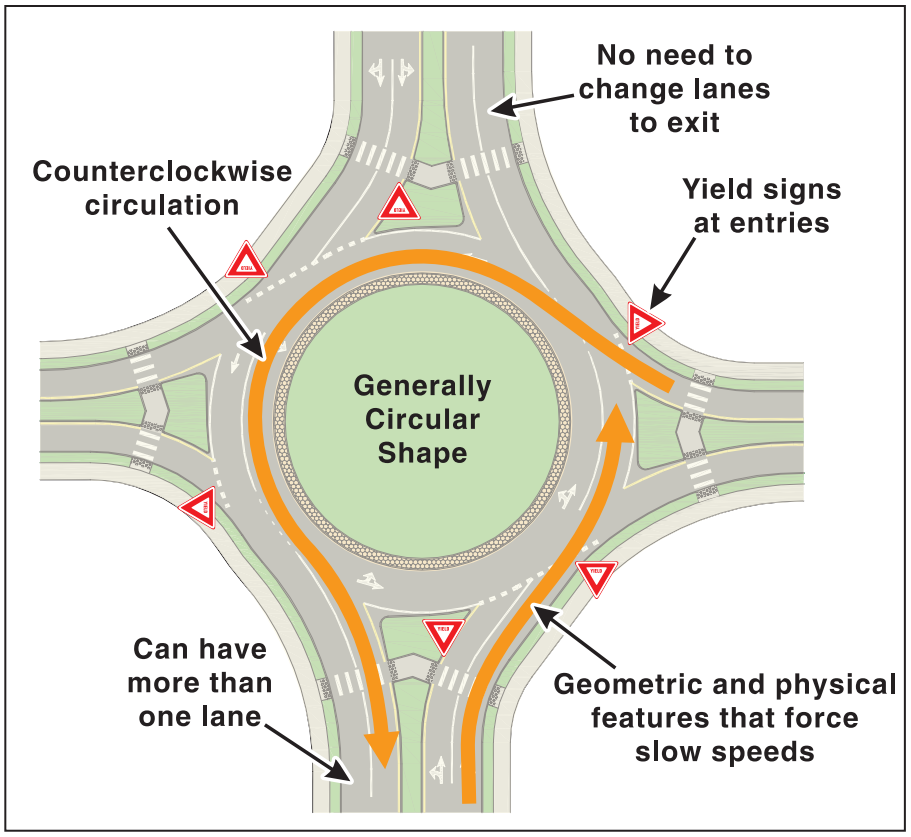


Figure 1. Features of Roundabouts

Roundabout Safety

NCHRP Report 572 examined crash data at 55 sites and reported the estimated change in performance when converting to a roundabout from a variety of intersection types.[3] Table 1 summarizes these findings and presents crash reduction factors (CRFs) and standard errors for each type of control in the before condition. Each CRF is associated with a certain standard error, which is a measure of the accuracy of estimate of the true value of the CRF. A relatively small standard error indicates that a CRF is relatively accurately known. A relatively large standard error indicates that a CRF is not accurately known. The standard error may be used to estimate a confidence interval of the true value of the CRF.

The results shown in Table 1 demonstrate that roundabouts produce a statistically significant reduction in all types of crashes and particularly injury crashes for a variety of conditions. The notable exceptions are the findings for all-way stop-controlled intersections, which demonstrated no statistically significant difference between the safety performance of all-way stop-controlled intersections and that of roundabouts (standard error exceeded the magnitude of the estimate). NCHRP Report 572 also found very few reported crashes involving pedestrians or bicycles, although it did identify conditions that may make crossings more chal-

2. United States Access Board. "Pedestrian Access to Modern Roundabouts: Design and Operational Issues for Pedestrians who are Blind." http://www.access-board.gov/research/roundabouts/bulletin.htm.

3. Rodegerdts, L. A., M. Blogg, E. Wemple, E. Myers, M. Kyte, M. Dixon, G. List, A. Flannery, R. Troutbeck, W. Brilon, N. Wu, B. Persaud, C. Lyon, D. Harkey, and E.C. Carter. NCHRP Report 572: *Roundabouts in the United States*. Washington, DC, Transportation Research Board of the National Academies, 2007.

Table 1. Safety Performance Estimates for Intersection Conversions to Roundabouts

Control Before	Crash Severity	Point Estimate of the Percentage Reduction in Crashes (Standard Error)
All Sites (all environments, all number of lanes)	All	35 (3)
	Fatal/Injury	76 (3)
Signalized (all environments, all number of lanes)	All	48 (5)
	Fatal/Injury	78 (6)
All-Way Stop (all environments)	All	No statistically significant change
	Fatal/Injury	No statistically significant change
Two-Way Stop (all environments)	All	44 (4)
	Fatal/Injury	82 (3)
Two-Way Stop (rural only)	All	72 (4)
	Fatal/Injury	87 (3)

lenging, particularly for pedestrians with visual impairments. Further information, including a more detailed breakdown of results by factors such as environment, number of lanes, and so on, can be found in the report.

Fatal crashes at roundabouts are extremely rare events and thus were not a specific focus of the report study. A March 2007 report by the Maryland Highway Administration indicates that 19 single-lane roundabouts with at least 2 years of history since construction (and an average of 6.4 years of history since construction) have experienced a 100 percent reduction in fatal crashes.[4]

These analyses suggest that well designed roundabouts can be safer and more efficient than conventional intersections. Safety considerations and benefits of roundabouts include the following:

- Roundabouts have fewer conflict points in comparison to conventional intersections. The potential for hazardous conflicts, such as high-speed right-angle, left-turn, and head-on crashes, is virtually eliminated by the geometry of a roundabout. Low absolute speeds associated with roundabouts allow users more time to react to one another, thus contributing to fewer and less severe crashes.
- Roundabouts with single-lane approaches produce greater safety benefits than roundabouts with multilane approaches because of fewer potential conflicts between road users. However, roundabouts with multilane approaches show similar improvements in reducing injury crashes.
- Roundabouts in a range of settings (urban, suburban, and rural) result in reduced total and injury crashes when compared to signalized and two-way stop intersections. Safety benefits for installation of roundabouts in rural settings have been found to be particularly significant.
- Recent research has not found substantial safety problems for nonmotorists at roundabouts. However, roundabouts have demonstrated challenges related to the accessibility and usability of roundabout crosswalks for pedestrians with visual impairments. Research is being conducted on the effectiveness of a variety of treatments to address this problem. The United States Access Board has issued draft accessibility guidelines stating that, at roundabouts with multilane crossings, a pedestrian-activated signal shall be provided for each segment of each crosswalk, including the splitter island.[5]

Safety Problems Susceptible to Correction by Roundabouts

The decision to install a roundabout as a safety improvement should be based on a demonstrated safety problem of the type susceptible to correction by a roundabout. A review of crash reports and the type of crashes occurring is essential. Some types of crashes, including rear-end crashes and fixed-object crashes, may not improve or

4. Cunningham, R. B. *Maryland's Roundabouts: Accident Experience and Economic Evaluation*. Traffic Development and Support Division, Office of Traffic and Safety, Maryland State Highway Administration, Maryland Department of Transportation, March 2007.

5. United States Access Board. "Revised Draft Guidelines for Accessible Public Rights-of-Way." November 23, 2005. http://www.access-board.gov/prowac/draft.htm (accessed July 2009).

may actually increase with the installation of a roundabout.

Examples of safety problems susceptible to correction by roundabouts include high frequencies of right-angle, head-on, and left-turn/U-turn crashes and high severity that could be reduced by the slower speeds associated with roundabouts.

Issues to Review When Considering Roundabout Alternatives

Roundabouts are an intersection form that is proving to be useful in a variety of settings and circumstances. Roundabouts are not always the most appropriate choice, as other intersection forms may prove to be better options on a case-by-case basis. A common constraint in retrofit situations is right-of-way needs, which may be larger for a roundabout at the intersection corners than for other alternatives. In addition, some higher-volume installations may require larger designs (e.g., 3-lane entries and 3-lane circulatory roadways) that have had limited experience in the United States to date and might be more appropriately addressed with other intersection forms. However, they should at least be considered as an alternative and judged with other alternatives based on objective evaluation criteria (e.g., safety, operational performance, accessibility, environmental impacts, costs, and so forth).

The following issues should be considered during the planning and design of a roundabout:[6]

- **Context.** Is the roundabout the first in a community? Is it being located in a new roadway system, or is it replacing an existing intersection?
- **Space feasibility.** Is there enough right-of-way to build the roundabout? Is right-of-way acquisition required?
- **Physical or geometric complications.** Are there existing buildings, utility conflicts, drainage problems, and/or unfavorable topography that may limit visibility or complicate construction?
- **Significant traffic generators.** Are there generators of significant traffic nearby that could significantly affect the operation of the intersection, including high volumes of oversized trucks, heavy pedestrian traffic, or high bicycle use?
- **Operational considerations.** Is there traffic congestion that would cause routine backups into the roundabout, such as nearby traffic signals? This could include conditions that may require changes in traffic priority rules, such as queue clearance for an at-grade railroad crossing. Note that roundabouts may offer better operational performance than other intersection types, even if there is no significant safety improvement (e.g., comparisons with all-way stop-controlled intersections).
- **Delay to the major street.** Is the subject intersection one between a major arterial and a minor arterial or local road where an unacceptable delay to the major road could be created? Roundabouts introduce some delay to all traffic entering the intersection, including traffic on the major arterial that would not be present if the intersection were operated with two-way stop-control. Likewise, intersections located on arterial streets within a well-coordinated signal network may operate more efficiently as signalized intersections than as roundabouts due to the ability to promote progression of through movements.

Each of these conditions poses challenges for all types of intersections, not just roundabouts. Roundabouts have, in fact, been built at locations that exhibit nearly all of the conditions listed above. Each condition can be typically resolved through careful analysis and design, coordination with and support from other agencies, and potential implementation of specific mitigation actions. An objective comparison of alternatives is essential in aiding good decision making.

6. Robinson, B. W., L. Rodegerdts, W. Scarbrough, W. Kittelson, R. Troutbeck, W. Brilon, L. Bondzio, K. Courage, M. Kyte, J. Mason, A. Flannery, E. Myers, J. Bunker, and G. Jacquemart. *Roundabouts: An Informational Guide*. Report FHWA-RD-00-067. FHWA, U.S. Department of Transportation, June 2000. (This document is being updated, with publication likely in 2010.)

A-19

The Clear Zone Concept
(PennDOT Publication 13M (DM-2), Section 12.1)

Utility Poles and Trees
(PennDOT Publication 13M (DM-2), Section 12.3.I)

CHAPTER 12

GUIDE RAIL, MEDIAN BARRIER AND ROADSIDE SAFETY DEVICES

12.0 INTRODUCTION

Highways should be designed through judicious arrangement and balance of geometric features to preclude or minimize the need for roadside or median barrier. To provide for maximum roadside safety, a thorough study during the early stages of design is necessary to recognize and eliminate, where practical, those items and conditions which require barrier and impact attenuating devices.

While every reasonable effort should be made to keep a motorist on the roadway, the highway design engineer should acknowledge the fact that this goal will never be fully realized. Motorists continue to run off the road for many reasons, including driver error in the form of excessive speed, falling asleep, reckless or inattentive driving, or driving under the influence of alcohol or other drugs. A driver may also leave the road deliberately to avoid a collision with another motor vehicle or with objects on the road.

The consistent application of geometric design standards for roads and streets provides motorists with a high degree of safety. Design features such as horizontal and vertical curvature, pavement and shoulder width, and signing and pavement markings each play an important role towards achieving the desired level of safety. Roadside safety features, such as breakaway supports, bridge railings and impact attenuating devices provide an extra margin of safety to motorists who inadvertently leave the roadway. Most appurtenances are installed based on an analysis of their benefits to the motorists. In some instances, however, it may not be immediately obvious that the benefits to be gained from a specific safety design feature or treatment equal or exceed the additional costs. The design engineer must decide how and where limited funds should be spent to achieve the greatest overall benefits.

Railing systems mounted on bridges require a high level of protection be afforded to motorists. Select railing system Test Levels in accordance with the criteria of Section 12.10.

Policy and/or guidelines presented in this chapter, relative to clear zone, are applicable to all projects including new location, reconstruction and 3R projects. For resurfacing, restoration and rehabilitation (3R) projects, where major upgrading to horizontal or vertical alignment is not practical, clear zone widths less than those indicated in Table 12.1 may be suitable for attainment or retention. The cost of full reconstruction for these facilities will often not be justified. The designer must do specific site investigation and crash history analysis to determine a cost effective design by selectively upgrading the roadway and roadside to optimize the clear zone widths. Consideration must be given to the location and type of obstruction, existing roadway geometry and right-of-way widths, the ability to improve existing roadway geometry, signing and pavement marking and/or to require additional right-of-way, and the costs and benefits involved.

The following information and criteria are a guide and should be supplemented with sound engineering judgment. For additional guidelines, refer to the Standard Drawings for typical guide rail and median barrier placement and installation details. Also refer to the AASHTO Roadside Design Guide for additional source references.

12.1 THE CLEAR ZONE CONCEPT

Clear zone is defined as the total roadside border area, starting at the edge of traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The width of the clear zone is influenced by the traffic volume, the design speed and embankment slope.

Table 12.1 can be used to determine the clear zone width recommended for selected traffic volumes, design speeds and embankment slopes. Clear zone widths shown in Table 12.1 represent values that are extrapolated from the curves in the AASHTO Roadside Design Guide and are a general approximation since they are based on limited empirical data.

TABLE 12.1 (METRIC)
CLEAR ZONE WIDTH
(in meters from edge of through traveled way)

DESIGN SPEED	DESIGN ADT	FORESLOPE			BACKSLOPE		
		1V:6H OR FLATTER	1V:5H TO 1V:4H	1V:3H	1V:3H	1V:5H TO 1V:4H	1V:6H OR FLATTER
60 km/h or less	Under 750	2.0	2.0	**	2.0	2.0	2.0
	750 - 1500	3.0	3.5	**	3.0	3.0	3.0
	1500 - 6000	3.5	4.5	**	3.5	3.5	3.5
	Over 6000	4.5	5.0	**	4.5	4.5	4.5
70-80 km/h	Under 750	3.0	3.5	**	2.5	2.5	3.0
	750 - 1500	4.5	5.0	**	3.0	3.5	4.5
	1500 - 6000	5.0	6.0	**	3.5	4.5	5.0
	Over 6000	6.0	7.5	**	4.5	5.5	6.0
90 km/h	Under 750	3.5	4.5	**	2.5	3.0	3.0
	750 - 1500	5.0	6.0	**	3.0	4.5	5.0
	1500 - 6000	6.0	7.5	**	4.5	5.0	6.0
	Over 6000	6.5	8.0	**	5.0	6.0	6.5
100 km/h	Under 750	5.0	6.0	**	3.0	3.5	4.5
	750 - 1500	6.0	8.0	**	3.5	5.0	6.0
	1500 - 6000	8.0	9.0	**	4.5	5.5	7.5
	Over 6000	9.0	9.0	**	6.0	7.5	8.0
110 km/h	Under 750	5.5	6.0	**	3.0	4.5	4.5
	750 - 1500	7.5	8.5	**	3.5	5.5	6.0
	1500 - 6000	8.5	9.0	**	5.0	6.5	8.0
	Over 6000	9.0	9.0	**	6.5	8.0	8.5

** Since recovery is less likely on the unshielded, traversable 1V:3H slopes, consider removal of fixed objects present beyond the toe of these slopes. Determination of the width of the recovery area provided, if any, at the toe of slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope.

TABLE 12.1 (ENGLISH)
CLEAR ZONE WIDTH
(in feet from edge of through traveled way)

DESIGN SPEED	DESIGN ADT	FORESLOPE			BACKSLOPE		
		1V:6H OR FLATTER	1V:5H TO 1V:4H	1V:3H	1V:3H	1V:5H TO 1V:4H	1V:6H OR FLATTER
40 mph or less	Under 750	7	7	**	7	7	7
	750 - 1500	10	12	**	10	10	10
	1500 - 6000	12	14	**	12	12	12
	Over 6000	14	16	**	14	14	14
45-50 mph	Under 750	10	12	**	8	8	10
	750 - 1500	14	16	**	10	12	14
	1500 - 6000	16	20	**	12	14	16
	Over 6000	20	24	**	14	18	20
55 mph	Under 750	12	14	**	8	10	10
	750 - 1500	16	20	**	10	14	16
	1500 - 6000	20	24	**	14	16	20
	Over 6000	22	26	**	16	20	22
60 mph	Under 750	16	20	**	10	12	14
	750 - 1500	20	26	**	12	16	20
	1500 - 6000	26	30	**	14	18	24
	Over 6000	30	30	**	20	24	26
65-70 mph	Under 750	18	20	**	10	14	14
	750 - 1500	24	28	**	12	18	20
	1500 - 6000	28	30	**	16	22	26
	Over 6000	30	30	**	22	26	28

** Since recovery is less likely on the unshielded, traversable 1V:3H slopes, consider removal of fixed objects present beyond the toe of these slopes. Determination of the width of the recovery area provided, if any, at the toe of slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope.

When obstructions exist behind curbs, a minimum horizontal clearance of 0.5 m (1.5 ft) should be provided beyond the face of curbs to the obstructions. This offset may be considered the minimum allowable horizontal clearance (or operational offset), but it should not be construed as an acceptable clear zone distance. Since curbs do not have a significant redirectional capability, obstructions behind a curb should be located at or beyond the minimum clear-zone distances shown in Table 12.1. In many instances, it will not be practical to obtain the recommended clear zone distances on existing facilities. On new construction where minimum recommended clear zones cannot be provided, fixed objects should be located as far from traffic as practical on a project-by-project basis, but in no case closer than 0.5 m (1.5 ft) from the face of the curb.

The designer must keep in mind site-specific conditions, design speeds, rural versus urban locations, and practicality. The numbers in Table 12.1 suggest only the approximate values to be considered and not a precise distance to be held as absolute.

The designer may choose to modify the clear zone width obtained from Table 12.1 for horizontal curvature by using the horizontal curve adjustment factors in Table 12.2. These modifications are normally considered only where crash histories indicate a need, or a specific site investigation shows a definitive crash potential. This potential could be significantly lessened by increasing the clear zone width, provided such increases are cost-effective. Horizontal curves, particularly for high-speed facilities, are usually superelevated to increase safety and to provide a more comfortable ride.

For relatively flat and level roadsides, the clear zone concept is simple to apply. Application is more complex when the roadway is in a fill or cut section where roadside slopes may be either positive, negative, or variable, or where a ditch exists near the traveled way. For additional clear zone information refer to the 2004 AASHTO Green Book and the AASHTO Roadside Design Guide.

A. Foreslopes. Foreslopes parallel to the flow of traffic may be identified as recoverable, non-recoverable, or critical. Recoverable foreslopes are 1V:4H or flatter. If such slopes are relatively smooth and traversable, the suggested clear zone width may be taken directly from Table 12.1. Motorists who encroach on recoverable foreslopes can generally stop their vehicles or slow them enough to return to the roadway safely.

A non-recoverable foreslope is defined as one that is traversable, but from which most vehicles are unable to stop or to return to the roadway easily. Vehicles traversing such slopes typically can be expected to reach the bottom. Foreslopes between 1V:3H and 1V:4H generally fall into this category. Since a high percentage of encroaching vehicles may reach the toe of these slopes, the clear zone distance cannot logically end on the slope. Fixed obstacles are normally not constructed along such slopes and a clear runout area at the base is desirable. Figure 12.1 provides an example of parallel embankment slope design thru recoverable and non-recoverable slopes. The basic philosophy behind the recovery area is that a vehicle can traverse a 1V:3H slope but is not likely to recover (control steering) and therefore, recovery may be expected to occur beyond the toe of slope. Determination of the width of the clear zone distance at the toe of slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety needs and crash history.

A critical foreslope is one which a vehicle is likely to overturn. Foreslopes steeper than 1V:3H generally fall into this category. If a foreslope steeper than 1V:3H begins closer to the through traveled way than the suggested clear zone width for that specific roadway, a roadside barrier might be required (Table 12.5) if the slope cannot readily be flattened.

B. Transverse Slopes. Common obstacles on roadsides are transverse slopes created by median crossovers, berms, driveways or intersecting side roads. These are generally more critical to errant motorists than foreslopes or backslopes because they are typically struck head-on by run-off-the-road vehicles. Transverse slopes of 1V:6H or flatter are suggested for high-speed roadways, particularly for that section of the transverse slope that is located immediately adjacent to traffic. This slope can then be transitioned to a steeper slope as the distance from the through traveled way increases.

Transverse slopes of 1V:10H are desirable; however, their practicality may be limited by width restrictions and the maintenance problems associated with the long tapered ends of pipes or culverts. Transverse slopes steeper than 1V:6H may be considered for urban areas or for low-speed facilities.

TABLE 12.2 (METRIC)
HORIZONTAL CURVE ADJUSTMENTS
K_{cz} (CURVE CORRECTION FACTOR)

RADIUS (m)	DESIGN SPEED (km/h)					
	60	70	80	90	100	110
900	1.1	1.1	1.1	1.2	1.2	1.2
700	1.1	1.1	1.2	1.2	1.2	1.3
600	1.1	1.2	1.2	1.2	1.3	1.4
500	1.1	1.2	1.2	1.3	1.3	1.4
450	1.2	1.2	1.3	1.3	1.4	1.5
400	1.2	1.2	1.3	1.3	1.4	—
350	1.2	1.2	1.3	1.4	1.5	—
300	1.2	1.3	1.4	1.5	1.5	—
250	1.3	1.3	1.4	1.5	—	—
200	1.3	1.4	1.5	—	—	—
150	1.4	1.5	—	—	—	—
100	1.5	—	—	—	—	—

$CZ_c = (L_c)\ (K_{cz})$

Where: CZ_c = CLEAR ZONE WIDTH ON OUTSIDE OF CURVATURE (m)
L_c = CLEAR ZONE WIDTH (m), TABLE 12.1
K_{cz} = CURVE CORRECTION FACTOR

Note: THE CLEAR ZONE CORRECTION FACTOR IS APPLIED TO THE OUTSIDE OF CURVES ONLY. CURVES WITH A RADIUS GREATER THAN 900 m DO NOT REQUIRE AN ADJUSTED CLEAR ZONE WIDTH.

TABLE 12.2 (ENGLISH)
HORIZONTAL CURVE ADJUSTMENTS
K_{cz} (CURVE CORRECTION FACTOR)

RADIUS (ft)	DESIGN SPEED (mph)						
	40	**45**	**50**	**55**	**60**	**65**	**70**
2860	1.1	1.1	1.1	1.2	1.2	1.2	1.3
2290	1.1	1.1	1.2	1.2	1.2	1.3	1.3
1910	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1640	1.1	1.2	1.2	1.3	1.3	1.4	1.5
1430	1.2	1.2	1.3	1.3	1.4	1.4	—
1270	1.2	1.2	1.3	1.3	1.4	1.5	—
1150	1.2	1.2	1.3	1.4	1.5	—	—
950	1.2	1.3	1.4	1.5	1.5	—	—
820	1.3	1.3	1.4	1.5	—	—	—
720	1.3	1.4	1.5	—	—	—	—
640	1.3	1.4	1.5	—	—	—	—
570	1.4	1.5	—	—	—	—	—
380	1.5	—	—	—	—	—	—

$$CZ_c = (L_c)\ (K_{cz})$$

Where: CZ_c = CLEAR ZONE WIDTH ON OUTSIDE OF CURVATURE (ft)
L_c = CLEAR ZONE WIDTH (ft), TABLE 12.1
K_{cz} = CURVE CORRECTION FACTOR

Note: THE CLEAR ZONE CORRECTION FACTOR IS APPLIED TO THE OUTSIDE OF CURVES ONLY. CURVES WITH RADII GREATER THAN 2860 ft DO NOT REQUIRE AN ADJUSTED CLEAR ZONE WIDTH.

At the trailing end of guide rail, a distance of 15.0 m (50 ft) beyond the end treatment is to be kept clear of all roadside obstructions. This "downstream clear zone" is intended to minimize the likelihood that a vehicle may be directed into an obstruction by the barrier.

H. Non-Traversable Roadside Obstructions. Non-traversable roadside obstructions require special consideration to provide safety and to afford protection if encountered by motorists and pedestrians within the clear zone or adjacent to the highway right-of-way. These obstructions include: (1) permanent bodies of water; (2) mined areas including coal strip mining, stone quarries and other open pit mining operations and (3) storage locations of hazardous substances.

Because of the size of some of these features along the roadway, the probability of an errant vehicle encountering such a condition is greater than that of a vehicle encountering a fixed object. Therefore, any non-traversable obstruction that requires shielding should be removed, if practical. Otherwise, a longitudinal barrier system, such as guide rail, should be considered. A barrier system shall be provided for permanent bodies of water, with depths greater than 0.6 m (2 ft), that are located within the clear zone or adjacent to the right-of-way. For mined areas, earthen barrier and safety barricades for protection of both motorists and pedestrians should be provided.

I. Utility Poles and Trees. For new construction or reconstruction projects, every effort should be made to install or relocate utility poles as far from the traveled way as practical.

For existing utility pole installations, a concentration of crashes at a site or a certain type of crash that seems to occur frequently in a given jurisdiction may indicate that the highway/utility system is contributing to the crash potential. Utility pole crashes are subject to the same patterns as other types of roadway crashes; thus, they are subject to traditional highway crash study procedures.

Generally, guide rail should not be used to shield a line of utility poles or trees. However, where guide rail is used in front of utility poles and trees due to other roadside obstacles, the minimum unobstructed distance behind the guide rail post shall be as presented in Table 12.3.

The removal of individual trees should be considered when they are determined both to be an obstruction and to be in a location where they are likely to be hit. Such trees can often be identified by past crash history at similar sites, by scars indicating previous crashes or by field reviews. Because tree removal can be expensive and often has adverse environmental impacts, this countermeasure should be used only when it is an effective solution.

Roadways through wooded areas with heavy nighttime traffic volumes, frequent fog and narrow lanes should be well delineated. Pavement markings and post mounted delineators are among the most effective and least costly improvements that can be made to a roadway.

J. Guide Rail End Treatments. The terminal end of the guide rail should be designed and located so that there are no exposed rail element ends on which a vehicle could be impaled. The preferred treatment is to bury the end of the guide rail into a backslope, retaining its full height even if the guide rail must be extended a short distance to accomplish this.

Provide appropriate end treatments, on both the approach and trailing ends of the guide rail on two-lane highways with two-way traffic. On four-lane divided highways, end treatments are required on the approach ends only for strong post guide rail. End treatments are required on both ends of weak post guide rail for anchoring purposes.

A crashworthy end treatment is considered essential if the barrier terminates within the clear zone and/or is in an area where it is likely to be hit by an errant vehicle.

The designer must exercise sound engineering judgment and ensure that the most appropriate available guide rail terminals are specified and provisions incorporated so they can be properly installed based on the type of facility. Higher type treatments should be considered in sensitive locations, in areas with tight geometrics, areas with an unusually high crash history, etc.

A-20

Speed Limits
(PennDOT Publication 212, Section 212.108)

Posting Regulatory Speed Limits
(PennDOT Publication 46, Section 2.4.6)

§ 212.107. Except Right Turn Sign (R1-1-1).

When a major traffic movement at an intersection is a right turn, the Except Right Turn Sign (R1-1-1) may be placed below the Stop Sign (R1-1) on that approach to minimize the total delay at the intersection. When this sign is used, Stop Signs (R1-1) are required on all other intersection approaches except for the approach with a corresponding left-turn movement.

§ 212.108. Speed limits.

(a) *General*. This section applies to maximum speed limits established according to 75 Pa.C.S. §§ 3362 and 3363 (relating to maximum speed limits; and alteration of maximum limits). Engineering and traffic studies are not required for statutory speed limits, but documentation should be on file for urban districts and residence districts to show that the requirements defined in the Vehicle Code are satisfied.

(b) *Engineering and traffic studies*. Speed limits established in accordance with 75 Pa.C.S. § 3363 may be established in multiples of 5 miles per hour up to the maximum lawful speed. The speed limit should be within 5 miles per hour of the average 85th percentile speed or the safe-running speed on the section of highway, except the speed limit may be reduced up to 10 miles per hour below either of these values if one or more of the following conditions are satisfied:

(1) A major portion of the highway has insufficient stopping sight distance if traveling at the 85th percentile speed or the safe-running speed.

(2) The available corner sight distance on side roads is less than the necessary stopping sight distance values for through vehicles.

(3) The majority of crashes are related to excessive speed and the crash rate during a minimum 12-month period is greater than the applicable rate in the most recent high-crash rate or high-crash severity rate table included in the appendix of Official Traffic-Control Devices (Department Publication 212). Crashes related to excessive speed include those crashes with causation factors of driving too fast for conditions, turning without clearance or failing to yield right-of-way.

(c) *Variable speed limits*. To improve safety, speed limits may be changed as a function of traffic speeds or densities, weather or roadway conditions or other factors.

(d) *Special speed limits*.

(1) Within a rest area or welcome center, a 25 mile per hour speed limit may be established without the need for an engineering and traffic study if pedestrians walk across the access roadways between the parking lot and the rest facilities.

(2) Within a toll plaza or a truck weight station, an appropriate speed limit may be established without an engineering and traffic study by the authorities in charge to enforce the safety of the operations or to protect the scales.

(e) *Posting of speed limits*. A Speed Limit Sign (R2-1) or variable speed limit sign showing the maximum speed limit shall be placed on the right side of the highway at the beginning of each numerical change in the speed limit, but an additional sign may also be installed on the left side of the highway. If the new speed limit begins at an intersection, the first sign should be installed within 200 feet beyond the intersection. The placement of this sign must satisfy both the requirement to post the beginning of the new speed limit and the requirement to post the end of the previous speed limit. Additional requirements for posting are as follows:

(1) Speed limits of 50 miles per hour or less shall be posted as follows:

(i) A Reduced Speed (____) Ahead Sign (R2-5), or a Speed Reduction Sign (W3-5), shall be placed on the right side of the highway 500 to 1,000 feet before the beginning of every speed reduction unless one of the following applies:

(A) The speed reduction is 10 miles per hour or less.

(B) The speed reduction begins at an intersection and all traffic entering the roadway with the speed reduction has to either stop at a Stop Sign (R1-1) or make a turn.

(C) The new speed limit is posted on variable speed limit signs.

(ii) Speed Limit Signs (R2-1) or a variable speed limit sign showing the maximum speed shall be placed on the right side of the highway at the beginning of the speed limit and at intervals not greater than 1/2 mile throughout the area with the speed limit.

(iii) The end of a speed limit is typically identified by the placement of a sign indicating a new speed limit, but the End Plaque (R2-10) may be placed above a Speed Limit Sign (R2-1) at the end of the zone if the appropriate speed limit is not known on the following section of roadway.

(2) On freeways, a Speed Limit Sign (R2-1) shall be installed after each interchange unless insufficient space exists for the signs.

§ 212.109. Bridge speed limits.

(a) *Establishment.* A bridge speed limit shall be established under 75 Pa.C.S. § 3365(a) (relating to special speed limitations) if an engineering investigation by a professional engineer establishes the need to reduce the vibration and impact of vehicles due to a structural condition of the bridge or elevated structure.

(b) *Posting.* An established bridge speed limit shall be posted similar to other speed limits in § 212.108(e) (relating to speed limits), except that a Bridge Sign (R12-1-2) must be mounted directly above each Speed Limit Sign (R2-1) and Reduced Speed (____) Ahead Sign (R2-5). The sign indicating the beginning of the bridge speed limit should be installed within 50 feet of the beginning of the structure. The end of the bridge or elevated structure must be the end of the bridge speed limit.

§ 212.110. Hazardous grade speed limits.

(a) *Establishment.* A hazardous grade speed limit may be established under 75 Pa.C.S. § 3365(c) (relating to special speed limitations) if an engineering and traffic study establishes the need for all vehicles or vehicles having a gross weight in excess of a designated weight to be limited to a maximum speed on a downgrade.

(1) The designated weight should be 26,000 pounds unless the engineering and traffic study determines that a different weight should be used.

(2) When a hazardous-grade speed limit is established, it should be consistent with the speed that similar vehicles can climb the hill or other Department-approved methodology, except that a hazardous-grade speed limit should not be greater than the lowest advisory speed or legal speed limit either on the hill or at the base of the hill.

(3) A hazardous-grade speed limit may be established when one or more of the following conditions exist:

2.4.5 In-Street Pedestrian Crossing Signs (R1-6)

Publication 35 identifies the types of In-Street Pedestrian Crossing (R1-6) signs approved for use in Pennsylvania in the section entitled "Traffic Accommodations and Control."

As noted in the sign standard in Publication 236M, the R1-6 sign may be positioned on the centerline of low-speed roadways near an unsignalized marked crosswalk. The standard forbids the use of R1-6 signs on roadways with a speed limit greater than 35 mph and on narrow roadways with a clear roadway width less than 20 feet. If there may be conflicts from long wheelbase vehicles, like buses or trucks, you may place the sign up to 50 feet from the crosswalk.

R1-6

In the past, BHSTE purchased some R1-6 signs for use by local authorities in efforts to reduce pedestrian crashes. Distribution of the "free devices" was a function of pedestrian crash rates, community safety programs, and the municipality's willingness to conduct after studies to measure motorist compliance. In these cases, the Sign Shop forwarded the necessary signs to the appropriate County Maintenance Districts for pickup by the municipalities.

The District Bicycle/Pedestrian Coordinator should be aware of any existing programs for local authorities.

2.4.6 Posting Regulatory Speed Limits

2.4.6.1 Posting of Speed Limits at Intersections

Use the following guidelines if a problem exists in the enforcement of a speed limit that ends at an intersection:

1. Ending a speed limit on the stem of a T-intersection. Since §3362(b) of the Vehicle Code (relating to posting of speed limit) requires that official traffic-control devices be posted at the beginning and end of each speed zone, it is necessary to install signs indicating the end of a speed limit on the stem of a T-intersection in one of two ways:

    - The preferred method is to install a Speed Limit (R2-1) sign indicating the appropriate speed limit on the other two legs within a reasonable distance beyond the intersection, e.g., within 200 feet of the intersection.

- A less desirable method is to install an END (R2-10) sign over a Speed Limit (R2-1) sign in advance of the T-intersection. However, this method may be necessary if there is no speed limit on the other roadway and it has not been determined through test runs that it is safe for travel at 55 mph.

2. Ending the speed limit at a four-way intersection. If a posted speed limit does not exist along the highway beyond the intersection and it has not been determined through test runs that the following section of highway is safe for travel at 55 mph, Districts may end the speed limit by installing an END (R2-10) sign above a Speed Limit (R2-1) sign in advance of the intersection.

   If the highway beyond the intersection and the intersecting highway have posted speed limits or are safe for travel at 55 mph, Speed Limit (R2-1) signs indicating the speed limit along the three other legs of the intersection may be installed within a reasonable distance from the intersection, e.g., within 200 feet of the intersection.

3. Speed limit for turning vehicles at intersections. Neither the Vehicle Code nor regulations require that drivers turning from one highway onto another highway be advised of the speed limit along the highway they are entering. Therefore, it is possible that a turning driver could travel up to one-half mile before knowing what the speed limit is along the highway they have entered.

   Normally, this is not a problem if the speed limit along the entered highway is higher that the speed limit along the highway the driver is leaving. However, this can create a possible "speed entrapment" condition if a lower speed limit exists along the second highway. In view of this, Districts should consider the installation of Speed Limit (R2-1) signs within a reasonable distance from intersections if the following conditions exist:

   - The speed limit along the second highway is lower then the speed limit along the first highway.

   - The normal one-half mile spacing of speed limit signs has not provided a sign within a reasonable distance from the intersection, e.g., within 500 to 1,000 feet of the intersection.

- There is a high number of turning, non-local vehicles.

2.4.6.2 Posting of Regulatory Speed Limits and Advisory Speeds

When the speed on an Advisory Speed (W13-1) plaque is lower than a posted regulatory speed limit, give priority to the installation of the warning signs with advisory speeds. For example:

1. Do not install a R2-1 sign within the area covered by the W13-1 plaque, or within a distance in feet in advance of the warning sign equal to 10 times the regulatory speed limit in miles per hour (e.g., 550 feet for a 55-mph speed limit).

2. An R2-1 sign may be installed immediately following the section of roadway covered by the warning signs (e.g., within 200 feet after the end of a curve).

Since this posting of signs may result in distances between R2-1 signs that are greater than one-half mile apart, it may be possible to install a supplemental R2-1 sign at an intermediate location. In any event, it is more in the interest of motorists' safety to tell drivers the safe speed than to possibly confuse them by installing conflicting regulatory and advisory signs.

2.4.6.3 Posting of Regulatory Speed Limits and School Speed Limits

Whenever possible, do not install conflicting Speed Limit (R2-1) signs within a 15-mph school zone speed limit, or within a distance of 10 times the speed limit, in feet, of the beginning of the school speed limit.

2.4.7 PASS WITH CARE Signs

PASS WITH CARE (R4-2) signs may be installed only at the end of no-passing zones.

To reduce sign clutter, generally reserve these signs for the locations where the police have identified a serious problem that the signs could correct. These locations may include areas with frequent passing maneuvers across a solid yellow line, or sections of highway where police wish to enforce the restriction.

2.4.8 ONE-WAY Sign Installations

Property owners are initially responsible for installing and maintaining ONE-WAY (R6-1, R6-2) signs to notify motorists that they are exiting a non-residential driveway onto a one-way highway. This responsibility (in the case of driveways) is uniform for

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Advanced Warning Signs for Turns and Curves
(LTAP Technical Information Sheet #90)

Left Turn Sign
(PennDOT Publication 236M, W1-1L)

Right Turn Sign
(PennDOT Publication 236M, W1-1R)

Left Curve Sign
(PennDOT Publication 236M, W1-2L)

Right Curve Sign
(PennDOT Publication 236M, W1-2R)

Left Reverse Turn Sign
(PennDOT Publication 236M, W1-3L)

Right Reverse Turn Sign
(PennDOT Publication 236M, W1-3R)

Left Reverse Curve Sign
(PennDOT Publication 236M, W1-4L)

Right Reverse Curve Sign
(PennDOT Publication 236M, W1-4R)

Advisory Speed Plaque
(PennDOT Publication 236M, W13-1)

The Pennsylvania Local Roads Program

Advanced Warning Signs for Turns and Curves

Mark Hood, LTAP Transportation Safety Engineer

LTAP TECHNICAL INFORMATION SHEET # 90
Summer 2001

Has there been a crash at a "bad" curve on one of your roads? Is there evidence of "near misses," such as skid marks on the pavement? Do residents call attention to "dangerous" turns on a particular stretch of roadway? Do you have safety concerns about winding roads in your municipality?

It may be time to examine these and less "notorious" locations to determine whether installing or enhancing warning signs, delineation, and pavement markings (a form of delineation) will provide low-cost safety improvement. Statistics indicate that the potential for "run off the road" and "hit fixed object" crashes is greater at curves and turns than along other sections of roadway.

Turn sign (W1-1L) with Advisory Speed plaque (W13-1).

This tech sheet will address the installation of warning signs placed in advance of turns and curves. A future tech sheet will consider delineation of curves and turns with the Large Single Arrow sign, Chevron Alignment signs, and road delineation markers.

ADVANCED WARNING SIGNS

In general, "warning signs call attention to unexpected conditions on or adjacent to a highway or street and to situations that might not be readily apparent to road users. Warning signs alert road users to conditions that might call for a reduction of speed or an action in the interest of safety and efficient traffic operations," states the Federal Highway Administration's recently revised *Manual on Uniform Traffic Control Devices (MUTCD).* Warning signs are used primarily for the protection of the driver who is unfamiliar with the road.

The particular warning signs used to alert drivers to turns and curves are in the W1 series in the *MUTCD,* as well as in PENNDOT's Publications 68, *Official Traffic Control Devices,* and 236M, *Handbook of Approved Signs*. The W1 signs placed in advance of turns and curves (advanced warning signs) to alert drivers that they are approaching these changes in horizontal alignment include (see images top of page 2):

- Turn sign (W1-1L and W1-1R).
- Curve sign (W1-2L and W1-2R).
- Reverse Turn and Reverse Curve signs (W1-3L, W1-3R, W1-4L, W1-4R).
- Winding Road sign (W1-5L and W1-5R).

Turn sign, W1-1L (left)

Curve sign, W1-2R (right)

Reverse Turn sign, W1-3L (left)

Reverse Curve sign, W1-4R (right)

Winding Road sign, W1-5L (left)

TURN SIGN, CURVE SIGN, OR WHAT?

While engineering judgment should always be used in determining whether the Turn or Curve sign is called for, the Turn sign is intended for use when an engineering study of the roadway, geometric, and operating conditions demonstrates both of the following conditions:

Number of alignment changes (number of turns or curves)	Recommended (advisory) speed	
	#30 mph	>30 mph
1	Turn (W1-1)	Curve (W1-2)
2	Reverse Turn (W1-3)	Reverse Curve (W1-4)
3 or more	Winding Road (W1-5)	

Guide to the appropriate W1 sign.

- A maximum safe speed for most vehicles through the change in alignment under good weather and road conditions is 30 miles per hour (mph) or a lower speed.

- The 30-mph (or lower) speed is equal to or less than the posted speed limit on the approach.

If the engineering study demonstrates that a maximum safe speed through the change in alignment is 35 mph or a greater speed, the Curve sign should be used.

The Reverse Turn and Reverse Curve signs (W1-3, W1-4) are intended to warn a motorist of two successive turns or curves that bend in opposite directions. The two turns or curves may be separated by a brief straight section (tangent) of, at most, 600 feet. If the tangent is longer, they should be treated as individual turns or curves. Apply the same conditions in choosing between a Reverse Turn sign and a Reverse Curve sign as in choosing between a single Turn or Curve sign. However, if one of the changes in alignment qualifies as a curve and the other as a turn, use the Reverse Turn sign. All Turn, Curve, Reverse Turn, and Reverse Curve signs may be modified to show side roads or cross roads.

The Winding Road sign (W1-5) is intended for use in advance of the first of three or more successive turns or curves when each turn or curve is separated by a tangent of 600 feet or less. The same sign is used whether the changes in alignment would qualify as turns or curves.

Of course, choose the left or right (L or R) version of the appropriate sign to represent the directions of the turns or curves the driver will encounter. The table above, adapted from table 2C-5 of the *MUTCD*, will help you choose the appropriate sign.

BALL BANK STUDY

Suppose you must decide between a Turn sign and a Curve sign. Or maybe you believe drivers should reduce their speed below the posted speed limit for safe travel through a turn or curve, and you need help in deciding what speed to use on an Advisory Speed plaque (W13-1), to be placed below the Turn or Curve sign. How do you determine a maximum safe speed (advisory speed) through a change of alignment?

The preferred way to determine what the *MUTCD* refers to as the recommended speed, or advisory speed, on a turn or curve is to use an instrument called a ball bank indicator. This device is mounted in a vehicle that is driven through the turn or curve several times at multiples of 5 mph, beginning at a speed that you think will be slower than a maximum safe speed for most vehicles under good weather and road conditions.

The ball in the ball bank indicator will swing off center to a particular degree of bank as the vehicle travels through the turn or curve, providing a rough measure of lateral forces on the vehicle. As speeds increase, lateral forces on the vehicle increase, and so does the degree of bank. The ball will fluctuate during each trial run, requiring a judgment by the observer on the most frequently occurring degree of bank (read-

ing). PENNDOT provides guidelines for conducting "recommended speeds for curves" studies on page A-16 of its Publication 201, *Engineering and Traffic Studies.*

The *MUTCD* and Publication 201 also provide guidelines that will help you relate ball bank readings to recommended speeds, which are expressed in 5-mph increments. The guidelines are based on national guidelines set forth in *A Policy on the Geometric Design of Highways and Streets*, more commonly known as the Green Book, published by American Association of State Highway and Transportation Officials (AASHTO). The guidelines are summarized in the table below:

Recommended speed (mph)	Ball bank reading (degrees)
20 or a lower speed	14
25 or 30	12
35 or a higher speed	10

Ball bank readings and corresponding recommended speeds through turns and curves.

The recommended speed (advisory speed) for a turn or curve will be the highest trial-run speed that produced a ball bank reading not exceeding the applicable reading in the table. For example:

- If you obtained ball bank readings of 6 degrees at 15 mph, 9 degrees at 20 mph, and 13 degrees at 25 mph, you would choose 20 mph as the recommended speed and use a Turn sign at the location. If you decide that an Advisory Speed plaque should be used with the Turn sign, you would put 20 M.P.H. on the plaque.

- If you obtained ball bank readings of 10 degrees at 25 mph, 12 degrees at 30 mph, and 14 degrees at 35 mph, you would choose 25 mph as the recommended speed, use a Turn sign at the location, and put 25 M.P.H. on an Advisory Speed plaque.

- If you obtained ball bank readings of 8 degrees at 40 mph, 9 degrees at 45 mph, and 12 degrees at 50 mph, you would choose 45 mph as the recommended speed, use a Curve sign at the location, and put 45 M.P.H. on an Advisory Speed plaque.

Advisory Speed plaque, W13-1.

ADVISORY SPEED PLAQUE?

As just noted, the recommended speed may be shown on an Advisory Speed plaque (W13-1) placed below the appropriate advanced warning sign. On an Advisory Speed plaque placed below a Reverse Turn, Reverse Curve, or Winding Road sign, use the lowest recommended speed that resulted from the ball bank studies on the successive turns or curves. For example, if the recommended speed for one turn of a reverse turn is 30 mph and for the other is 25 mph, use 25 mph on the Advisory Speed plaque.

An Advisory Speed plaque is not necessary if the recommended speed resulting from a ball bank study is less than 5 mph below the speed limit posted on the approach to the turn or curve. However, if the recommended speed represents a reduction of 5 mph or more from the speed limit posted on the approach, an Advisory Speed plaque should be used.

The *MUTCD* allows for a Combination Horizontal Alignment/Advisory Speed sign (W1-9), which includes an advisory speed with a turn or curve warning (see below). While not yet approved for use in Pennsylvania, it is intended for placement at the beginning of a turn or curve to supplement a Turn or Curve sign placed in advance of the turn or curve.

Horizontal Alignment/Advisory Speed sign, W1-9R.

WHERE ARE THE SIGNS PLACED?

Obviously, to be effective, advanced warning signs must be placed in advance of the conditions that they alert the driver about. Guidance to an appropriate distance is provided in table 2C-4 of the *MUTCD* and in table 5-1 of PENNDOT's *Sign Foreman's Manual* (Publication 108). The table below, adapted from those tables, gives distances that should allow drivers adequate time to see and identify the signs discussed in this article, evaluate the information that the signs provide, decide how to react to the information, and perform any maneuvers necessary (including deceleration) to enable safe negotiation of turns and curves.

If speed limit (mph) posted on the approach is:	If recommended speed (advisory speed) (mph) determined for turn, reverse turn, curve, reverse curve or winding road segment is:								
	10	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
	Distance (feet) in advance of initial turn or curve that warning sign should be placed is:								
25	100	100	100						
30	150	125	100	100					
35	200	188	175	175	175				
40	275	263	250	213	175	175			
45	350	325	300	275	250	250	225		
50	425	413	400	363	325	275	225	225	
55	500	488	475	438	400	350	300	300	300
60	575	563	550	525	500	450	400	350	300
65	650	650	625	600	575	538	500	425	375

Table shows distances in advance of the initial turn or curve that the warning signs discussed in this article should be placed. Engineering judgment should be used in the application of these distances. For example, if the 85th percentile speed (the speed at, or below which, 85 percent of vehicles are traveling) on the approach to a turn or curve is greater than the posted speed limit, it may be necessary to increase the distances.

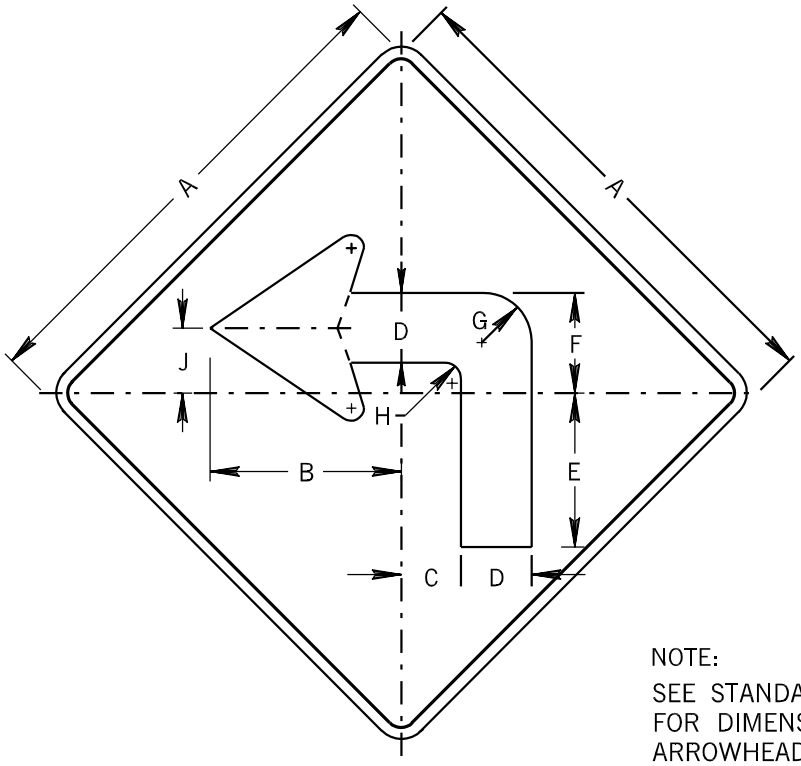
FURTHER INFORMATION

Remember that warning signs should not be used for conditions that are readily apparent to a road user, because excessive use tends to breed disrespect for signs in general. In fact, the use of warning signs must be based on an engineering study or engineering judgment. LTAP offers Roads Scholar courses on Traffic Signs and on Engineering and Traffic Studies annually at locations across the state, and LTAP's transportation safety engineers can bring the courses directly to your municipality as roadshows. The engineers also can provide technical assistance on use of a ball bank indicator and your municipality's signing dilemmas. Call 800-FOR-LTAP for further information.

W1–1L

LEFT TURN SIGN

The Left Turn Sign (W1–1L) may be used in advance of a turn to the left where the recommended speed on the turn is 50 km/h (30 MPH) or less, and this recommended speed is equal to or less than the legal speed limit. Where a W1–1L sign is warranted, other delineation may be used on the outside of the turn.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)											
SIGN SIZE A x A	B	C	D	E	F	G	H	J	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	300 (12)	94 (3.8)	110 (4.4)	228 (9.1)	156 (6.2)	75 (3)	25 (1)	101 (4.0)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	480 (19.2)	150 (6)	175 (7)	387 (15.5)	250 (10)	122 (4.9)	40 (1.6)	162 (6.5)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

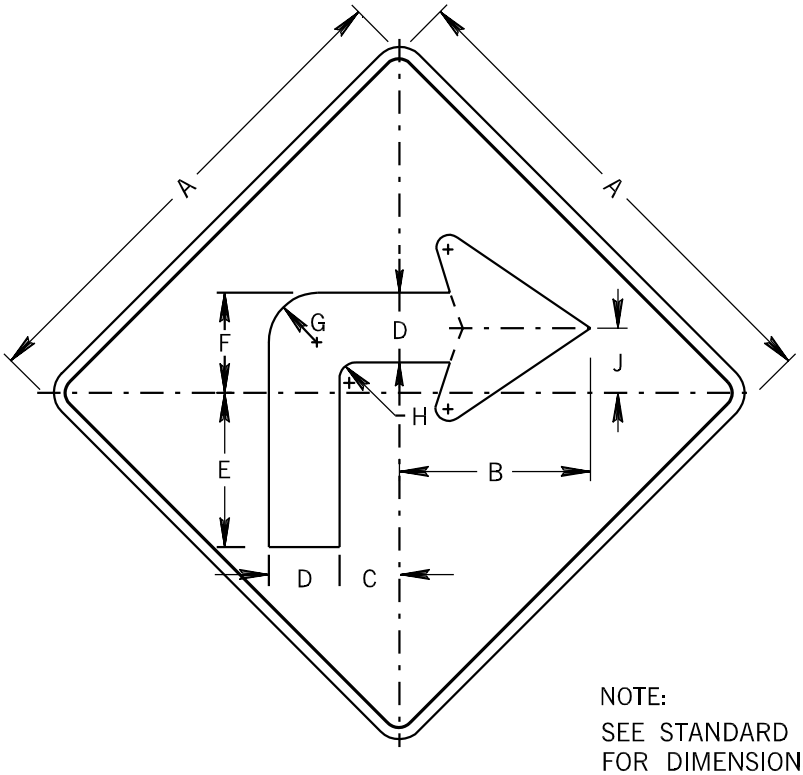
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–1R

RIGHT TURN SIGN

The Right Turn Sign (W1–1R) may be used in advance of a turn to the right where the recommended speed on the turn is 50 km/h (30 MPH) or less, and this recommended speed is equal to or less than the legal speed limit. When a W1–1R sign is warranted, other delineation may be used on the outside of the turn.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)											
SIGN SIZE A x A	B	C	D	E	F	G	H	J	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	300 (12)	94 (3.8)	110 (4.4)	228 (9.1)	156 (6.2)	75 (3)	25 (1)	101 (4.0)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	480 (19.2)	150 (6)	175 (7)	387 (15.5)	250 (10)	122 (4.9)	40 (1.6)	162 (6.5)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

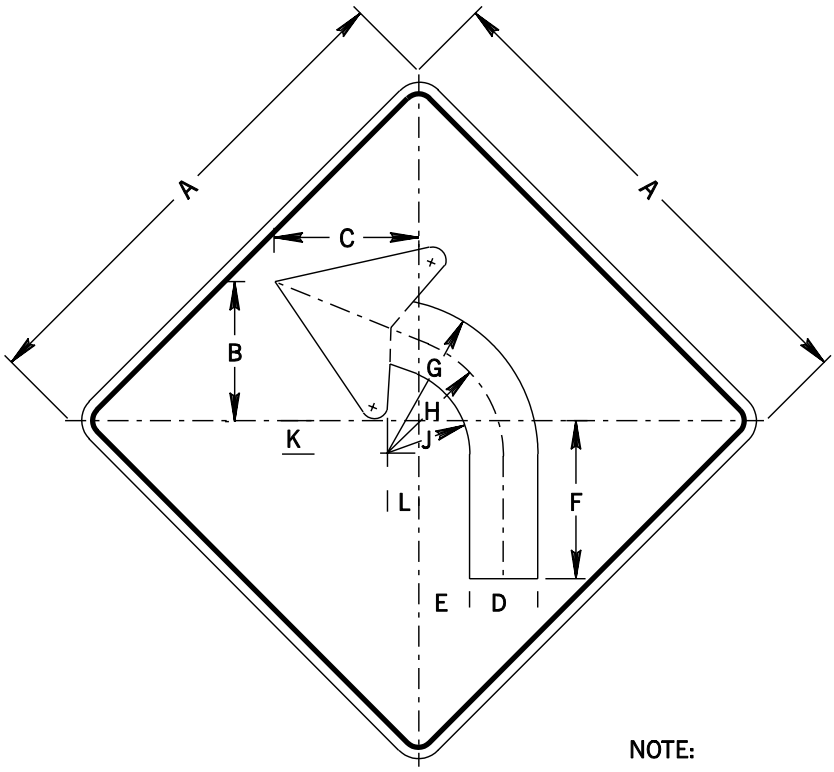
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–2L

LEFT CURVE SIGN

The Left Curve Sign (W1–2L) may be used in advance of a curve to the left where the recommended speed on the curve is greater than 50 km/h (30 MPH) but less than or equal to the legal speed limit.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)													
SIGN SIZE A x A	B	C	D	E	F	G	H	J	K	L	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	225 (9)	230 (9.2)	110 (4.4)	86 (3.4)	260 (10.4)	251 (10)	196 (7.8)	141 (5.6)	74 (3)	55 (2.2)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	360 (14.4)	368 (14.7)	176 (7)	138 (5.5)	415 (16.6)	402 (16)	314 (12.5)	226 (9)	119 (4.8)	88 (3.5)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

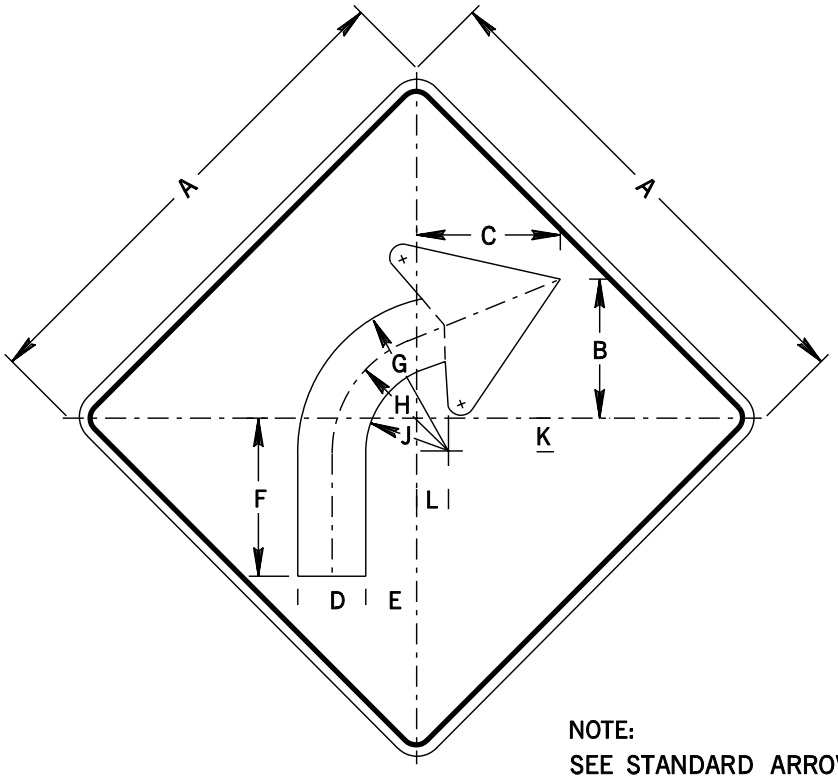
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–2R

RIGHT CURVE SIGN

The Right Curve Sign (W1–2R) may be used in advance of a curve to the right where the recommended speed on the curve is greater than 50 km/h (30 MPH) but less than or equal to the legal speed limit.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)													
SIGN SIZE A x A	B	C	D	E	F	G	H	J	K	L	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	225 (9)	230 (9.2)	110 (4.4)	86 (3.4)	260 (10.4)	251 (10)	196 (7.8)	141 (5.6)	74 (3)	55 (2.2)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	360 (14.4)	368 (14.7)	176 (7)	138 (5.5)	415 (16.6)	402 (16)	314 (12.5)	226 (9)	119 (4.8)	88 (3.5)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

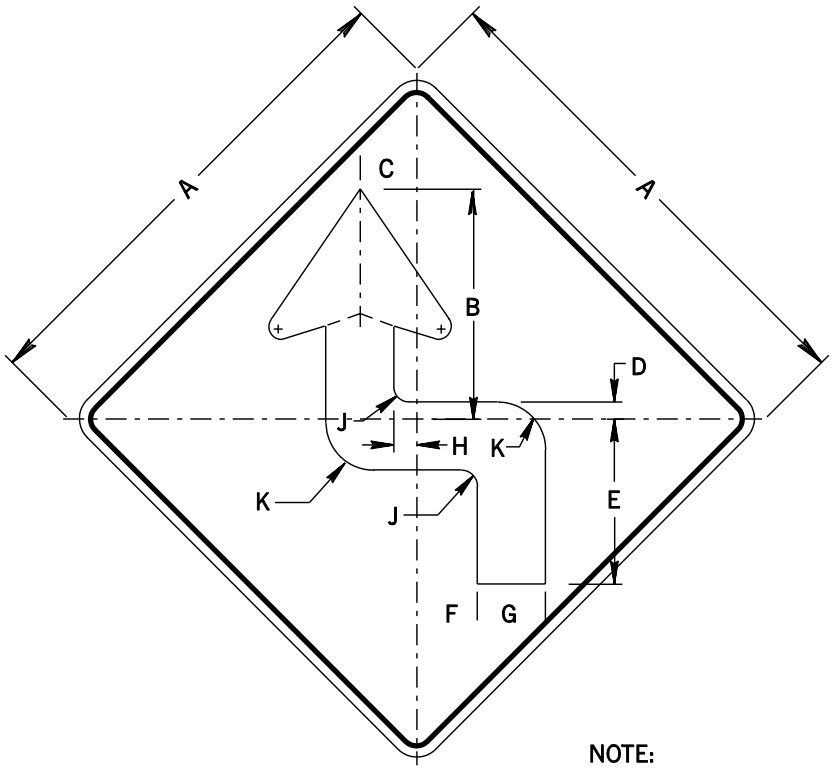
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–3L

LEFT REVERSE TURN SIGN

The Left Reverse Turn Sign (W1–3L) shall be authorized for use where two turns or a curve and a turn in opposite directions as defined in the warrants for Turn (W1–1R) and Curve (W1–2R) signs are separated by a tangent of less than 180 m (600'). It shall be used when the first turn or curve is to the left.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)												
SIGN SIZE A x A	B	C	D	E	F	G	H	J	K	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	365 (14.6)	85 (3.4)	35 (1.4)	260 (10.4)	95 (3.8)	110 (4.4)	30 (1.2)	25 (1)	75 (3)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	580 (23.2)	140 (5.6)	55 (2.2)	415 (16.6)	150 (6)	176 (7)	52 (2.1)	40 (1.6)	120 (4.8)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

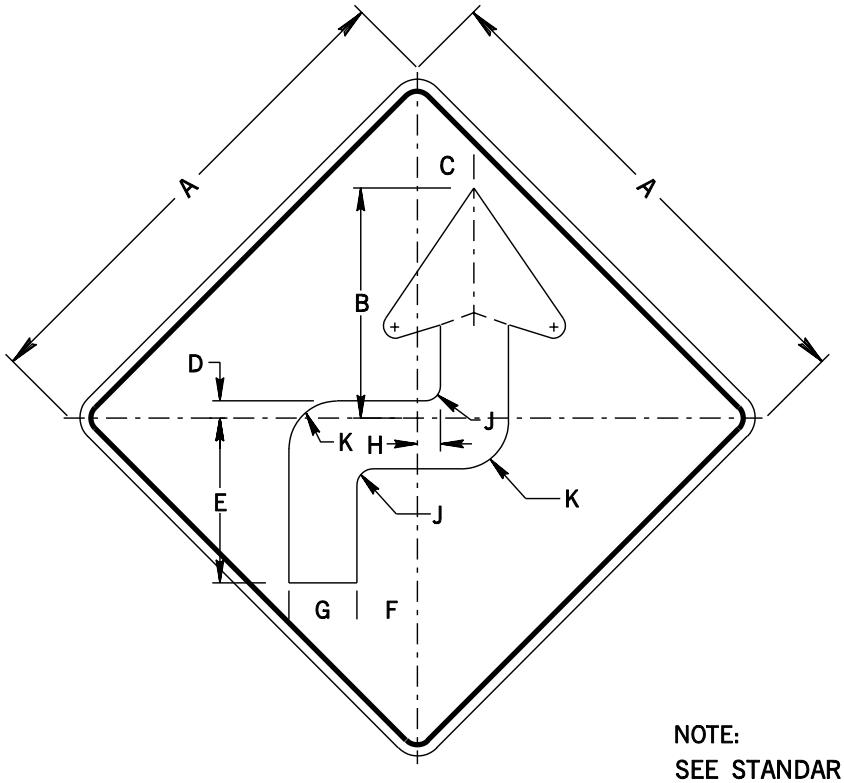
By : Glen C Rowe Date : 01–03–06

Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–3R

RIGHT REVERSE TURN SIGN

The Right Reverse Turn Sign (W1–3R) shall be authorized for use where two turns or a curve and a turn in opposite directions as defined in the warrants for Turn (W1–1R) and Curve (W1–2R) signs are separated by a tangent of less than 180 m (600'). It shall be used when the first turn or curve is to the right.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)												
SIGN SIZE A x A	B	C	D	E	F	G	H	J	K	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	365 (14.6)	85 (3.4)	35 (1.4)	260 (10.4)	95 (3.8)	110 (4.4)	30 (1.2)	25 (1)	75 (3)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	580 (23.2)	140 (5.6)	55 (2.2)	415 (16.6)	150 (6)	176 (7)	52 (2.1)	40 (1.6)	120 (4.8)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

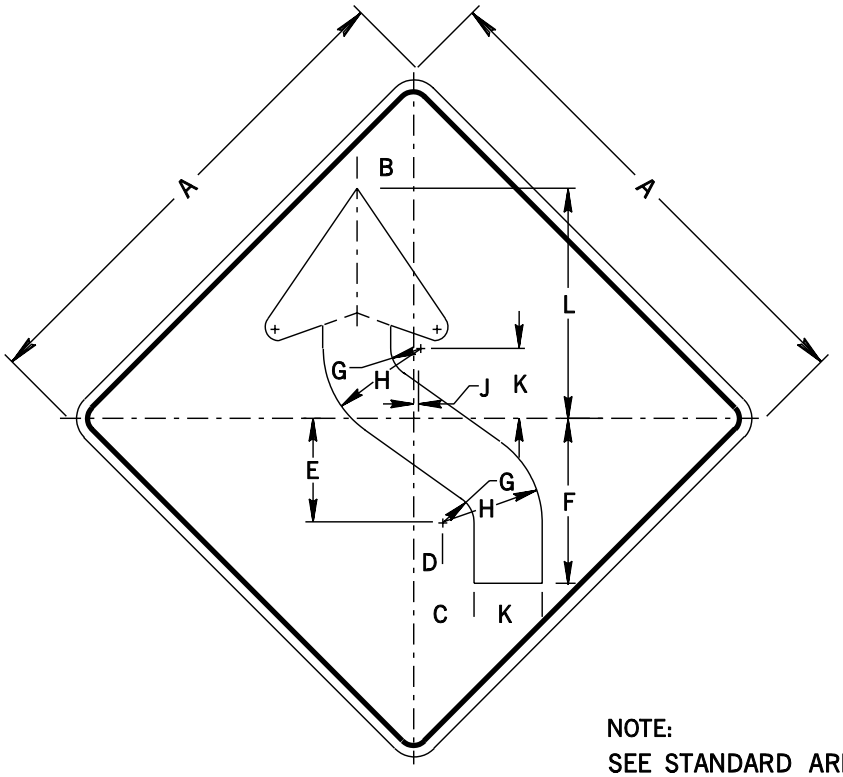
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–4L

LEFT REVERSE CURVE SIGN

The Left Reverse Curve Sign (W1–4L) shall be authorized for use where two curves in opposite directions, as defined in the warrants for Curve Sign (W1–2R), are separated by a tangent of less than 180 m (600'). It shall be used when the first curve is to the left.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)													
SIGN SIZE A x A	B	C	D	E	F	G	H	J	K	L	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	100 (4)	82 (3.3)	34 (1.4)	165 (6.6)	260 (10.4)	48 (1.9)	158 (6.3)	3 (0.1)	110 (4.4)	350 (14)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	158 (6.3)	130 (5.2)	55 (2.2)	265 (10.6)	415 (16.6)	75 (3)	251 (10)	5 (0.2)	176 (7)	565 (22.6)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

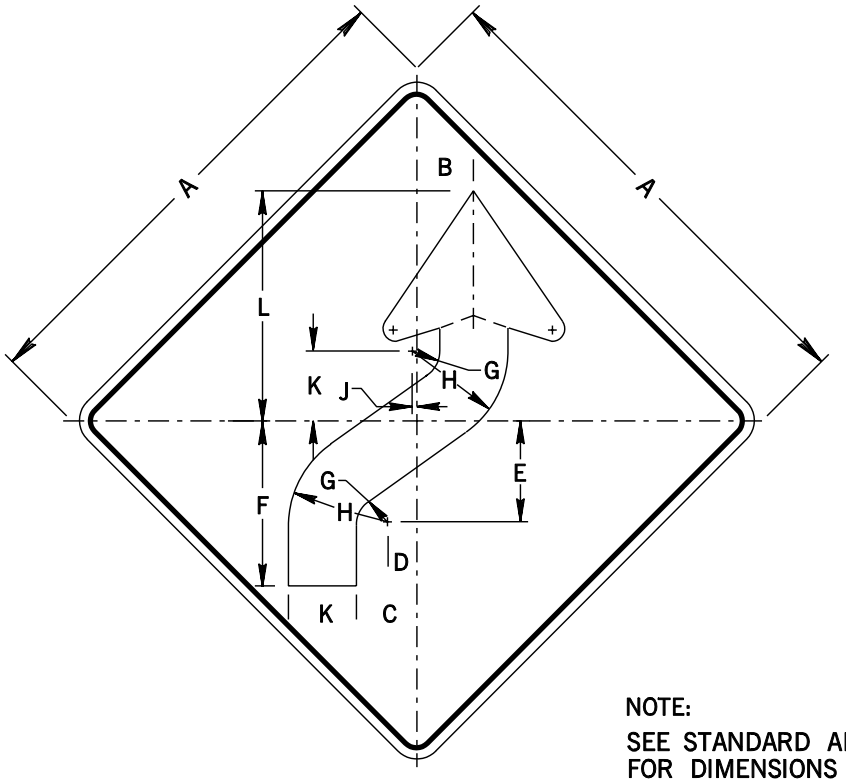
APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–4R

RIGHT REVERSE CURVE SIGN

The Right Reverse Curve Sign (W1–4R) shall be authorized for use where two curves in opposite directions, as defined in the warrants for Curve Sign (W1–2R), are separated by a tangent of less than 180 m (600'). It shall be used when the first curve is to the right.



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)													
SIGN SIZE A x A	B	C	D	E	F	G	H	J	K	L	MAR–GIN	BOR–DER	BLANK STD.
750 x 750 (30" x 30")	100 (4)	82 (3.3)	34 (1.4)	165 (6.6)	260 (10.4)	48 (1.9)	158 (6.3)	3 (0.1)	110 (4.4)	350 (14)	10 (0.4)	20 (0.8)	B3–750 (B3–30)
1200 x 1200 (48" x 48")	158 (6.3)	130 (5.2)	55 (2.2)	265 (10.6)	415 (16.6)	75 (3)	251 (10)	5 (0.2)	176 (7)	565 (22.6)	20 (0.8)	30 (1.2)	B3–1200 (B3–48)

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1_4R.DGN

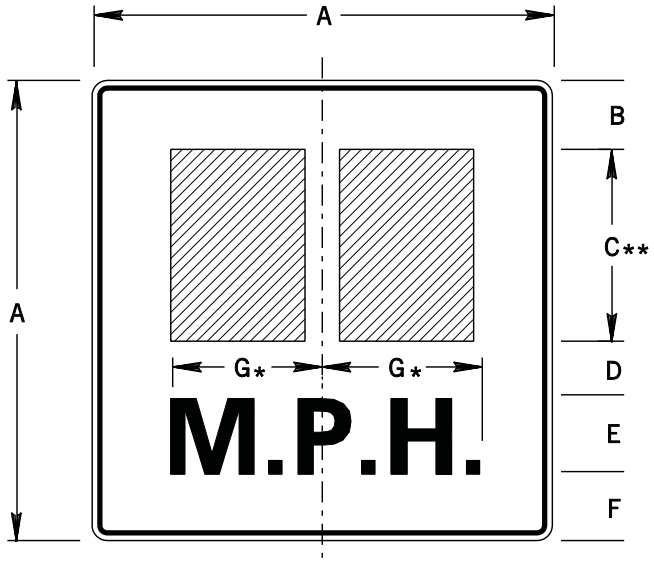
W13–1

ADVISORY SPEED PLAQUE

(a) Justification. The Advisory Speed Plaque (W13–1) shall be authorized for use in conjunction with any standard warning sign to indicate the maximum safe speed. It shall not be used in conjunction with any sign other than a warning sign, nor shall it be used alone. It shall be mounted below the warning sign.

The speed shown shall be a multiple of 5 MPH (10 km/h), to be determined by accepted traffic engineering procedures.

(b) Size. The 450 mm by 450 mm (18" x 18") size should be used with a warning sign of 750 mm by 750 mm (30" x 30"), the 600 mm by 600 mm (24" x 24") with 900 mm by 900 mm (36" x 36") sign, the 750 mm by 750 mm (30" x 30") size with 1200 mm by 1200 mm (48" x 48") signs.



DIMENSIONS – mm (IN)									
SIGN SIZE A x A	B	C	D	E	F	G	MAR–GIN	BOR–DER	BLANK STD.
450 x 450 (18" x 18")	63 (2.5)	200E (8E)	50 (2)	75E (3E)	62 (2.5)	135 (5.3)	10 (0.4)	10 (0.4)	B3–450 (B3–18)
600 x 600 (24" x 24")	90 (3.6)	250E (10E)	70 (2.8)	100E (4E)	90 (3.6)	180 (7.1)	10 (0.4)	15 (0.6)	B3–600 (B3–24)
750 x 750 (30" x 30")	105 (4.2)	300E (12E)	90 (3.6)	150E (6E)	105 (4.2)	269 (10.7)	15 (0.6)	20 (0.8)	B3–750 (B3–30)

* INCREASE SPACING 100%

** OPTICALLY SPACE NUMERALS ABOUT VERTICAL ℄

COLOR:

LEGEND AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

By : Glen C Rowe Date : 01–03–06

Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W13_1.DGN

A-22

Delineation of Turns and Curves
(LTAP Technical Information Sheet #91)

Delineators
(Manual on Uniform Traffic Control Devices, Chapter 3D)

Delineation
(PennDOT Publication 212, Section 212.203)

Delineation and Markers
(PennDOT Publication 111M, TC-8604)

Large Single Arrow Sign
(PennDOT Publication 236M, W1-6)

Chevron Alignment Sign
(PennDOT Publication 236M, W1-8)

The Pennsylvania Local Roads Program

Delineation of Turns and Curves

Mark Hood, LTAP Transportation Safety Engineer

LTAP TECHNICAL INFORMATION SHEET # 91
Fall 2001

Technical Information Sheet # 90, *Advanced Warning Signs for Turns and Curves,* discussed how to choose and place advanced warning signs to alert motorists that they are approaching turns and curves in the roadway. But what should you do when advanced warning signs are not enough? What if crashes or "near misses" continue to occur?

It may be appropriate to take the next step: delineation of the turn or curve with improved pavement markings, additional warning signs, and road delineation markers. This tech sheet provides information on choosing and placing additional warning signs and the kind of road delineation markers called post-mounted delineators, or, simply, delineators, to help guide motorists through turns and curves. Pavement markings and the road delineation markers called raised pavement markers will be considered in a future tech sheet.

Turn delineated with reflective strips on flexible posts, Large Single Arrow sign (W1-6), and Chevron Alignment signs (W1-8) (barely visible). Note divergence of utility lines, which, in the absence of the signs and delineators, could mislead drivers about roadway alignment at night.

IS DELINEATION NEEDED?

Here are four conditions in which a turn or curve could benefit from additional warning signs and post-mounted delineators:

- Accident lists show that there have been "run off the road," "hit fixed object," or other turn- and curve-related crashes at the location.
- Physical evidence such as shoulder damage, scars on adjacent trees, or other marks on the shoulder or berm indicates errant vehicles left the road.
- Day and night test runs suggest that additional warning signs and delineators are needed to adequately indicate the travel path to drivers.
- The turn or curve is "hidden" from drivers, or the roadway offers few or confusing cues to the alignment ahead. (For example, the signs and delineators may be needed where a turn or curve immediately follows a crest in the road, or where an overhead utility line diverges from the highway.)

With a mission to help Pennsylvania's municipalities solve road and bridge management problems, LTAP is sponsored by the Pennsylvania Department of Transportation, the Federal Highway Administration and The Pennsylvania State University in partnership with the Governor's Center for Local Government Services. For information about LTAP services across the state that include Roads Scholar courses, on-site training (roadshows), technical assistance and publications, write or call:

LTAP
The Pennsylvania
Local Roads Program
Penn State Eastgate Ctr.
1010 N. 7th St., Suite 304
Harrisburg, PA
17102-1410

(800) FOR-LTAP

WHICH SIGNS AND DELINEATORS TO USE?

The primary devices for alerting drivers about turn and curve severity, delineating the travel path, and providing guidance through the curvature are the Large Single Arrow sign (W1-6), Chevron Alignment signs (W1-8), and post-mounted delineators. Post-mounted delineators are reflective buttons, squares, or strips attached to metal or flexible posts. All the devices provide both day and night delineation. Each or a combination of the devices may be used on a turn or curve, depending on engineering judgment based on field conditions. Here are items to consider in making a judgment:

An oversized Large Single Arrow sign (W1-6).

The Large Single Arrow sign typically is used at short turns and curves (300 to 350 feet long) to mark a severe change in alignment. The standard size is 48 inches by 24 inches.

Chevron Alignment signs are used in a series at longer turns and curves (greater than 7 degrees), although they also may be used as an alternative, or supplement, to the Large Single Arrow sign. The standard size is 18 inches by 24 inches.

Chevron Alignment sign (W1-8).

Chevrons also should be considered where conditions described on the previous page persist after post-mounted delineators have been installed. In other words, they can be added where standard delineation practices have proven inadequate.

Chevrons should *not* be used on a winding road segment where they could confuse drivers (who may be confronted with the last in a series of chevrons at the point where the road begins to turn in the reverse direction), or where a turn or curve within the segment has inadequate length for proper spacing (chevrons must be used in a series of at least three).

Relectorized, post-mounted delineators, placed in a series on the side of the road, provide a succession of reflective points that is particularly helpful to drivers at night. An individual delineator has a minimum reflective area of 7 square inches.

Traditional post-mounted delineator.

MORE ON DELINEATORS

A delineator usually is a center-mount "button" or a square attached to a rigid post, or a strip of reflective sheeting attached to a flexible post. Buttons are 3 to 3.25 inches in diameter. Squares typically are 4 inches by 4 inches, often made in the local shop from old sign blanks or scrap sheet aluminum covered with Type III or IV reflective sheeting. More than one button or square can be mounted on a post to provide a longer reflective area. All models of flexible posts currently approved (see Section 900 of PENNDOT Publication 35) include 3 inches by 12 inches of Type III, IV, or VI reflective sheeting to provide greater reflectivity.

As noted, delineators may be attached to rigid or flexible posts. Rigid posts often are made from channel bar. They usually require replacement if hit by an errant vehicle. Flexible posts are designed to withstand high-speed impacts and return to an upright position. Because they usually are made of a white or light-colored plastic material, they are noticeable enough to provide some guidance during those hours when vehicle headlights may not be in use.

(Note that barrier-mounted, guiderail-mounted, and road-surface-mounted delineators are for applications not discussed in this tech sheet.)

The color of the reflector on each post must be the same as the color of the nearest edge line (white or yellow pavement stripe). For example, if you install post-mounted delineators adjacent to the lane of travel on a two-way road, the delineators must be white. If you install them on a one-way road or divided highway, they must be white on the right side and yellow on the left side in the one-way direction. Refer to PENNDOT Publication 68, *Official Traffic Control Devices*, for information on pavement marking.

(Note that if you are marking the location of a potential hazard, such as a culvert end, with a post-mounted delineator, the delineator should be yellow. Red delineators may be installed on posts where they would be viewed by motorists traveling in the wrong direction on a ramp, divided highway, or one-way road.)

PLACEMENT OF SIGNS

The Large Single Arrow sign must be placed on the outside of a turn or curve at a right angle to approaching traffic (see photos previous page).

Chevron Alignment signs also are placed on the outside of a turn or curve at right angles to approaching traffic, in a series of at least three. Most often they are mounted back to back on one post, one sign serving motorists traveling in one direction, and the other sign serving motorists traveling in the opposite direction. The point of the chevron must, of course, indicate the direction of curvature.

A series of chevrons should be installed from the beginning to end of a turn or curve such that two chevrons are always in a driver's view until the alignment of the road eliminates the need for additional signs. To be most effective, chevrons should be visible for at least 500 feet.

PLACEMENT OF DELINEATORS

Post-mounted delineators must be placed so the top of the reflective area is 4 feet above the near edge of the roadway. The posts must be installed 2 to 6 feet outside the edge of the shoulder or in line with a guiderail, if applicable. They should not be greater than 12 feet or less than 2 feet from the outside edge of the roadway. Their distance from the outside edge of the roadway should be kept constant, except where an obstruction intrudes into their alignment. In that case, the line of posts should make a smooth transition to the inside of the obstruction and then return to its normal alignment once the obstruction is passed (see diagram next page).

Along a turn or curve, spacing between post-mounted delineators depends on the radius of the turn or curve, to ensure that several delineators remain visible to the driver at a glance. On straight sections of roadway, delineators normally should be from 200 to 528 feet apart. In the areas of transition into and out of turns and curves, spacing varies. Guidance is available in PENNDOT Publication 111M, TC-8709, Sheet 3 of 5, and in Publication 68. The table below, adapted from these documents, provides approximate spacing between delineators along turns and curves of various radii and in the transition areas leading into and out of the curvature.

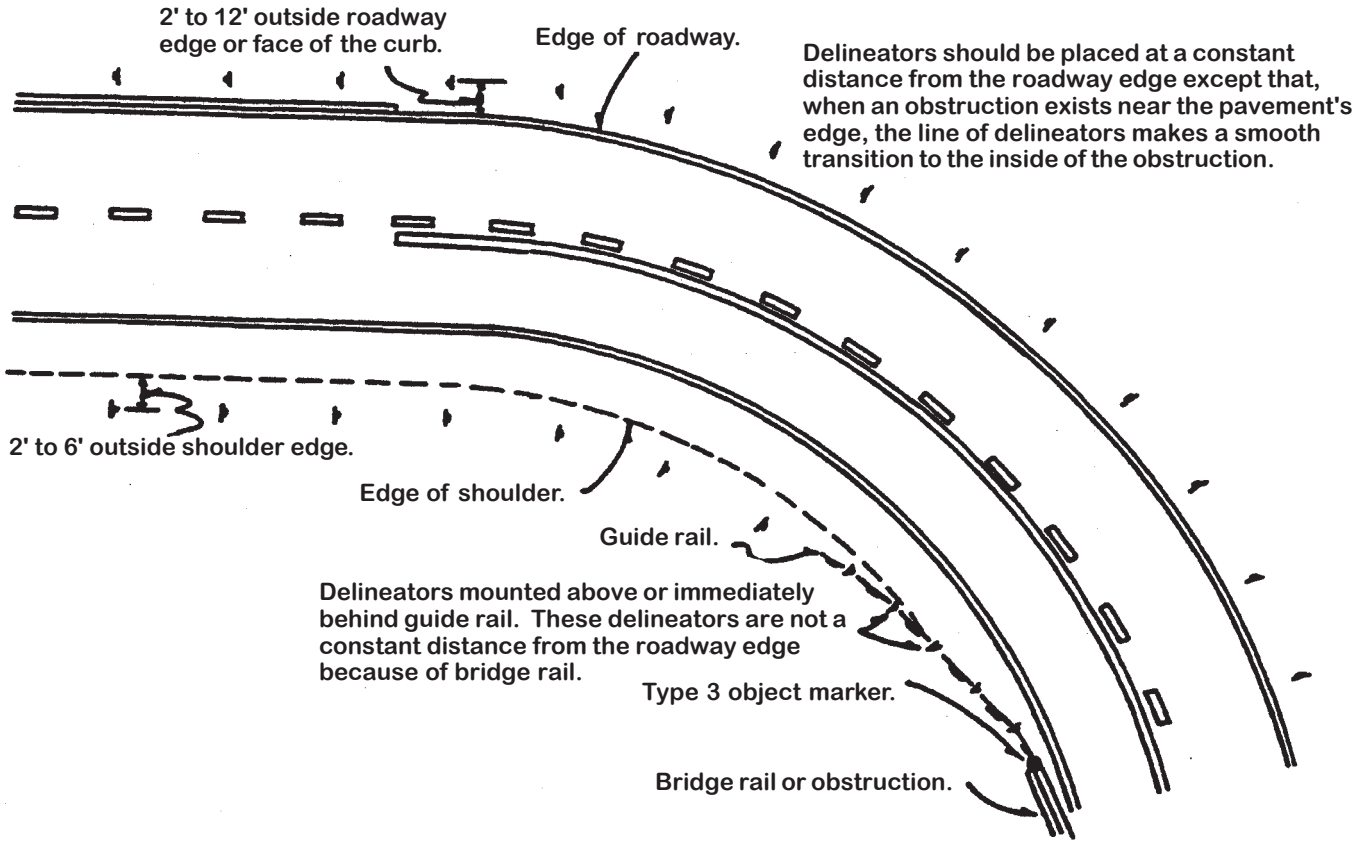
Spacing between delineators within turns and curves and in the transition areas leading into and from the curvature.

Radius (R) of turn or curve (feet)	Delineator spacing (S) within turn or curve (feet)	Delineator spacing in advance of and beyond curvature		
		1st delineator	2nd delineator	3rd delineator
50	20	40	65	125
150	30	60	90	180
200	35	70	110	215
250	40	85	125	250
300	50	95	145	290
400	55	110	170	300
500	65	125	190	300
600	70	140	210	300
700	75	150	230	300
800	80	165	245	300
900	85	175	260	300
1000	90	185	275	300

Spacing on turns and curves that have radii not shown may be interpolated from the table or computed from the formula:

$$S = \sqrt{(R - 50)}$$

The shortest spacing on turns and curves should be 20 feet, and the greatest should not exceed 300 feet. The first delineator in advance of the point of curvature and the first delineator after the curvature ends should be placed at approximately 2S from the beginning and end of the curvature, the second at 3S, and the third at 6S, but not at a spacing that exceeds 300 feet.



Typical delineator installation, taken from PENNDOT's Sign and Pavement Marking Handbook for Local Municipalities.

FURTHER INFORMATION

Guidelines for the placement of Large Single Arrow signs, Chevron Alignment signs, and post-mounted delineators may be found in PENNDOT's Publications 68 and 108 and the *Sign and Pavement Marking Handbook for Local Municipalities.* Sign standards are provided in Publication 236M, *Handbook of Approved Signs.* Remember that warning signs such as Large Single Arrow signs and Chevron Alignment signs should not be used where the alignment and severity of curvature are readily apparent to a road user, because excessive use tends to breed disrespect for signs in general. In fact, use of warning signs must always be based on engineering judgment.

LTAP offers Roads Scholar courses on Traffic Signs, Roadway Safety Improvement Program, and Engineering and Traffic Studies annually at locations across the state, and LTAP's transportation safety engineers can bring the courses directly to your municipality as roadshows. The engineers also can provide technical assistance on the delineation of curves and turns in your municipality. Call 800-FOR-LTAP for further information.

CHAPTER 3D. DELINEATORS

Section 3D.01 Delineators

Support:

Delineators are particularly beneficial at locations where the alignment might be confusing or unexpected, such as at lane reduction transitions and curves. Delineators are effective guidance devices at night and during adverse weather. An important advantage of delineators in certain locations is that they remain visible when the roadway is wet or snow covered.

Delineators are considered guidance devices rather than warning devices.

Option:

Delineators may be used on long continuous sections of highway or through short stretches where there are changes in horizontal alignment.

Section 3D.02 Delineator Design

Standard:

Delineators shall be retroreflective devices mounted above the roadway surface and along the side of the roadway in a series to indicate the alignment of the roadway. Delineators shall consist of retroreflector units that are capable of clearly retroreflecting light under normal atmospheric conditions from a distance of 300 m (1,000 ft) when illuminated by the high beams of standard automobile lights.

Retroreflective elements for delineators shall have a minimum dimension of 75 mm (3 in).

Option:

Elongated retroreflective units of appropriate size may be used in place of two retroreflectors mounted as a unit.

Section 3D.03 Delineator Application

Standard:

The color of delineators shall conform to the color of edge lines stipulated in Section 3B.06.

Single delineators shall be provided on the right side of freeways and expressways and on at least one side of interchange ramps, except in the following cases:

A. On tangent sections of freeways and expressways when all of the following conditions are met:
   1. Raised pavement markers are used continuously on lane lines throughout all curves and on all tangents to supplement pavement markings.
   2. Where whole routes or substantial portions of routes have large sections of tangent alignment.
   3. Roadside delineators are used to lead into all curves.

B. On sections of roadways where continuous lighting is in operation between interchanges.

Option:

Delineators may be provided on other classes of roads. Single delineators may be provided on the left side of roadways.

Guidance:

Single delineators should be provided on the outside of curves on interchange ramps.

Where median crossovers are provided for official or emergency use on divided highways and where these crossovers are to be marked, a double yellow delineator should be placed on the left side of the through roadway on the far side of the crossover for each roadway.

Double or vertically elongated delineators should be installed at 30 m (100 ft) intervals along acceleration and deceleration lanes.

Option:

Red delineators may be used on the reverse side of any delineator where it would be viewed by a road user traveling in the wrong direction on that particular ramp or roadway.

Delineators of the appropriate color may be used to indicate a lane reduction transition where either an outside or inside lane merges into an adjacent lane.

Guidance:

For lane reduction transitions, the delineators should be used adjacent to the lane or lanes reduced for the full length of the transition and should be so placed and spaced to show the reduction (see Figure 3B-12).

Support:

Delineators are not necessary for traffic moving in the direction of a wider pavement or on the side of the roadway where the alignment is not affected by the lane reduction transition.

Guidance:

On a highway with continuous delineation on either or both sides, delineators should be carried through transitions.

Option:

On a highway with continuous delineation on either or both sides, the spacing between a series of delineators may be closer.

Standard:

When used on a truck escape ramp, delineators shall be red.

Guidance:

Red delineators should be placed on both sides of truck escape ramps. The delineators should be spaced at 15 m (50 ft) intervals for a distance sufficient to identify the ramp entrance. Delineator spacing beyond the ramp entrance should be adequate for guidance according to the length and design of the escape ramp.

Section 3D.04 Delineator Placement and Spacing

Guidance:

Delineators should be mounted on suitable supports so that the top of the highest retroreflector is 1.2 m (4 ft) above the near roadway edge. They should be placed 0.6 to 2.4 m (2 to 8 ft) outside the outer edge of the shoulder, or if appropriate, in line with the roadside barrier that is 2.4 m (8 ft) or less outside the outer edge of the shoulder.

Delineators should be placed at a constant distance from the edge of the roadway, except that where an obstruction intrudes into the space between the pavement edge and the extension of the line of the delineators, the delineators should be transitioned to be in line with or inside the innermost edge of the obstruction. If the obstruction is a guardrail, the delineators should be transitioned to be either just behind, directly above (in line with), or on the innermost edge of the guardrail.

Delineators should be spaced 60 to 160 m (200 to 530 ft) apart on mainline tangent sections. Delineators should be spaced 30 m (100 ft) apart on ramp tangent sections.

Support:

Examples of delineator installations are shown in Figure 3D-1.

Option:

When uniform spacing is interrupted by such features as driveways and intersections, delineators which would ordinarily be located within the features may be relocated in either direction for a distance not exceeding one quarter of the uniform spacing. Delineators still falling within such features may be eliminated.

Delineators may be transitioned in advance of a lane transition or obstruction as a guide for oncoming traffic.

Guidance:

The spacing of delineators should be adjusted on approaches to and throughout horizontal curves so that several delineators are always simultaneously visible to the road user. The approximate spacing shown in Table 3D-1 should be used.

Figure 3D-1. Examples of Delineator Placement

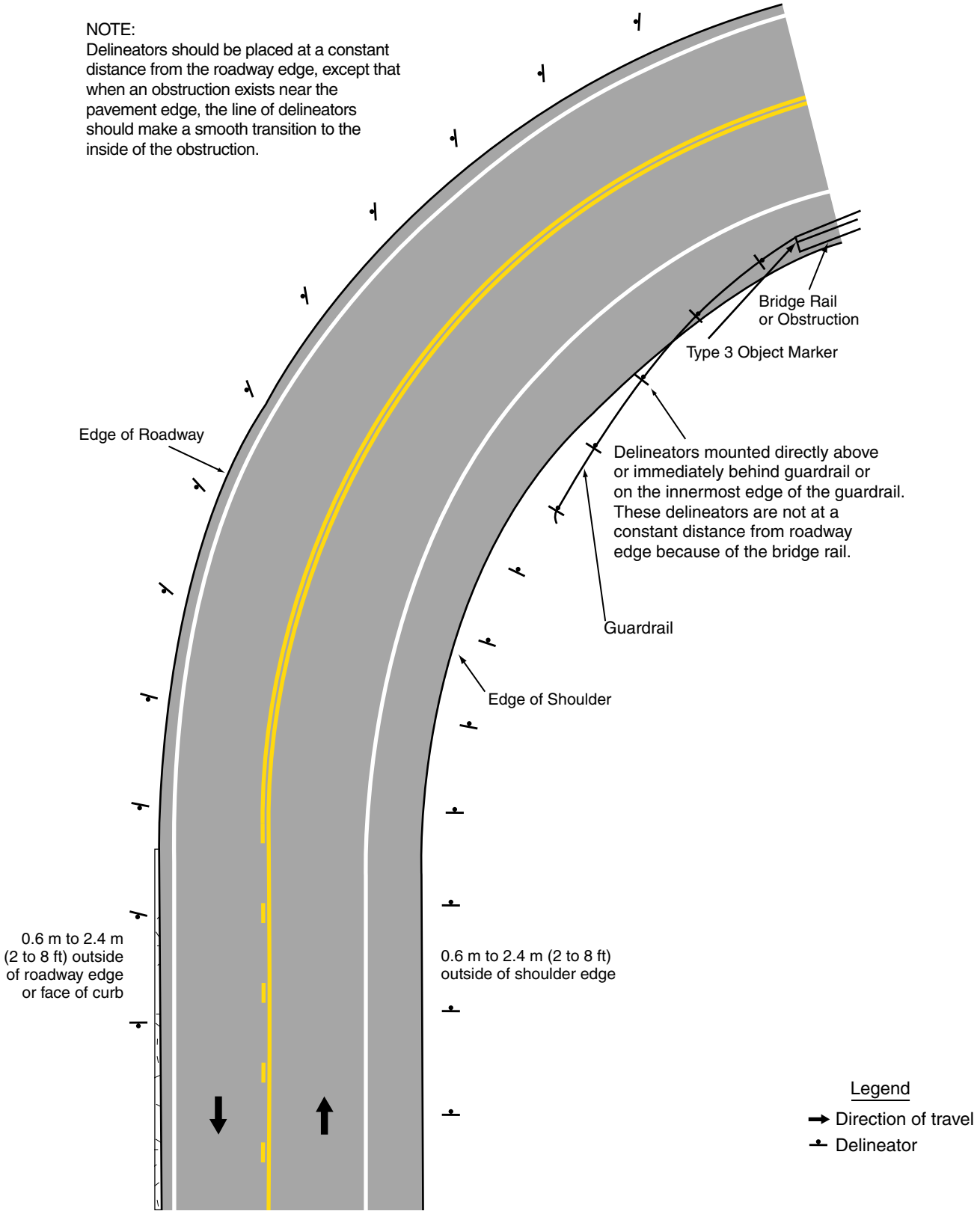


Table 3D-1. Approximate Spacing for Delineators on Horizontal Curves

Radius (R) of Curve (meters)	Approximate Spacing (S) on Curve (meters)
15	6
35	8
55	11
75	13
95	15
125	18
155	20
185	22
215	24
245	26
275	27
305	29

Radius (R) of Curve (feet)	Approximate Spacing (S) on Curve (feet)
50	20
115	25
180	35
250	40
300	50
400	55
500	65
600	70
700	75
800	80
900	85
1,000	90

Distances in feet were rounded to the nearest 5 feet.

Spacing for specific radii may be interpolated from table. The minimum spacing should be 6.1 m (20 ft). The spacing on curves should not exceed 90 m (300 ft). In advance of or beyond a curve, and proceeding away from the end of the curve, the spacing of the first delineator is 2S, the second 3S, and the third 6S but not to exceed 90 m (300 ft). S refers to the delineator spacing for specific radii computed from the formula $S=1.7\sqrt{R-15}$ for metric units and $S=3\sqrt{R-50}$ for English units.

(8) At locations where the roadway width is very restrictive, shoulders are nonexistent or in poor condition, the roadway cross-section has an excessive crown, or obstacles are close to the roadway.

(9) In areas where traffic volumes are very heavy and there would be very limited opportunities for motorists to pass other vehicles.

(10) At locations where a passing zone would otherwise be less than 600 feet in length.

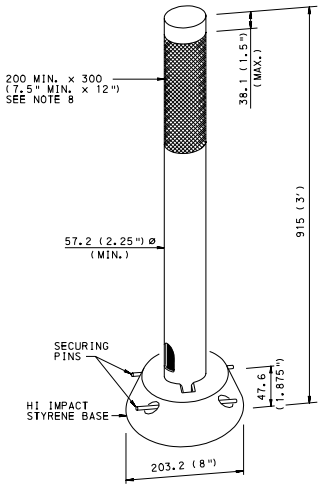
(11) At locations where engineering judgment indicates that allowing passing is undesirable because a better passing area exists farther ahead.

(b) *Minimum advance distance*. No passing zones established according to subsection (a)(1)--(5) must precede the location by the minimum distance noted in the following table:

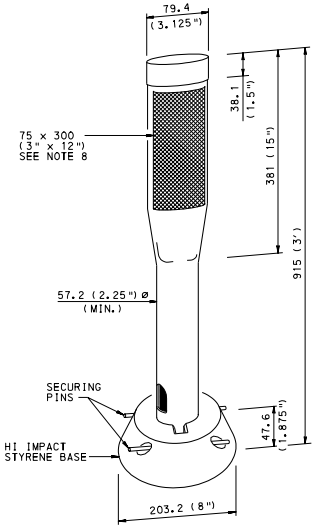
Speed Limit or 85th Percentile Speed (mph)	**Distance (feet)**
35 or less	300
40	350
45	400
50	450
55	500

§ 212.203. Delineation.

The 4-foot mounting height for delineators specified in the MUTCD (relating to delineator placement and spacing) is not applicable for guide rail and barrier-mounted delineators. In addition, post-mounted delineators may be 4 feet above the ground instead of 4 feet above the near edge of pavement as specified in the MUTCD.

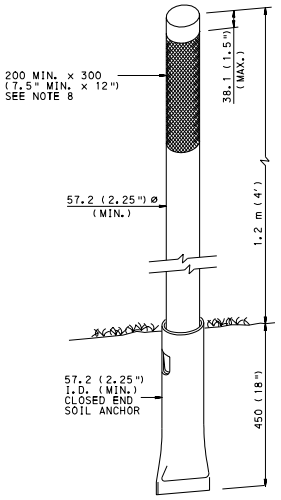


TYPE SM-1

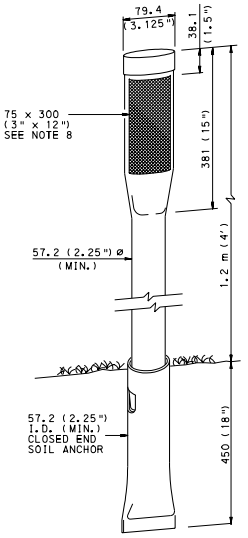


TYPE SM-2

SURFACE-MOUNTED POSTS



TYPE GM-1

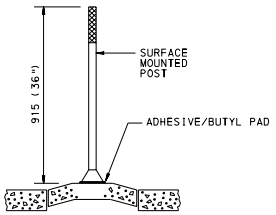


TYPE GM-2

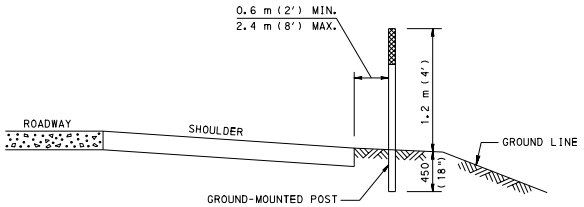
GROUND-MOUNTED POSTS

NOTES:

1. USE MATERIALS AND WORKMANSHIP IN ACCORDANCE WITH PUBLICATION 408.
2. GALVANIZED METAL SOIL ANCHOR, AFTER FABRICATION, IN ACCORDANCE WITH ASTM A 123.
3. FOR GUIDE RAIL AND BARRIER DELINEATORS, SEE SHEET 2 OF 4.
4. FOR INTERCHANGE AREAS LOCATION DETAILS, SEE SHEET 3 OF 4.
5. FOR LOCATION/PLACEMENT NOTES, SEE SHEET 4 OF 4.
6. FOR DELINEATOR SPACING ON CURVES, SEE SHEET 3 OF 4.
7. USE TYPE SM-1 AND GM-1 POSTS IN AREAS WHERE TRAFFIC MOVEMENTS NEED MULTI-DIRECTION DELINEATION, SUCH AS ISLANDS, RADII AT INTERSECTIONS AND THE ENDS OF MEDIANS.
8. ASTM TYPE III, IV, V, VII, VIII, IX OR X RETRO-REFLECTIVE SHEETING.
9. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
10. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.



CONCRETE MEDIAN/TRAFFIC ISLAND
TYPICAL SECTION



TYPICAL SECTION

PLACEMENT

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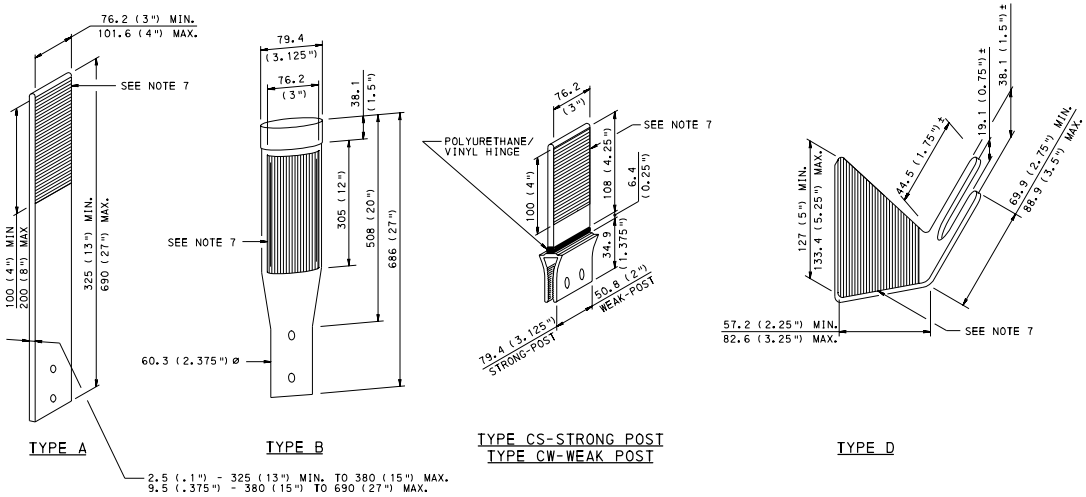
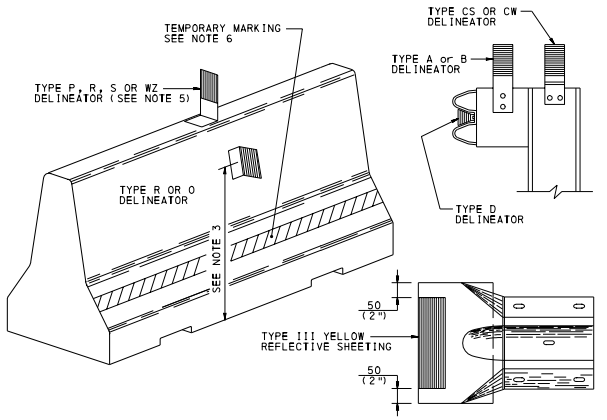
DELINEATION

FLEXIBLE POSTS DETAILS

RECOMMENDED JUN. 23, 2009 CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION	RECOMMENDED JUN. 23, 2009 ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING	SHT. 1 OF 4 TC-8604



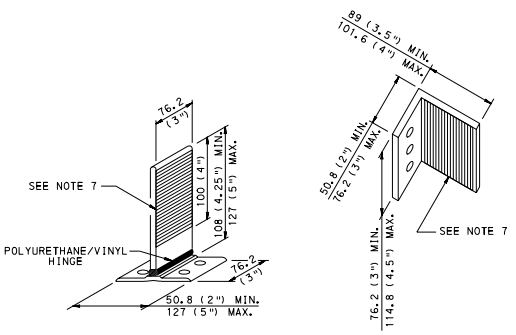
GUIDE-RAIL DELINEATORS



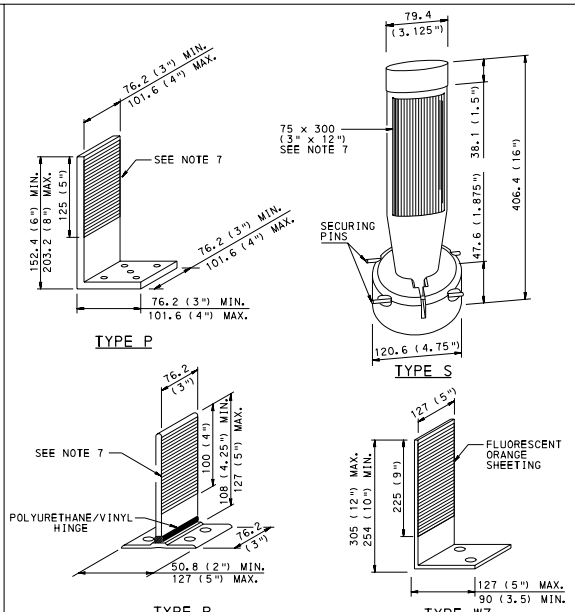
TERMINAL SECTION DETAIL

DELINEATOR PLACEMENT

1. SEE PUB. 72M, RC-52M & RC-53M FOR GUIDE RAIL DETAILS.
2. SEE PUB. 72M, RC-57M FOR CONCRETE MEDIAN BARRIER DETAILS.



SIDE-MOUNT



TOP-MOUNT

BARRIER DELINEATORS

NOTES:

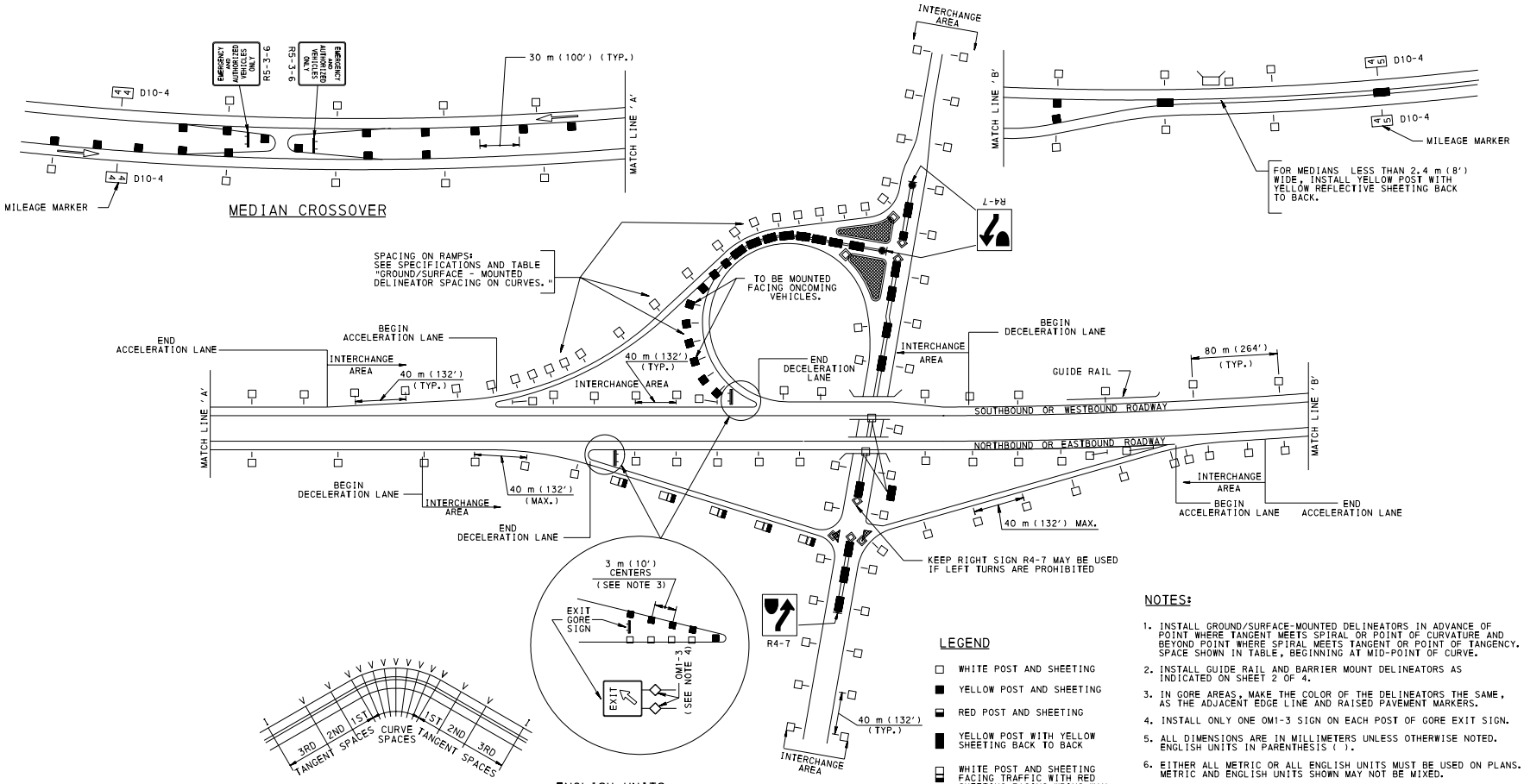
1. USE MATERIALS AND WORKMANSHIP IN ACCORDANCE WITH PUBLICATION 408.
2. INSTALL DELINEATORS ON GUIDE RAIL AT 11.43 m (37.5') SPACING ON HORIZONTAL CURVES WITH A RADIUS LESS THAN OR EQUAL TO 305 m (1000') AND AT 22.86 m (75') SPACING ON HORIZONTAL CURVES WITH A RADIUS GREATER THAN 305 m (1000') AND TANGENTS. INSTALL 0.09^{2}m (1 FT^2) MINIMUM OF TYPE III YELLOW REFLECTIVE SHEETING ON TERMINAL SECTION END TREATMENTS.
3. SIDE-MOUNTED DELINEATORS TYPE "R" OR TYPE "O" SHALL BE LOCATED 660 mm (26") FROM THE PAVEMENT TO THE CENTER OF THE DELINEATOR. AN ADDITIONAL SIDE-MOUNTED DELINEATOR MAY BE LOCATED ON THE LOWER SLOPE OF THE BARRIER WHEN JUSTIFIED BY ENGINEERING JUDGEMENT.
4. MOUNT DELINEATORS ON THE TOP AND/OR SIDE OF BARRIERS OR BRIDGE PARAPETS AS SPECIFIED AT A MAXIMUM LONGITUDINAL SPACING OF 24 m (80') FOR TANGENT SECTIONS AND 12 m (40') FOR CURVE SECTIONS WITH A RADIUS LESS THAN 305 m (1,000').
5. IN WORK ZONES, INSTALL TYPE WZ DELINEATORS ON THE TOP OF ALL TEMPORARY BARRIERS THAT ARE ADJACENT TO TRAVEL LANES AT MAXIMUM 12 m (40') SPACING. USE FLUORESCENT ORANGE SHEETING. USE SHEETING ON BOTH SIDES OF DELINEATOR WHEN USED BETWEEN TRAFFIC TRAVELING IN OPPOSITE DIRECTIONS. TYPE WZ DELINEATORS MAY BE MADE OF ANY LIGHTWEIGHT MATERIALS THAT MAINTAIN A VERTICAL ORIENTATION (±10 DEGREES) AND DO NOT NEED TO BE OF AN APPROVED TYPE LISTED IN BULLETIN 15.
6. IN AN EFFORT TO MINIMIZE ERADICATION IN WORK ZONES, CONTINUOUS WHITE OR YELLOW 150 mm (6") WIDE PAVEMENT MARKINGS MAY BE INSTALLED AS SHOWN ON TEMPORARY BARRIER INSTEAD OF BEING PLACED ON THE ROAD SURFACE. THE LINE MAY BE ANY APPROVED PAINT OR PAVEMENT MARKING TAPE THAT SATISFIES THE MINIMUM RETROREFLECTIVITY REQUIREMENTS.
7. USE ASTM TYPE III, IV, V, VI, VII, VIII, IX OR X RETROREFLECTIVE SHEETING.
8. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
9. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

DELINEATION

GUIDE RAIL AND BARRIER DETAILS

RECOMMENDED JUN. 23, 2009	RECOMMENDED JUN. 23, 2009	SHT. 2 OF 4
CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION	ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING	TC-8604



METRIC UNITS

RADIUS ON CURVE MAX. m	RADIUS ON CURVE MIN. m	SPACING ON CURVE m	SPACING IN ADVANCE OF AND BEYOND CURVES FIRST SPACE m	SECOND SPACE m	THIRD SPACE m
2100	1651	66	80	80	80
1650	1201	60			
1200	881	54			
880	741	48			
740	601	42			
600	471	36			
470	351	30	60		
350	226	24	48		
225	101	18	36	54	72
100	51	12	24	36	54
50	30	6	12	24	48

ENGLISH UNITS

RADIUS ON CURVE MAX. FEET	RADIUS ON CURVE MIN. FEET	SPACING ON CURVE FEET	SPACING IN ADVANCE OF AND BEYOND CURVES FIRST SPACE FEET	SECOND SPACE FEET	THIRD SPACE FEET
7000	5501	220	264	264	264
5500	4001	200			
4000	2901	180			
2900	2451	160			
2450	2001	140			
2000	1551	120			
1550	1151	100	200		
1150	751	80	160		
750	351	60	120	180	240
350	151	40	80	120	180
150	100	20	40	80	160

GROUND/SURFACE-MOUNTED DELINEATOR SPACING ON CURVES

LEGEND

- WHITE POST AND SHEETING
- YELLOW POST AND SHEETING
- RED POST AND SHEETING
- YELLOW POST WITH YELLOW SHEETING BACK TO BACK
- WHITE POST AND SHEETING FACING TRAFFIC WITH RED SHEETING FACING WRONG-WAY MOVEMENT
- DELINEATORS LOCATED AS DIRECTED BY THE ENGINEER
- W16-1 OR YELLOW FLEXIBLE DELINEATOR POST (FOR NARROW MEDIANS)
- DIRECTION OF TRAVEL

NOTES:

1. INSTALL GROUND/SURFACE-MOUNTED DELINEATORS IN ADVANCE OF POINT WHERE TANGENT MEETS SPIRAL OR POINT OF CURVATURE AND BEYOND POINT WHERE SPIRAL MEETS TANGENT OR POINT OF TANGENCY. SPACE SHOWN IN TABLE, BEGINNING AT MID-POINT OF CURVE.
2. INSTALL GUIDE RAIL AND BARRIER MOUNT DELINEATORS AS INDICATED ON SHEET 2 OF 4.
3. IN GORE AREAS, MAKE THE COLOR OF THE DELINEATORS THE SAME, AS THE ADJACENT EDGE LINE AND RAISED PAVEMENT MARKERS.
4. INSTALL ONLY ONE OM1-3 SIGN ON EACH POST OF GORE EXIT SIGN.
5. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
6. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

DELINEATION

LOCATION DETAILS INTERCHANGE AREAS

RECOMMENDED JUN. 23, 2009
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RECOMMENDED JUN. 23, 2009
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SHT. 3 OF 4

TC-8604

1. LOCATION:

A. LIGHTED THROUGH ROADWAYS - DO NOT PLACE DELINEATORS ON THE THROUGH ROADWAY BETWEEN INTERCHANGES WHERE FIXED SOURCE LIGHTING IS INSTALLED UNLESS OTHERWISE SPECIFIED.

B. UNLIGHTED THROUGH ROADWAYS - ON ROADWAYS WITHOUT FIXED SOURCE LIGHTING, CONTINUOUSLY PLACE DELINEATORS ALONG THE RIGHT SIDE OF THE THROUGH ROADWAYS. PLACE DELINEATORS ON THE LEFT SIDE OF THROUGH ROADWAYS AT THE FOLLOWING LOCATIONS:

I. WHERE GUIDE RAIL OR CONCRETE BARRIER IS LOCATED ON THE LEFT WITHIN 1.8 m (6') OF THE EDGE OF SHOULDER.

II. ALONG RIGHT-HAND HORIZONTAL CURVES WITH A RADIUS OF 600 m (2000') OR LESS.

III. ALONG COMBINATIONS OF OVER-VERTICALS AND RIGHT-HAND HORIZONTAL CURVES WITH A RADIUS LESS THAN 880 m (2900').

IV. ON THE APPROACH AND THROUGHOUT LEFT LANE DROPS OR PAVEMENT WIDTH TRANSITIONS.

V. WITHIN THE LIMITS OF MEDIAN CROSSOVERS (AS SHOWN ON SHEET 3 OF 4).

VI. WITHIN THE LIMITS OF VARIABLE MEDIAN WIDTHS (AS SHOWN ON SHEET 3 OF 4).

VII. ALONG PAVED MEDIANS WITH CURBING.

C. INTERCHANGE AREAS - PLACE DELINEATORS ALONG THE RIGHT SIDE IN ALL INTERCHANGE AREAS AND ALONG THE LEFT SIDE WITHIN THE LIMITS OF ALL LEFT-HAND RAMPS. PLACE DELINEATORS ALONG ACCELERATION, DECELERATION AND SPEED CHANGE LANES; ALONG THE RIGHT SIDE OF THE THROUGH ROADWAY AND ALONG THE OUTSIDE OR BOTH SIDES AS SPECIFIED ON ALL RAMPS.

D. BRIDGE PARAPETS - PLACE DELINEATORS ON PARAPETS OF ALL BRIDGES WHERE RPMs ARE USED ON APPROACH ROADWAY.

E. SPECIAL PURPOSE DELINEATION - PLACE OBJECT AND CLEARANCE MARKER GROUP (W16 SERIES) ALONG THE THROUGH ROADWAY AND WITHIN THE INTERCHANGE AREA AS SPECIFIED IN ADDITION TO THE ABOVE SPECIFIED DELINEATORS.

F. MAINTENANCE MARKERS - PLACE ONE RED FLEXIBLE DELINEATOR POST ADJACENT TO NEAR EDGE OF MAINTENANCE APPURTENANCE (END PIPE, END WALL, INLET, ETC....). MATCH REFLECTIVE SHEETING COLOR WITH THE NEAREST PAVEMENT MARKING EDGE LINE COLOR.

2. LONGITUDINAL SPACING:

A. RIGHT SIDE OF THROUGH ROADWAYS - INSTALL DELINEATORS AT 80 m (264') EXCEPT IN INTERCHANGE AREAS WITH RIGHT-HAND RAMPS, ACCELERATION OR DECELERATION LANES AND ALONG HORIZONAL CURVES.

B. LEFT SIDE OF THROUGH ROADWAYS - WHEN REQUIRED, INSTALL DELINEATORS AT 80 m (264') EXCEPT IN INTERCHANGE AREAS WITH LEFT-HAND RAMPS, ACCELERATION OR DECELERATION LANES, ON MEDIAN BARRIERS AND ALONG HORIZONTAL CURVES.

C. INTERCHANGE AREAS - SPACE DELINEATORS IN INTERCHANGE AREA AT 40 m (132').

D. HORIZONTAL CURVES - SPACE DELINEATORS AS INDICATED IN THE TABLE "GROUND/SURFACE-MOUNTED DELINEATOR SPACING ON CURVES," SEE SHEET 3 OF 4.

E. EXIT GORES, CHANNELIZING ISLANDS AND RAMP TERMINALS - THE DESIGN VARIES SUFFICIENTLY AT THESE LOCATIONS MAKING TYPICAL SPACING UNAVAILABLE FOR EVERY SITUATION. DETERMINE DELINEATOR SPACING AND APPLICATION ON SITE AND AS DIRECTED BY THE ENGINEER. HOWEVER, USE A MINIMUM SPACING OF 6 m (20') EXCEPT AS INDICATED.

F. SPECIAL PURPOSE DELINEATION - PLACE SPECIAL PURPOSE DELINEATION (W16 SERIES) ALONG THE ROADWAY WITHOUT REGARD TO LONGITUDINAL SPACING. SPACE DELINEATION ON MEDIAN BARRIERS IN ACCORDANCE WITH NOTE 4 ON SHEET 2 OF 4.

G. MEDIAN CROSSOVERS - PLACE DELINEATORS AT 30 m (100') SPACING AS INDICATED ON SHEET 3 OF 4 WITH A MINIMUM OF FIVE DELINEATORS ON THE APPROACH TO THE CROSSOVER AND THREE DELINEATORS BEYOND THE CROSSOVER.

H. MAINTENANCE MARKERS - PLACE MAINTENANCE MARKERS ALONG THE ROADWAY WITHOUT REGARD TO LONGITUDINAL SPACING.

3. VERTICAL PLACEMENT:

INSTALL DELINEATORS THAT THE TOPS ARE APPROXIMATELY 1.2 m (4') ABOVE THE GROUND. INSTALL ON CONCRETE BARRIERS OR GUIDE RAIL AS INDICATED ON SHEET 2 OF 4.

4. LATERAL PLACEMENT:

A. NO GUIDE RAIL - INSTALL DELINEATORS 0.6 m (2') TO 2.4 m (8') BEHIND THE OUTER EDGE OF THE SHOULDER, OR AS DIRECTED.

B. GUIDE RAIL - INSTALL DELINEATORS IN THE WEB OF GUIDE RAIL OR ON GUIDE RAIL POSTS, AS INDICATED ON SHEET 2 OF 4, IF THE GUIDE RAIL IS LESS THAN 2.4 m (8') FROM THE OUTER EDGE OF SHOULDER. DO NOT USE GROUND-MOUNTED DELINEATORS IN AREAS WITH GUIDE RAIL. IF THE GUIDE RAIL IS MORE THAN 2.4 m (8') FROM THE OUTER EDGE OF THE SHOULDER, INSTALL DELINEATORS AS SPECIFIED IN NOTE 4.A.

C. CURB IN PLACE - INSTALL DELINEATORS IMMEDIATELY BEHIND CURB PROVIDED PLACEMENT WILL NOT EXCEED 2.4 m (8') BEHIND THE EDGE OF SHOULDER. IF THE CURB IS MORE THAN 2.4 m (8') FROM THE EDGE OF SHOULDER, INSTALL DELINEATORS AS SPECIFIED IN NOTE 4.A.

D. OBSTRUCTION MARKERS - INSTALL OBSTRUCTION MARKER DELINEATORS ADJACENT TO NEAR EDGE OF THE OBSTRUCTION.

E. MAINTENANCE MARKERS - INSTALL MARKERS ADJACENT TO NEAR EDGE OF THE APPURTENANCE (END PIPE, END WALL, INLET, ETC....).

5. TYPES OF DELINEATOR:

A. WHITE DELINEATORS - PLACE ON RIGHT SIDE OF THROUGH ROADWAYS, ALONG RIGHT-HAND ACCELERATION, DECELERATION AND SPEED-CHANGE LANES, RAMPS AND ON CHANNELIZING OR DIVISIONAL ISLANDS WHERE TRAFFIC IN THE SAME DIRECTION MAY PROCEED ON BOTH SIDES OF THE ISLAND.

B. YELLOW DELINEATORS - PLACE ON LEFT SIDE OF THROUGH ROADWAYS, RAMPS AND ON CHANNELIZING OR DIVISONAL ISLANDS WHERE TRAFFIC IN THE SAME DIRECTION TRAVELS TO THE RIGHT OF THE ISLAND AND ALONG LEFT-HAND ACCELERATION, DECELERATION AND SPEED CHANGE LANES AND ON FAR SIDE OF MEDIAN CROSSOVERS. ALSO AT EDGE OF OBSTRUCTIONS ADJACENT TO THE ROADWAY AND AT POINT WHERE GUIDE RAIL BECOMES TANGENT TO THE ROADWAY.

C. RED DELINEATORS - PLACE ON RIGHT, LEFT, OR BOTH SIDES OF ROADWAYS OR RAMPS TO INDICATE WRONG-WAY MOVEMENT. ALSO PLACE ON BOTH SIDES OF RUN-AWAY TRUCK ESCAPE RAMPS.

D. SPECIAL PURPOSE DELINEATOR (W16-1) MARKERS - PLACE MARKERS AT LOCATIONS SHOWN ON SHEET 3 OF 4.

E. MAINTENANCE MARKERS - PLACE RED POST WITH WHITE REFLECTIVE SHEETING ON RIGHT SIDE OF THROUGH HIGHWAY. PLACE RED POST WITH YELLOW REFLECTIVE SHEETING ON LEFT SIDE OF THROUGH HIGHWAY.

NOTES:

1. MAINTENANCE MARKERS ARE RED FLEXIBLE DELINEATOR POSTS INSTALLED TO CALL OUT THE LOCATION OF END PIPES, END WALLS, INLETS, ETC... FOR MAINTENANCE PURPOSES ONLY. ANY MAINTENANCE APPURTENANCE WITHIN OR ADJACENT TO THE ROADWAY THAT IS DEEMED A HAZARD SHOULD BE REMOVED, MODIFIED OR DELINEATED AS SUCH.
2. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

DELINEATION AND MARKERS

LOCATION / PLACEMENT NOTES

RECOMMENDED JUN. 23, 2009 CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION	RECOMMENDED JUN. 23, 2009 ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING	SHT. 4 OF 4 TC-8604

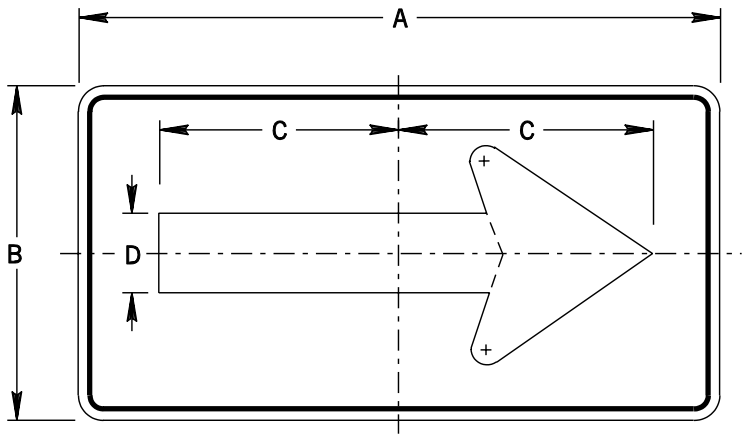
W1–6

LARGE SINGLE ARROW SIGN

(a) Justification. The Large Single Arrow Sign (W1–6) shall be authorized for use on the outside of a curve or on a turn, in line with, and at right angles to, approaching traffic.

This sign shall not be used to mark the ends of median strips, center piers, etc., where there is no change in the direction of traffic.

(b) Size. The standard size of the W1–6 shall be 1200 mm by 600 mm (48" x 24").



NOTE:
SEE STANDARD ARROW FOR DIMENSIONS OF ARROWHEAD

DIMENSIONS – mm (IN)					
SIGN SIZE A x B	C	D	MAR–GIN	BOR–DER	BLANK STD.
1200 x 600 (48" x 24")	490 (19.5)	165 (6.6)	15 (0.6)	20 (0.8)	B5–1200600 (B5–4824)
2400 x 1200 (96" x 48")	975 (39)	325 (13)	20 (0.8)	30 (1.2)	_____
3000 x 1500 (120" x 60")	1220 (48.8)	400 (16)	25 (1)	30 (1.2)	_____

COLOR:

ARROW AND BORDER:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE SECRETARY OF TRANSPORTATION

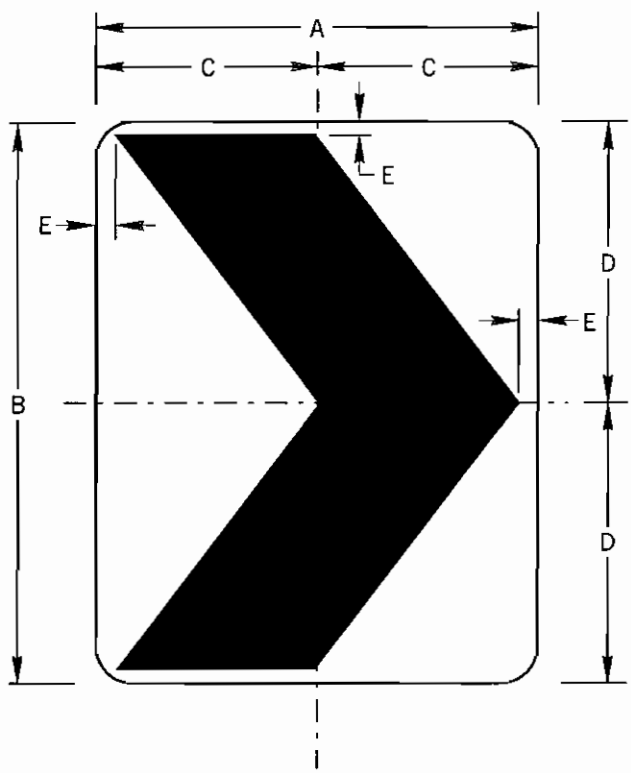
By : Glen C Rowe Date : 01–03–06
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1–8

CHEVRON ALIGNMENT SIGN

(a) Justification. The Chevron Alignment Sign (W1–8) will be authorized to emphasize changes in the horizontal alignment of the roadway at locations where standard delineation practices have proven to be inadequate. The W1–8 sign may be used as an alternate or as a supplement to the Large Single Arrow Sign (W1–6).

(b) Placement. When used, the W1–8 sign shall be erected on the outside of a curve or sharp turn, in line with and at right angles to approaching traffic. The sign should be rotated so as to indicate the direction of the change of alignment. Spacing of the W1–8 sign should be such that the driver always has two signs in view until the change in alignment eliminates the need for additional signs. To be effective, the W1–8 signs should be visible for at least 150 m (500').



DIMENSIONS – mm (IN)				
SIGN SIZE A x B	C	D	E	BLANK STD.
450 x 600 (18" x 24")	225 (9)	300 (12)	20 (0.8)	B5–600450 (B5–2418)
600 x 750 (24" x 30")	300 (12)	375 (15)	23 (0.9)	B5–750600 (B5–3024)
750 x 900 (30" x 36")	375 (15)	450 (18)	25 (1)	B5–900750 (B5–3630)
900 x 1200 (36" x 48")	450 (18)	600 (24)	30 (1.2)	B5–1200900 (B5–4836)

COLOR:

CHEVRON:
BLACK (NON–REFLECTORIZED)

BACKGROUND:
YELLOW (REFLECTORIZED)

APPROVED FOR THE ~~SECRETARY OF~~ TRANSPORTATION

By : _____ Date : 2-1-2010
Chief, Traffic Engineering and Operations Division
Bureau of Highway Safety and Traffic Engineering

W1_8.DGN

A-23

Raised Pavement Markers
(Manual on Uniform Traffic Control Devices, Sections 3B.11, 3B.12, 3B.13, and 3B.14)

Snowplowable Raised Pavement Markers
(PennDOT Publication 111M, TC-8602)

Under both formulas, L equals the taper length in meters (feet), W equals the width of the offset distance in meters (feet), and S equals the 85th-percentile speed or the posted or statutory speed limit, whichever is higher.

Standard:

The minimum taper length shall be 30 m (100 ft) in urban areas and 60 m (200 ft) in rural areas.

Support:

Examples of approach markings for obstructions in the roadway are shown in Figure 3B-13.

Option:

Where observed speeds exceed posted or statutory speed limits, longer tapers may be used.

Standard:

If traffic is required to pass only to the right of the obstruction, the markings shall consist of a two-direction no-passing zone marking at least twice the length of the diagonal portion as determined by the appropriate taper formula (see Figure 3B-13).

Option:

If traffic is required to pass only to the right of the obstruction, yellow diagonal approach markings may be placed in the neutral area between the no-passing zone markings as shown in Figure 3B-13. Other markings, such as yellow delineators, raised pavement markers, and white crosswalk pavement markings, may also be placed in the neutral area.

Standard:

If traffic can pass either to the right or left of the obstruction, the markings shall consist of two channelizing lines diverging from the lane line, one to each side of the obstruction. In advance of the point of divergence, a solid wide white line or solid double normal white line shall be extended in place of the broken lane line for a distance equal to the length of the diverging lines (see Figure 3B-13).

Option:

If traffic can pass either to the right or left of the obstruction, additional white markings may be placed in the neutral area between the channelizing lines as shown in Figure 3B-13.

Section 3B.11 Raised Pavement Markers

Standard:

A raised pavement marker shall be a device with a height of at least 10 mm (0.4 in) mounted on or in a road surface that is intended to be used as a positioning guide or to supplement or substitute for pavement markings or to mark the position of a fire hydrant.

The color of raised pavement markers under both daylight and nighttime conditions shall conform to the color of the marking for which they serve as a positioning guide, or for which they supplement or substitute.

Option:

Blue raised pavement markers may be used to mark the positions of fire hydrants.

Support:

Retroreflective and internally illuminated raised pavement markers are available in monodirectional and bidirectional configurations. The bidirectional marker is capable of displaying the applicable color for each direction of travel.

Guidance:

Nonretroreflective raised pavement markers should not be used alone, without supplemental retroreflective or internally illuminated markers, as a substitute for other types of pavement markings.

Directional configurations should be used to maximize correct information and to minimize confusing information provided to the road user. Directional configurations also should be used to avoid confusion resulting from visibility of markers that do not apply to the road user.

The spacing of raised pavement markers used to supplement or substitute for other types of longitudinal markings should correspond with the pattern of broken lines for which the markers supplement or substitute.

Standard:

The value of N for the spacing of raised pavement markers for a broken or dotted line shall equal the length of one line segment plus one gap. The value of N referenced for solid lines shall equal the N for the broken or dotted lines that might be adjacent to or might extend the solid lines (see Sections 3B.13 and 3B.14).

Support:

Figures 9-20 through 9-22 in the "Traffic Control Devices Handbook" (see Section 1A.11) contain additional information regarding the spacing of raised pavement markers on longitudinal markings.

Section 3B.12 Raised Pavement Markers as Vehicle Positioning Guides with Other Longitudinal Markings

Option:

Raised pavement markers may be used as positioning guides with longitudinal line markings without necessarily conveying information to the road user about passing or lane-use restrictions. In such applications, markers may be positioned between the two lines of a one-way or two-way no-passing zone marking or positioned in line with or immediately adjacent to single solid or broken centerline or lane line markings.

Support:

A typical spacing for such applications is 2N, where N equals the length of one line segment plus one gap (see Section 3B.11).

Option:

Where it is desired to alert the road user to changes in the travel path, such as on sharp curves or on transitions that reduce the number of lanes or that shift traffic laterally, the spacing may be reduced to N or less.

On freeways and expressways, a spacing of 3N may be used for relatively straight and level roadway segments where engineering judgment indicates that such spacing will provide adequate delineation under wet night conditions.

Section 3B.13 Raised Pavement Markers Supplementing Other Markings

Guidance:

The use of raised pavement markers for supplementing longitudinal line markings should conform to the following:

A. Lateral Positioning
   1. When supplementing double line markings, pairs of raised pavement markers placed laterally in line with or immediately outside of the two lines should be used.
   2. When supplementing wide line markings, pairs of raised pavement markers placed laterally adjacent to each other should be used.

B. Longitudinal Spacing
   1. When supplementing solid line markings, raised pavement markers at a spacing no greater than N (see Section 3B.11) should be used, except when supplementing left edge line markings, a spacing of no greater than N/2 should be used. Raised markers should not supplement right edge line markings.
   2. When supplementing broken line markings, a spacing no greater than 3N should be used. However, when supplementing broken line markings identifying reversible lanes, a spacing of no greater than N should be used.
   3. When supplementing dotted line markings, a spacing appropriate for the application should be used.
   4. When supplementing longitudinal line markings through at-grade intersections, one raised pavement marker for each short line segment should be used.
   5. When supplementing edge line extensions through freeway interchanges, a spacing of no greater than N should be used.

Option:

Raised pavement markers also may be used to supplement other markings for channelizing islands or approaches to obstructions.

Section 3B.14 Raised Pavement Markers Substituting for Pavement Markings

Option:

Retroreflective or internally illuminated raised pavement markers, or nonretroreflective raised pavement markers supplemented by retroreflective or internally illuminated markers, may be substituted for markings of other types.

Guidance:

If used, the pattern and color of the raised pavement markers should simulate the pattern and color of the markings for which they substitute.

The normal spacing of raised pavement markers, when substituting for other markings, should be determined in terms of the standard length of the broken line segment.

Option:

The side of a raised pavement marker that is visible to traffic proceeding in the wrong direction may be red.

Standard:

If raised pavement markers are used to substitute for broken line markings, a group of three to five markers equally spaced at a distance no greater than N/8 (see Section 3B.11) shall be used. If N is other than 12 m (40 ft), the markers shall be equally spaced over the line segment length (at 1/2 points for 3 markers, at 1/3 points for 4 markers, and at 1/4 points for 5 markers). At least one retroreflective or internally illuminated marker per group shall be used or a retroreflective or internally illuminated marker shall be installed midway in each gap between successive groups of nonretroreflective markers.

When raised pavement markers substitute for solid lane line markings, the markers shall be equally spaced at no greater than N/4, with retroreflective or internally illuminated units at a spacing no greater than N/2.

Guidance:

Raised pavement markers should not substitute for right edge line markings.

Standard:

When raised pavement markers substitute for dotted lines, they shall be spaced at no greater than N/4, with not less than one raised pavement marker per dotted line. At least one raised marker every N shall be retroreflective or internally illuminated.

Option:

When substituting for wide lines, raised pavement markers may be placed laterally adjacent to each other to simulate the width of the line.

Section 3B.15 Transverse Markings

Standard:

Transverse markings, which include shoulder markings, word and symbol markings, stop lines, yield lines, crosswalk lines, speed measurement markings, speed hump markings, parking space markings, and others, shall be white unless otherwise specified herein.

Guidance:

Because of the low approach angle at which pavement markings are viewed, transverse lines should be proportioned to provide visibility equal to that of longitudinal lines.

Standard:

Pavement marking letters, numerals, and symbols shall be installed in accordance with the Pavement Markings chapter of the "Standard Highway Signs" book (see Section 1A.11).

Section 3B.16 Stop and Yield Lines

Standard:

If used, stop lines shall consist of solid white lines extending across approach lanes to indicate the point at which the stop is intended or required to be made.

If used, yield lines (see Figure 3B-14) shall consist of a row of solid white isosceles triangles pointing toward approaching vehicles extending across approach lanes to indicate the point at which the yield is intended or required to be made.

Guidance:

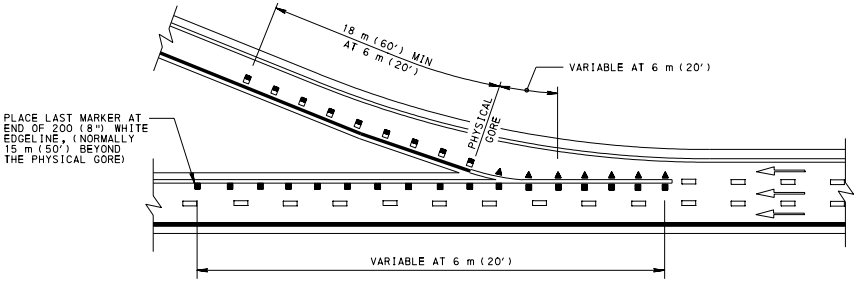
Stop lines should be 300 to 600 mm (12 to 24 in) wide.

Stop lines should be used to indicate the point behind which vehicles are required to stop, in compliance with a STOP (R1-1) sign, traffic control signal, or some other traffic control device, except YIELD signs.

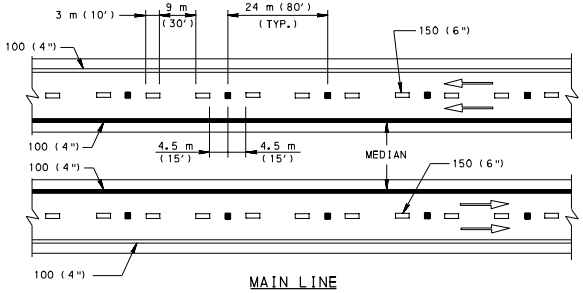
The individual triangles comprising the yield line should have a base of 300 to 600 mm (12 to 24 in) wide and a height equal to 1.5 times the base. The space between the triangles should be 75 to 300 mm (3 to 12 in).

Option:

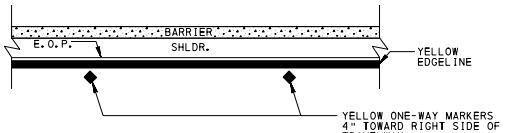
Yield lines may be used to indicate the point behind which vehicles are required to yield in compliance with a YIELD (R1-2) sign or a Yield Here to Pedestrians (R1-5 or R1-5a) sign.



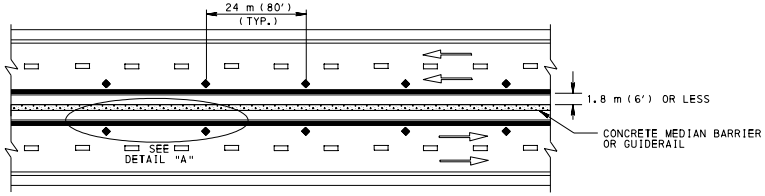
EXIT GORE AREA



MAIN LINE



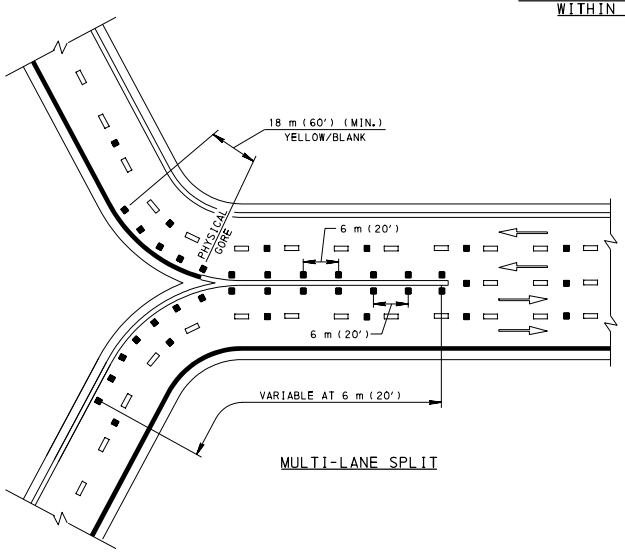
DETAIL "A"



CONCRETE MEDIAN BARRIER OR GUIDERAIL
WITHIN 6 FEET OF TRAVEL LANE

LEGEND

- TWO-WAY MARKER WITH WHITE/BLANK REFLECTOR
- TWO-WAY MARKER WITH YELLOW/BLANK REFLECTOR
- TWO-WAY MARKER WITH WHITE/RED REFLECTOR
- TWO-WAY MARKER WITH YELLOW/RED REFLECTOR
- WHITE
- YELLOW
- BROKEN WHITE
- DIRECTION OF TRAVEL



MULTI-LANE SPLIT

INSTALLATION PATTERNS - FREEWAYS & EXPRESSWAYS

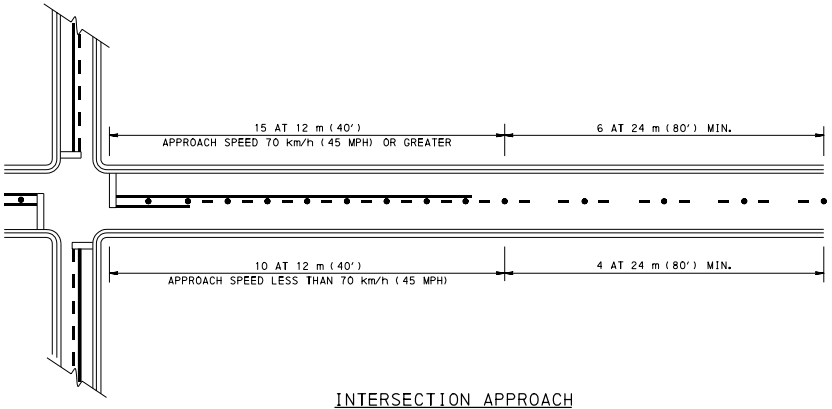
NOTES:

1. MATERIAL AND WORKMANSHIP IN ACCORDANCE WITH PENNSYLVANIA DEPARTMENT OF TRANSPORTATION PUBLICATION 408, OR AS INDICATED OR DIRECTED.
2. PLACE MARKERS ALONG A LANE LINE (BROKEN LINE) MIDWAY BETWEEN THE PAINTED PORTIONS.
3. PLACE MARKERS ALONG AN EDGE OR CHANNELIZING LINE WITH NEAR EDGE OF MARKER CASTING 100 mm (4") FROM NEAR EDGE OF PAINTED LINE, WHEN CONCRETE MEDIAN BARRIER OR GUILDRAIL IS WITHIN 1.8 m (6') OF TRAVEL LANE.
4. INSTALL MARKERS 100 mm (4") MIN. FROM ANY PAVEMENT SEAM, JOINT OR EDGE.
5. SEE SHEET 4 OF 4 FOR MARKER DETAILS.
6. FOR MARKER SPACING ON CURVES SEE SHEET 3 OF 4.
7. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
8. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.

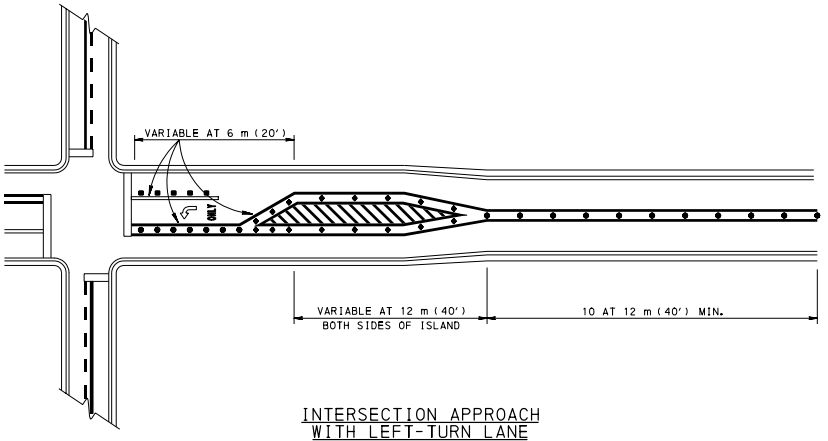
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

SNOWPLOWABLE RAISED PAVEMENT MARKERS

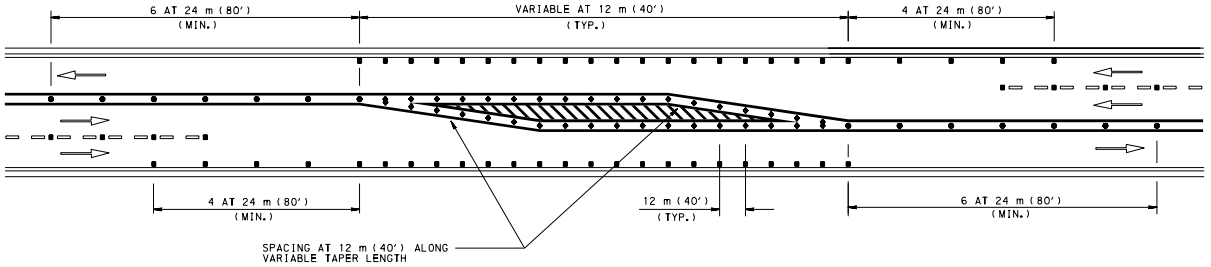
RECOMMENDED JUN. 23, 2009	RECOMMENDED JUN. 23, 2009	SHT. 1 OF 4
CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION	ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING	TC-8602



INTERSECTION APPROACH



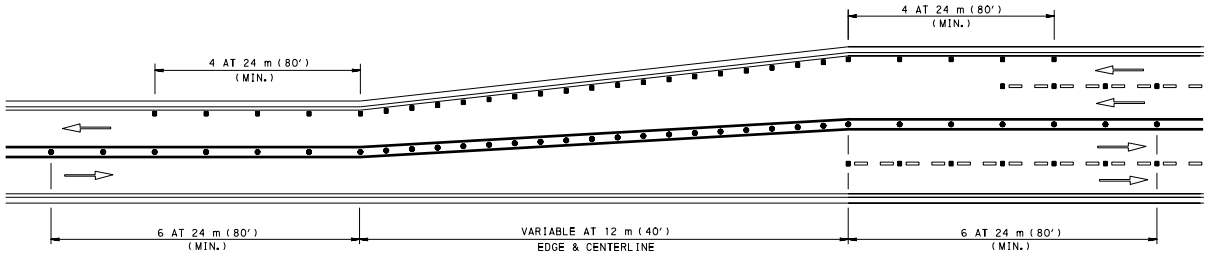
INTERSECTION APPROACH
WITH LEFT-TURN LANE



TWO LANES TO ONE LANE

LEGEND

- TWO-WAY MARKER WITH WHITE/BLANK REFLECTOR
- TWO-WAY MARKER WITH YELLOW/BLANK REFLECTOR
- TWO-WAY MARKER WITH YELLOW/YELLOW REFLECTOR
- WHITE
- YELLOW
- BROKEN WHITE
- BROKEN YELLOW
- DIRECTION OF TRAVEL



FOUR LANES TO TWO LANES

TRANSITION

NOTES:

1. SEE SHEET 3 OF 4 FOR ADDITIONAL NOTES.
2. FOR MARKER SPACING ON CURVES SEE SHEET 3 OF 4.
3. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
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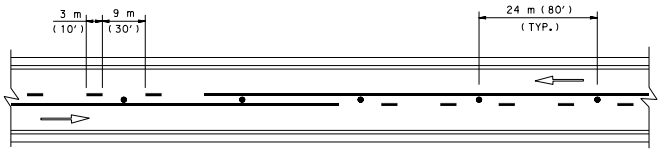
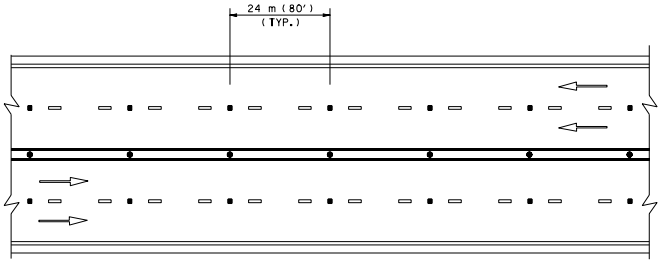
SNOWPLOWABLE RAISED PAVEMENT MARKERS

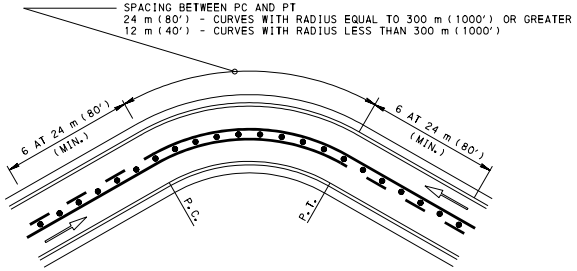
RECOMMENDED JUN. 23, 2009	RECOMMENDED JUN. 23, 2009	SHT. 2 OF 4
CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION	ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING	TC-8602



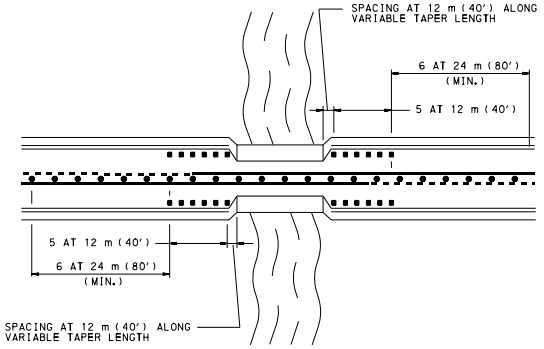
TWO-LANE ROADWAY



UNDIVIDED FOUR LANES



CURVES

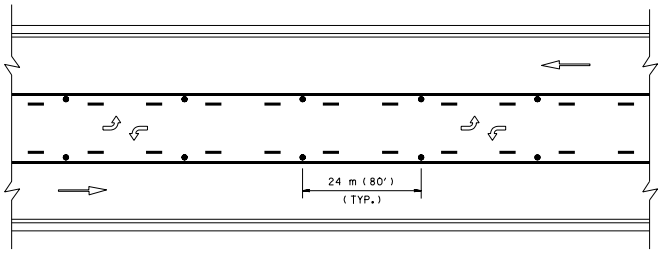


NARROW BRIDGE

ACROSS STRUCTURE USE BARRIER-MOUNT DELINEATORS

NOTES:

1. MARKERS INSTALLED AT THE DOUBLE YELLOW CENTER LINE SHALL BE PLACED BETWEEN THE TWO PAINTED LINES. MARKERS SHALL NOT BE PLACED WITHIN THE LIMITS OF THE PAINTED LINES EXCEPT WHERE LINES DEVIATE VISIBLY FROM THEIR CORRECT ALIGNMENT, AND THEN ONLY WITH THE APPROVAL OF THE ENGINEER.
2. PLACE MARKERS INSTALLED ALONG A LANE LINE (BROKEN LINE) MIDWAY BETWEEN THE PAINTED PORTION.
3. PLACE MARKERS ALONG AN EDGE OR CHANNELIZING LINE WITH THE NEAR EDGE OF THE MARKER CASTING 25 mm (1") MAXIMUM FROM THE NEAR EDGE OF THE PAINTED LINE.
4. SPACE MARKERS INSTALLED AT THE CENTERLINE AT 24 m (80') UNLESS OTHERWISE SHOWN ON THE DRAWINGS. (AT LOCATIONS IDENTIFIED AS FOG AREAS OR AREAS WITH A HIGH INCIDENCE OF HEAD-ON OR SIDESWIPE CRASHES, SPACE THE CENTERLINE MARKERS AT 12 m (40')).
5. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.



CENTER LANE LEFT-TURN ONLY

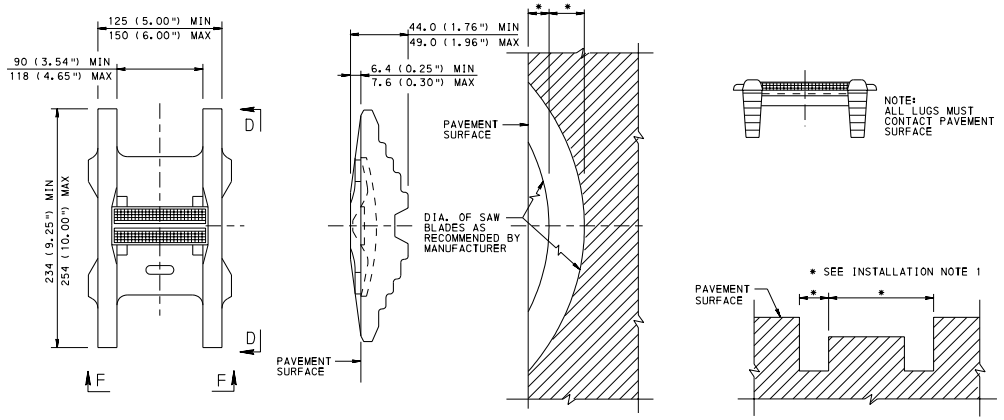
LEGEND

- TWO-WAY MARKER WITH WHITE/BLANK REFLECTOR
- TWO-WAY MARKER WITH YELLOW/YELLOW REFLECTOR
- WHITE
- YELLOW
- BROKEN WHITE
- BROKEN YELLOW
- DIRECTION OF TRAVEL

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

SNOWPLOWABLE RAISED PAVEMENT MARKERS

RECOMMENDED JUN. 23, 2009	RECOMMENDED JUN. 23, 2009	SHT. 3 OF 4
CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION	ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING	TC-8602

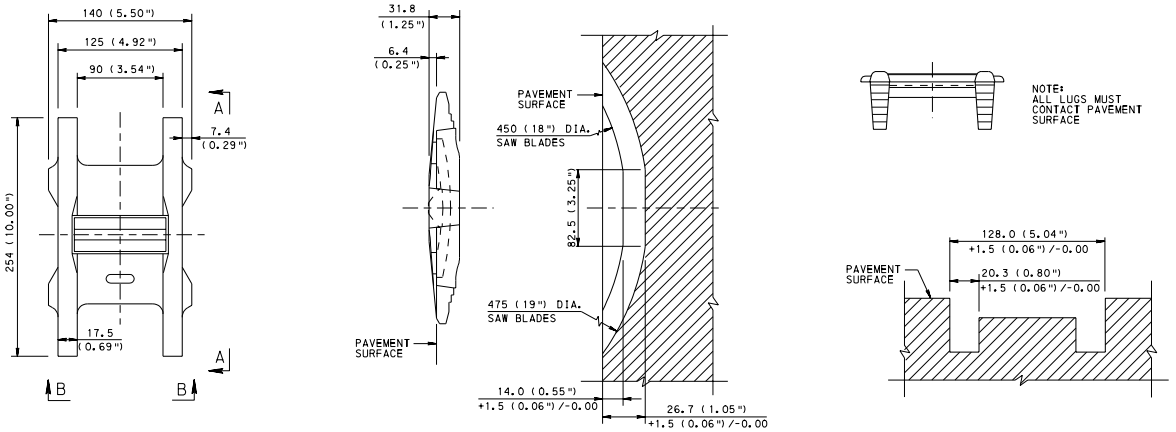


PLAN VIEW
TWO-WAY

SECTION D-D

SECTION F-F

RAISED PAVEMENT MARKERS



PLAN VIEW

SECTION A-A

SECTION B-B

BRIDGE DECK MARKER

INSTALLATION NOTES:

1. SAW CUT TO DIMENSIONS RECOMMENDED BY MANUFACTURER.
2. INSPECT SAW CUT FOR PROPER FIT OF THE MARKER.
   - PROVIDE APPROXIMATELY 3.2 mm (0.125") CLEARANCE (SIDE-TO-SIDE MOVEMENT) FOR THE CASTING WHEN INSERTED INTO THE CUT.
   - INSTALL MARKER WITH ALL LEVELING LUGS IN CONTACT WITH THE PAVEMENT.
   - INSURE THE LEADING EDGES OF THE CASTING LIE BELOW THE PAVEMENT SURFACE.
3. SAW CUT AREAS TO BE DRY AND FREE OF MATERIAL THAT ADVERSELY AFFECTS THE ADHESIVE BOND.
4. INSTALL THE MARKERS WITH TWO-COMPONENT EPOXY ADHESIVE THAT MEETS AASHTO STANDARD SPECIFICATION M237 AND CLASSIFIED AS TYPE IV, BY FIRST FILLING THE SAW CUT TO WITHIN APPROXIMATELY 10 mm (0.375") OF PAVEMENT SURFACE AND THEN PLACING THE MARKER BY HAND INTO THE EPOXY FILLED SAW CUT. AFTER PLACEMENT OF MARKER, MAKE THE EPOXY FLUSH OR SLIGHTLY BELOW PAVEMENT SURFACE. NO EPOXY SHOULD OBSCURE OR BLOCK THE LENS.

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED. ENGLISH UNITS IN PARENTHESIS ( ).
2. EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH UNITS SHOWN MAY NOT BE MIXED.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING

SNOWPLOWABLE RAISED PAVEMENT MARKERS

RECOMMENDED JUN. 23, 2009	RECOMMENDED JUN. 23, 2009	SHT. 4 OF 4
CHIEF, TRAFFIC ENGINEERING AND OPERATIONS DIVISION	ACTING DIR. BUR. OF HIGHWAY SAFETY AND TRAFFIC ENGINEERING	TC-8602

A-24

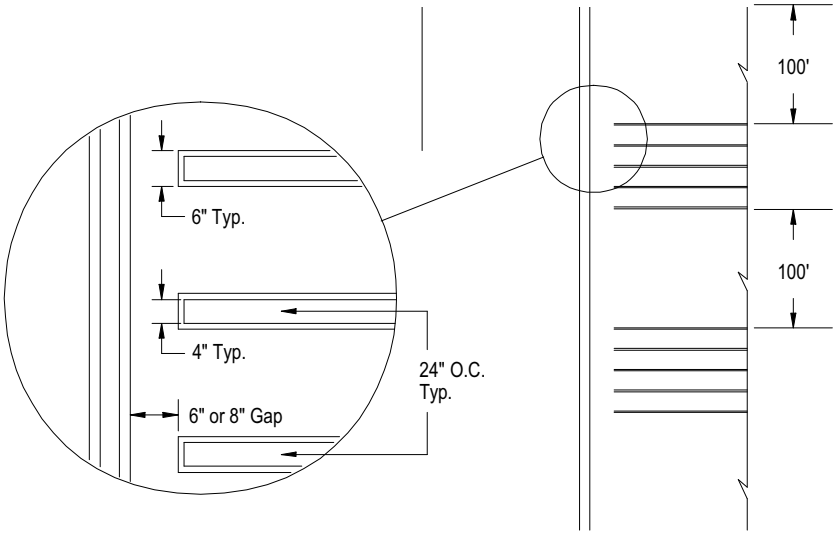
Transverse Markings
(PennDOT Publication 383, Page 63)

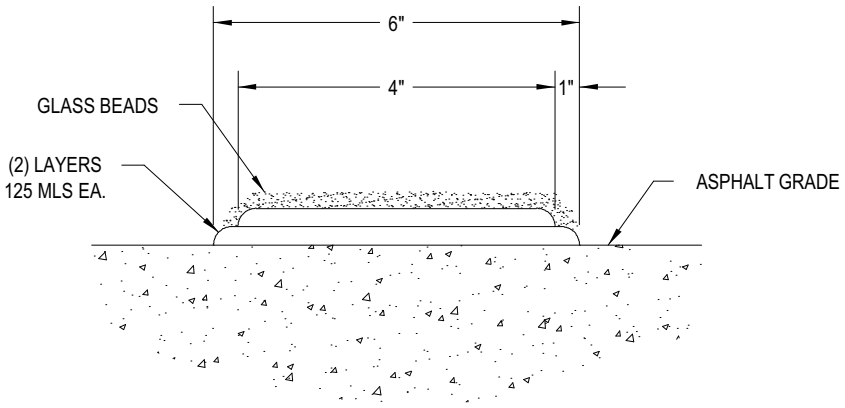
New Pavement Markings Provide Curve Warning
(LTAP Technical Information Sheet #93)

Transverse Markings

Double thick thermoplastic transverse pavement markings have been successful in slowing traffic in diverse areas such as school zones, hospitals, approaches to severe curves, and stop signs. These markings typically consist of five transverse, 6-inch-wide stripes, installed 2 feet on center, repeated every 100 feet. Depending on conditions, three to five sets of clusters are installed per approach. It is estimated that each cluster reduces approach speeds by 1 to 3 mph. As vehicles travel over these thermoplastic markings the noise and vibration alerts the driver. Because of the noise they generate, it may be inappropriate to use this application in locations with nearby residents.

Transverse Markings





The Pennsylvania Local Roads Program

New Pavement Markings Provide Curve Warning

Mark Hood, LTAP Technology Transfer Specialist

LTAP TECHNICAL INFORMATION SHEET # 93
Spring 2002

Traditional safety treatments at curves, involving warning signs and delineation, were covered in *Technical Information Sheets # 90 and # 91* in the summer and fall 2001 issues of *Moving Forward*. Well, what if you installed the treatments, but you feel a location would benefit from further treatment? Perhaps you're still finding skid marks or evidence that vehicles have left the road. Perhaps residents complain about squealing tires at the location, or run-off-the-road incidents have occurred there. Maybe one of your roads includes a winding road segment that is difficult to negotiate. PENNDOT has developed and continues to test a new, low-cost countermeasure: pavement markings applied in advance of troublesome curves (Advanced Curve-Warning Treatment) that encourage a driver to reduce speed.

Advanced Curve-Warning Treatment

PENNDOT developed the treatment (see photo) to address driver behavior ahead of curves that have experienced a high number of curve-related crashes: crashes in which vehicles run off the road, hit fixed objects, roll over, or sideswipe other vehicles. It is one of the treatments PENNDOT is deploying to achieve its goal of a 10-percent reduction in annual highway fatalities statewide by 2005. Furthermore, PENNDOT encourages municipalities to apply this treatment on local roads where roadway curvature has contributed to crashes.

DESCRIPTION

The standard markings consist of two transverse bars, a SLOW legend, and an arrow indicating the direction of the upcoming curve, all in white, as shown in the photo. A durable material, such as thermoplastic, is preferable to highway paint. Durable materials also provide slight profile. That is, in addition to seeing them, drivers can "feel" them as their vehicles cross the markings. The markings are installed on the approach to a curve at a distance in advance of the point of curvature (p.c.) that is based on the posted speed limit and the advisory speed. (See illustrations on next page for dimensions and placement.) In this article, the term "curve" denotes a location to which the advanced warning sign Curve (W1-2), Turn (W1-1), Reverse Curve (W1-4), Reverse Turn (W1-3), or Winding Road (W1-5) applies, with Advisory Speed plaque (W13-1) if applicable.

OBJECTIVE

The objective of the markings is to reduce the 90th percentile speed of vehicles approaching a curve, thus reducing the number of vehicles that stray from the travel lane in the curve.

PENNDOT implemented a pilot program at a small sample of curves to evaluate the treatment's usefulness and identify the most effective markings. Selected sites had experienced five or more curve-related crashes and were free of intersections or driveways. An evaluation of the pilot program suggested that the treat-

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LTAP
The Pennsylvania
Local Roads Program
Penn State Eastgate Ctr.
1010 N. 7th St., Suite 304
Harrisburg, PA
17102-1410

(800) FOR-LTAP

ment reduced the 90th percentile speed. That is, the treatment reduced the speed at or below which 90 percent of drivers approached the curves. As a result, PENNDOT estimates that the treatment is capable of reducing curve-related deaths 15 percent over a five-year period if applied at high-crash locations statewide.

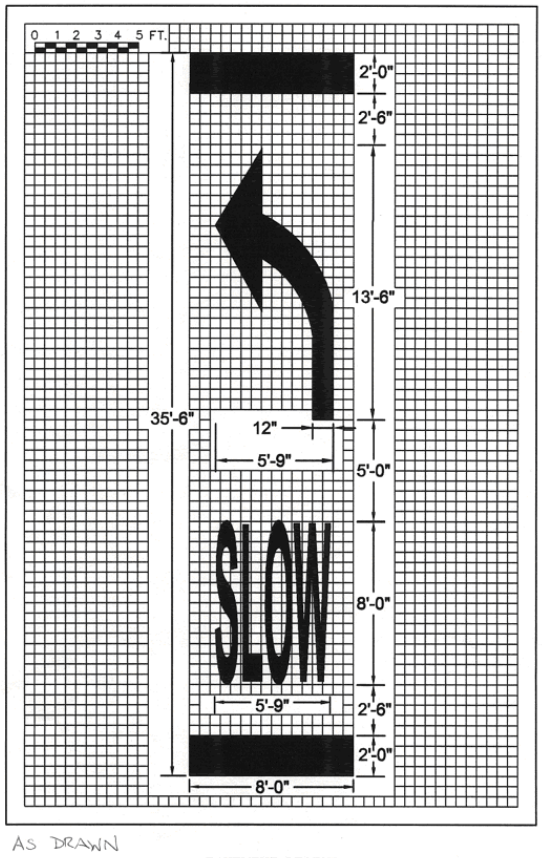
Now that a design for the markings has been chosen, the treatment is being evaluated on a larger scale. In summer 2001, nearly 200 approaches to curves across Pennsylvania were treated with the markings.

GUIDELINES

The new pavement markings are intended to provide additional warning in advance of curves where a high number of curve-related crashes have occurred, or curves that have characteristics similar to such high-crash locations. Installation should be limited to two-lane, two-way roadways, unless an engineering and traffic study shows the treatment is feasible for another roadway type.

The markings should not be installed where intersecting roadways or driveways may confuse drivers about the reason for the markings.

You should review each potential location carefully. When you consider sites that have multiple or reverse curves, the approach to the curve where the most "curve-type" crashes have occurred should be treated. When crashes cannot be linked to particular curves, consider using the markings in advance of the first curve in the group.



Dimensions of pavement markings

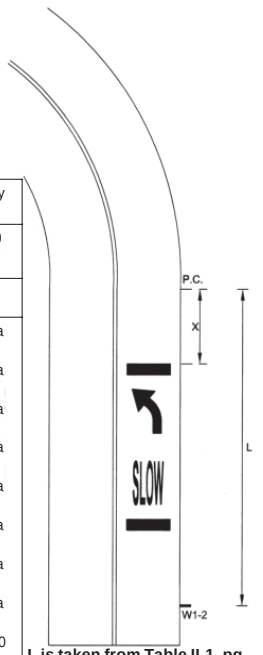
All curve warning signs, delineation, and pavement striping should be brought to standard at a site before installation of the new markings (see *Technical Information Sheets # 90 and # 91*).

You may adjust the placement of the markings if vertical geometry (crests and dips) or other sight distance restrictions would obscure them at the prescribed location.

Placement of pavement markings in relation to point of curvature (P.C.).

Posted Speed	Condition C-Deceleration to listed advisory speed or desired speed at condition				
MPH	10	20	30	40	50
	MPH				
	Value of X (in feet)				
20	*	n/a	n/a	n/a	n/a
25	30	n/a	n/a	n/a	n/a
30	55	30	n/a	n/a	n/a
35	80	65	n/a	n/a	n/a
40	115	105	65	n/a	n/a
45	155	130	105	n/a	n/a
50	190	180	140	90	n/a
55	230	215	180	130	n/a
60	265	255	230	180	130

* Pavement marking location depends on conditions at site..



L is taken from Table II-1, pg. 2C-3 of the MUTCD.

Example: If posted speed limit on approach is 45 MPH and advisory speed for curve is 30 MPH, first transverse bar is placed 105 feet (x) in advance of point of curvature (P.C.).

COST

PENNDOT estimates that installation of each set of markings (curved arrow, SLOW legend, and two transverse bars) will cost approximately $1,350 for durable marking materials, equipment, and labor. This is based on its pilot installations at five locations in five counties.

FURTHER INFORMATION

Between 1993 and 1997, 1,631 fatalities occurred at curves statewide, more than at any other highway location. The Advanced Curve-Warning Treatment should prove effective in reducing vehicle speeds on the approach to, and through, curves that have a history of crashes. Speed reduction at curves should translate into fewer crashes and fatalites—on state and local roads.

To learn more about installing the markings in your municipality, call 1-800-FOR-LTAP.

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Rumble Strips
(PennDOT Publication 46, Section 11.11)

Milled Centerline Rumble Strips (CLRS)
(PennDOT Publication 46, Appendix 11D)

Edge Line Rumble Strips (ELRS)
(PennDOT Publication 46, Appendix 11E)

11.11 Rumble Strips, Speed Bumps, and Speed Humps

11.11.1 References

Pennsylvania Traffic Calming Handbook, January 2001, PennDOT, Publication 383.

Work Zone Traffic Control Guidelines, January 2006, PennDOT, Publication 213.

11.11.2 Transverse Rumble Strips

Highway agencies have successfully used transverse rumble strips for about 40 years to alert drivers of potential dangers. Although these devices are very useful, two common problems need emphasis:

1. Making depressions too deep and creating unnecessary driver panic.

2. Failing to consider the potential noise impacts in residential areas.

Section 6F.84 of the *MUTCD* and Application "PATA 42" in the Work Zone Traffic Control Guidelines (Publication 213) shows temporary bituminous rumble strips to alert drivers to unusual conditions on the approach to work zones. Districts may use transverse rumble strips for permanent installations, in advance of the following problem areas:

1. High crash intersections where STOP sign observance studies indicate that a high percentage of drivers do not stop.

2. Curves or other high crash areas where conventional traffic control has not been successful.

Although PATA 42 shows rectangular-shaped grooves that are recessed 1/2-inch, Districts are encouraged to reduce the depth of the rectangular-shaped grooves for permanent applications to 3/8-inch deep to reduce the panic factor, especially if the grooves are milled. Avoid installing transverse rumble strips on horizontal curves or over-vertical curves, or on shoulders where bicycles or pedestrian traffic may be common.

When used, in accordance with the standard, use five (Pattern A) or six (Pattern B) sets of rumble strip clusters in advance of the intersection or other condition, as indicated in PATA 42, with the closest set located approximately at the same location as the Intersection, Turn Curve or other advance warning sign.

Install a RUMBLE STRIP AHEAD (W8-15) sign in advance of transverse rumble strips.

11.11.3 Longitudinal Rumble Strips

The following types of longitudinal rumble strips alert drivers if their vehicle strays from its normal travel path:

1. Shoulder rumble strips (SRS) and Bicycle tolerable shoulder rumble strips" (BTSRS).
2. Centerline rumble strips (CLRS).
3. Edge line rumble strips (ELRS).

Shoulder Rumble Strips

In the mid-1980's, shoulder rumble strips (SRS) came into existence in the United States. Research at the Pennsylvania Transportation Institute indicates that shoulder rumble strips reduce the number of single-vehicle, run-off-the-road crashes by at least 20 percent based upon state and national crash data. Details for shoulder rumble strips are included in the RC-25M Standard, where Sheet 4/7 is for limited access highways, Sheet 5/7 is for conventional roads, and Sheet 6/7 is for gore areas.

However, because shoulder rumble strips can pose problems for bicyclists, "bicycle-tolerable shoulder rumble strips" (BTSRS) are now being used. Therefore, bicycle tolerable rumble strips are considered cost effective on rural highways with ADT of 1,500 or greater, and paved shoulders that are 6 feet or more in width.

Where the existing graded shoulder width is 6 feet or greater and is partially paved and the cost is not substantial, Engineering Districts should consider building a full width paved shoulder such that the bicycle tolerable shoulder rumble strip (BTSRS) can be incorporated into the design.

Engineering Districts may incorporate bicycle tolerable shoulder rumble strips (BTSRS) on 3R projects (100 percent state and federal-aid) using the criteria in Appendix 11C.

Centerline Rumble Strips (CLRS)

Based upon an analysis of head-on and opposing crash data, centerline rumble strips produce a conservative crash reduction factor of 20 percent. Moreover, based on average installation costs in Pennsylvania, centerline rumble strips are cost-effective on rural two-lane highways where the ADT is 1,500 or greater.

Therefore, Engineering Districts should consider centerline rumble strips on all rural two-lane and four-lane undivided 3R (federal-aid and 100 percent state) projects were the ADT is greater than 1,500 and the pavement width is 20 feet or greater using the criteria in Appendix 11D, except not on concrete pavements with an overlay of 2.5 inches or less. If the average surface life is 10 years, this initiative should save an estimated 275 lives.

Edge line rumble Strips (ELRS)

Edge line rumble Strips (ELRS) may be used in lieu of shoulder rumble strips when the travel lane and shoulders are both of sufficient width. ELRS may be more beneficial than shoulder rumble strips because they provide an earlier alert to a driver that is about to run off the road. All ELRS shall be in accordance with Appendix 11E.

While the crash reduction potential is significant, the Department has insufficient experience with the combined impact of both centerline and edge line rumble strips on the same project to warrant full deployment. Of primary concern are the tight travel lane restrictions and the more frequent departures to one of the rumble strips. However, to gain that knowledge and experience, Engineering Districts may experiment on 3R projects, but should omit edge line rumble strips on the inside of moderate-to-sharp curves, which encompass dwellings.

Timely Placement of Pavement Markings

After installing CLRS or ELRS, apply pavement markings over CLRS and ELRS as soon as possible. Although one may think that these rumble strips would reduce nighttime retroreflectivity of the markings, highway agencies generally observe enhanced wet-night benefits of the milled surfaces, perhaps because water has an opportunity to drain off the pavement marking and pond in the recesses.

11.11.4 Speed Bumps

A speed bump is an abrupt pavement feature, 3 inches or more in height, and only 1 to 3 feet in length (measured in the direction of travel). State law and/or regulations do not prohibit speed bumps; however, the Department does not permit them on State highways and discourages their use on any local road or facilities open to the public.

Speed bumps can cause extreme discomfort to all motorists, including firefighters riding on the back of a fire truck, motorcyclists, and bicyclists. Studies have shown that in some cases, drivers of cars and trucks actually speed up to reduce the impact of the bump or to reduce the delay caused by slowing for the bump. Therefore, speed bumps generally have negative effects on safety.

Milled Centerline Rumble Strips (CLRS)
(For Non-Interstate and Non-Expressways Use)

Responsibilities:

District Safety Engineer is the process Owner.

Guidelines for Use:

1. The purpose of milled Center Line Rumble Strips (CLRS) is to reduce the occurrence of head-on and/or sideswipe crashes on undivided two-lane or four-lane highways.

2. Consider CLRS on the following locations and under following conditions:

Roadway Description	Typical Drawing Detail
Roadway with 12 feet or greater lane width and minimum of 3 feet of paved shoulder.	Detail #1
Roadway with 11 feet lane width and minimum of 3 feet of paved shoulder.	Detail #1 or Detail #2
Roadway with 11 feet lane width and less than 3 feet of shoulder or no shoulder.	Detail #2
Roadway with 10 feet lane width with or without shoulder	Detail #2
Roadway with less than 10 feet lane width	Consult BHSTE

3. Milled centerline rumble strips (CLRS) are for use on bituminous pavement.

4. Installing CLRS on bituminous pavement requires an ID-2 or ID-3 surface with BCBC base or better.

5. If it is desired to retrofit CLRS on existing pavement, the pavement should be in sufficiently good condition, as determined by the District, to effectively accept the milling process without raveling or deteriorating. Otherwise the pavement needs upgraded prior to milling any desired CLRS

6. CLRS should not be installed on existing concrete pavements with overlay less than 2.5 inches in depth.

7. Do not install CLRS on bridge decks.

8. CLRS may be installed in passing zones where deemed appropriate by District safety personnel. Consider reducing depth of cut to 3/8” in areas where passing is permitted.

If CLRS are being discontinued for a passing zone, use engineering judgment as to where to terminate CLRS in advance of a passing zone.

9. CLRS are to be broken for intersections. Also consider breaking for driveways according to engineering judgment. When breaking CLRS pattern, discontinue CLRS 25 feet from the Point of Curvature of any such highway or driveway (refer to Typical Detail #3).

10. Coordinate the milling of CLRS with all necessary project phases. Do not mill the CLRS until all appropriate construction phases are completed.

11. Coordinate the milling of CLRS with traffic line painting operations a) to avoid milling newly applied traffic lines and b) to install new yellow centerlines within two weeks of CLRS completion.

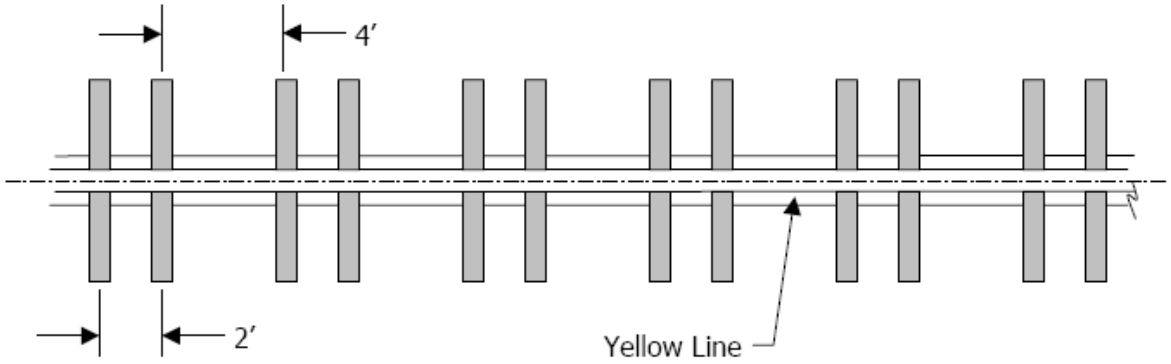
12. Consult the Bureau of Highway Safety and Traffic Engineering before installing CLRS on highways with travel lane widths that are less than 10 feet.

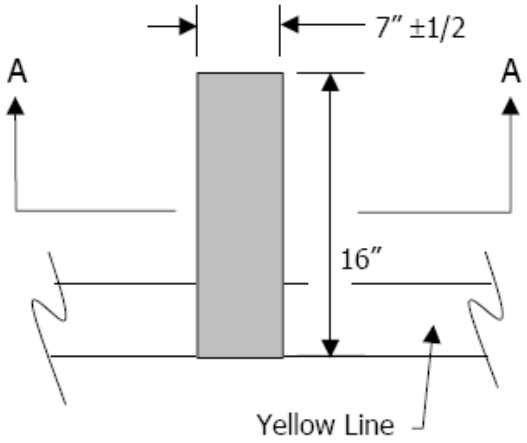
13. Take into consideration potential noise impacts when contemplating the installation of CLRS in residential or urban areas.

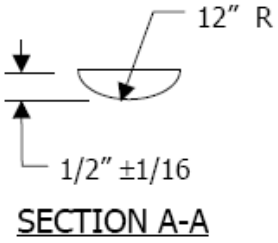
Design Deviation

Deviation from the above specifications and guidelines may be considered by the district; however, they must be approved by the Bureau of Highway Safety and Traffic Engineering prior to being implemented.

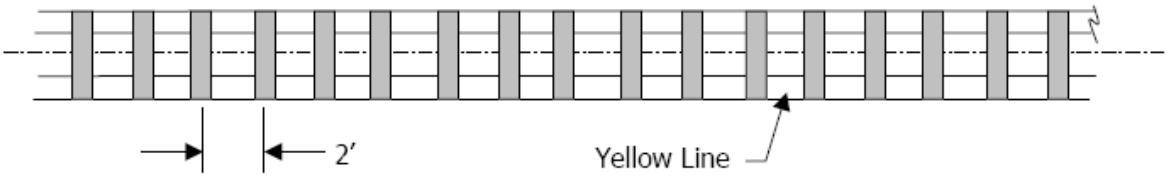
Milled Centerline Rumble Strips
Typical Drawing Detail #1

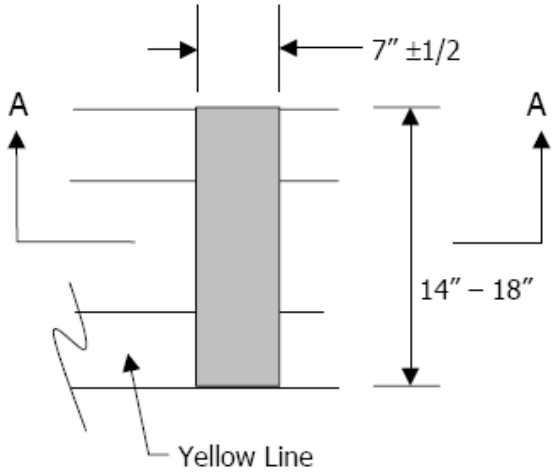


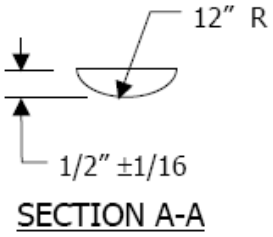




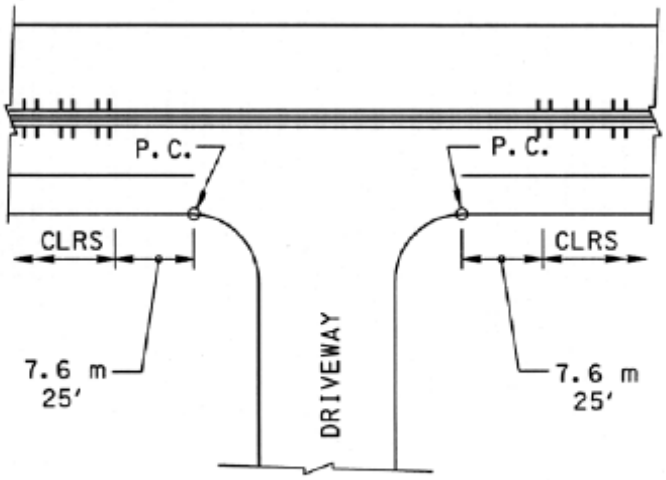
Milled Centerline Rumble Strips
Typical Drawing Detail #2



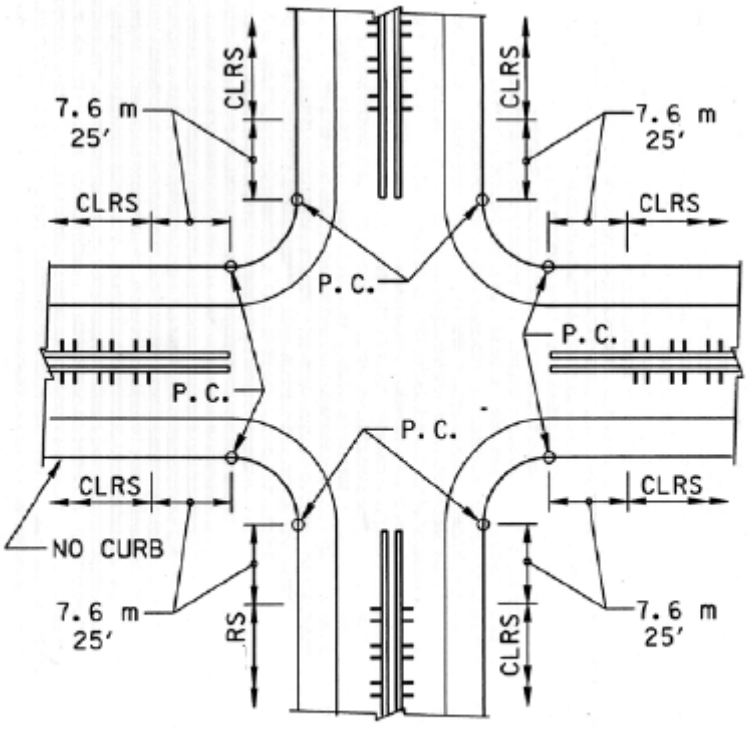




Center Line Rumble Strips
Typical Drawing Detail #3



TYPICAL DRIVEWAY DETAIL



TYPICAL INTERSECTION DETAIL

Edge Line Rumble Strips (ELRS)
(For Non-Interstate and Non-Expressways Use)

Responsibilities:

District Safety Engineer is the process owner.

District Pedestrian/Bicycle Coordinator and the District Safety Engineer shall jointly review the areas to be targeted.

Guidelines for Use:

Consider milled Edge Line Rumble Strips (ELRS) on the following locations and under the following conditions:

The purpose of ELRS is to reduce run off the road crashes on highways (except interstates and expressways).

Consider ELRS for the following types of two-to-four lane highways (except interstate and expressways):

- On highways with 11 feet or greater lane width and 4 to 6 feet of paved shoulder, ELRS shall be installed on the edge of the roadway as shown in Typical Drawing Detail #1.

- If the shoulder width is greater than or equal to 6 feet, consider the Bicycle Friendly Shoulder Rumble Strips shown in Appendix 11B.

If there is concern with the pavement joint between the roadway and the shoulder, district may consider the following options:

- Where shoulder width is between 5-6 feet, offset ELRS 2 to 4 inches from the joint into the shoulder surface.

- Where shoulder width is less than 5 feet, district may offset ELRS 2 to 4 inches from the joint into the travel lane surface.

The ELRS shall be discontinued 50 feet before and after adjacent guiderail, where the face of the guiderail is located less than 4 feet from the edge line of the roadway.

The paved shoulder and the adjacent travel lane should be of equal smoothness.

Installing ELRS on bituminous pavement requires an ID-2 or ID-3 surface with BCBC base or better.

If it is desired to retrofit ELRS on existing pavement, the pavement and shoulder should be in sufficiently good condition, as determined by the District, to effectively accept the milling process without raveling or deteriorating the pavement. Otherwise both the pavement and shoulders need to be upgraded prior to milling any desired ELRS.

Do not install ELRS on bridge decks.

ELRS are to be broken for intersections. Also, consider breaking for driveways according to engineering judgment. When breaking ELRS pattern, discontinue ELRS 25 feet from the Point of Curvature of any such highway or driveway (refer to Typical Detail #2).

Coordinate the milling of ELRS with all necessary project phases. Do not mill the ELRS until all appropriate construction phases are completed.

Coordinate the milling of ELRS with traffic line painting operations a) to avoid milling newly applied traffic lines and b) to install new white edge lines within 2 weeks of ELRS completion.

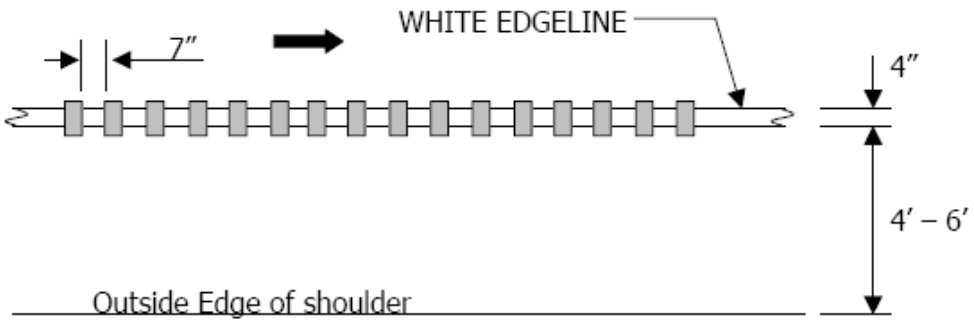
Take into consideration potential noise impacts when contemplating the installation of ELRS in residential or urban areas. Do not install ELRS on the inside of moderate to sharp curves that are in the immediate vicinity of any residence.

As part of multi-modal transportation system planning, consult the District Pedestrian/Bicycle Coordinator where ELRS are being planned for installation, and determine if the District Coordinator has any concerns. These concerns may include Bicycle PA Routes, other local bike routes, Adventure Cycling association, National Bike Route segments in Pennsylvania, proposed bike routes from MPO/LDD regional plans, potential ADA violations and others.

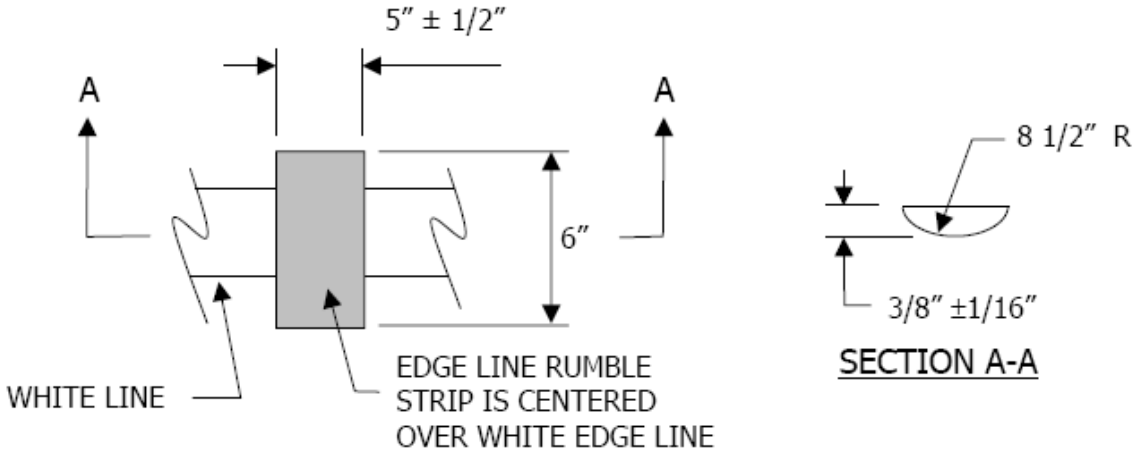
Design Deviations

Deviation from the above specifications and guidelines may be considered by the District; however, they must be approved by the Bureau of Highway Safety and Traffic Engineering prior to being implemented.

Edge Line Rumble Strips
Typical Drawing Detail #1

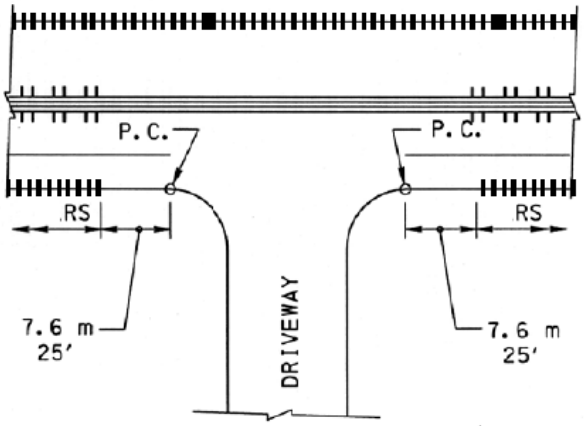


TYPICAL PLAN VIEW FOR MILLED EDGE LINE RUMBLE STRIP PATTERN

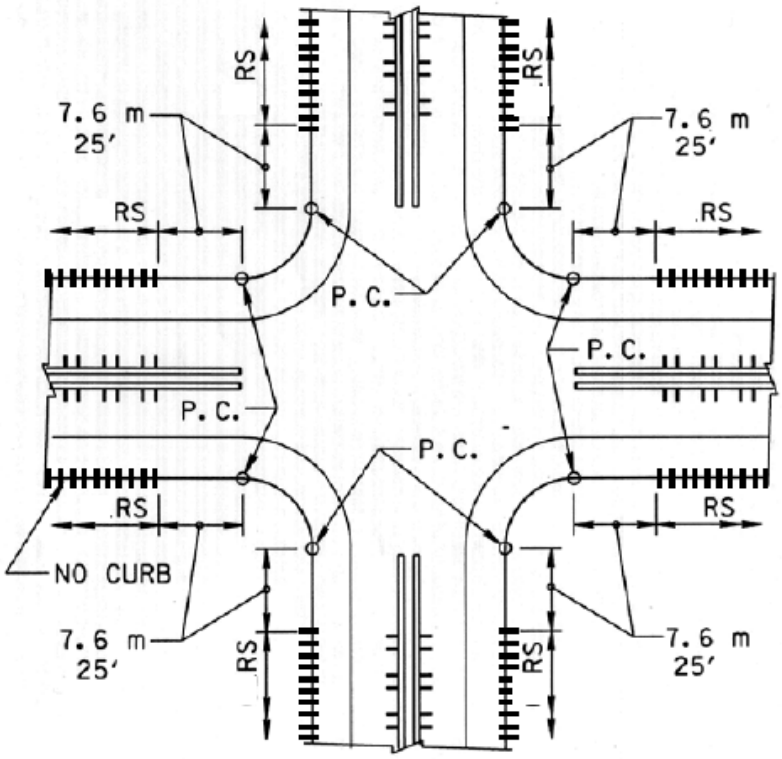


SECTION A-A

Edge Line Rumble Strips
Typical Drawing Detail #2



TYPICAL DRIVEWAY DETAIL



TYPICAL INTERSECTION DETAIL