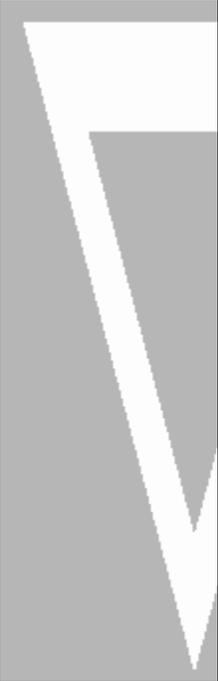
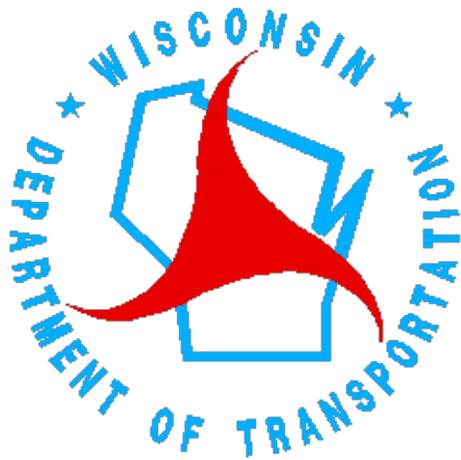
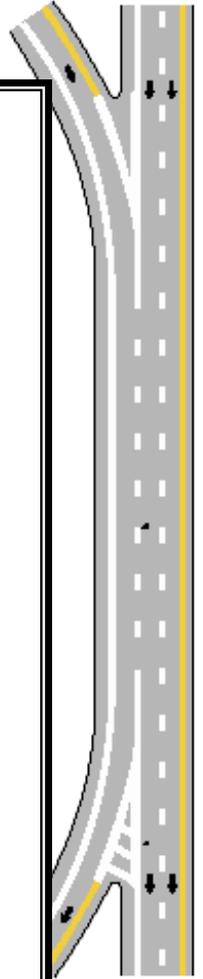


A black and white railroad crossing advance sign featuring two 'R's crossed by a large 'X'.A large, stylized white letter 'V' on a grey background, positioned to the left of the main title box.

PAVEMENT MARKING OPERATIONS MANUAL



January 2014 Edition

Large, bold, black text spelling out the word 'ONLY' vertically on the left side of the page.

PAVEMENT MARKING OPERATIONS MANUAL

PREFACE

This reference manual on Pavement Marking Operations was developed with the intent to bring uniformity and standardization to statewide field operations relating to the Region's pavement marking operations. The primary reason to standardize operations is to reduce the potential hazards to the crew and the motoring public. There also is a need to provide an instructional manual for new personnel coming into these activities.

A Pavement Marking Task Force was established to redevelop this manual. The task force was made up of Pavement Marking Crew Chiefs, Regional Shop Coordinators, and representatives from Central Office. We expect questions and ongoing revisions as need dictates and will begin to review and update the manual on a needed basis. There may be situations in the field that may require crews to take exception to the guidelines as written. In those situations it is necessary that performance is reasonable and supportable in the event of a liability action. Obviously, a guideline that creates an unsafe condition or situation needs to be reviewed and changed. Therefore, we encourage you to study, discuss and send the Bureau of Traffic Operations any recommendations or suggestions for improvement of this revised effort.

PAVEMENT MARKING CONTACTS

CENTRAL OFFICE TRAFFIC OPERATIONS

Debby Kozol
State Marking Engineer
O: (608) 266-5096
C: (608) 516-6325

		<u>Phone</u>	<u>Cell</u>	<u>State Patrol</u>
SOUTHWEST REGION				
Madison	Jeff Holloway	(608) 246-3268	(608) 516-6437	(608) 846-8500
La Crosse	Kory Keppel	(608) 785-9953	(608) 792-6204	(608) 374-0513
SOUTHEAST REGION				
Waukesha	Donald Steel	(262) 548-6765		(262) 785-4700
	Chuck Saldivar	(414) 266-1164	(414) 750-1682	
NORTHEAST REGION				
Green Bay	Steve Herlache	(920) 492-3512	(920) 366-0338	(920) 929-3700
NORTH CENTRAL REGION				
Wisconsin Rapids	Mike Worzella	(715) 421-8003	(715) 459-4257	(715) 845-1143
NORTHWEST REGION				
Eau Claire	Chloe Anderson	(715) 855-7672	(715) 577-4493	(715) 839-3800

PAVEMENT MARKING CONTRACTOR CONTACTS

AAA STRIPING SERVICES, INC.

12220 43RD St. NE
ST. MICHAEL, MN 55376
763-428-4322(BUS)
763-428-8557 (FAX)

BRICKLINE INC.

3342 COMMERCIAL AVE.
MADISON, WI 53714
608-244-5163(BUS)
608-244-5133(FAX)

CENTURY FENCE COMPANY

1300 HICKORY ST.
PEWAUKEE, WI 53072-5727
262-547-3331(BUS)
262-691-3487(FAX)

CROWLEY CONSTRUCTION CORP

1353 N 68TH STREET
MILWAUKEE, WI 53213
414-257-2141(BUS)
414-257-2141(FAX)

FAHRNER ASPHALT SEALERS, LLC

6615 USH 12 W
EAU CLAIRE, WI 54702
715-874-6070(BUS)
715-874-6717(FAX)

**GUIDE LINES PAVEMENT
MARKING, LLC**

N5144 LUDWIG RD
RIO, WI 53960
920-992-3175(BUS)
920-992-3174(FAX)

WARNING LIGHTS OF MINNESOTA

4700 LYNDAL AVE N
MINNEAPOLIS, MN 55430
612-521-4200 (BUS)
612-521-0646 (FAX)

MEGA RENTALS

2573 ADVANCE ROAD
MADISON, WI 53718
608-222-2247(BUS)
608-222-1768 (FAX)

SAFEMARK LLC

N5661 Thunderbird Road
Portage, Wisconsin 53901-8900
(608) 577-3925(BUS)
(608) 467-1418(FAX)

SWANSTON EQUIPMENT COMPANY

3450 MAIN AVE.
FARGO, ND 58103
701-293-7325(BUS)
701-293-7868(FAX)

TRAFFIC MARKING SERVICES, INC.

621 DIVISION STREET EAST
MAPLE LAKE, MN 55358
320-963-1484(BUS)
320-963-0266(FAX)

**TRAFFIC & PARKING CONTROL CO.
INC.**

5100 WEST BROWN DEER ROAD
MILWAUKEE, WI 53223
262-814-7000(BUS)
414-354-5480(FAX)

PAVEMENT MARKING COUNTY CONTRACTOR CONTACTS
Southeast

Milwaukee	Beth Liban	(414) 313-1742
Racine	Mike Kirshling	(262) 770-9690
Walworth	Gerry Abbe	(262) 949-7835
Washington	Randy Miller	(262) 483-3081
Waukesha	Pete Chladil	(414) 548-7843

Northeast

Brown	Jim Burkel	(920) 609-4020
Calumet	Andy Fuhrman	(920)418-2320
Fond du lac	John Hoffman	(920) 929-3491
Kewaunee	Keith Paplahm	(920) 255-3876
Marinette	Joe Baranek	(715) 923-6874
Sheboygan	Brian Olson	(920) 459-3822

North Central

Adams	Dennis Premo	(608) 339-3355
Langlade	Crystal Wells	(715) 627-6351
Portage	Steve Schlice	(715) 345-5235
Shawano	Casey Beyersdorf	(715) 853-1699
Waushara	Tom Dahlke	(920) 787-3327

Northwest

Taylor	Kevin Kalepp	(715) 748-2456
Trempealeau	Jim Johnson	(715) 538-4799 ext 27

South West

Adams	Dennis Premo	(608) 339-3355
Dane	Gary Keegan	(608) 575-5209
Dodge	Wally Fett	(920) 296-2376
Iowa	Jeff Anderson	(608) 574 2934
Vernon	Phil Hewitt	(608) 637-5451

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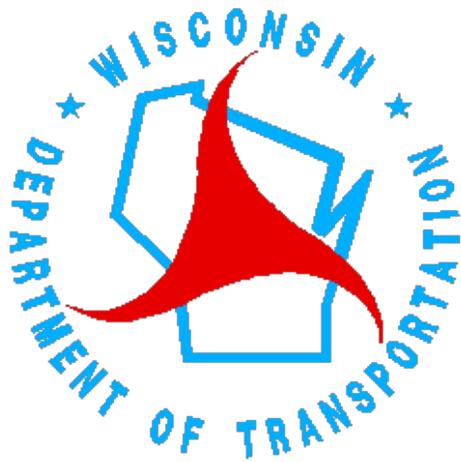
Project Engineers refer to the *Construction & Materials Manual* Chapter 6.50.:

<http://roadwaystandards.dot.wi.gov/standards/cmm/index.htm>

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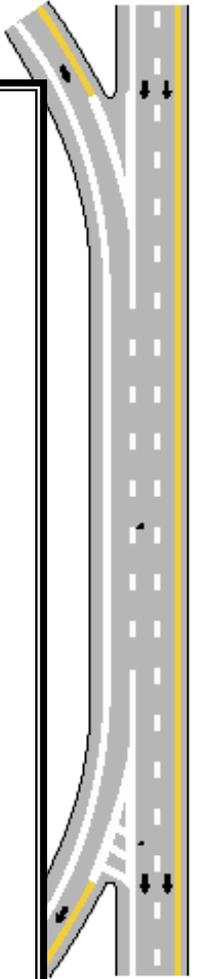
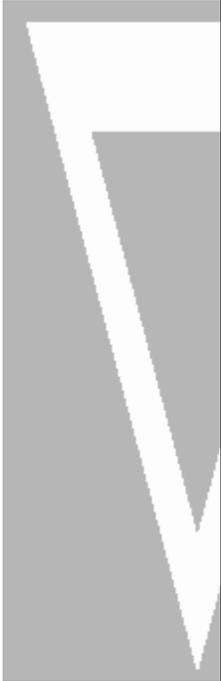
SECTION 1

**GENERAL
PAVEMENT
MARKING**



January 2014 Edition

ONLY



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The General Pavement Marking Operations section provides general information for pavement marking crews, Regional Pavement Marking Coordinators and Project Engineers.

1.1 ACRONYMS & DESCRIPTIONS

CMM – *Construction and Maintenance Manual*.

FDM – *Facilities Development Manual*. This manual provides policy, procedural requirements, and guidance encompassing the facilities development process within the Wisconsin Department of Transportation System Development (DTSD). It is applicable to all types of highway improvements on the State Trunk Highway System, other street/highway systems for which federal-aid highway funds *may* be utilized, state facilities road systems funded with state funds administered by the department, and other highways and roads for which the department *may* act as an administrative agent.

HMA – Hot Mix Asphalt

HMS – Highway Maintenance System

May – a *permissive* condition. No requirement for design or application is intended.

MSDS – Material Safety Data Sheets

MUTCD – *Manual on Uniform Traffic Control Devices*. Detailed drawings of the Standard Highway Signs prescribed or provided for in the Manual on Uniform Traffic Control Devices (MUTCD) 2009 have been prepared by the Office of Transportation Operations, Federal Highway Administration, U.S. Department of Transportation, for use by all traffic authorities, agencies, jurisdictions and persons involved with the fabrication, installation and maintenance of traffic signs on streets and highways in the United States.

PCC – Portland Cement Concrete

PMC – Pavement Marking Coordinator

Preformed Thermoplastic – Preformed thermoplastic is a durable pavement marking system where thermoplastic symbols and legends are supplied in their final form and shape. Typically, the marking is supplied in large pieces, which are put together as a giant puzzle. Preformed thermoplastic pavement marking material combines the convenience of preformed markings with the performance qualities of hot applied thermoplastic.

Shall – a *mandatory* condition. Where certain requirements in the design or application of the device are described with the “shall” stipulation, it is mandatory when an installation is made that these requirements are met.

Should – an *advisory* condition. Where the word “should” is used, it is considered to be advisable usage, recommended but not mandatory.

TAM – Transportation Administrative Manual. The Transportation Administrative Manual (TAM) is the official Department of Transportation file for Staff Listings, Organizational Mission Statements, Administrative Directives and Departmental Procedures.

TGM – *Traffic Guidelines Manual*. This Manual contains policy, guidelines and procedures related to traffic engineering and related functions as practiced within the Wisconsin Department of Transportation, more specifically the regional field and office forces of the Division of Transportation System Development, the staff of the Bureau of Highway Operations in the central office, and other agencies of the Department which *may* be involved in traffic engineering at some point. Traffic engineering functions include the installation and maintenance of traffic control devices, highway lighting facilities, traffic regulations, safety analyses, and support for the improvement program. The content of the Manual is applicable only to the state trunk highway system. The table of contents for TGM Chapter 3 Pavement Marking is found on page 3-1 in this manual.

TMA – Transportation Maintenance Agreement.

WisMUTCD – *Wisconsin Supplement to the Manual on Uniform Traffic Control Devices*. In an effort to provide guidance and leadership in the stewardship of Wisconsin's roadway network, WisDOT, in conjunction with county, city and local governmental agencies collaborated to develop the Wisconsin Manual on Uniform Traffic Control Devices (WisMUTCD). This manual in combination with the Federal Highway Administration's MUTCD provides guidance on the installation and proper use of traffic control devices. The WisMUTCD pages are for the guidance of design engineers, technicians, inspection personnel, contractors, municipalities, counties, townships and others who are involved in highway design, construction, maintenance and operations. The goal is to provide uniform application of traffic control devices and other related items used on the Wisconsin highway system.

The *Standard Specifications for Highway and Structures* (Standard Specifications) and the *Work Zone Safety Guide* **shall** also be followed for all pavement marking projects.

The manuals listed above can be found at https://trust.dot.state.wi.us/extntgtwy/dtid_bho/extranet/manuals/index.shtm for Contractors and County personnel, and at http://dotnet/dtid_bho/extranet/manuals/index.shtm for WisDOT personnel.

NOTE: The word Contractor pertains to county and private forces.

1.2 TYPES OF ROAD MARKINGS AND DEFINITIONS

Skip Line: Broken or dashed centerline.

Dash: Painted portion of skip line.

Skip: Unpainted parts of skip line or gap.

Cycle: Dash and skip pattern measured from the beginning of one skip to the beginning of the next skip. **Note:** Cycles vary according to use and state policy. Counties and cities cycles *may* be different than those used by the state. Wisconsin DOT uses a 50 ft cycle, 12.5 ft painted dash, 37.5 ft. skip on all state highways.

Mini Dash / Cat Track: A cycle and painted dash length that is shorter than conventional cycle. Example would be a 12 ft. cycle with a 3 ft. painted dash. There will be locations with a 9 ft. cycle with a 3 ft. painted dash. Restripe what is present. (Refer to Sections 4.13- 4.15 SDD 15C 8-16b-d, 4.19 SDD 15C 9-9b, 4.20 SDD 15C 10-10, 4.28 SDD 15C 28-2, 4.29- 4.32 SDD 15C 29-3a-d, and 4.36- 4.39 SDD 15C 31-1a-d.

- **Yellow Dash Skip Cycle:** Centerline of a two- lane roadway where passing is permitted. (Refer to Section 4.12 SDD 15C 8-16a)
- **White Dash Skip Cycles:** Lane line for multilane roadway. (Refer to Section 4.12 SDD 15C 8-16a)
- **Solid Yellow Line in Driver's Lane:** Indicates no-passing zone in the direction of travel on a two- lane highway. (Refer to Section 4.12 SDD 15C 8-16a)
- **Two Solid Yellow Lines (Double Yellow):** Indicates no-passing zone in both directions of traffic on a two- lane highway. (Refer to Section 4.12 SDD 15C 8-16a)
- **Solid White Line on Right Hand Edge of Pavement:** Edge line for two-lane roadway, or multilane highway. (Refer to Section 4.12 SDD 15C 8-16a)
- **Solid Yellow Line on Left-Hand Edge of Pavement:** Edge line for divided highway. (Refer to Section 4.12 SDD 15C 8-16a)
- **Channelizing Line:** 8" or wider solid white line used to form traffic islands where travel in the same direction is permitted on both sides. Also in cross-hatching, and to separate travel in the same direction where crossing the line is discouraged, such as right and left turn bays at intersections and truck stopping lanes. (Refer Sections 4.13 SDD 15C 8-16b, 4.16 SDD 15C 8-16e, 4.17 SDD15C 8-16f, 4.19 SDD15C 9-9b, and 4.28 SDD 15C 28-2, 4.29 - 4.32 SDD 15C 29-3a-d)
- **Median Island:** Double 4" solid yellow line used to form median islands. (Refer Section 4.22 SDD 15C 18-3)

- **Corrugated Median Marking:** Solid yellow marking on median flat surface between opposing traffic. (Refer to Section 4.1 SDD 11B 1-5 & Section 4.17 SDD 15C 8-16f)
- **Diagonals or Chevrons:** A diagonal or angular line outside the edge line or the traffic lane, where traffic is discouraged. (Refer to Section 4.22 SDD 15C 18-3 and Section 4.41 SDD 15C 32-1b for 12” width, Section 4.27 SDD 15C 21-5 for 18” width, and Section 4.36- 4.39 SDD 15C 31-1a-d for 24” width)
- **Gore Lines:** A line, which guides approaching traffic around obstacles, also marks departures, such as exit ramps on to the main line. These are usually V-shaped. (Refer to Section 4.36- 4.39 SDD 15C 31-1a-d)
- **Yield Line Symbols Markings:** Consists of a row of solid white isosceles triangles across approach lanes to indicate the point at which the yield is intended or required to be made. (Refer to Section 4.26 SDD 15C 20-1 for 18” height)
- **Word & Symbol Markings:** Used for guiding, warning, or regulating traffic. (Refer to Section 4.8 SDD 15C 7-12a, Section 4.9 SDD 15C 7-12b, Section 4.18 SDD 15C 9-9a, and Section 4.33 & 4.34 SDD 15C 29-3e & 15C 29-3f)
- **Arrows:** Used to convey either guidance or mandatory messages. (Refer to Section 4.10 SDD 15C 7-12c and 4.11 SDD 15C 7-12d)
- **Wet Reflective Markings:** Provide supplemental guidance during darkness and especially wet weather. (Refer to 4.12 SDD 15C 8-16a and 4.20 SDD 15C 10-10)
 - **Wet Reflective Tape:** Pavement marking tape with reflective elements.

“**T**”: A mark on the roadway, which indicates the beginning and ending points of a barrier line. T’s are used to identify the point at which the paint gun is turned on or off to paint the barrier line.

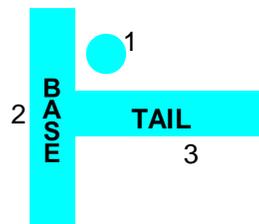


Figure 1.2a. Spotting “T”

1. **Dot.** Indicates the center of the road.
2. **Base.** Indicates the beginning and the end of a barrier line.
3. **Tail.** Indicates on which side of the center of the road the barrier **shall** be placed.

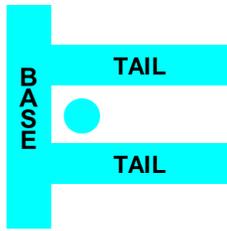


Figure 1.2b. Double "T"

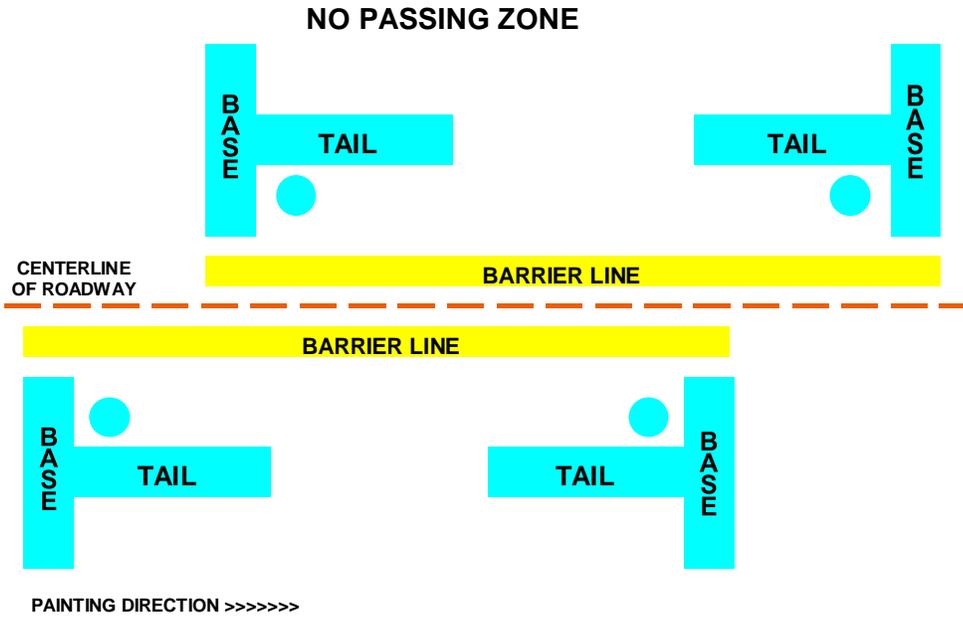


Figure 1.2c. No Passing Zone Marking

“X”: An “X” on the end of the line indicates that it needs to be extended or this portion of the line needs to be removed. Examples follow

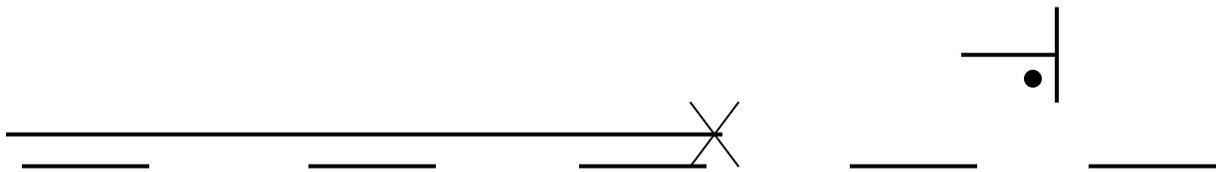


Figure 1.2d. Indicates line extension to the “T”

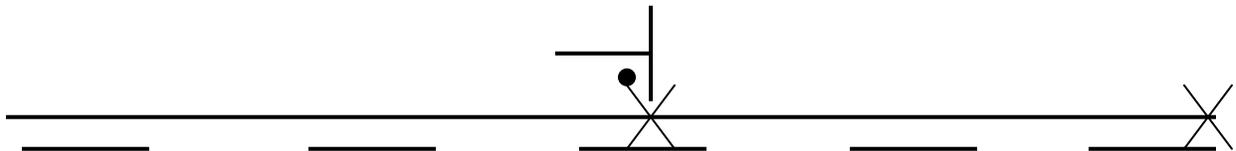


Figure 1.2e. Indicates line removal between the “X”

For more information on No Passing Zones, refer to TGM 3-2-2.

1.3 APPLICATION STANDARDS AND DAILY REPORTS

1.3.1 Application Standards

Wisconsin Standard Specification calls for a minimum of 15 mil wet paint film thickness for Waterborne Paint. Waterborne Paint is applied at a rate of 17.6 gallons per line mile or 300 feet per gallon of continuous 4-inch line. Glass beads are applied at a rate of 8 lbs. to 10 lbs. per gallon of paint. Pavement markings **shall** be in accordance with the MUTCD, WisMUTCD, Facilities Development Manual and the State of Wisconsin Standard Specifications Section 646.

1.3.2 Pavement Marking Daily Report

Each Striping Crew performing marking on the WisDOT system is responsible for completing a Pavement Marking Daily Report. Some of the information requested on the form is shown on the included example. The following reports are to be sent to the Regional Pavement Marking Coordinator (PMC) or representative at the end of every week, or as often as the Regional PMC requests them only when a contractor performs pavement marking work on a State project. State actual time spent not painting (i.e. drive time, weather delay, maintenance, etc.) at bottom of report. Refer to the Form DT1870 Pavement Marking Daily Report in Exhibit 5.4. An electronic copy of the daily reports are available on the Internet at <\\dotforms\n2public\BMS\FORMS\dt2130.xlsx> and <\\dotforms\n2public\BMS\FORMS\dt2131.xlsx>. Contact the Regional PMC for a hard copy of the daily report form if the Internet version is not available. Examples on how to fill out this form are located in Figures 1.3a (Long Line) and 1.3b (Special Marking).

Special Provisions

Contact the Regional PMC for any special provisions relating to the TMA.

From and To

The beginning and the ending points of the stripping operation *should* be entered on the form. The reference points used *should* be those found on State or County road maps, and *may* include: roadway junctions, city limits, or construction limits.

Mileage

The total miles recorded *should* represent the total road miles between the beginning and the ending point.

Footage Counters:

The counter readings represent the distance each spray gun was activated and is displayed in feet. These readings will be used to determine the total line miles painted within the stripping operations area.

Application Rates:

Gallons of paint and beads need to be tracked to determine application rates. Being able to use a calibrated dipstick to know how much paint or beads were used in the area painted. All counter readings are converted from feet to miles, this is done by dividing the counter readings by 5,280 feet. This will give you the miles of lane line painted for each paint gun. Totaling the miles each gun has painted and dividing the gallons of paint used will give the application rate of gallons per mile. Yellow paint divided by total Yellow gun miles, White paint gallons divided by total White gun miles. Pounds of beads used divided by the gallons of paint used will give you beads per gallon. This will give you the miles of lane line painted for each paint gun. Totaling the miles each gun has painted and dividing the gallons of paint used will give the application rate of gallons per mile. Yellow paint divided by total yellow gun miles, white paint gallons divided by total white gun miles. Gallons of paint and beads need to be tracked to determine application rates.

1.3.3 Material Safety Data Sheets (MSDS)

MSDS **shall** be in all pavement marking vehicles in case of an accident.

1.3.4 Certification

Provide the Regional PMC with the certification papers of the product being used.

1.3.5 Licensing

Drivers are required to meet all State and Federal regulations pertaining to licensing.

1.3.6 Safety and Training

Contractors must abide by OSHA standards, counties must abide by the Wisconsin Department of Commerce rules, while State employees must abide by the Transportation Administrative Manual (TAM). Refer to TAM SD30, SD36 and SD57 in Exhibits 5.1 through 5.3 for safety apparel needs when on the roadway. Training of the workers is the responsibility of the contractor. All contractors' personnel **shall** receive safety training in regards to all matters involving pavement marking operations. This *should* involve everything from traffic control, materials handling, etc.

PAVEMENT MARKING DAILY REPORT - Long Line

Wisconsin Department of Transportation
 DT2130 5/2012

DATE: (mmdd/yyyy)		PROJECT ID:		REGION:		CONTRACTOR:		FOREMAN:	
6/28/2012		1009-38-44		NE		Century		Jaden Gilbertson	
1st HIGHWAY		WATERBORNE		Left Counter (ft.)		Right Counter (ft.)		Counters sub-total (ft.)	
EPOXY		COUNTY:		47722		47722		47722	
REF. #		Brown		Paint Miles		Paint Miles		Sub-total Miles	
43		FROM: 96		9.0		0.0		9.0	
ITEM (X one)		TO: 57		0.0		0.0		0.0	
4" YELLOW X				Paint Miles		Paint Miles		Paint Miles	
6" WHITE				9.0		0.0		9.0	
8" WHITE				0.0		0.0		0.0	
REMOVALS (LF)				0.0		0.0		0.0	
2nd HIGHWAY		WATERBORNE		Left Counter (ft.)		Right Counter (ft.)		Counters sub-total (ft.)	
EPOXY		COUNTY:		36173		36173		36173	
REF. #		Brown		Paint Miles		Paint Miles		Sub-total Miles	
43		FROM: 96		6.9		6.9		6.9	
ITEM (X one)		TO: 57		0.0		0.0		0.0	
4" YELLOW X				Paint Miles		Paint Miles		Paint Miles	
6" WHITE				6.9		6.9		6.9	
8" WHITE				0.0		0.0		0.0	
REMOVALS (LF)				0.0		0.0		0.0	
3rd HIGHWAY		WATERBORNE		Left Counter (ft.)		Right Counter (ft.)		Counters sub-total (ft.)	
EPOXY		COUNTY:		39311		39311		39311	
REF. #		Brown		Paint Miles		Paint Miles		Sub-total Miles	
43		FROM: 96		7.4		7.4		7.4	
ITEM (X one)		TO: 57		0.0		0.0		0.0	
4" YELLOW				Paint Miles		Paint Miles		Paint Miles	
6" WHITE				7.4		7.4		7.4	
8" WHITE				0.0		0.0		0.0	
4" White Seals X				0.0		0.0		0.0	
REMOVALS (LF)				0.0		0.0		0.0	
Rate of Application		Rate of Application		Rate of Application		Rate of Application		Rate of Application	
Paint (gal.)		Paint (gal.)		Paint (gal.)		Paint (gal.)		Paint (gal.)	
159.08		120.58		131.04		131.0		17.6	
Beads (lbs.)		Beads (lbs.)		Beads (lbs.)		Beads (lbs.)		Beads (lbs.)	
3977.0		3014.0		3276.0		3276.0		25.0	
Beginning:		Beginning:		Beginning:		Beginning:		Beginning:	
Ending:		Ending:		Ending:		Ending:		Ending:	
Used:		Used:		Used:		Used:		Used:	
Coverage Rate:		Coverage Rate:		Coverage Rate:		Coverage Rate:		Coverage Rate:	
(gal. per sq. ft.)		(gal. per sq. ft.)		(gal. per sq. ft.)		(gal. per sq. ft.)		(gal. per sq. ft.)	
159.1		120.6		131.0		131.0		17.6	
25.0		25.0		25.0		25.0		25.0	
(lbs. per gal.)		(lbs. per gal.)		(lbs. per gal.)		(lbs. per gal.)		(lbs. per gal.)	
2nd HIGHWAY		3rd HIGHWAY		Equipment		Personnel		Equipment	
Tape		Tape		Equipment Type		# Workers		# Vehicles	
Tape		Tape		Grinder		2		Grinder	
Tape		Tape		Other:				Other:	
Tape		Tape		Pavement Marking Vehicle:				Pavement Marking Vehicle:	
Tape		Tape		Pilot Vehicle:		1		Pilot Vehicle:	
Tape		Tape		Shadow Vehicle:		1		Shadow Vehicle:	
Tape		Tape		Single / Two Axle Truck:		1		Single / Two Axle Truck:	
Tape		Tape		Three Axle Truck:		1		Three Axle Truck:	
Tape		Tape		Totals:		5		Totals:	
Tape		Tape		# Hours / Worker		20.0		# Hours / Vehicle	
Tape		Tape		20.0		20.0		9.0	
Tape		Tape		9.0		9.0		9.0	
Tape		Tape		9.0		9.0		10.0	
Tape		Tape		10.0		10.0		10.0	
Tape		Tape		48.0		48.0		29.0	
Tape		Tape		COMMENTS:		(Start entries in box below)		COMMENTS:	
Tape		Tape		(Start entries in box below)		(Start entries in box below)		(Start entries in box below)	
Tape		Tape		SUNNY					
Tape		Tape		Weather:				Weather:	
Tape		Tape		SUNNY				SUNNY	
Tape		Tape		Name:		Steven Marzetta		Name:	
Tape		Tape		City:		Green Bay		City:	
Tape		Tape		Phone #:				Phone #:	
Tape		Tape		Cell #:		505-366-0308		Cell #:	
Tape		Tape		Email:		stevem.marzetta@wis.gov		Email:	
Tape		Tape		Instructions:		Fill out form electronically and then email to the WISDOT contact person above.		Instructions:	

Figure 1.3a. Example of the Pavement Marking Activities Daily Report (Long Line).

1.3.7 Equipment/Product Questions

Any questions pertaining to the pavement markings in the Regions *should* be referred to the Regional PMC.

1.3.8 Contractor Paint Claims

Contractors are responsible for paint claims resulting from their painting activities. The name and telephone number of the person responsible for managing paint claims **shall** be provided to the project manager, prior to the start of the project.

1.3.9 Work Zones

For information on work zones, refer to Chapter 6 of the MUTCD, standard detail drawings in the FDM and the Work Zone Safety Guide.

1.4 CHARACTERISTICS AND APPLICATION OF PAVEMENT MARKING

Refer to the Approved Products List located at <http://www.dot.wisconsin.gov/business/engrserv/approvedprod.htm> for pavement marking waterborne paint, epoxy and preformed thermoplastic.

The following information is taken from the *Mid-Atlantic Regional Technician Certification Program (MARTCP) Pavement Marking Student Manual* funded by the Federal Highway Administration, March 2005.

1.4.1 Characteristics of Waterborne Paint

There are many disadvantages and advantages to using waterborne paints for pavement markings. One major disadvantage of waterborne paint is its sensitivity to temperature. Precautions must be taken to protect stored material from freezing and extreme heat. During application, latex paint is very sensitive to high humidity, which can drastically increase drying time. Conversely, low humidity creates a quicker drying time. Paint is also the least durable of all the markings and is not recommended for roadways with high traffic volumes.

Some advantages of waterborne paint are cost. It is the least expensive of all pavement markings. It can be applied at a faster rate than most other markings and under ideal conditions it can have a very fast dry time. Also, no solvents are needed for clean up. Fast dry waterborne paint will achieve its best drying times under perfect ambient conditions: daytime, sunny, 70°F, low humidity and a breeze.

Some characteristics of waterborne paint are:

- Heat sensitivity
- Freezes easily
- Strong ammonia odor
- Humidity *may* affect drying times
- Can be flushed out with water and/or ammonia
- Generally not a hazardous waste for disposal - placarding not required (dependant on formulation)
- Reacts adversely to metals other than stainless steel
- Requires specially lined drums to prevent chemical reaction
- Can settle in the drum

1.4.2 Characteristics of Solvent Borne Paint

Some characteristics of solvent borne paint are:

- Humidity generally not an application problem
- Heat exchanger can be heated higher to assist in drying times
- Can film form at lower temperatures than waterborne
- Solvent blend critical to prevent skimming
- Requires placarding of vehicle

- Clean up flush material is hazardous waste
- Unused paint is hazardous waste for disposal purposes
- Can be very flammable
- Can easily settle in drum

Traffic paint is a one-component material that is generally shipped in 55-gallon drums with full open top lids. Traffic paint generally has a shelf life of one year. This information *should* appear on the shipping documents. Quality assurance tests *may* be performed to confirm that the original formulation is approved by the government agency and to verify the manufacturer's certification.

No paint forms a film well when applied at low temperatures.

1.4.3 Methods of Application for Waterborne and Solvent Borne Paint

Traffic paint is applied by conventional or airless spraying.

Conventional

Conventional spraying uses air jets in the tip of the paint gun to break up, or atomize the paint. The tip then defines the shape of the spray to produce a properly applied line. The quantity of atomizing air needed to sufficiently break up the paint will depend to a large extent on the paints rheology, or flow characteristics.

The pressure needed to force the paint through the application system and out of the gun can vary from 60 to 140 psi, depending on the size of the plumbing and the type of spray gun used. This can be achieved using one of the following methods:

- In a pressure-pot system, the holding tank is pressurized to push the paint through the heat exchangers and lines to the gun for application.
- In a pumper system, the holding tank is not pressurized. A diaphragm pump is used to draw the paint from the tank and force it through the system and out to the gun.

Airless

In an airless system, the paint is forced out through an orifice in the tip of the gun at a high pressure. The size of the hole determines how much paint is applied and the angle of the inner surfaces of the tip determines the width. Unlike the conventional system, there is no air mixed with the paint in the gun. The pressure created by the pump mechanism explosively forces the paint through the gun tip breaking the paint up into very small particles. The primary method for altering the width and thickness of the applied line is to change the tip.

Additional factors must also be considered when applying traffic paint:

Material Temperature

The manufacturer's Product Data Sheets specifies the material application temperature ranges. Fast-dry (ammoniated), waterborne paint only needs enough heat to allow a good flow of material through the application system (generally in the range of 90°F to 120°F at the gun tip).

It is very important not to overheat the solvent or waterborne traffic paint because they can ignite. Overheating fast dry, waterborne paint can also "drive off" the methanol and ammonia creating longer dry times. These two additives act as driers to keep the paint film open, helping the water escape.

Ambient Conditions

Waterborne paint requires liquids to evaporate. This evaporation is dependent on the humidity (moisture in the air). Humid days will cause drying problems. Lower humidity and good air movement greatly improves waterborne materials drying. To achieve the optimal results, neither solvent nor waterborne traffic paint shall be applied below 50 ° F (air temperature).

Pavement Surface Considerations

The pavement shall be free of dirt, oil, grease, laitance, curing compounds, and moisture. On new HMA pavements, paint may dissolve road oils and cause a discoloration of the line. This line should be repainted as soon as it has dried in order to achieve the proper color.

Quality Assurance Field Testing

Quality assurance field-testing shall be conducted in accordance with the *Standard Specifications*.

1.4.4 Troubleshooting for Waterborne & Solvent Borne Paint

Table 1.4a and 1.4b are troubleshooting guides for conventional and airless paint application problems.

CONVENTIONAL PAINT APPLICATION TROUBLESHOOTING			
PROBLEM	CAUSE	EFFECT	REMEDY
Excessive Thickness (overall)	<ul style="list-style-type: none"> • Paint tank pressure too high • Paint gun volume control (if present open too wide • Pump pressure too high • Applicator speed too low 	<ul style="list-style-type: none"> • Buried beads – poor initial nighttime retroreflectivity • Slow drying time – paint tracked by motorists • Paint won't cure properly – shortened life 	<ul style="list-style-type: none"> • Reduce tank pressure • Adjust paint gun volume control • Reduce pump pressure • Increase speed
Excessive Thickness (middle of line)	<ul style="list-style-type: none"> • Paint tank pressure too high • Paint gun volume control (if present open too wide • Pump pressure too high • Atomizing air pressure off or too low • Material buildup in paint gun tip and/or shroud 	<ul style="list-style-type: none"> • Buried beads – poor initial nighttime retroreflectivity • Slow drying time – paint tracked by motorists • Paint won't cure properly – shortened life 	<ul style="list-style-type: none"> • Reduce tank pressure • Adjust paint gun volume control • Reduce pump pressure • Increase atomizing air pressure • Clean tip and/or shroud
Excessive Thickness (along one side)	<ul style="list-style-type: none"> • Material buildup in paint gun tip and/or shroud • Clogged hole(s) in paint gun atomizing tip 	<ul style="list-style-type: none"> • Buried beads – poor initial nighttime retroreflectivity • Slow drying time – paint tracked by motorists 	<ul style="list-style-type: none"> • Clean paint tip and/or shroud • Clear clogged hole(s) in paint gun atomizing tip
Insufficient Thickness	<ul style="list-style-type: none"> • Paint tank pressure too low • Paint gun volume control (if present open too wide • Pump pressure too low • Applicator speed too low • Atomizing pressure too high • Material buildup in paint gun tip and/or shroud • Material buildup in paint filter(s) and/or plumbing 	<ul style="list-style-type: none"> • Poor line quality and/or shortened life • Beads won't adhere and/or poor or no nighttime retroreflectivity 	<ul style="list-style-type: none"> • Increase tank pressure • Adjust paint gun volume control • Increase pump pressure • Decrease speed • Decrease atomizing air pressure • Clean paint gun tip and/or shroud • Clean paint filter(s) and/or plumbing
Wide Paint Line	<ul style="list-style-type: none"> • Paint gun set too high • Worn or damaged paint gun Tip and/or shroud 	<ul style="list-style-type: none"> • Line does not meet standards • Line has fuzzy edges 	<ul style="list-style-type: none"> • Lower gun • Repair or replace tip and/or shroud
Narrow Paint Line	<ul style="list-style-type: none"> • Paint gun too low • Paint gun tip slot not at 90° angle to paint line • Clogged paint gun tip and/or shroud • Low air pressure in paint machine tire. 	<ul style="list-style-type: none"> • Line does not meet standards • Not as visible as a full-width line (day or night) 	<ul style="list-style-type: none"> • Raise paint gun • Reposition paint gun tip • Clean paint gun tip and/or shroud • Inflate tire
Uneven Paint Line (spotty)	<ul style="list-style-type: none"> • Atomizing air pressure too low • Paint tank pressure too low • Old paint (viscosity too high) • Loose paint gun tip and/or shroud • Insufficient heat • No shroud 	<ul style="list-style-type: none"> • Poor appearance • Line has fuzzy edges • Slow drying time • Paint won't flow smoothly 	<ul style="list-style-type: none"> • Increase atomizing air pressure • Increase material tank pressure • Rotate material stock • Secure paint gun tip and/or shroud • Increase heat (enough to get paint to flow evenly)

			• Install shroud
--	--	--	------------------

Table 1.4a. Conventional paint application troubleshooting guide.

AIRLESS PAINT APPLICATION TROUBLESHOOTING			
PROBLEM	CAUSE	EFFECT	REMEDY
Heavy centers	• Inadequate fluid delivery	• Tracking • Erratic wear patterns • “Railroad Tracks” initially	• Increase fluid pressure • Decrease tip size
Light centers	• Inadequate fluid delivery	• Tracking from the edges • Erratic wear patterns • “Railroad Tracking” with time	• Increase tip size • Replace tip
Surging pattern	• Pulsating fluid delivery	• Does not conform to standards • Erratic wear patterns	• Reduce demand • Remove restrictions in supply system • Check supply hose for leaks
“Lop-sided” millage	• Worn tip sides • Clogged tip	• Erratic wear patterns	• Replace tips • Clean tips
Line too wide	• Gun too high • Too wide a fan angle on tip	• Does not meet standards	• Lower gun • Adjust tip size if necessary
Line too narrow	• Gun too low • Too narrow a fan angle on tip	• Poor durability • Does not meet standards	• Change tip size • Decrease speed of application • Verify pressure settings
Applied line too thick	• Too large a tip size • Traveling too slow for tip size • Change in delivery pressure	• Too long a cure time • May cause shape problems • Poor retroreflectivity due to buried heads	• Change tip size • Increase speed to application • Verify pressure settings

Table 1.4b. Airless paint application troubleshooting guide.

1.4.5 Characteristics of Epoxy Paint

Epoxy striping material is classified as 100 percent solids, meaning the evaporation of solvents or water is not used to cure the material. Thus, without this evaporation process, a typical application rate of 20 mils wet yields 20 mils of dry material. Epoxy striping material is cured via a thermoset chemical reaction.

Advantages

- Good wet-night visibility
- Can be applied at lower temperature
- Makes a mechanical bond with the road surface
- Good bead retention
- Low profile resists snowplow damage
- Good life cycle costs
- Epoxy does not contribute volatile organic compounds

Disadvantages

- Slow cure (no-track time)

- Mix proportions are critical

1.4.6 Method of Application for Epoxy Paint

The mixed epoxy material is heated and sprayed onto the road surface. The equipment performing this operation is a specially designed epoxy truck that cannot be used to apply any other liquid binder material. Because of the composition of the material, environmental temperatures will increase or decrease the no-track times.

Shelf Life

Epoxy material has a shelf life of one year. The manufacture date should be stated in the shipping documents.

How to Mix the Material

The mix ratio for epoxy resin material is typically 2:1 (2 parts resin to 1 part hardener). It is very important that components are mixed thoroughly and at the correct ratio prior to being sprayed on the road surface. The mixing operation is a function of the epoxy installation truck. It shall be performed in accordance with manufacturer's recommendations.

Temperature

Epoxy shall not be applied unless the surface and ambient temperatures are a minimum of 35°F and rising. Remember that no-track times increase as the temperature decreases and vice versa. Always check temperature minimums (air and surface) for each agency when applying epoxy.

Pavement Surface Considerations

The road surface shall be free of curing compounds, laitance, oil, grease, salt, dust, or other debris. Epoxy materials shall not be applied if moisture is present on the road surface. Epoxy material can be applied behind the HMA paving operation as long as the mat has cooled enough to support the weight of the epoxy application truck. Epoxy materials can be applied over other epoxy materials.

Current State practices restripe two times over the original line. After that, pavement marking removal may be required. Table 1.4b is an epoxy application troubleshooting guide.

Quality Assurance Field Testing

Quality assurance field-testing shall be conducted in accordance with the *Standard Specifications*.

1.4.7 Troubleshooting for Epoxy Paint

Table 1.4c is for epoxy application troubleshooting.

EPOXY SPRAY APPLICATION TROUBLESHOOTING			
PROBLEM	CAUSE	EFFECT	REMEDY
Heavy centers	<ul style="list-style-type: none"> Inadequate fluid delivery 	<ul style="list-style-type: none"> Tracking Erratic wear patterns “Railroad Tracks” initially 	<ul style="list-style-type: none"> Increase fluid pressure Decrease tip size
Light centers	<ul style="list-style-type: none"> Inadequate fluid delivery 	<ul style="list-style-type: none"> Tracking from the edges Erratic wear patterns “Railroad Tracking” with time 	<ul style="list-style-type: none"> Increase tip size Replace tip
Surging pattern	<ul style="list-style-type: none"> Pulsating fluid delivery 	<ul style="list-style-type: none"> Does not conform to standards Erratic wear patterns 	<ul style="list-style-type: none"> Reduce demand Remove restrictions in supply system Check supply hose for leaks
“Lop-sided” millage	<ul style="list-style-type: none"> Worn tip sides Clogged tip 	<ul style="list-style-type: none"> Erratic wear patterns 	<ul style="list-style-type: none"> Replace tips Clean tips
Line too wide	<ul style="list-style-type: none"> Gun too high Too wide a fan angle on tip 	<ul style="list-style-type: none"> Does not meet standards 	<ul style="list-style-type: none"> Lower gun Adjust tip size if necessary
Line too narrow	<ul style="list-style-type: none"> Gun too low Too narrow a fan angle on tip 	<ul style="list-style-type: none"> Poor durability Does not meet standards 	<ul style="list-style-type: none"> Change tip size Decrease speed of application Verify pressure settings
Applied line too thick	<ul style="list-style-type: none"> Too large a tip size Traveling too slow for tip size Change in delivery pressure 	<ul style="list-style-type: none"> Too long a cure time May cause shape problems Poor retroreflectivity due to buried heads 	<ul style="list-style-type: none"> Change tip size Increase speed to application Verify pressure settings
Too much hardener	<ul style="list-style-type: none"> Displacement pumps not properly synchronized 	<ul style="list-style-type: none"> Dark or black lines Takes too long to cure 	<ul style="list-style-type: none"> Adjust pumps
Too little hardener	<ul style="list-style-type: none"> Displacement pumps not properly synchronized 	<ul style="list-style-type: none"> Poor durability 	<ul style="list-style-type: none"> Adjust pumps

Table 1.4c. Epoxy spray application troubleshooting guide

1.4.8 Component Characteristics of Preformed Thermoplastic

Preformed thermoplastic is a durable pavement marking system where thermoplastic symbols and legends are supplied in their final form and shape. Typically, the marking is supplied in large pieces, which are put together as a giant puzzle. Preformed thermoplastic pavement marking material combines the convenience of preformed markings with the performance qualities of hot applied thermoplastic. This heavy-duty intersection grade pavement marking material is ideal for high traffic areas where maximum wear and tear is present. Various brands are applied differently, so it is important to be familiar with the installation instructions for the type you are using. Always follow manufacturer instructions.

Type of Materials

There are two basic types of preformed thermoplastic markings:

- 1) Don't require preheating the road surface to a given temperature
- 2) Require preheating the road surface to a certain temperature

Components

Preformed thermoplastic markings are composed of pigments, reflective glass beads, fillers, binders and additives.

Pigments

Pigments are primarily used to impart color and to provide some chemical property, such as UV stability. Titanium dioxide is typically added to provide a white color. Lead chromate or organic pigment is typically added to provide a yellow color. Because of environmental and health concerns, the use of lead chromate compounds in pavement marking material is being eliminated.

Reflective Glass Beads

Preformed thermoplastic is produced at the factory with a certain percentage of beads intermixed within the melted material. Additional beads are also added to the surface of the material when it is applied.

Fillers

Fillers are typically a pigment and also provide bulk. Once the necessary color has been obtained, fillers such as a mixture of calcium carbonate, sand, and other inert materials are used to provide the volume of filler to give the necessary durability.

Binders (Resins)

Binders are thermoplastic; they melt when heat is applied. The binder holds the pigments, reflective beads, and fillers together. Heat is used to form the initial shape. The material does not change chemically on heating and application.

Additives

Additives such as plasticizers are added to control flow characteristics. Because the plasticizer can burn away, overheating and excessive reheating of preformed thermoplastic can affect the durability and overall quality of the marking.

Solvents

Preformed thermoplastic pavement markings contain no solvents. It is the heating process that transforms the thermoplastic material from a solid into a liquid.

1.4.9 Material Characteristics of Preformed Thermoplastic

Other factors that should be considered when using preformed thermoplastics are packaging, shelf life and primers/sealers.

Packaging

Linear preformed thermoplastic is packaged in 3 to 4 foot long strips in sturdy cardboard boxes. Symbols are manufactured in pieces so they may be packaged and shipped easily.

Shelf Life

Preformed thermoplastic has a shelf life of one year when stored inside at a temperature between 35°F and 95°F. Due to the heavy weight of the thermoplastic, no more than 25 packs shall be stacked on top of one another.

Primers/Sealers

Primers/Sealers are used as a "bridge" between preformed thermoplastic and the surface where preformed thermoplastic will not readily adhere such as worn old HMA. Essentially, the primer bonds to the surface, and the thermoplastic bonds to the primer. In order to prevent moisture from entering under the marking on PCC, it is important to seal the surface with a primer/sealer before the marking is installed. This will help prevent failures during freeze/thaw periods.

Follow manufacturer recommended installation instructions to ensure that the correct type of primer/sealer is used.

1.4.10 Method of Application for Preformed Thermoplastic

Preformed thermoplastic can be applied with a propane-fueled heat torch. When you arrive at the work location, review the temperature conditions, weather conditions, and pavement conditions to make sure that the preformed thermoplastic can be successfully applied based on manufacturer recommendations. If the situation does not comply with the manufacturer's recommendations, it is recommended that you wait until conditions improve before installing the preformed thermoplastic.

Heat Torch

This method of application ensures that proper heat is applied to the preformed thermoplastic for a good bond to the road surface. The flame of the propane fueled heat torch should be moved in a fan shaped pattern to ensure even heating of the material. To obtain the best results, the torch should be moved in a slow even motion approximately 4 to 12 inches over the material. It is helpful to keep the wind at your back so the heat will be carried across the marking.

Application on HMA

- 1) Thoroughly clean the application area. All loose particles (sand, dust, and other debris) must be removed. Utilize a power blower or compressed air if possible. Otherwise, sweep the entire area completely.



Figure 1.4a. Cleaning pavement prior to application

- 2) Ensure that no moisture is present prior to positioning the preformed thermoplastic material on the pavement surface. A heat torch may be used to remove moisture.
- 3) If required, preheat the surface to the temperature recommended by the manufacturer. Not all types of preformed thermoplastic require preheating.
- 4) Position the preformed thermoplastic on the pavement surface. Position all connecting parts of the marking on the road with the exposed beaded side up. Make sure the marking is properly placed and that there are no gaps between the segments of legends and symbols.



Figure 1.4b. Placement of material.

- 5) Begin heating the material by moving the torch slowly and steadily over the material. Move the heat torch in a sweeping motion, approximately 2 feet wide over the marking at a height of 4 to 12 inches so that heat is evenly distributed across the marking, slowly melting the material. The preformed thermoplastic material must be heated throughout the process to achieve a bond with the pavement.



Figure 1.4c. Arrow symbol being applied by heat torch.

- 6) As you heat the preformed thermoplastic, monitor the visual signs or temperature requirements. It is important not to "overheat" the material otherwise the top coating of beads will sink into the preformed thermoplastic and be less retroreflective initially.
- 7) Inspect the freshly applied preformed thermoplastic marking to ensure that complete bonding has occurred over the entire area. After the preformed thermoplastic has cooled to near ambient temperature, try to lift an edge or cut an area in the interior of the material with a chisel where it appears to have been heated the least. Try to lift a portion of the material; if the material can be lifted without evidence of asphalt on the underside, insufficient heat has been applied. Simply reapply heat until adequate bonding has occurred. This is called an "adhesion test."



Figure 1.4d. Adhesion test being performed

- 8) When performing the adhesion test on material applied on PCC roads, you should see a thin layer of the material adhering to the road surface. After performing the adhesion test, remember to reheat the tested area.
- 9) Preformed thermoplastic will cool and set rapidly within a few minutes of application. If desired, setting time can be accelerated with a spray of cool water or hand casting of additional reflective glass beads on top of the marking.

Application on PCC or Old HMA

- 1) Follow steps 1, 2 and 3 as stated above for application on HMA. Worn, polished concrete should be ground or milled so the surface becomes rough.
- 2) Lay out the marking pattern using chalk or crayon as required for guidance.
- 3) Apply primer/sealer to areas outlined in chalk or crayon. Allow the primer/sealer to dry until it will not transfer to the finger when touched. The more porous the surface, the more sealer is required. **Caution: Do not accelerate the drying process by using an open flame. The sealer may be flammable at this stage.**
- 4) It is important to apply primer/sealer to the entire area where the preformed thermoplastic will be applied.
- 5) Continue with steps 4 through 9 as stated above for application on HMA.

Application Considerations

The pavement surface must be dry before applying preformed thermoplastic or primer/sealer. The pavement surface must also be free of dirt, dust, chemicals, and oily substances. Do not apply on top of any existing marking materials other than thermoplastic. However, first remove any loose thermoplastic and ensure that no moisture is present. If the old thermoplastic is oxidized (powdery surface), grind or heat it and scrape the top surface so fresh material is exposed. A primer/sealer may be required on PCC or old HMA. Make sure to follow manufacturer instructions.

Most preformed thermoplastic materials may be applied at air temperatures down to 35°F. However, surface temperature is critical and must conform to manufacturer recommendations.

Protective clothing shall be worn during the installation of preformed thermoplastic pavement marking materials. The protective clothing shall consist of leather boots or work shoes, and long pants (note: synthetic fabrics should be avoided). General safety rules should be followed when using propane.

Inspection and Quality Control

A vital component of quality assurance is inspection and quality control before, during, and after application. Regardless of the method of installation, there are some absolutes that must be followed.

The following factors must be addressed in order to achieve good application:

- Sufficient heating of the material during application
- Ambient and surface conditions

- Reflective bead embedment

Never leave the job sites without performing the adhesion test (refer to Application on HMA Step 7, under Application Methods) to test the bond between the HMA and the material. Any deviation from manufacturer recommendations may result in application failures and shall be properly documented if unavoidable.

1.4.11 Troubleshooting for Preformed Thermoplastic

Table 1.4d shows troubleshooting for preformed thermoplastic.

PREFORMED THERMOPLASTIC APPLICATION TROUBLESHOOTING			
PROBLEM	CAUSE	EFFECT	REMEDY
Bonding/Adhesion	• Surface is not clean	• Poor surface bond – low durability	• Clean with blower to remove surface debris
Bonding/Adhesion	• Moisture in road surface	• Poor surface bond – low durability	• Heat road to remove moisture
Bonding/Adhesion	• Non-conforming existing marking (i.e. tape, paint, etc.)	• Poor surface bond – low durability	• Remove or install before or behind old marking
Bonding/Adhesion	• Deteriorating road surface	• Poor surface bond – low durability	• Resurface
Bonding/Adhesion	• Too little heating	• Poor surface bond – low durability	• Visual signs/temperature should be observed
Bonding/Adhesion	• Deicing chemicals on road surface	• Poor surface bond – low durability	• Power wash area or wait until after rain to install
Bonding/Adhesion	• Dated Material	• Poor surface bond – low durability	• Rotate stock/1 year shelf life
Bonding/Adhesion	• Curing agents on Portland Concrete Cement	• Poor surface bond – low durability	• Blast or power wash
Bonding/Adhesion	• Worn polished aggregates on road surface	• Poor surface bond – low durability	• Grind and blow clean
Bonding/Adhesion	• Lack of sealer	• Poor surface bond – low durability	• Use sealer
Low or No Retroreflectivity	• Too little or too much heat	• Glass beads not embedded enough or sunken into material	• Look for visual signs when heating
Low or No Retroreflectivity	• No surface beads/poor hand casting	• Glass beads too few and unevenly distributed	• Use shaker to apply beads evenly
Low skid resistance	• Too much heat	• Glass beads sunken into material	• Look for visual signs
Low skid resistance	• No surface beads/poor hand casting	• No beads to assist with skid resistance	• Use shaker to apply beads evenly
Smearing and discoloration	• Opened to traffic before marking has cooled down	• Reduced visibility	• Use reflective glass beads or water to cool material down or wait until cool
Discoloration of newly installed marking	• Tracking from new HMA • Oil dripping or other chemical spills	• Reduced visibility	• Use additional reflective beads to protect the new marking
Gaps between individual pieces not melted together	• Too little heat • Shelf life exceeded • Individual pieces not touching before heating	• Poor adhesion • Poor appearance	• Heat more • Rotate stock • Make sure pieces are touching before heating

Table 1.4d. Preformed thermoplastic application troubleshooting guide

1.4.12 Characteristics of Preformed Tape (Preformed Plastic)

Preformed tapes come in rolls. The tape consists of pigments, resins, and reflective materials (glass beads or reflective elements) and comes ready to use with or without adhesives. Additional adhesive (primer) can be applied to the pavement to enhance the bond. This material can be used for lane lines, legends, symbols, and transverse markings.

Components

Tapes are similar to other markings: pigments are used to produce color, and suitable resins are used to provide the necessary wear characteristics.

Resins

Resins Pre-reacted resins hold the beads and pigments in place. For this reason, the tape is ready for installation upon delivery. Additionally, there may be an adhesive backing on the bottom side of the resin for adhesion to the roadway surface.

Reflective Materials

The manufacturer has already added reflective materials to the resin. Additional reflective materials are not added in the field.

Primers/Glues

Tapes, depending upon the type, may use primer and/or adhesives in addition to those already applied by the manufacturer. These various compounds are used to promote adhesion to the roadway surface.

Generally, tape that has been properly stored (sheltered at room temperature) will be usable for a period of one year. In addition to the normal requirements for accepting materials on the project, the manufacturer's expiration date must also be clearly shown. Certification letters for the tape, and for all related sealers and primers must be provided.

Types of Preformed Tapes

Tapes fall into one of two categories: permanent and removable.

Permanent Tapes

Permanent pavement marking tapes are either flat or patterned. These tapes may require the use of a primer/sealer (unless otherwise recommended by the manufacturer). The cost of the sealer is usually included in the price of the tape. When applied properly, this material resists movement under traffic. A primer/sealer shall be applied to the roadway prior to the application of this material. Permanent tapes are generally used for longitudinal edge lines, skip lines, stop lines, crosswalks, legends, and symbols.

When preformed plastic is used on an existing asphaltic pavement or on pc concrete, a high VOC primer *may* be applied to the surface prior to the tape or symbol. This installation process is not allowed during the months of May, June, July, August and September in the ozone non-attainment or maintenance counties as identified by the Clean Air Act as follows:

Kewaunee	Manitowoc	Milwaukee	Ozaukee	Kenosha
Racine	Sheboygan	Washington	Waukesha	

Patterned tape is textured, and is sometimes referred to as "profile tape." Patterned tape used for longitudinal edge lines or skip lines on HMA is usually in-laid.

Removable Tapes

Removable tapes can be removed (pulled from the pavement surface) without using heat, solvents, or mechanical eradication. Generally, these tapes should be removed within 6 months of installation and should not leave any permanent residue on the road surface. The use of primers or additional glue may or may not be required. Although these tapes are similar in appearance to permanent tape, they may have an additional fiber mesh bonded in the resin. This mesh provides the necessary tensile strength allowing the tape to be pulled up from the roadway without breaking or tearing.

Blackout or black tape is another type of removable tape that is used to temporarily cover existing marking on an HMA road. Black tape, however, does not contain any reflective material. For example, if a permanent lane needs to be temporarily moved during construction and then reestablished at a later time, the black tape could be applied over the existing lines to hide them and new lines applied with another removable tape. When construction is complete, the original lanes can be reestablished by removing the black tape and the other temporary tapes. Black tape shall not be used on PCC roads.

1.4.13 Methods of Application for Preformed Tape

Flat and patterned tapes are normally installed by using a roller applicator. This is a walk-behind push cart that holds and applies one or two rolls of tape. The applied tape is then pressed onto the road surface using a walk-behind tamper cart. Weights are stacked on this cart to provide the necessary force to press the tape to the road. The tape manufacturers specify the required weight needed for each type of tape. This roller applicator and tamper procedure helps ensure that the tape is applied straight, especially in long line applications. If the manufacturer requires additional primers or glues, they can either be rolled or sprayed onto the tape and/or road surface.

When patterned tape is in-laid, no primer is used. It is in-laid with the last pass of the paving roller; the temperature of HMA is critical.

Pavement Surface Considerations

The minimum application temperature is determined by manufacturer recommendations. Prior to the application of the tape, the surface must be free of contaminants. Contaminants may include dust, dirt, or moisture. If tape is applied to a surface containing dust, dirt, or moisture, poor adhesion will result. This situation should be avoided.

1.4.14 Troubleshooting for Preformed Tape

Table 1.4e shows troubleshooting for preformed tape.

PREFORMED TAPE APPLICATION TROUBLESHOOTING			
PROBLEM	CAUSE	EFFECT	REMEDY
Material rolls up or shifts	<ul style="list-style-type: none">• Not bonded prior to traffic• Tape crossing traffic• No primer adhesive	<ul style="list-style-type: none">• Loss of effectiveness	<ul style="list-style-type: none">• Replace material with proper tamping, adhesive and primer
Poor Material adherence	<ul style="list-style-type: none">• Moisture in pavement• Dirty surface• No primer• Expired shelf life	<ul style="list-style-type: none">• Errant delineation• Loss of Material• No delineation	<ul style="list-style-type: none">• Replace material applying properly

Table 1.4e Preformed tape troubleshooting chart

*Note: Since the material is preformed, the only actions that are necessary are being sure that the material is the correct material specified, is placed properly, and is applied properly. FOLLOW MANUFACTURER RECOMMENDATIONS.

1.5 REFLECTIVE GLASS BEADS

The following information on reflective glass beads is taken from *Mid-Atlantic Regional Technician Certification Program (MARTCP) Pavement Marking Student Manual* funded by the Federal Highway Administration.

1.5.1 Background

Highway accidents and deaths began with the advent of the wheel. However, man has always been able to solve his problems. In fact, early highway safety methods were truly ingenious. Records show that in Rome, before Christ, recessed bricks or rocks were used in the center of the roads to keep chariots on their own side of the road. Also, over 350 years ago, light-colored rocks imbedded in the center of the roads in Mexico were used for the same purpose. Thus, markings have been used for many years to increase highway safety.

The first striping in the United States is credited to Edward Hines, a road commissioner in Wayne County, Michigan, back in the early 1900's. In 1921, a black stripe was painted by hand for one block of Madison, Wisconsin, because the Highway Commission concluded that the stripe kept traffic on the right side of the road. The obvious benefits of this centerline stripe were eventually recognized, and the idea spread.

In the early days, a substantial problem was how to get the stripe on the road. One of the first striping machines consisted of a wheelbarrow frame, a five-gallon tank, and a canvas-wrapped wheel with white paint in the tank channeled to drop onto the wheel. This allowed a man pushing the wheelbarrow to paint a white line down the center of the road. Using white paint improved the visibility of the line and helped channel traffic. However, at night the lines were hard to see and were found to wear rapidly.

The May 1924 issue of *Engineering News - Record* reported that the Ohio Highway Department placed white bricks in the center of a brick road at a cost of \$185 per lane mile. Brass cups or brass circles were also used in an attempt to find a material that was easy to see and would have better wearability. Radioactive ingredients were also mixed with traffic paint to try and get a better line. This idea of using reflective beads became widely known in the late 1930's when the *Canadian Engineer* published a paper on "Luminous Marking for Highways." This article stated that "good visibility obtained and also the high abrasion resistance of the final product, made use of glass spheres advantageous."

In the early 1940's, during World War II, reflective beaded lines were used on highways to expedite traffic during blackouts. World War II was largely responsible for the widespread acceptance of beads to provide nighttime delineation due to the blackout condition imposed.

In 1942, *Engineering News - Record* wrote, "Paint surfaced with reflective beads has been found superior to any other type painted pavement marking. Five hundred miles of this type have been laid in Philadelphia and found to be very satisfactory. Although glass-beaded paint costs more, experience shows that it wears four to five times as long." In the early 1940's, it cost about three times as much to put down a beaded line as it did to put down a standard non-reflectorized pavement marking. Since that time, advances in technology in the reflectorized paint field have brought the price down significantly. However, even when reflectorized paint was first introduced, the greater durability of the paint line made the reflectorized paint more cost effective. Adding reflective beads made such an improvement in the traffic lines that a reflectorized line became the standard. Today, we use both reflectorized center and edge lines for greater safety. Figures 1.5a and 1.5b illustrate the difference between using pavement markings with and without reflective beads.



Figure 1.5a. Pavement markings with reflective beads at night.

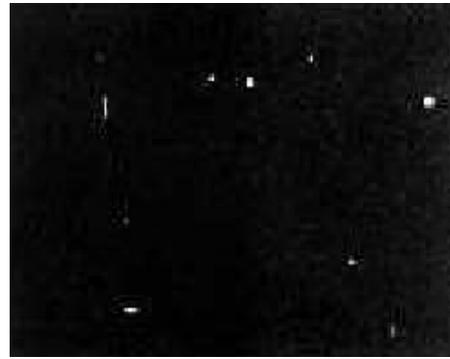


Figure 1.5b. Pavement markings without reflective beads at night.

1.5.2 Retroreflectivity

Using beaded lines for nighttime reflectivity is now accepted worldwide. The advantages of using reflective beads are apparent when driving on a rural road at night. Added benefits of reflective beads are to protect marking material from tracking and to improve durability. However, during the day, a non-beaded paint line will appear richer and a more uniform color. However, this is misleading because the non-beaded paint line *may* not be visible at night.

If an engineer made the decision based only on the daylight evaluation, he/she would probably select the unbeaded line. If the same engineer evaluated these lines at night, he/she would undoubtedly select the beaded line.

Unbeaded paint lines will reflect light randomly in all directions. When round reflective beads are added, light is reflected directly to the source of the light. In industry, this is called retroreflectivity. The following illustrations demonstrate this.

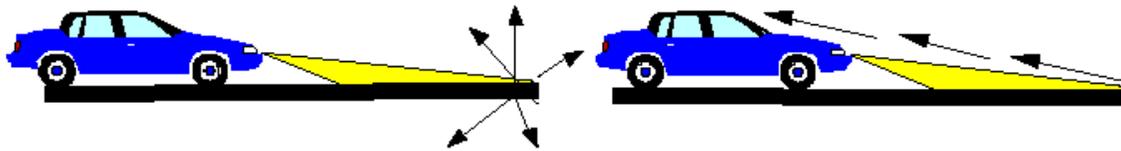


Figure 1.5c. Roadway with unbeaded markings

Figure 1.5d. Roadway with beaded markings

In Figure 1.5c the light rays from an automobile's headlights illuminate a surface that does not retroreflect. The light shining on the road, or a non-beaded line, is reflected in all directions. Only a very small amount is reflected directly back to the driver.

The beaded line illustrated in Figure 1.5d produces a much greater quantity of light reflecting directly back into the driver's eyes. Therefore, the driver sees the line better.

1.5.3 How Glass Beads Work

Refractive Index of Glass

Pavement markings are typically made of materials such as paint, epoxy or tape. Glass beads are mixed with the material (marking binder), or dropped on top when applying the materials to give the pavement markings nighttime visibility.

The glass beads should be embedded enough so that they adhere to the material, but not over embedded so they can provide retro-reflectivity to the material. Light from car head lights, enters the glass bead, it is then refracted and reflected. Refraction is the bending of light. Refraction is observed when a pencil is dropped into a half filled glass of water the pencil appears to be bent. Reflective glass beads ability to bend light is measured by its index of refraction.

Light from the cars headlights enter the glass bead, it is bent or refracted downward, by the curved surface of the glass bead to a point below where the glass bead is embedded in the binder material, thus when the light is reflected off the binder material at the back of the glass bead a large portion of that light is reflected through the glass bead and is refracted back toward the drivers eyes. It works allot like a mirror. If the binder material were not present, the light would continue through the bead and bounce in several directions. Water on pavement markings causes the levels of retro-reflectivity to decrease due to the decrease in refraction and reflection of incoming light to the glass beads which are embedded in the pavement marking materials. The water does not allow the beam from the headlights to pass through it and enter into the glass bead; it is deflected and not refracted back toward the drivers eye.

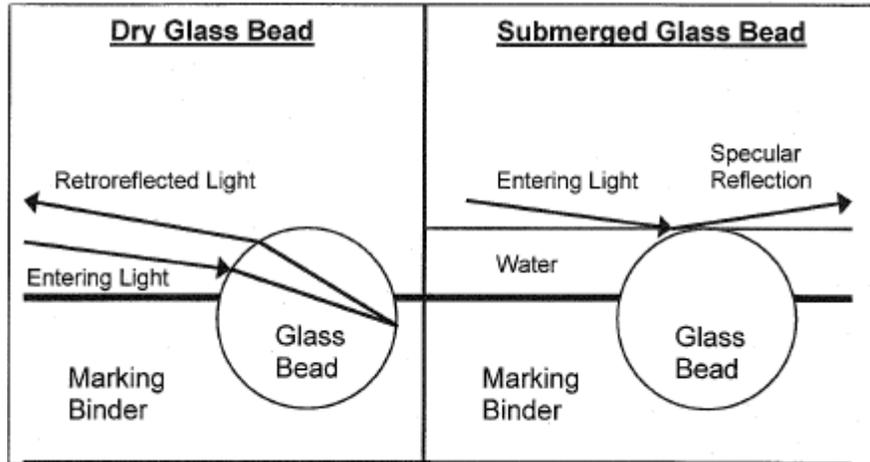


Figure 1.5e How beads retro reflect light

The amount of refraction of light is characteristic of the glass itself and is known as the refractive index (R.I.) of the glass or bead. The refractive index of the glass is dependent upon the chemical and physical make-up of the glass material. Various types of beads have different indices of refraction and cause different amounts of light to be retroreflected.

Water has an index of refraction of 1.33, while the typical bead made with soda glass has a refractive index of 1.50. Beads used in the pavement marking industry are available in refractive indexes of 1.50, 1.65 and 1.90. The highest refractive material is 1.90 and is a very expensive bead to produce. Also, its durability is not as good as the soda glass type. Beads with a refractive index of 1.90 are generally called, "airport beads," since this type of bead is used to mark runways at airports.

Glass Bead Embedment

Retroreflectivity is dependent upon the embedment depth of the bead in the pavement marking material. Optimum embedment of reflective beads is 50-60% assuring optimum retroreflectivity. Embedment of less than 50% *may* affect the longevity of the beads. Increasing embedment beyond 60% significantly decreases the amount of light that can be directed back to the driver. A bead totally embedded in the binder is non-retroreflective because no light enters the bead. In summary, the amount of glass bead embedment will affect the retroreflectivity and the line durability. For optimum retroreflectivity and durability, a bead *should* be embedded at 50-60% of its diameter. Not all beads will be embedded 50-60%. Some beads will be completely buried and others will be embedded less than 50%.

A new line will generally have 70% of all the beads completely buried in the paint or other marking material. The remaining 30% will be embedded in the surface and exposed to the headlights. Figure 1.5f shows beads that were sprayed too late behind the paint operation. The beads in this picture are insufficiently embedded.

Figures 1.5g and 1.5h show beads embedded in a paint line that is too thin. Figure 1.5i illustrates proper bead embedment.



Figure 1.5f. Improper bead embedment

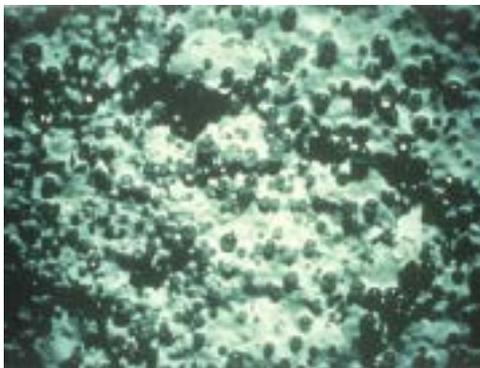


Figure 1.5g. Top view of reflective beads applied to a layer of paint that is too thin



Figure 1.5h. Magnified view of reflective beads applied to a layer of paint that is too thin

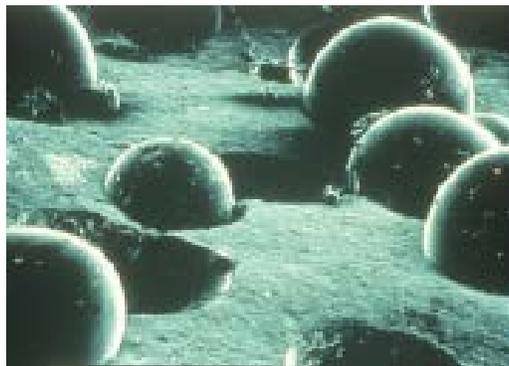


Figure 1.5i. Magnified view of reflective beads at proper embedment depth

Figure 1.5j illustrates the embedment of various sizes of beads in a 15 mil wet line. Figure 1.5k illustrates the embedment of the same beads after the line has dried to 8 mils. Notice the embedment depth of the 40-50 mesh beads in each line. These figures illustrate how 40-50 mesh beads end up at the proper embedment depth when applied to a 15 mil wet line that dries to 8 mils.



Figure 1.5j. Beads in a 15 mil wet line



Figure 1.5k. Beads in an 8 mil dry line

1.5.4 Manufacturing Methods

There are two basic manufacturing methods to make beads: the direct method and the indirect method. In the direct method, liquefied (molten) glass is sprayed and atomized into spheres similar to how water will form droplets when it is sprayed from the nozzle of a garden hose. As the molten glass is sprayed or forced out of the bead making tank, it is suspended as spherical droplets, which are cooled, collected, and then sifted through specifically - designed grading screens. This method, generally used for special formulations, can be used for 1.65 and 1.90 R.I. beads because their rheology will change from a molten state to a hardened bead.

The indirect method is the most commonly employed process for 1.50 R.I. In this method, a selected material (either new or reclaimed cullet) is pulverized into glass powder. This powder is then poured, sprayed, or sprinkled into a large three- to four-story furnace (Figure 1.5l). The individual particles are blown through several flames until they soften and take the shape of spheres. These spherical droplets are cooled in the top half of the furnace and are then collected and sifted through specifically designed grading screens. Material from either method can be mixed to provide the necessary gradations to meet desired specification limits. After manufacturing, these highway beads are bagged and stocked for shipment.

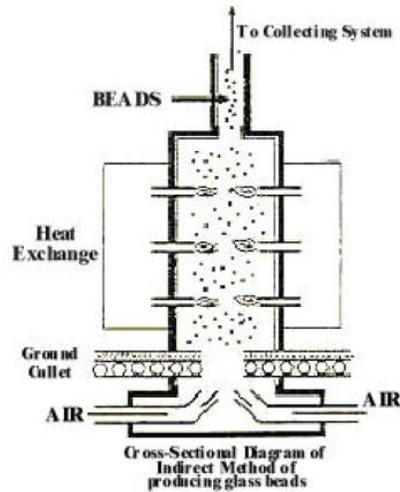


Figure 1.5l. Indirect method for manufacturing glass beads

1.5.5 Bead Properties

The size range or gradation and the roundness of the beads have a definite influence on the initial and long-term retroreflectivity of the pavement markings. Bead coatings will affect bead handling and adhesion to the pavement marking material. Numerous evaluations and years of experience have resulted in the selection of bead sizes for optimal performance under normal traffic conditions.

Size or Gradation

The 20 to 80 mesh bead sizes are generally recommended based on the following assumptions:

- Striping equipment does not apply a uniform paint line because of uneven pavement and possible spray/atomization problems.
- The paint line is applied wet and thickness varies when dried.
- For optimum durability and visibility, a sphere *should* be embedded 50% to 60% of its diameter.
- The resulting reflectorized line will give the best possible retroreflectivity under all conditions.

Note: Figure 1.5m illustrates the typical sizes of glass beads.

Typical Highway Gradation				Range For Larger Beads Depending On Binder			
	U.S Sieve	Microns	Inches		U.S Sieve	Microns	Inches
•	80	180	.0070	●	16	1180	.0469
●	50	300	.0117	●	14	1400	.0555
●	30	600	.0234	●	12	1700	.0661
●	20	850	.0334				

Figure 1.5m. Relative bead size comparison

Roundness

In order to be retroreflective, beads must be round. Only round beads can reflect light back toward the light source.

When standard beads are specified, they **shall** conform to AASHTO M247 or government agency specifications and must have a minimum percentage of round beads. Beads **shall** be smooth and spherically shaped.

While the manufacturing process generally produces round glass beads, a percentage of the beads are not round. Some glass beads take on an oval or “football” appearance. Also, some beads adhere to each other in the solidifying process.

Bead Coatings

Reflective beads can be effective without any coatings. However, in some humid areas it is difficult to apply the beads because they clump in the bead hopper or tank of the striping machines. To overcome this problem, a moisture- proof coating is applied to the beads allowing them to remain free flowing under all striping conditions. This coating alleviates problems during application, but was not designed to improve wet weather visibility. The moisture proof coating allows the beads to be stored, handled and applied without clumping. The proper coating will also enhance the adhesion between the bead surface and the pavement marking material. The coating that is generally used is a thermosetting silicone resin. Each manufacturer has their own system to make the beads flow without clumping. Some *may* use silicone oils or add inorganic particles such as china clay.

1.5.6 Evaluation of Glass Beads

Before glass beads are approved, they must be tested to ensure they meet the specifications for refractive index, size, and roundness.

Refractive Index Evaluation

To determine the refractive index of reflective beads, the beads are treated as a pigment. Most pigments are tested using the liquid immersion method at a temperature of 77° F. To determine the refractive index of beads, refer to government agency specifications.

Evaluation of Bead Size

To evaluate the bead size, the beads are hand sieved through standard sieves starting with the largest opening and progressing to the smallest opening sieve. The reflective beads are weighed on each sieve and the percent that passes through each sieve is calculated. Refer to Figure 1.5n for bead size guidelines.

SIEVE DESIGNATION	MASS PERCENT PASSING	
	Type I	Type II
U.S. Sieve Sizes		
20	100	-
30	75-95	100
40	-	90-100
50	12-35	50-75
80	-	0.5
100	0.5	-

Figure 1.5n. Gradation of glass beads

Evaluation of Roundness

To evaluate roundness, the controlled vibration of a glass plate held at a fixed slope mechanically separates the reflective beads. The round reflective spheres will roll down the slope while the irregularly shaped particles vibrate to the top. After testing the complete sample, the percent of round beads is calculated by weighing the quantity of round beads that have rolled down the glass slope versus the quantity of irregular shaped beads that have vibrated up the glass slope.

Another method used to evaluate bead roundness is visual evaluation using magnification where beads are adhered to a transparent adhesive surface and viewed under magnification. This method is normally used to evaluate larger beads.

1.5.7 Application of Glass Beads

The proper placement of beads and pavement marking material on a road surface is the most important step in obtaining a durable reflective line. During this process, all variables must be controlled. The following must be considered:

Liquid Pavement Markings

Most highway marking material is applied on Hot Mix Asphalt (HMA) or Portland Cement Concrete (PCC). The major problem with these surfaces is obtaining a lasting bond between the binder and the substrate. This bond *may* be affected by dirt, substrate texture, the chemical or mechanical properties of the surface, concrete latency, curing compounds and road surface oils in new HMA pavement. The presence of residue, expansion joints, cracks and sealants can adversely affect the performance of the line.

Binders

The resin in the marking material (paint, thermoplastic, etc.) is the "glue" adhering the beads to the road surface. The pigment/binder thickness is an important variable closely related to bead retainment and the quantity of beads used. The type and quantity of pigmentation and filler play an important role in the retroreflectivity of the beads as well as the daylight appearance of the line. After the best striping materials are selected, the three most important variables involved in the application of lines are the equipment, operator skill, and ambient conditions.

Equipment

The application equipment must be in good condition and properly designed for the type of product it is to apply. The development and use of computer-aided delivery systems have helped provide adequate means to accurately control film thickness and bead application rates.

Operator Skill

Operator skill is essential to achieve reasonable control over "liquid markings" and bead application. This applies to both the driver of the vehicle and the operator of the application controls.

Ambient Conditions

Pavement markings **shall** only be applied when the ambient conditions will give the best results. When striping must be done under more adverse conditions, the results *may* be affected.

1.5.8 Evaluation of Glass Bead Application

The visual evaluation of a newly applied pavement marking line is an important part of the quality control process. Proper bead distribution and depth are critical to ensure a durable and retroreflective line. Since visual evaluation of glass bead application can be

subjective, the following illustrations and descriptions are provided to demonstrate good and bad bead distribution. Figure 1.5o is a representation of a good stripe demonstrating uniform distribution of glass beads, whereas Figure 1.5p shows a stripe with good distribution but not enough glass beads.

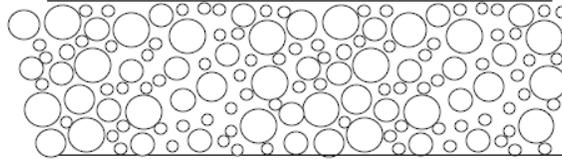


Figure 1.5o. Representation of good bead distribution

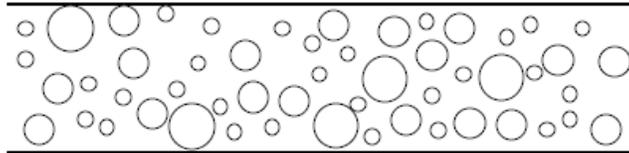


Figure 1.5p. Too few beads

Figure 1.5q shows striping material that is too thick in the center and too thin on the edges. The beads in the center of the stripe are covered with material and are non-reflective. The edges *may* be reflective but because of the thinner material film, not as durable. This *may* be due to improper atomizing pressure and/or improper material pressure and/or improper material viscosity.

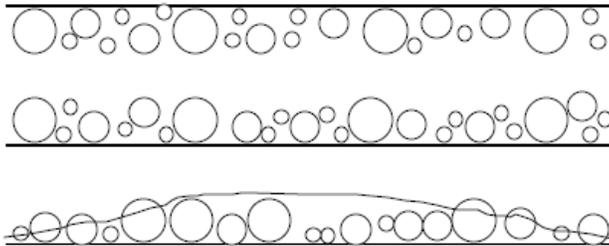


Figure 1.5q. A contoured line

Figure 1.5r illustrates poor distribution of beads. An improperly placed bead dispenser or possibly a windy day *may* result in the distribution of beads on only part of the stripe.

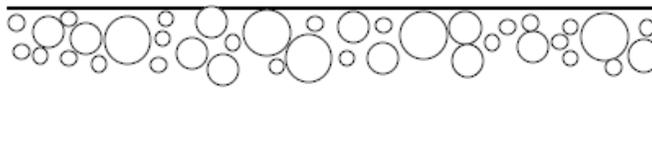


Figure 1.5r. Beads on only one portion of the line

Problems with inconsistent air pressure or pulsed air pressure *may* lead to pulsed or sporadic application of beads as illustrated in Figure 1.5s.

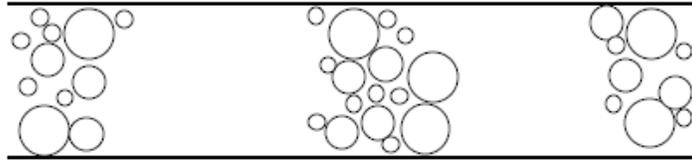


Figure 1.5t. Line from a pulsating bead gun

1.5.9 Evaluation of Retroreflectivity

While other aspects of appearance and durability are important to determine the useful life of pavement markings, those markings are only useful if they can be seen in all conditions, especially at nighttime. Retroreflectivity testing has improved the performance of pavement markings.

Retroreflectivity can be assessed either visually at night or by the use of retroreflectance meters such as the Delta LTL-2000, 2000Y and 2000X. The LTL-2000X also reads wet reflectivity of a marking. Currently in the United States, 15- and 30-meter geometry instruments, as well as mobile equipment technologies are used.

The color of the pavement marking *may* affect the results of the retroreflective instruments. For example, if a non-leaded yellow paint line begins to deteriorate from UV radiation (i.e. - get lighter in color) but has no bead loss from the initial application, the reflectometer values *may* increase. Daytime color can be read by a BYK-Gardner Color Meter whereas the LTL-2000Y can read nighttime color.

In summary, **retroreflectivity** and **durability** are a function of the following parameters:

- The refractive index of the glass bead material
- Gradation or size of the glass beads
- Roundness of the beads
- The coating on the beads
- The embedment of the beads in the material
- The distribution of glass beads in the pavement material
- The number of exposed beads on the marking surface
- The relationship between the diameter of the beads and the striping material thickness

The first four items are controllable manufacturing items. These can be specified and tested for minimum requirements. The last four items are related to the application of materials. Even if the first four items are strictly adhered to, either a bad application of binder material or a bad application of beads will negate the quality of the ingredients and result in a non-durable and/or non-retroreflective pavement marking.

1.5.10 New Materials

Advances in striping materials (i.e. higher solids, better reactive polymers, etc.) as well as advances in adherence type coatings on reflective beads allow larger reflective beads to be used. These larger reflective beads provide better wet night retroreflective

performance. Standard reflective beads, as previously described, *may* have their retroreflectivity "turned off" by a thin film of water. The new larger reflective beads stick up above a water film and continue to retroreflect headlights during rain. However, the larger beads are more susceptible to snow plow damage.

1.5.11 Troubleshooting for Reflective Glass Beads

Table 1.5a is a troubleshooting guide for bead application problems.

REFLECTIVE BEAD APPLICATION TROUBLESHOOTING			
PROBLEM	CAUSE	EFFECT	REMEDY
Beads on one side	<ul style="list-style-type: none"> • Bead gun out of alignment • Clogged bead gun 	<ul style="list-style-type: none"> • Poor night visibility 	<ul style="list-style-type: none"> • Adjust alignment of gun cap • Rebuild gun
Excessive bead use	<ul style="list-style-type: none"> • Worn gun needle, seat and orifice • Excessive glass bead pressure 	<ul style="list-style-type: none"> • Supply problems 	<ul style="list-style-type: none"> • Rebuild gun • Decrease pressure
Beads in middle of line	<ul style="list-style-type: none"> • Bead tank pressure too low • Bead gun "off" and "on" control screw not adjusted • Bead gun cap out of alignment • Too big of a bead gun tip 	<ul style="list-style-type: none"> • Poor night visibility 	<ul style="list-style-type: none"> • Increase pressure • Adjust control screw • Align cap deflector • Change to a smaller tip
All beads buried	<ul style="list-style-type: none"> • Bead gun too close to paint • Bead gun angle too shallow • Excessive paint millage 	<ul style="list-style-type: none"> • Poor night visibility 	<ul style="list-style-type: none"> • Re-align bead gun • Adjust angle of bead gun • Check wet millage thickness
All beads on top of line	<ul style="list-style-type: none"> • Bead gun too far from paint gun 	<ul style="list-style-type: none"> • Loss of durability • Initial very bright line 	<ul style="list-style-type: none"> • Re-align bead gun
Pulsed bead application	<ul style="list-style-type: none"> • Bead tank pressure inadequate 	<ul style="list-style-type: none"> • Violates standards • Loss of effectiveness 	<ul style="list-style-type: none"> • Raise tank pressure • Rebuild applicator to increase pressure
Excessive amount of beads on road beside line	<ul style="list-style-type: none"> • Too much overlap of bead pattern on line pattern 	<ul style="list-style-type: none"> • Loss of reflectivity 	<ul style="list-style-type: none"> • Move bead gun closer to roadway

Table 1.5a. Reflective bead troubleshooting chart

1.5.12 Field Equipment

The devices shown in the figures below can be used to measure pavement marking thickness, width, or retroreflectivity. Calibration and operation instructions for the retroreflectometer and color reading meter are provided with the equipment.



Figure 1.5u. LTL 2000 Retrometer testing.



Figure 1.5v. Transport of the retrometer on the construction site.



Figure 1.5w. Color guide meter.



Figure 1.5x. Wet mil thickness gauge.



Figure 1.5y. Tape measure.

1.6 ERADICATION

Eradication describes the removal of existing pavement markings. Pavement markings are eradicated to change or modify the existing travel lanes and to prepare the road surface for new markings.

If pavement markings are not eradicated properly, several different markings may exist at the same time, as shown in Figure 1.6a. Often, the scars left by some removal methods may appear like additional pavement markings. This may create a hazardous condition for motorists.



Figure 1.6a Road way with confusing multiple lines

1.6.1 Methods of Eradication

There is no method of eradication that is free from drawbacks. Whatever the method, it must effectively remove the marking to the specified degree, while at the same time doing the least damage to the pavement. Eradication methods must be submitted to the governing agency for approval prior to beginning the work.

Methods that have typically been used are:

- Blasting (hydro, sand or shot)
- Grinding

The effectiveness of the method is dependent on three things:

- The type and thickness of the marking being removed
- The type of pavement
- The skill of the operator

For example, thermoplastic markings cannot withstand abrasive blasting because the heat generated when the abrasives strike the marking melts the thermoplastic. Grinding is not acceptable on grooved or tined PCC because it will remove the texturing of the pavement surface. Most chemical strippers are hazardous materials with disposal problems. Heat can make HMA pavement slick. Depending on the amount of heat, safety problems may result. This is particularly true if yellow markings containing lead are removed. Hydro-jetting or hydro-blasting uses water and can cause slick pavements in the wintertime.

1.6.2 Specifications

Refer to the Standard Specification 646.3.4 - Removing Pavement Markings

- (1) Remove pavement markings from locations the plans show or as the engineer directs. Do not damage, discolor, leave a detrimental residue on the surface, or paint over existing markings. Provide a dust control system and remove accumulated sand or other materials.
- (2) If blast cleaning within 10 feet of a lane open to public traffic, remove all dust and other residue continuously while blast cleaning. Collect, haul, and dispose of dust or residue from removals. Repair damage caused by the contractor's removal operations.

1.6.3 Inspection

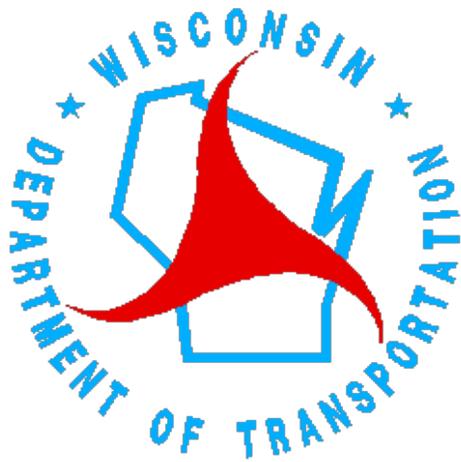
The eradicated lines are to be inspected for:

- Thoroughness of eradication
- Damage to the pavement surface

R X R

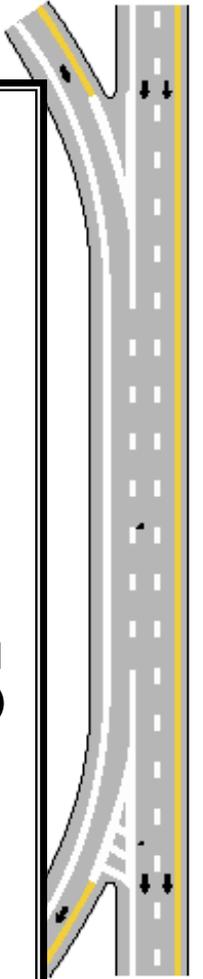
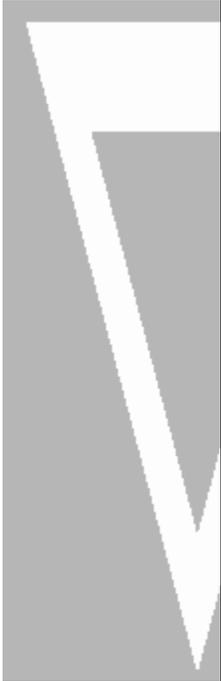
SECTION 2

**PAVEMENT
MARKING
COORDINATORS**



January 2014 Edition

ONLY



SECTION 2 – PAVEMENT MARKING COORDINATORS SECTION

2.1	TMA Examples	2-1
2.2	Expenditures	2-7
2.3	Estimates	2-8

2.1 TMA Examples

Marking operations *may* require timeframe restrictions for the completion of work performed in higher volume areas. A list of restrictions *may* be provided to the county or you *may* consult the Regional PMC for the restrictions. The PMC assigning the locations of the pavement marking operations should discuss with the county the special requirements necessary before authorization of the work. The special requirements can also become part of Screen 7 in the HMS program for the TMA.

The following are a list of example TMAs from different Regions.

E-H-485B 11-95 State of Wisconsin / Department of Transportation
12/13/2011

REVISED

DISCRETIONARY TRAFFIC MAINTENANCE AGREEMENT

COUNTY CALENDAR YEAR 2011

The State of Wisconsin Department of Transportation (hereafter called the Department) authorizes the maintenance project herein described, and the above designated County, represented by its County Highway Committee and Highway Commissioner, agree to perform such operations and furnish such materials as listed below. It is understood that the maintenance services authorized under this agreement shall be accomplished in compliance with state and federal law and under the general direction of the Department. Payment for services provided under this agreement shall be made to the County based on actual labor, including fringe benefit costs, machinery allowances as specified in the current WISCONSIN MANUAL, CHAPTER 5, and material purchases authorized by the Department. Such payment shall be made upon presentation of accounts itemized and verified in accordance with regulations of the Department.

In connection with the services provided under this agreement, the County agrees not to discriminate against any employee or applicant for employment because of sex, age, race, religion, color, handicap, physical condition, developmental disability as defined in s.51.15(5), sexual orientation, or national origin. This provision shall include, but not be limited to the following: employment separation, demotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The County further agrees to post in a conspicuous place, available for employees and applicants for employment, notices setting forth these provisions.

The disclaimer language as contained in the State Highway Maintenance Manual is included in this agreement by reference. The County is obligated to provide services under this agreement only to the extent it receives Department funding for the same. The Department recognizes that the County does not warrant that maintenance funds provided by the Department are sufficient to provide for a uniform level of service or standard of state highway maintenance applicable to all situations. Certain factors, including but not limited to, weather restrictions and funding or labor shortages, may make universal, year-round compliance with the goals expressed within this manual impossible to achieve.

PROJECT ID	COUNTY ACCT. NO.	DESCRIPTION	AMOUNT
1085-18-18	53321	PAVEMENT MARKING	
		NEW INTERSTATE	\$ 43,380
		ESTIMATED COUNTY COSTS	\$ 43,380

DATE: _____

	ESTIMATED AMOUNT BUDGETED
	COUNTY LABOR \$ 16,000
	COUNTY EQUIPMENT \$ 12,000
	COUNTY MATERIALS \$ 31,700
	ADMINISTRATIVE SUPPORT \$ 3,680
	TOTAL COUNTY COST \$ 43,380

County Highway Commissioner

County Highway Committee

Approved for DEPARTMENT OF TRANSPORTATION

DIST Regional Director Date

Director, Bureau of Highway Maintenance Date

E-H-665B 11-86

State of Missouri / Department of Transportation

REVISED
DISCRETION TRAFFIC MAINTENANCE AGREEMENT

BROWN COUNTY
CALENDAR YEAR 2011

PROJECT ID: 1885-18-10 (BHN INTERSTATE)

CENTERLINE AND EDGE LINE PAVEMENT MARKING
STATE TRUNK HIGHWAY SYSTEM IN BROWN AND BUTLER COUNTIES

FURNISH ALL LABOR, EQUIPMENT AND MATERIALS TO PROVIDE CENTERLINE AND
EDGE LINE PAVEMENT MARKING ON THE STATE TRUNK HIGHWAY SYSTEM IN BROWN AND
BUTLER COUNTIES, AS DESIGNATED AND SCHEDULED BY THE NORTHEAST REGION,
FOR THE PERIOD BEGINNING JANUARY 1, 2011 AND ENDING DECEMBER 31, 2011.

MATERIALS TO BE USED WILL BE:
MATERIALS PAINT - WHITE
MATERIALS PAINT - YELLOW
GLASS BEADS

THE ESTIMATED COSTS ARE BASED ON CURRENT LABOR AND EQUIPMENT RATES ON FILE
WITH THE DEPARTMENT OF TRANSPORTATION AND INCLUDE ANTICIPATED SMALL TOOL
ALLOWANCE, ANY HAZARDOUS WASTE DISPOSAL COSTS, FEES AND SPECIAL RECORDS
AND RECORDS AND REPORT ALLOWANCE.

CONTACT PERSON WITH THE DEPARTMENT OF TRANSPORTATION WILL BE
MICK FRENED (320) 492-5453.

ROADWAY	LOCATION	LENGTH	UNIT PRICE	QUANTITY
SR VARIOUS	VARIOUS STATE TRUNK HIGHWAYS IN BROWN AND BUTLER COUNTIES	.00	\$ 43,888 / LR	1.0
STATE FURNISHED MATERIALS				
COUNTY FURNISHED MATERIALS				
Quantity	Measure	Description		\$ 31,700
1.00	LUMP SUM	UNLISTED ROADWAY MATERIALS		
COUNTY LABOR				
\$ 16,000				
SALARY \$ 9,500				
FRINGE \$ 6,500				
OVERTIME				
COUNTY EQUIPMENT \$ 12,400				
ADMINISTRATIVE SUPPORT \$ 3,000				
TOTAL PROJECT COSTS			\$	65,848

CHARGES FOR THIS WORK SHALL BE CARRIED BY THE FOLLOWING ACTIVITY CODES:
90 PAVEMENT MARKING (FOR TRAFFIC MAINT. AGREEMENTS)

E-M-485C 11-86

State of Wisconsin / Department of Transportation

SECTIONARY MAINTENANCE AGREEMENT

COUNTY FURNISHED MATERIALS

BRIMS COUNTY

Project Id	Description	Quantity	Unit	Estimated Unit Price	Budget Assmt
1885-10-10	UNLISTED ROADWAY MATERIALS	1.000	LUMP SUM	\$51,700.0000	\$ 51,700.0000

PAGE 1 - DOCUMENT COMPLETED

E-H-605B 11-95

State of Wisconsin / Department of Transportation
12/18/2011

REVISED

DISCRETIONARY TRAFFIC MAINTENANCE AGREEMENT

FORTAGE COUNTY

CALENDAR YEAR 2011

The State of Wisconsin Department of Transportation (hereafter called the Department) authorizes the maintenance project herein described, and the above designated County, represented by its County Highway Committee and Highway Commissioner, agrees to perform such operations and furnish such materials as listed below. It is understood that the maintenance services authorized under this agreement shall be accomplished in compliance with state and federal law and under the general direction of the Department. Payment for services provided under this agreement shall be made to the County based on actual labor, including fringe benefit costs, machinery allowances as specified in the current MAINTENANCE MANUAL, CHAPTER 5, and material purchases authorized by the Department. Such payment shall be made upon presentation of accounts itemized and verified in accordance with regulations of the Department.

In connection with the services provided under this agreement, the County agrees not to discriminate against any employee or applicant for employment because of sex, age, race, religion, color, handicap, physical condition, developmental disability as defined in s. 51.55(5), sexual orientation, or national origin. This provision shall include, but not be limited to the following: employment upgrading, promotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The County further agrees to post in a conspicuous place, available for employees and applicants for employment, notices setting forth these provisions.

The disclaimer language as contained in the State Highway Maintenance Manual is included in this agreement by reference. The County is obligated to provide services under this agreement only to the extent it receives Department funding for the same. The Department recognizes that the County does not warrant that maintenance funds provided by the Department are sufficient to provide for a uniform level of service or standard of state highway maintenance applicable to all situations. Certain factors, including but not limited to, weather restrictions and funding or labor shortages, may make universal, year-round compliance with the goals expressed within this manual impossible to achieve.

PROJECT ID	COUNTY ACCT. NO.	DESCRIPTION	AMOUNT
1009-18-18	55323	PAVEMENT MARKING	
		NON INTERSTATE	\$ 178,800
		ESTIMATED COUNTY COSTS	\$ 178,800

DATE: _____

County Highway Commissioner

County Highway Committee

ESTIMATED AMOUNT BUDGETED

COUNTY LABOR	\$ 18,950
COUNTY EQUIPMENT	\$ 25,950
COUNTY MATERIALS	\$ 97,520
ADMINISTRATIVE SUPPORT	\$ 7,980

TOTAL COUNTY COST \$ 179,800

Approved for DEPARTMENT OF TRANSPORTATION

DTSD Regional Director Date

Director, Bureau of Highway Maintenance Date

E-H-4058 11-84

State of Wisconsin / Department of Transportation

REVISED
DISCRETION TRAFFIC MAINTENANCE AGREEMENT

PORTAGE COUNTY
CALENDAR YEAR 2011

PROJECT ID: 1049-18-10 (NON INTERSTATE)

PAVEMENT MARKING (NON-INTERSTATE)

PAVEMENT MARKING ON VARIOUS HIGHWAY RECORD MILE.

HIGHWAY	LOCATION	LENGTH	UNIT PRICE	QUANTITY
5TH VARIOUS	VARIOUS HIGHWAYS	.30	/	

STATE FURNISHED MATERIALS

COUNTY FURNISHED MATERIALS	Quantity	Measure	Description	
	1.00	L.E.	UNTESTED HIGHWAY MATERIALS	\$ 97,320

COUNTY LABOR \$ 58,950

SALARY \$ 22,750

PRIME \$ 15,170

OVERTIME \$ 1,000

COUNTY EQUIPMENT \$ 25,950

ADMINISTRATIVE SUPPORT \$ 7,000

TOTAL PROJECT COSTS \$ 179,000

CHARGES FOR THIS WORK SHALL BE SUMMARIZED BY THE FOLLOWING ACTIVITY CODES:
99 PAVEMENT MARKING (FOR TRAFFIC MAINT. AGREEMENTS)

PAGE 1 - DISCRETION COMPLETED

E-N-6800 11-84

State of Wisconsin / Department of Transportation

DISCRETIONARY MAINTENANCE AGREEMENT

COUNTY FURNISHED MATERIALS

PORTAGE COUNTY

Project Id	Description	Quantity	Unit	Estimated Unit Price	Budget Amount
1449-18-10	ISOLATED HIGHWAY MATERIALS	1.000	L.S.	\$97,320.0000	\$ 97,320.0000

PAGE 1 - AGREEMENT COMPLETED

2.2 Expenditures

SPECIAL PROJECTS COSTS - CALENDAR YEAR 2011								
TAYLOR COUNTY								
	MISC	MISC		TMA	TMA	LFA	TMA	
	0077-06-00	0072-01-50	0080-02-63	1060-18-20	1060-18-10	1000-08-49	1060-18-25	
	ALL	ALL	Directional		ALL	VARIOUS	ALL	
	General	Adopt	Arrow	State Funded	Fed-funded	Culvert	Fed-funded	
	Damage	a	Boards	Aluminum	Pavement	Replacem/	Plywood	
	Claim	Highway		Signs	Marking	Shoulders	Signs	TOTAL
JAN								0.00
FEB	1423							1422.80
MAR	159							158.56
APR	347							346.97
MAY			467		69706			70172.38
JUN					85528			85527.82
JUL	256				96948			97203.45
AUG					74726			74726.15
SEP					203345		19	203363.91
OCT	1227			312	101017	57618	28	160201.91
NOV					30977	15263		46240.00
DEC								0.00
TOTAL	3411	0	467	312	662247	72881	47	739363.95

SPECIAL PROJECTS COSTS - CALENDAR YEAR 2011										
TREMPEALEAU COUNTY										
	MISC	MISC		TMA	TMA	TMA	TMA	LFA	LFA	
	0077-06-00	0072-01-50	0080-02-53	1061-18-10	1061-18-25	0061-18-20	9227-01-14	7735-00-61	7130-01-60	
	ALL	ALL	TODS	ALL	ALL	ALL	ALL	STH 121	STH 93	
	General	Adopt	Tourist	Fed-funded	Fed-funded	State funded	Maint for	Asphalt	Asphaltic	
	Damage	a	Oriented	Pavement	Plywood	Aluminum	Pavement	Surface/	Leveling	
	Claim	Highway	Signs	Marking	Signing	signing	Marking	Shldring	Layer	TOTAL
JAN	987		166							1152
FEB	766									766
MAR	1590									1590
APR	8337			538						8875
MAY	22398		226	29572		8				52205
JUN	10808			77285		9				88102
JUL	524			140081		1699		16881		159185
AUG	7877			43345	965	373	4945	7440		64945
SEP	6202			8122		1030			22367	37721
OCT	4876			30285		1448			6457	43066
NOV										0
DEC										0
TOTAL	64364	0	392	329229	965	4567	4945		28823	457607

2.3 Estimates

ROUTINE MAINTENANCE COSTS - CALENDAR YEAR 2011 TREMPEALEAU COUNTY													
MONTH	MONTHLY BUDGET	MONTHLY AMOUNT BUDGETED	MONTHLY ACCLUM BUDGET	MONTHLY CHARGED (OVER)	MONTHLY DIFFER (OVER)	ACCLUM PERCENT	ESTIMATED PERCENT	ACCLUM PERCENT					
JAN	0.000	157.877	157.877	0.000	0.000	11.00%	11.00%	11.00%	11.00%	11.00%	11.00%	11.00%	11.00%
FEB	0.000	142.215	142.215	0.000	0.000	22.00%	22.00%	22.00%	22.00%	22.00%	22.00%	22.00%	22.00%
MAR	0.000	132.544	132.544	0.000	0.000	33.00%	33.00%	33.00%	33.00%	33.00%	33.00%	33.00%	33.00%
APR	0.000	122.873	122.873	0.000	0.000	44.00%	44.00%	44.00%	44.00%	44.00%	44.00%	44.00%	44.00%
MAY	0.000	113.202	113.202	0.000	0.000	55.00%	55.00%	55.00%	55.00%	55.00%	55.00%	55.00%	55.00%
JUN	0.000	103.531	103.531	0.000	0.000	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%
JUL	0.000	93.860	93.860	0.000	0.000	77.00%	77.00%	77.00%	77.00%	77.00%	77.00%	77.00%	77.00%
AUG	0.000	84.189	84.189	0.000	0.000	88.00%	88.00%	88.00%	88.00%	88.00%	88.00%	88.00%	88.00%
SEP	0.000	74.518	74.518	0.000	0.000	99.00%	99.00%	99.00%	99.00%	99.00%	99.00%	99.00%	99.00%
OCT	0.000	64.847	64.847	0.000	0.000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
NOV	0.000	55.176	55.176	0.000	0.000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
DEC	0.000	45.505	45.505	0.000	0.000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
TOTAL	0.000	1,100.000	1,100.000	0.000	0.000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

SPECIAL PROJECTS COSTS - CALENDAR YEAR 2011 TREMPEALEAU COUNTY													
MONTH	MONTHLY BUDGET	MONTHLY AMOUNT BUDGETED	MONTHLY ACCLUM BUDGET	MONTHLY CHARGED (OVER)	MONTHLY DIFFER (OVER)	ACCLUM PERCENT	ESTIMATED PERCENT	ACCLUM PERCENT					
JAN	0.000	157.877	157.877	0.000	0.000	11.00%	11.00%	11.00%	11.00%	11.00%	11.00%	11.00%	11.00%
FEB	0.000	142.215	142.215	0.000	0.000	22.00%	22.00%	22.00%	22.00%	22.00%	22.00%	22.00%	22.00%
MAR	0.000	132.544	132.544	0.000	0.000	33.00%	33.00%	33.00%	33.00%	33.00%	33.00%	33.00%	33.00%
APR	0.000	122.873	122.873	0.000	0.000	44.00%	44.00%	44.00%	44.00%	44.00%	44.00%	44.00%	44.00%
MAY	0.000	113.202	113.202	0.000	0.000	55.00%	55.00%	55.00%	55.00%	55.00%	55.00%	55.00%	55.00%
JUN	0.000	103.531	103.531	0.000	0.000	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%	66.00%
JUL	0.000	93.860	93.860	0.000	0.000	77.00%	77.00%	77.00%	77.00%	77.00%	77.00%	77.00%	77.00%
AUG	0.000	84.189	84.189	0.000	0.000	88.00%	88.00%	88.00%	88.00%	88.00%	88.00%	88.00%	88.00%
SEP	0.000	74.518	74.518	0.000	0.000	99.00%	99.00%	99.00%	99.00%	99.00%	99.00%	99.00%	99.00%
OCT	0.000	64.847	64.847	0.000	0.000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
NOV	0.000	55.176	55.176	0.000	0.000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
DEC	0.000	45.505	45.505	0.000	0.000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
TOTAL	0.000	1,100.000	1,100.000	0.000	0.000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

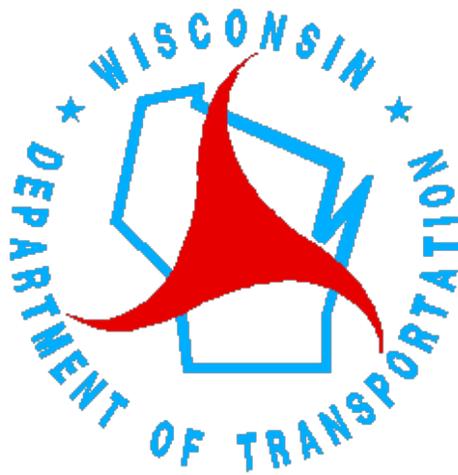
EXPENDITURES vs. Budget by Activity													
MONTH	BUDGET	ACTUAL	DIFFER	PERCENT									
JAN	157.877	157.877	0.000	100.00%	157.877	0.000	100.00%	157.877	0.000	100.00%	157.877	0.000	100.00%
FEB	142.215	142.215	0.000	100.00%	142.215	0.000	100.00%	142.215	0.000	100.00%	142.215	0.000	100.00%
MAR	132.544	132.544	0.000	100.00%	132.544	0.000	100.00%	132.544	0.000	100.00%	132.544	0.000	100.00%
APR	122.873	122.873	0.000	100.00%	122.873	0.000	100.00%	122.873	0.000	100.00%	122.873	0.000	100.00%
MAY	113.202	113.202	0.000	100.00%	113.202	0.000	100.00%	113.202	0.000	100.00%	113.202	0.000	100.00%
JUN	103.531	103.531	0.000	100.00%	103.531	0.000	100.00%	103.531	0.000	100.00%	103.531	0.000	100.00%
JUL	93.860	93.860	0.000	100.00%	93.860	0.000	100.00%	93.860	0.000	100.00%	93.860	0.000	100.00%
AUG	84.189	84.189	0.000	100.00%	84.189	0.000	100.00%	84.189	0.000	100.00%	84.189	0.000	100.00%
SEP	74.518	74.518	0.000	100.00%	74.518	0.000	100.00%	74.518	0.000	100.00%	74.518	0.000	100.00%
OCT	64.847	64.847	0.000	100.00%	64.847	0.000	100.00%	64.847	0.000	100.00%	64.847	0.000	100.00%
NOV	55.176	55.176	0.000	100.00%	55.176	0.000	100.00%	55.176	0.000	100.00%	55.176	0.000	100.00%
DEC	45.505	45.505	0.000	100.00%	45.505	0.000	100.00%	45.505	0.000	100.00%	45.505	0.000	100.00%
TOTAL	1,100.000	1,100.000	0.000	100.00%	1,100.000	0.000	100.00%	1,100.000	0.000	100.00%	1,100.000	0.000	100.00%

GRAND TOTAL REVENUES													
MONTH	BUDGET	ACTUAL	DIFFER	PERCENT									
JAN	157.877	157.877	0.000	100.00%	157.877	0.000	100.00%	157.877	0.000	100.00%	157.877	0.000	100.00%
FEB	142.215	142.215	0.000	100.00%	142.215	0.000	100.00%	142.215	0.000	100.00%	142.215	0.000	100.00%
MAR	132.544	132.544	0.000	100.00%	132.544	0.000	100.00%	132.544	0.000	100.00%	132.544	0.000	100.00%
APR	122.873	122.873	0.000	100.00%	122.873	0.000	100.00%	122.873	0.000	100.00%	122.873	0.000	100.00%
MAY	113.202	113.202	0.000	100.00%	113.202	0.000	100.00%	113.202	0.000	100.00%	113.202	0.000	100.00%
JUN	103.531	103.531	0.000	100.00%	103.531	0.000	100.00%	103.531	0.000	100.00%	103.531	0.000	100.00%
JUL	93.860	93.860	0.000	100.00%	93.860	0.000	100.00%	93.860	0.000	100.00%	93.860	0.000	100.00%
AUG	84.189	84.189	0.000	100.00%	84.189	0.000	100.00%	84.189	0.000	100.00%	84.189	0.000	100.00%
SEP	74.518	74.518	0.000	100.00%	74.518	0.000	100.00%	74.518	0.000	100.00%	74.518	0.000	100.00%
OCT	64.847	64.847	0.000	100.00%	64.847	0.000	100.00%	64.847	0.000	100.00%	64.847	0.000	100.00%
NOV	55.176	55.176	0.000	100.00%	55.176	0.000	100.00%	55.176	0.000	100.00%	55.176	0.000	100.00%
DEC	45.505	45.505	0.000	100.00%	45.505	0.000	100.00%	45.505	0.000	100.00%	45.505	0.000	100.00%
TOTAL	1,100.000	1,100.000	0.000	100.00%	1,100.000	0.000	100.00%	1,100.000	0.000	100.00%	1,100.000	0.000	100.00%

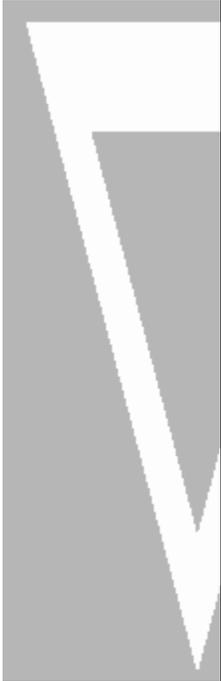
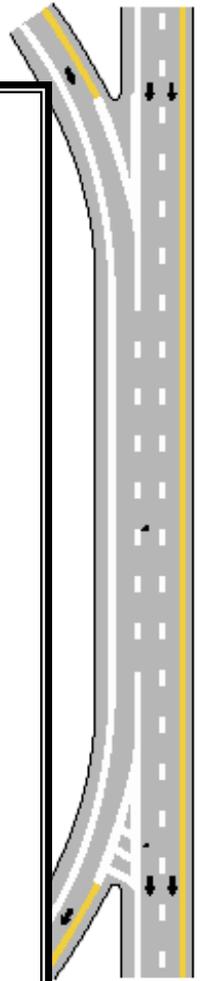
R X R

SECTION 3

**PAVEMENT
MARKING
GUIDANCE**



January 2014 Edition



ONLY



SECTION 3 – PAVEMENT MARKING GUIDANCE SECTION

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 3.1.1 Traffic Guidelines Manual (TGM) Policies 3-1
3.2 No Passing Zones..... 3-2
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3.3 Obsolete Curb Ramp Detail For Remarketing Info Only 3-3

3.1 Pavement Marking Guidance

3.1.1 Traffic Guidelines Manual (TGM) Policies

Additional pavement marking guidance can be found in the Traffic Guidelines Manual. The content of the Manual is applicable only to the state trunk highway system.

The Chapter 3 Pavement marking Table of Contents are reprinted for reference.

Traffic guidelines manual			
Extranet customers! - How to turn off security alert popups (for Internet Explorer)			
Chapter 3 - Markings 			
Subject no.	Subject title	Effective date	Supersede date
Section 2 - Applications			
3-2-1	Yellow centerline pavement markings	Apr 2009	
3-2-2	No passing zone standards	Aug 2013	Feb 2013
3-2-4	White lane line pavement markings	Apr 2009	
3-2-5	Interchange ramps	July 2012	May 2011
3-2-6	Edgelines	Feb 2007	Dec 2004
3-2-16	Stop lines	Dec 1999	
3-2-18	Crosswalks	Mar 2011	Sep 2009
3-2-19	Parking spaces	Mar 2011	Feb 2008
3-2-20	Arrows and words	Mar 2011	June 2005
3-2-21	Aerial enforcement bars	Mar 2011	Apr 2001
3-2-23	Island Marking	Mar 2011	Jan 2001
3-2-23.1	Curb ramp markings	Mar 2011	Feb 2008
Section 3 - Roundabouts			
3-3-1	Marking for roundabouts	Jan 2013	July 2012
Section 6 - Delineation			
3-6-1	Delineators	Mar 2011	June 2005
Section 10 - Program			
3-10-1	Pavement marking policy	Mar 2011	Apr 2009
Section 15 - Comprehensive Policy			
3-15-10	Push Over Markings	Mar 2011	Apr 2008

3.2 No Passing Zones

The start and ending of existing zones should be documented prior to placement of overlay or other operations that would obliterate the centerline marking to ensure correct placement of the zones.

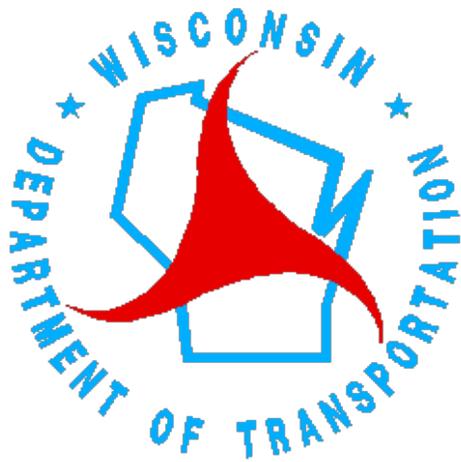
3.2.1 Same Day Marking

Same day marking (on the centerline) is required when the marking is obliterated or following paving. If weather or pavement conditions preclude same day application, contact the Region Traffic Staff for guidance in delineating the travel lanes. Apply centerlines and no-passing barrier lines within 14 days as soon as conditions allow.

R X R

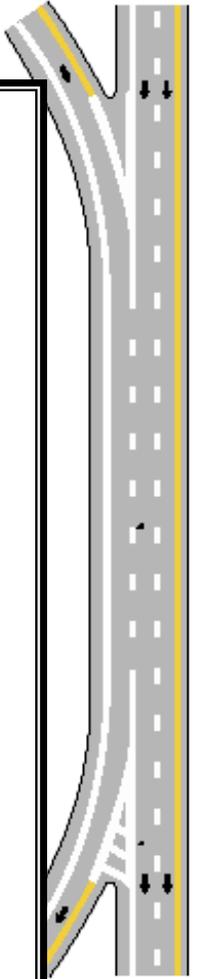
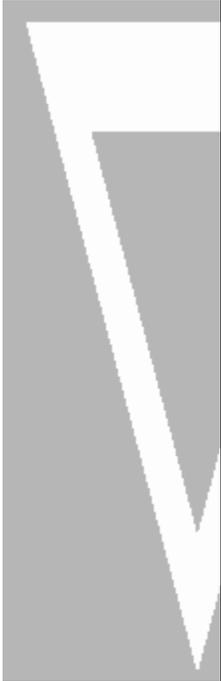
SECTION 4

**STANDARD
DETAIL
DRAWINGS**



January 2014 Edition

ONLY

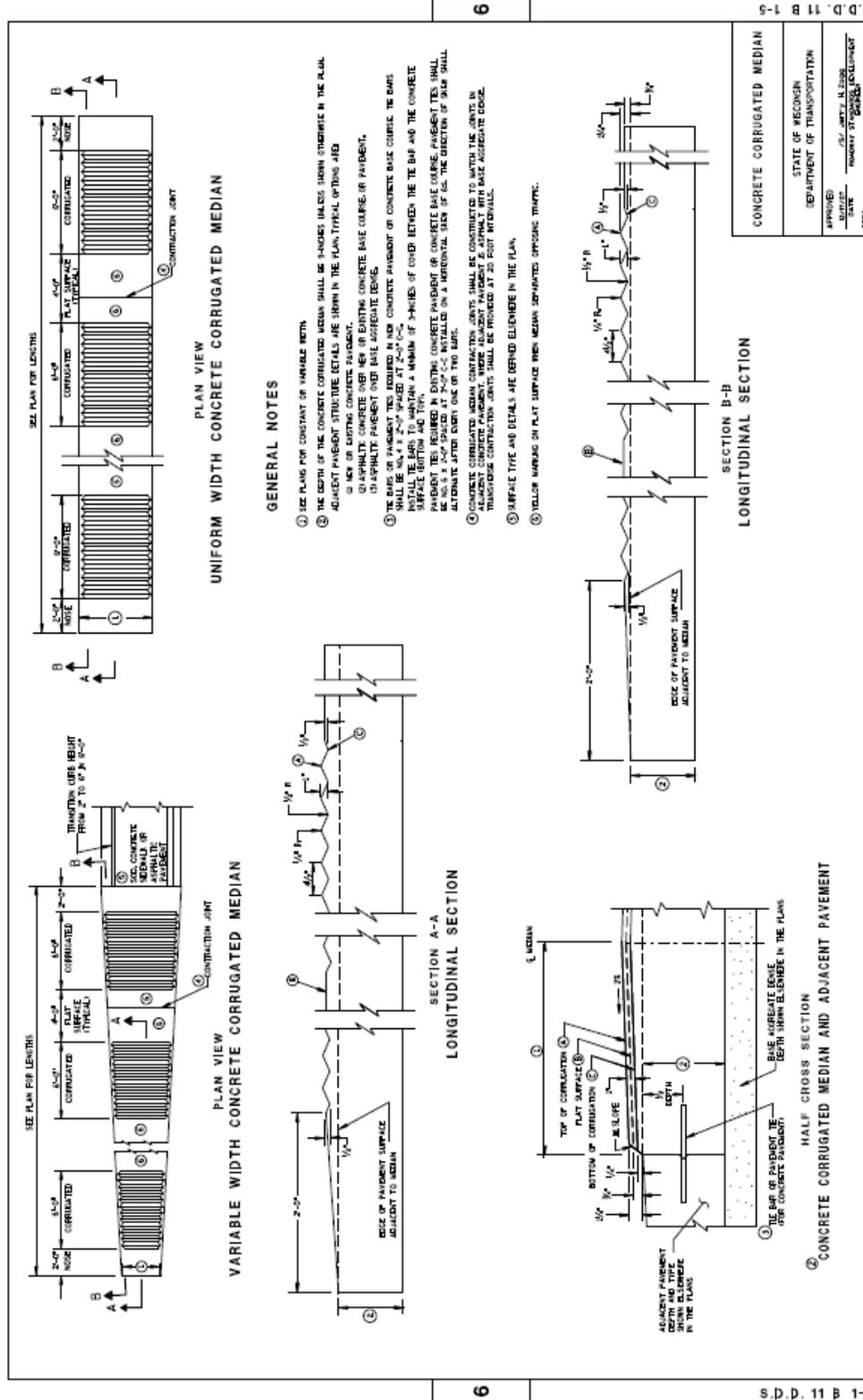


SECTION 4 – STANDARD DETAIL DRAWINGS

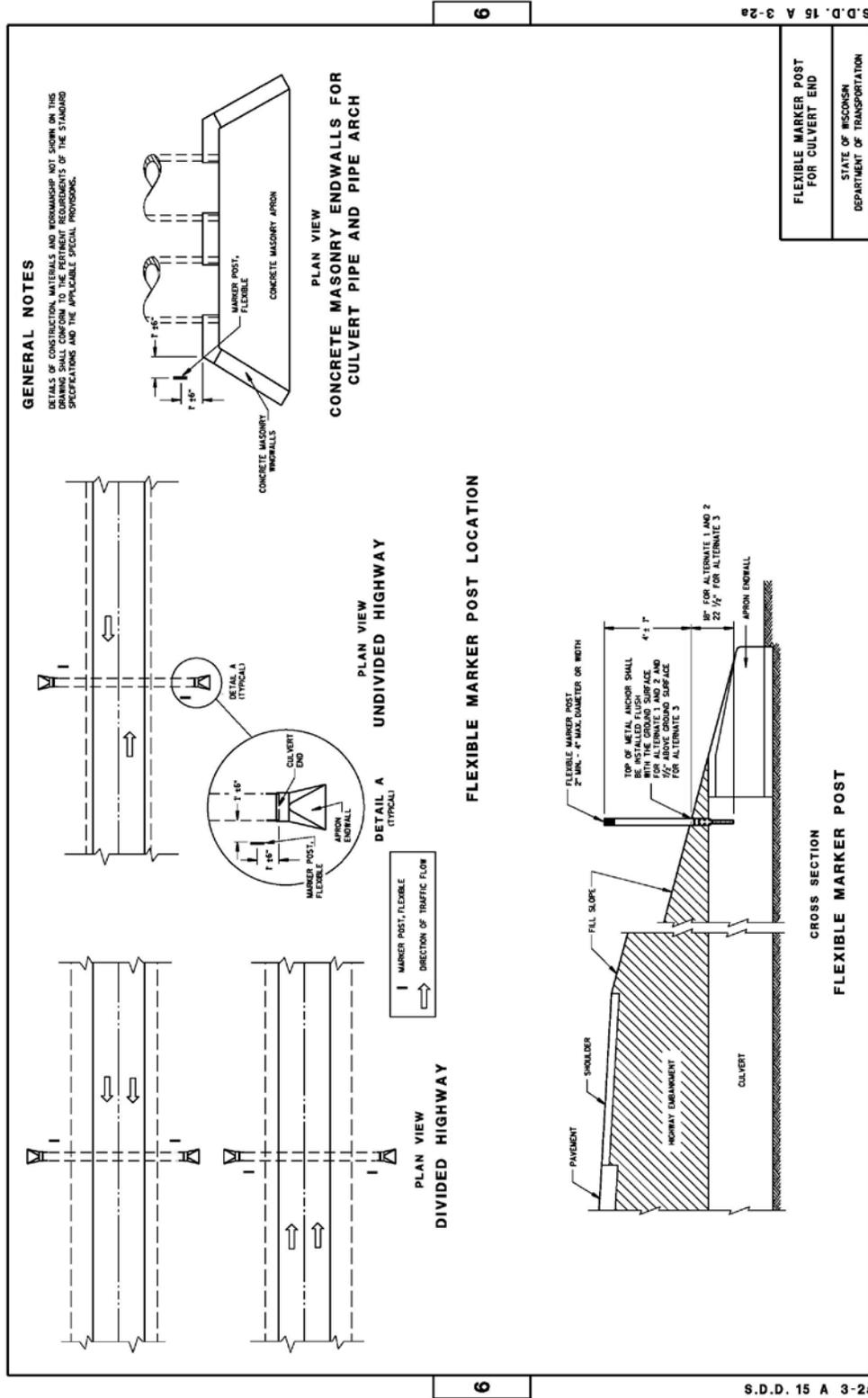
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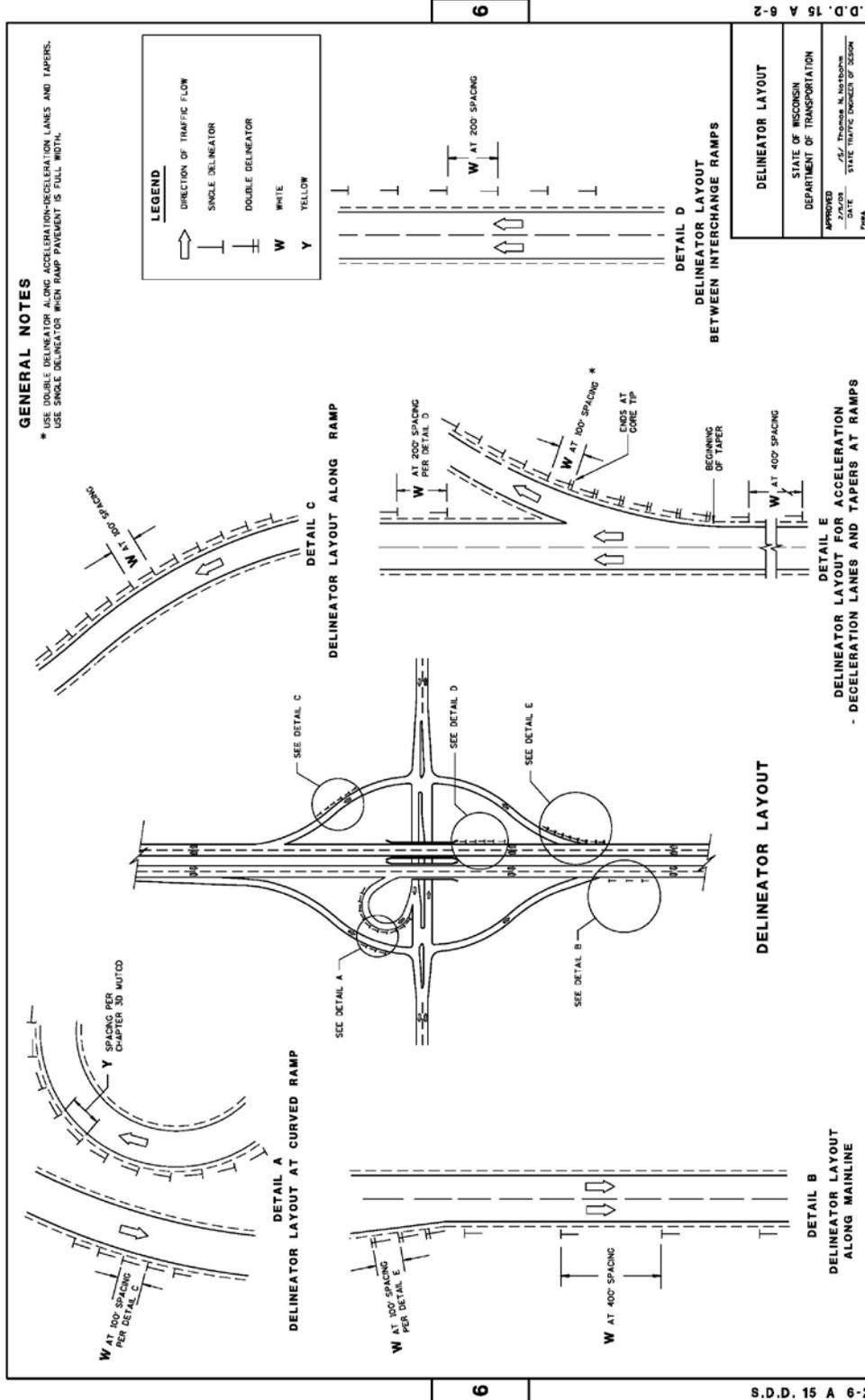
4.1 SDD 11B 1-5 - CONCRETE CORRUGATED MEDIAN



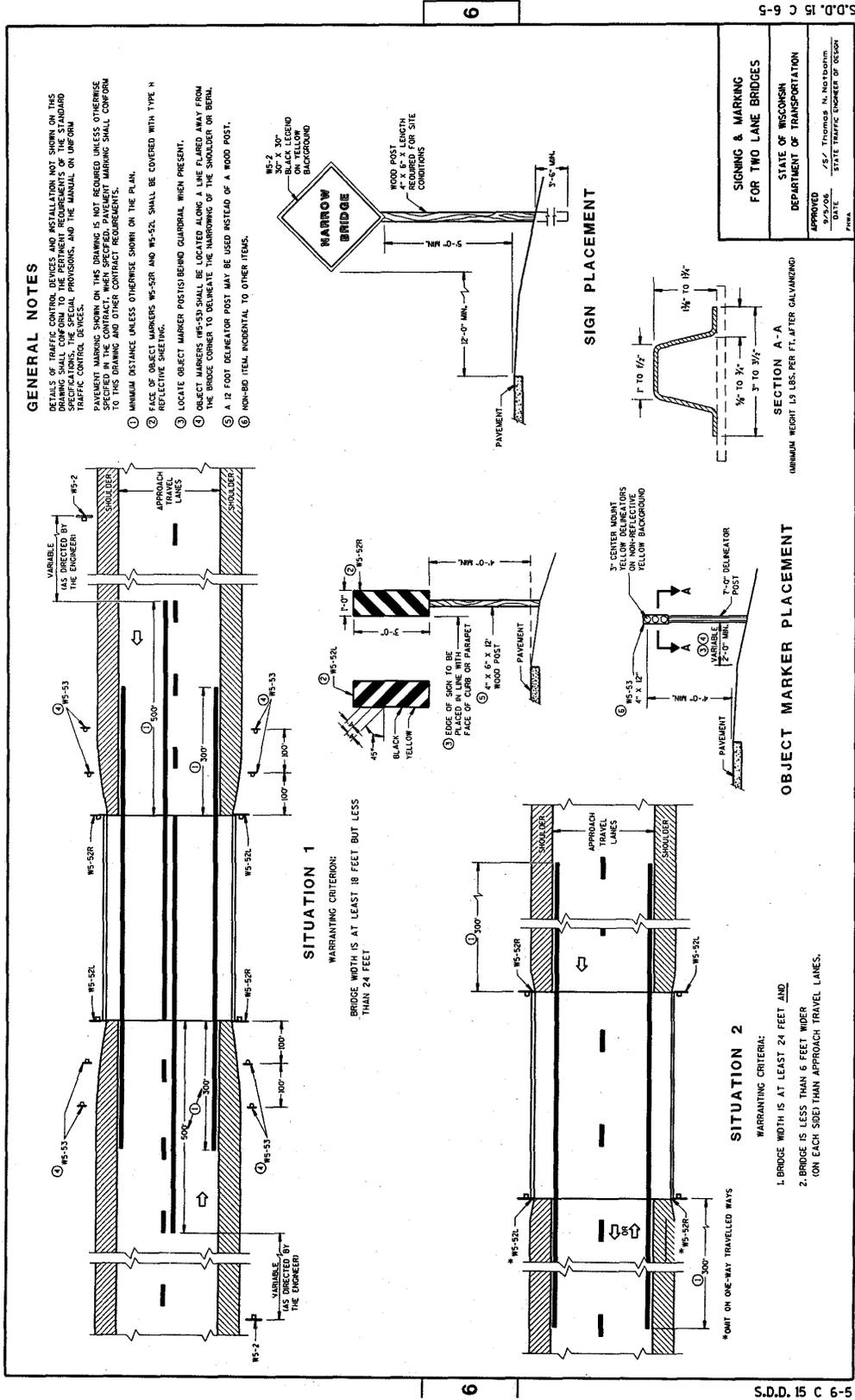
4.3 SDD 15A03-02A - FLEXIBLE MARKER POST FOR CULVERT END



4.6 SDD 15A06-02 - DELINEATOR LAYOUT



4.7 SDD 15C 6-5 - SIGNING & MARKING FOR TWO LANE BRIDGES

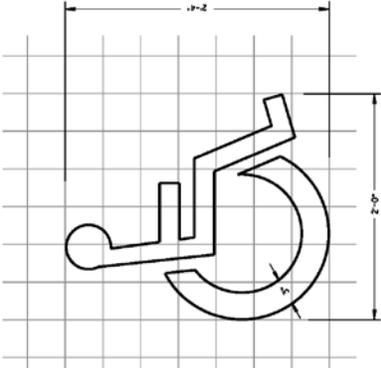


S.D.D. 15 C 6-5

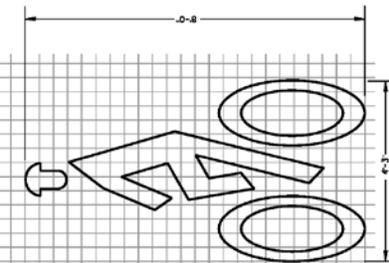
S.D.D. 15 C 6-5

4.8 SDD 15C 7-12a - PAVEMENT MARKING SYMBOLS

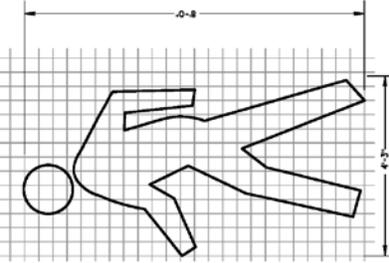
GENERAL NOTES
 DETAILS OF INSTALLATION, MATERIALS AND WORKMANSHIP NOT SHOWN ON THIS DRAWING SHALL CONFORM TO THE PERTINENT REQUIREMENTS OF THE STANDARD SPECIFICATIONS AND APPLICABLE SPECIAL PROVISIONS.
 ALL LETTERS, ARROWS AND SYMBOLS SHALL BE IN CONFORMANCE WITH REQUIREMENTS INCLUDED IN "STANDARD ALPHABETS FOR HIGHWAY SIGNS AND PAVEMENT MARKING" BOOK BY THE FEDERAL BUREAU OF SURVEYING AND MAPPING, WASHINGTON, D.C. 20540. DIMENSIONS FOR REFLECTORIZED SMALL DIFFERENCES IN DIMENSIONS WITHIN THE TOLERANCES OF THAT BOOK ARE ACCEPTABLE.
 A DETAILED DRAWING OF THE HANDICAPPED PARKING SYMBOL IS ILLUSTRATED IN THE "STANDARD HIGHWAY SIGNS MANUAL" BY THE FEDERAL HIGHWAY ADMINISTRATION.



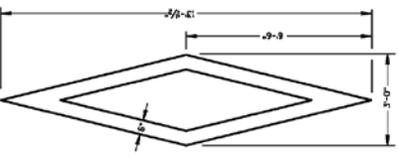
HANDICAPPED PARKING SYMBOL



BIKE CROSSING SYMBOL



PEDESTRIAN SYMBOL



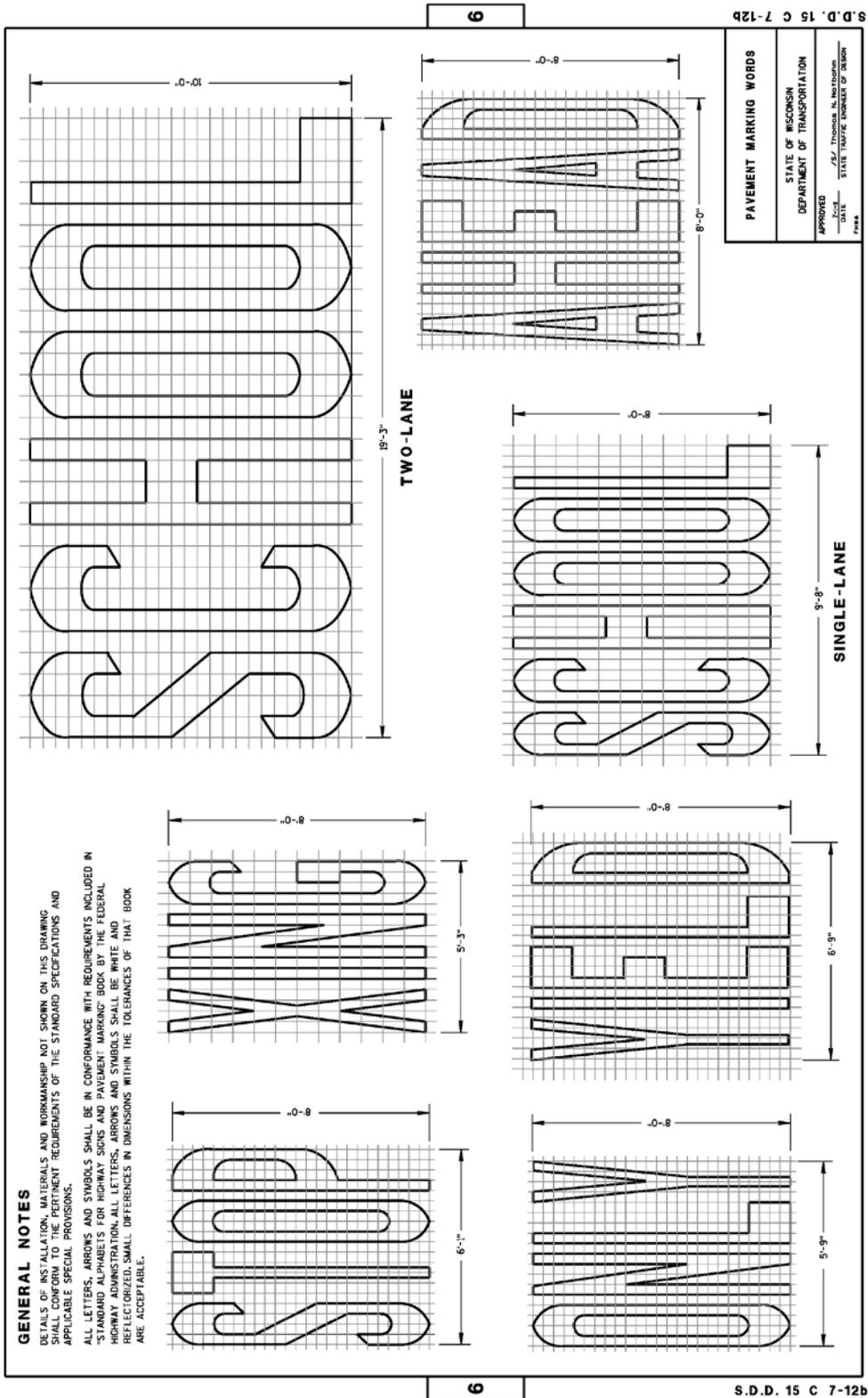
PREFERENTIAL LANE SYMBOL

6

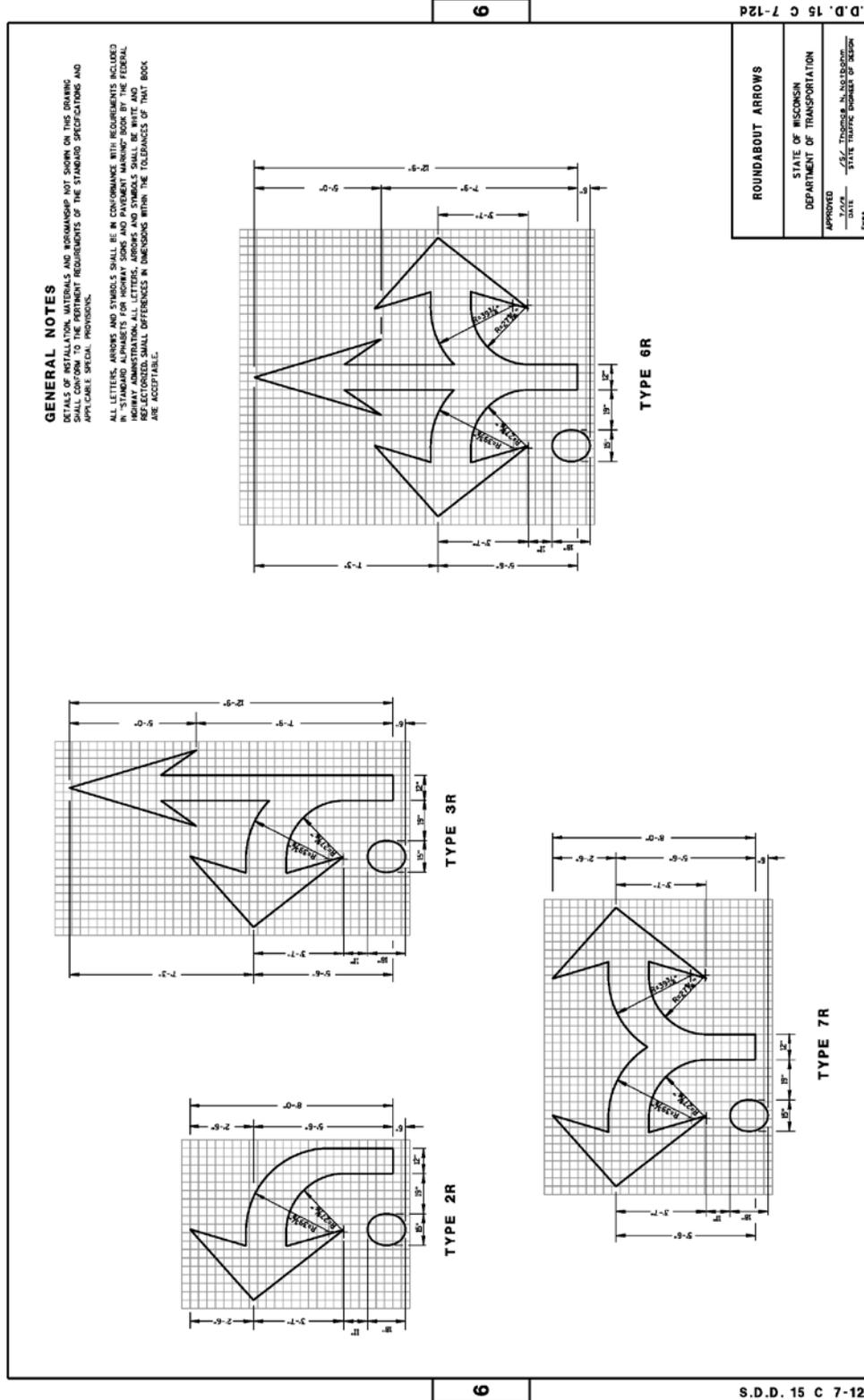
S.D.D. 15 C 7-12a

PAVEMENT MARKING SYMBOLS	
STATE OF WISCONSIN DEPARTMENT OF TRANSPORTATION	
APPROVED _____ DATE _____	THOMAS A. HATCHERSON STATE TRAFFIC ENGINEER OF WISCONSIN
S.D.D. 15 C 7-12a	Form 4

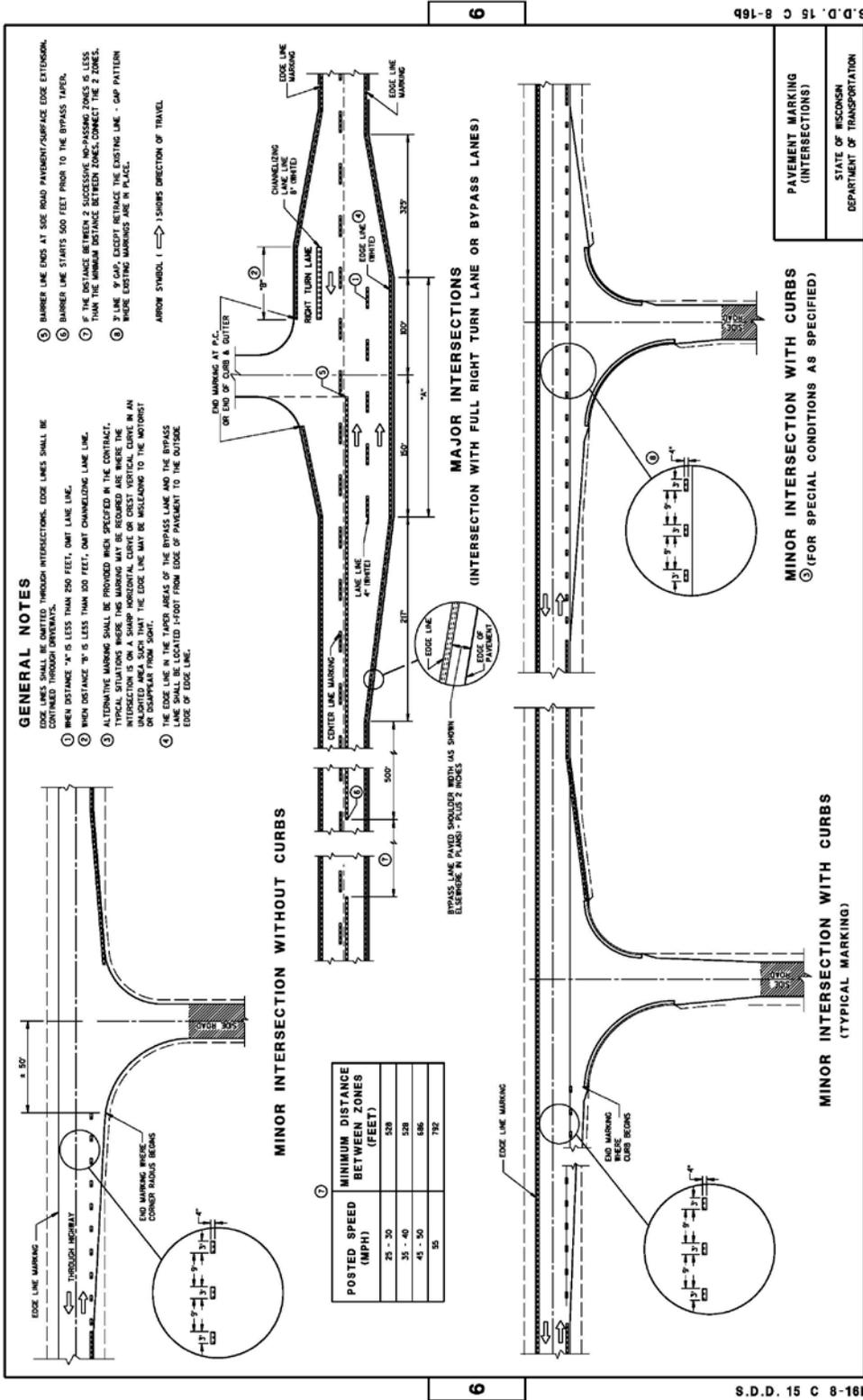
4.9 SDD 15C 7-12b - PAVEMENT MARKING WORDS



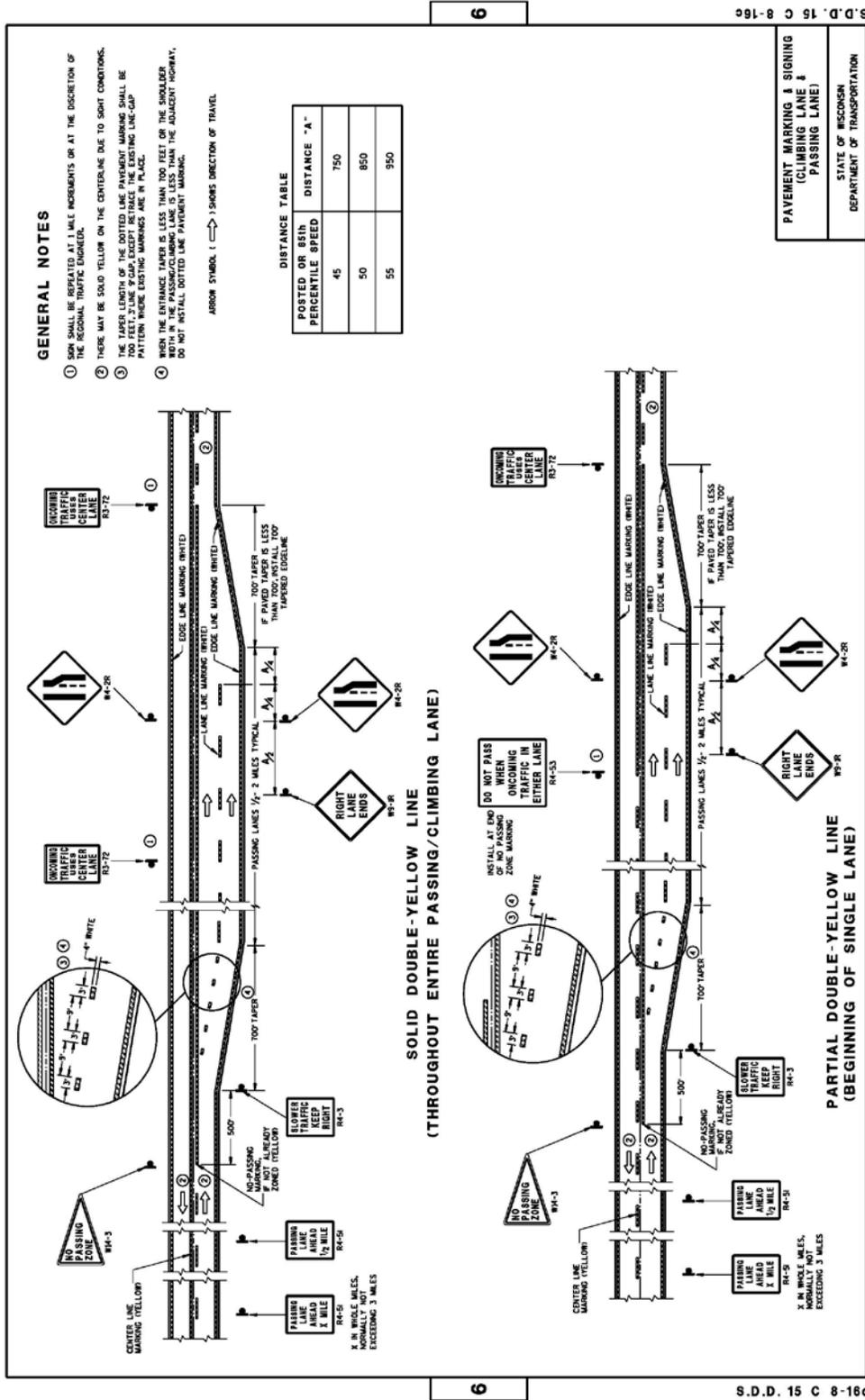
4.11 SDD 15C 7-12d ROUNDABOUT ARROWS



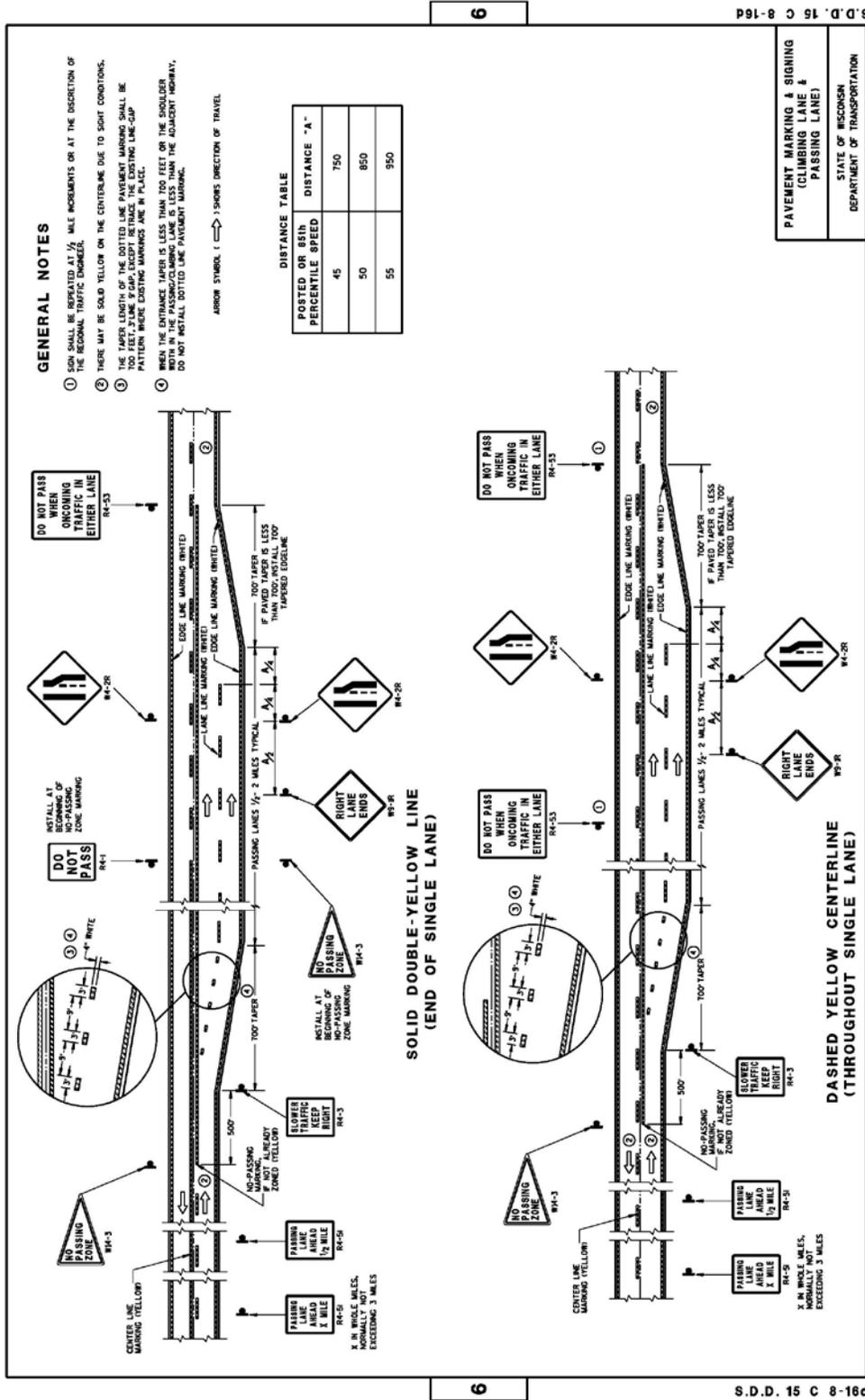
4.13 SDD 15C 8-16b - PAVEMENT MARKING (INTERSECTIONS)



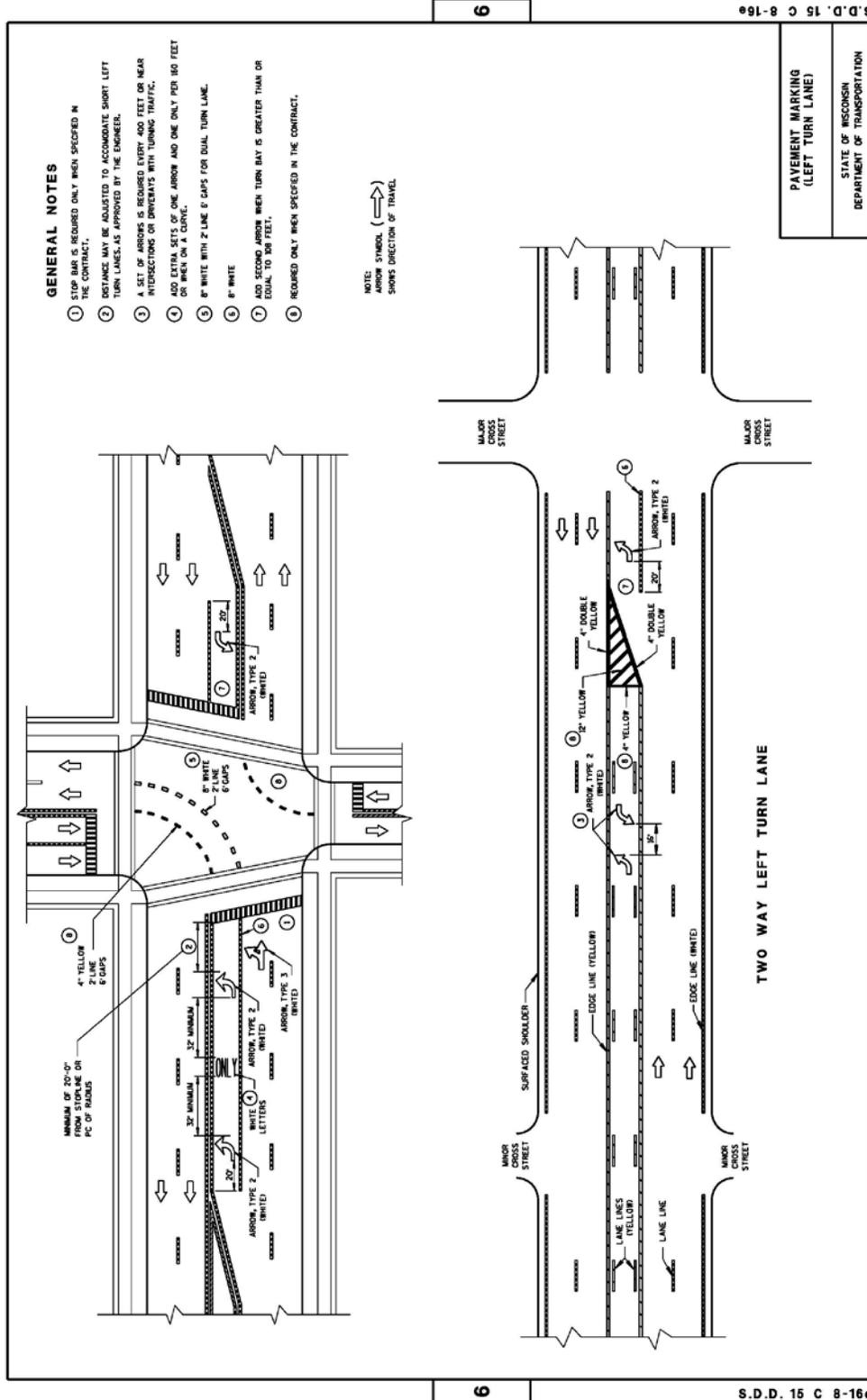
4.14 SDD 15C 8-16c - PAVEMENT MARKING (CLIMBING LANE & PASSING LANE)



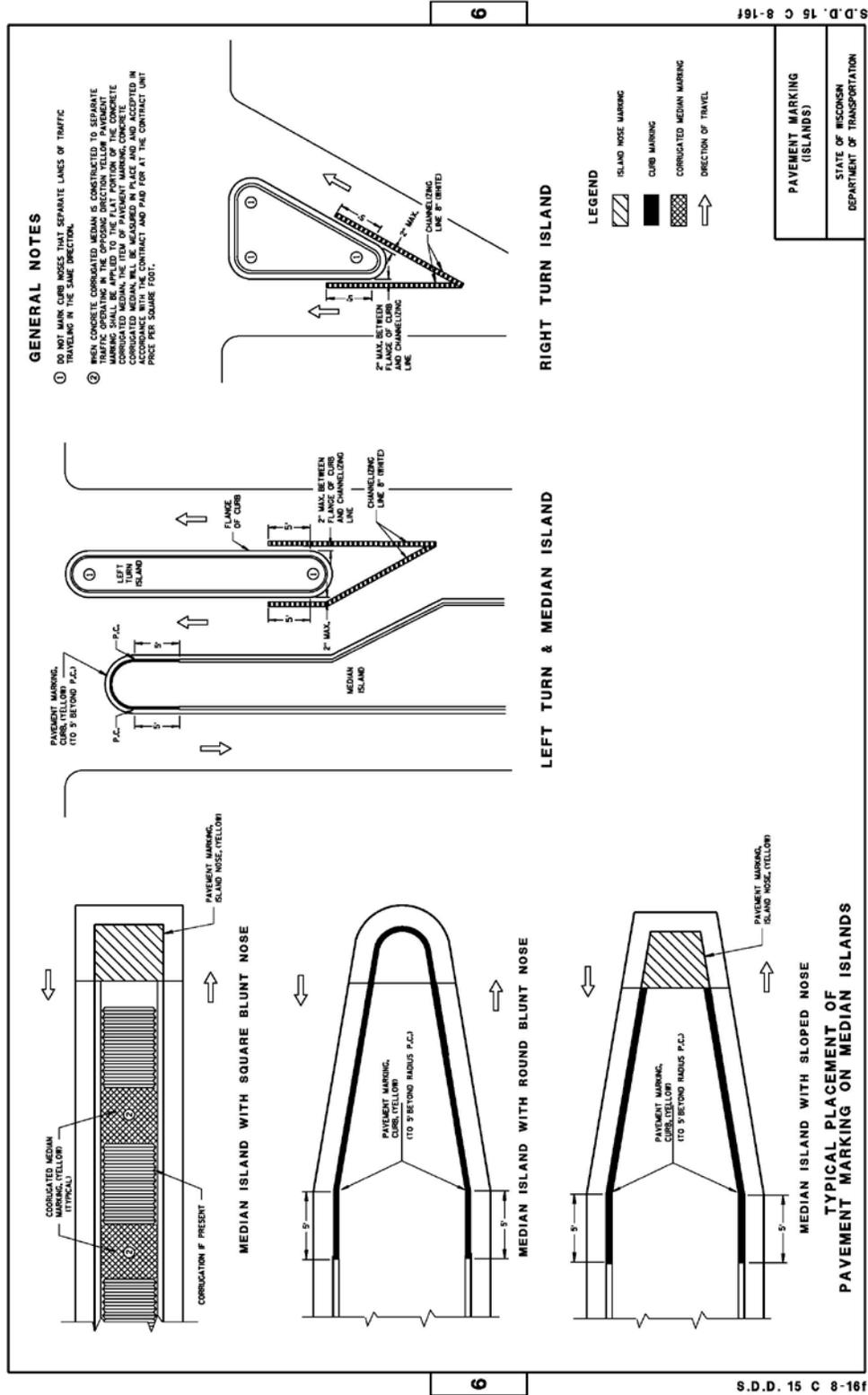
4.15 SDD 15C 8-16d - PAVEMENT MARKING (CLIMBING LANE & PASSING LANE)



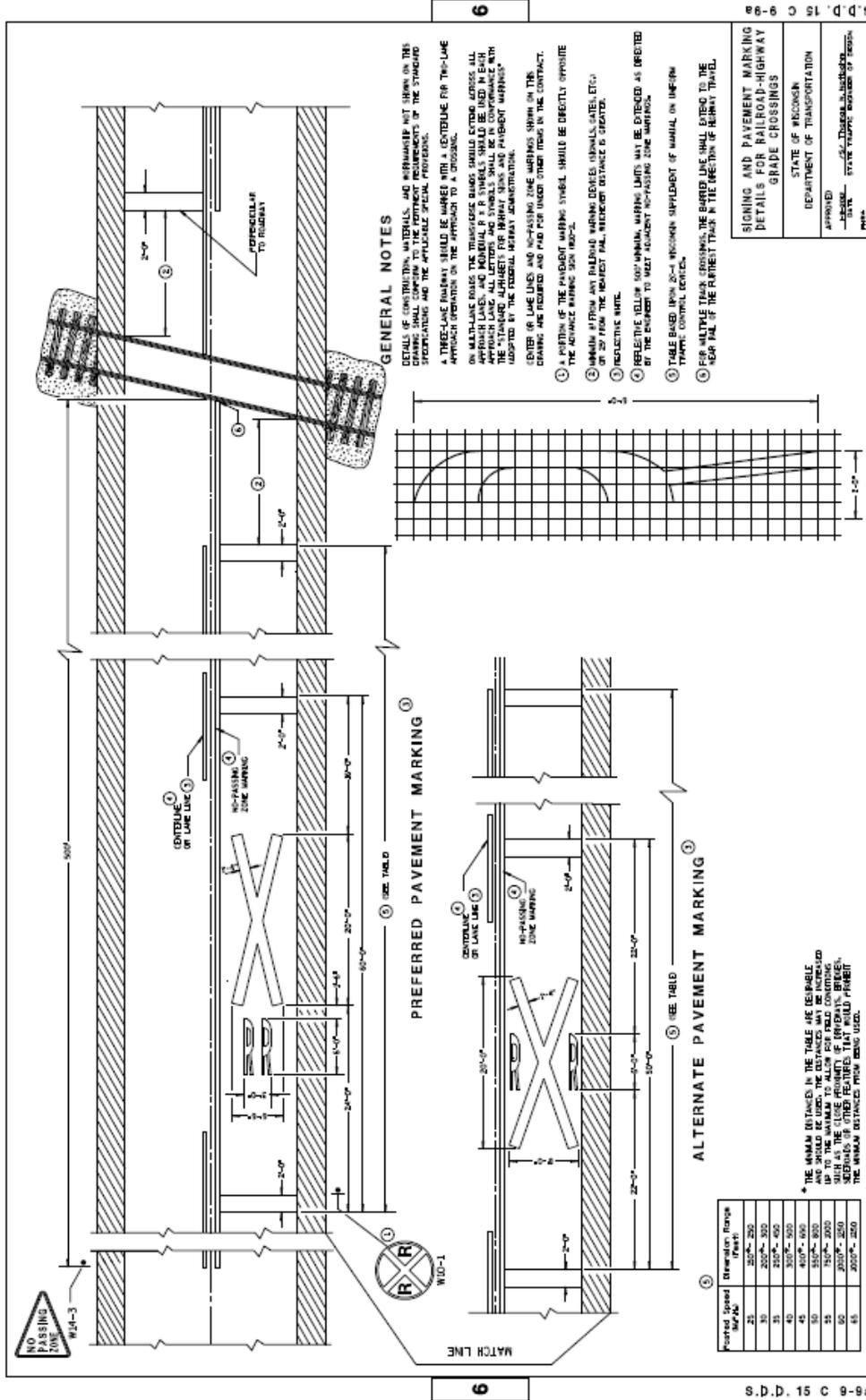
4.16 SDD 15C 8-16e - PAVEMENT MARKING (LEFT TURN LANE)



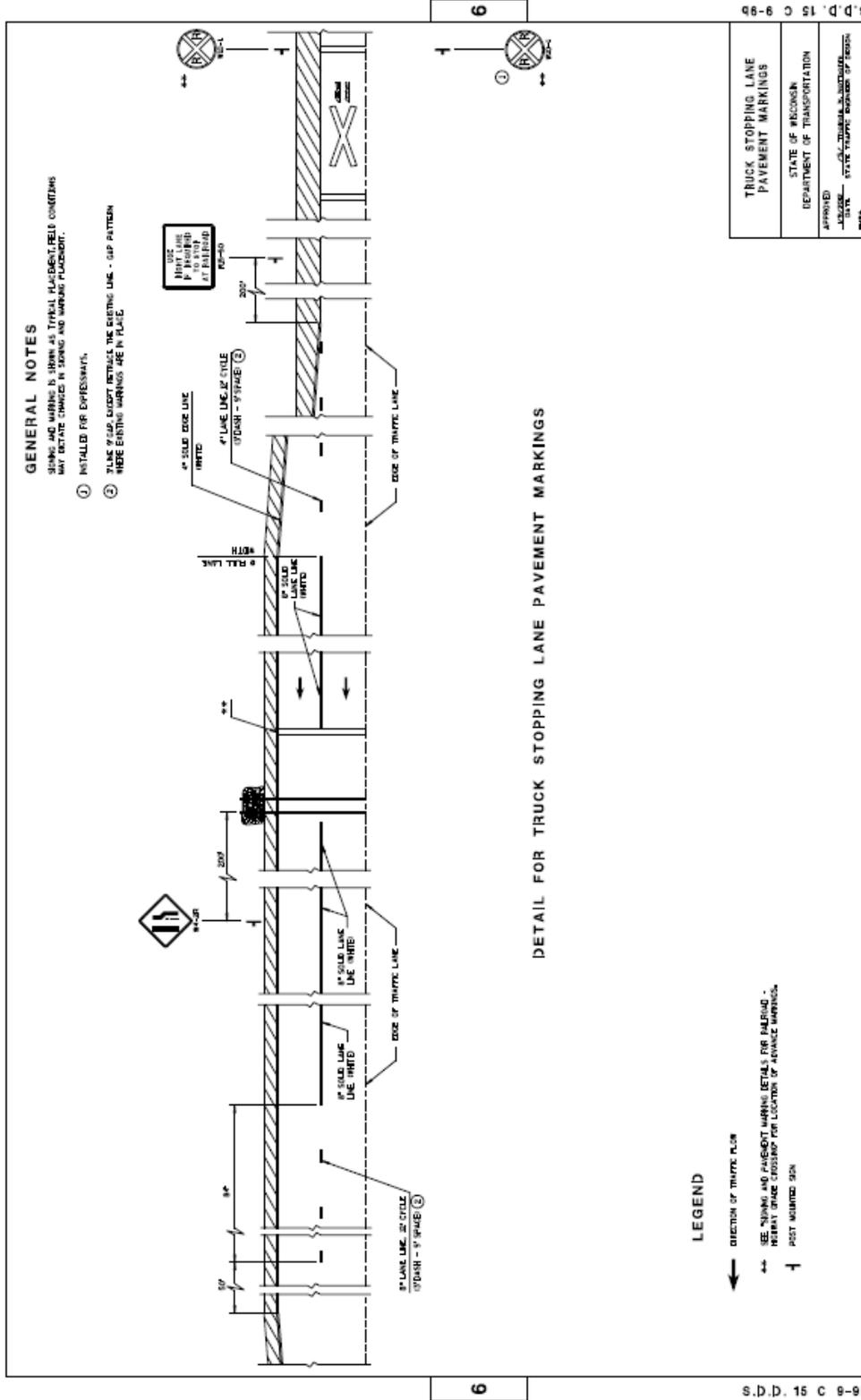
4.17 SDD 15C 8-16f- PAVEMENT MARKING (ISLANDS)



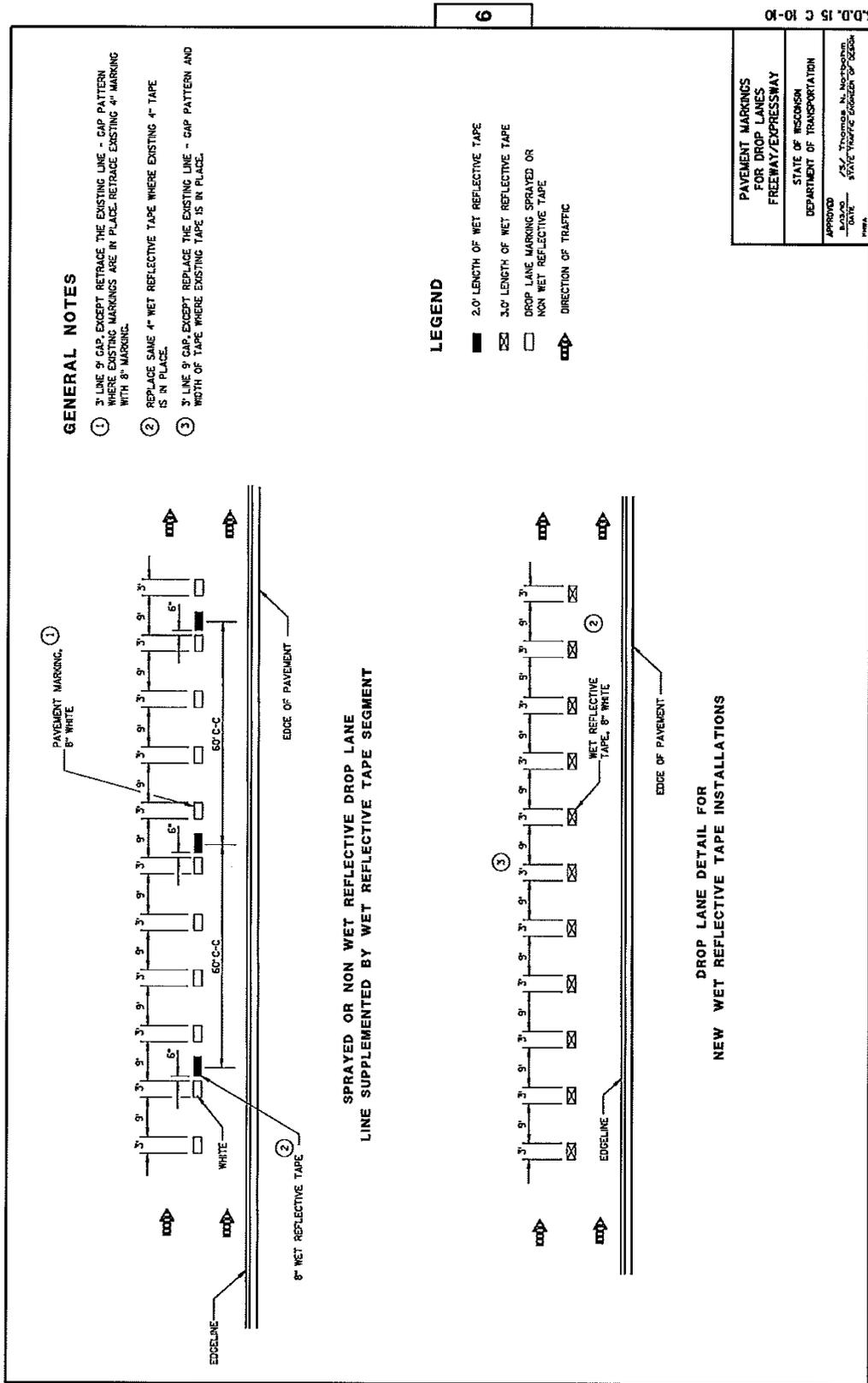
4.18 SDD 15C 9-9a - SIGNING & PAVEMENT MARKING DETAILS FOR RAILROAD-HIGHWAY GRADE



4.19 SDD 15C 9-9b – TRUCK STOPPING LANE PAVEMENT MARKINGS



4.20 SDD 15C 10-10 – PAVEMENT MARKING FOR DROP LANES



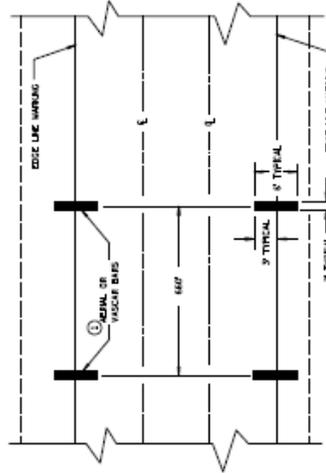
S.D.D. 15 C 10-10

S.D.D. 15 C 10-10

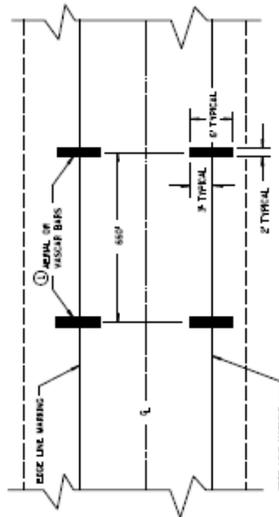
4.21 SDD 15C 14-1 – AERIAL ENFORCEMENT BARS

GENERAL NOTES

- 1 NUMBER OF VASCAR OR AERIAL BARS SHALL BE A MINIMUM OF 2 OR A MAXIMUM OF 5 AT EACH POINT.
- 2 CUR CAN BE PROVIDED BY THE REGIONAL STATE PATROL FOR TRAFFIC CONTROL.



TYPICAL FOR MULTILANE TRAFFIC



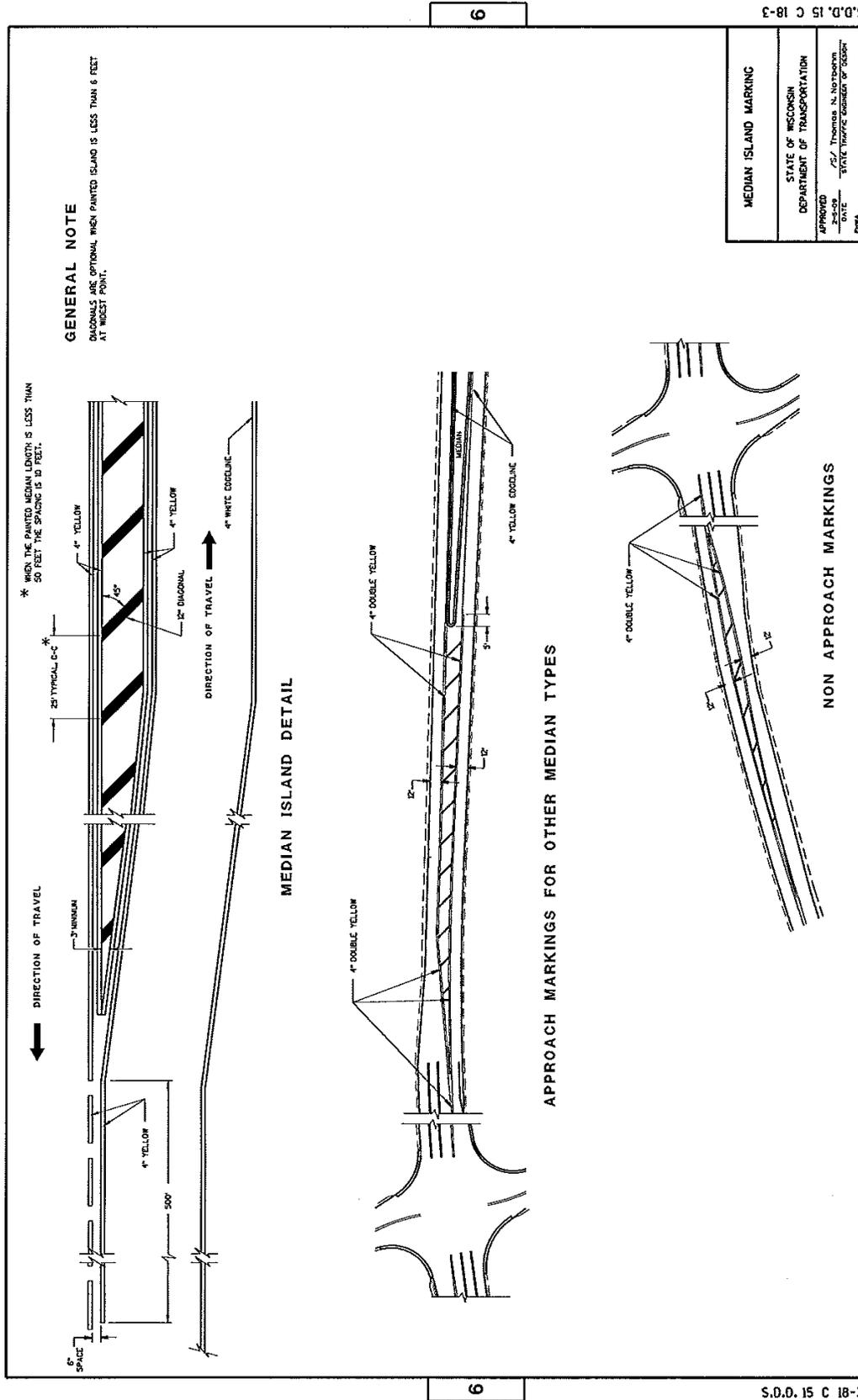
TYPICAL FOR TWO WAY OR ONE WAY TRAFFIC

SPEED ENFORCEMENT ZONE WITH AERIAL OR VASCAR BARS

AERIAL ENFORCEMENT BARS PAYMENT MARKING DETAILS	
STATE OF MICHIGAN	
DEPARTMENT OF TRANSPORTATION	
APPROVED	
DRAWN	
CHECKED	
DATE	
S.D.D. 15 C 14-1	

S.D.D. 15 C 14-1

4.22 SDD 15C 18-3 – MEDIAN ISLAND MARKINGS



MEDIAN ISLAND MARKING
STATE OF WISCONSIN DEPARTMENT OF TRANSPORTATION
APPROVED DATE 7/27 Thomas N. Harboern BY STATE TRAFFIC DIVISION OF DODP P.004

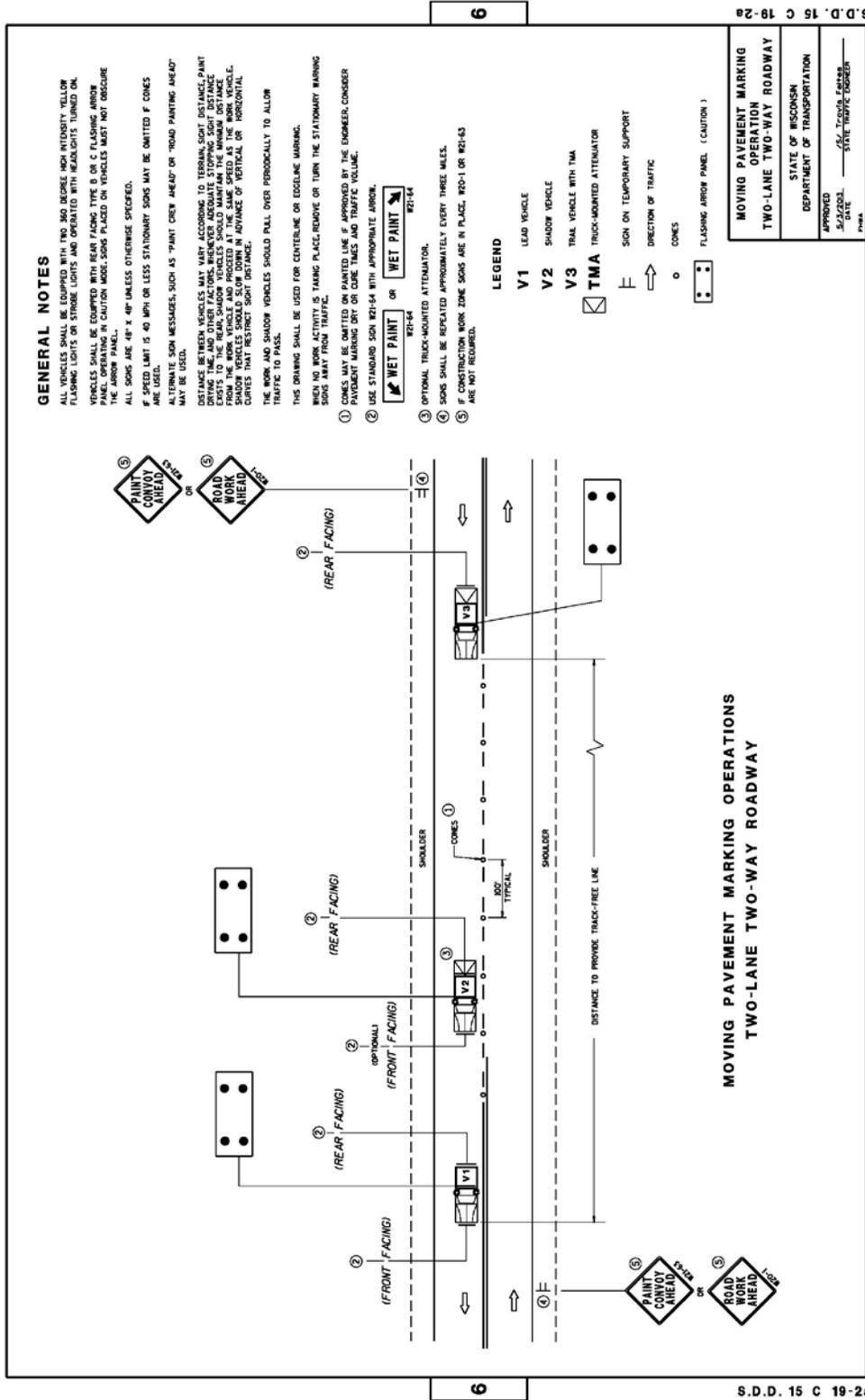
S.D.O. 15 C 18-3

S.D.O. 15 C 18-3

6

6

4.23 SDD 15C 19-2a –MOVING PAVEMENT MARKING OPERATIONS – TWO – LANE TWO – WAY ROADWAY

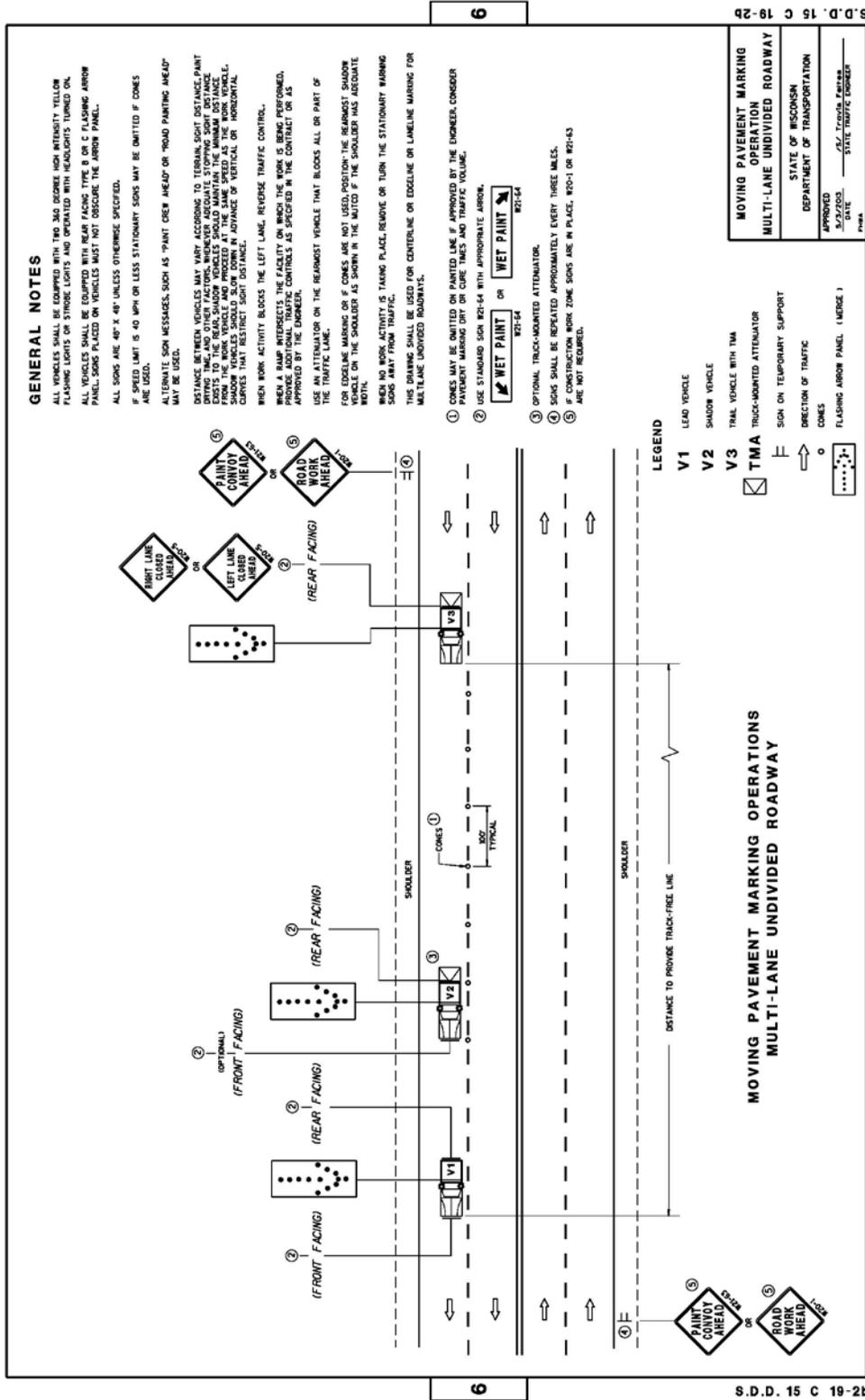


S.D.D. 15 C 19-2a

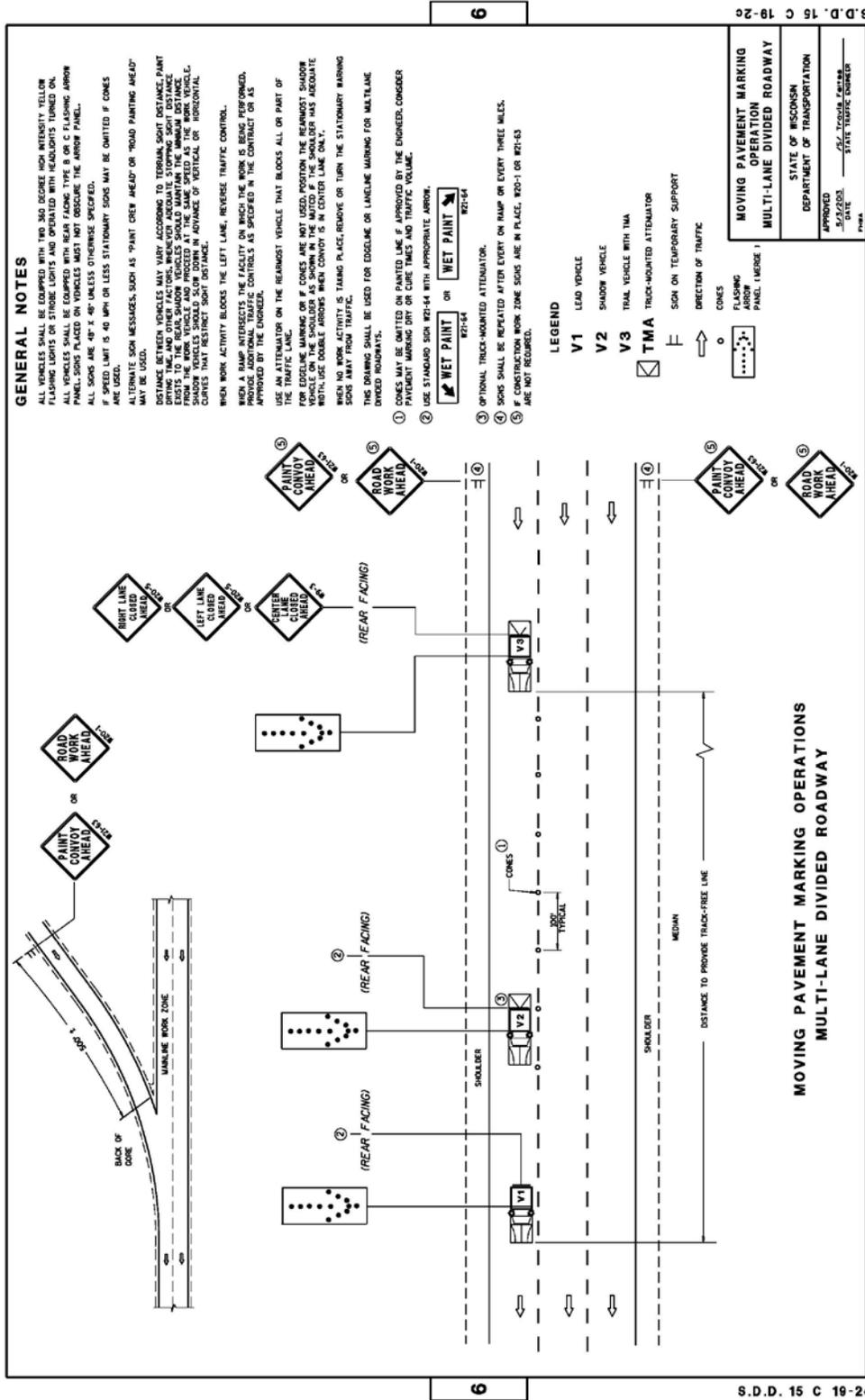
MOVING PAVEMENT MARKING OPERATIONS TWO-LANE TWO-WAY ROADWAY

S.D.D. 15 C 19-2a

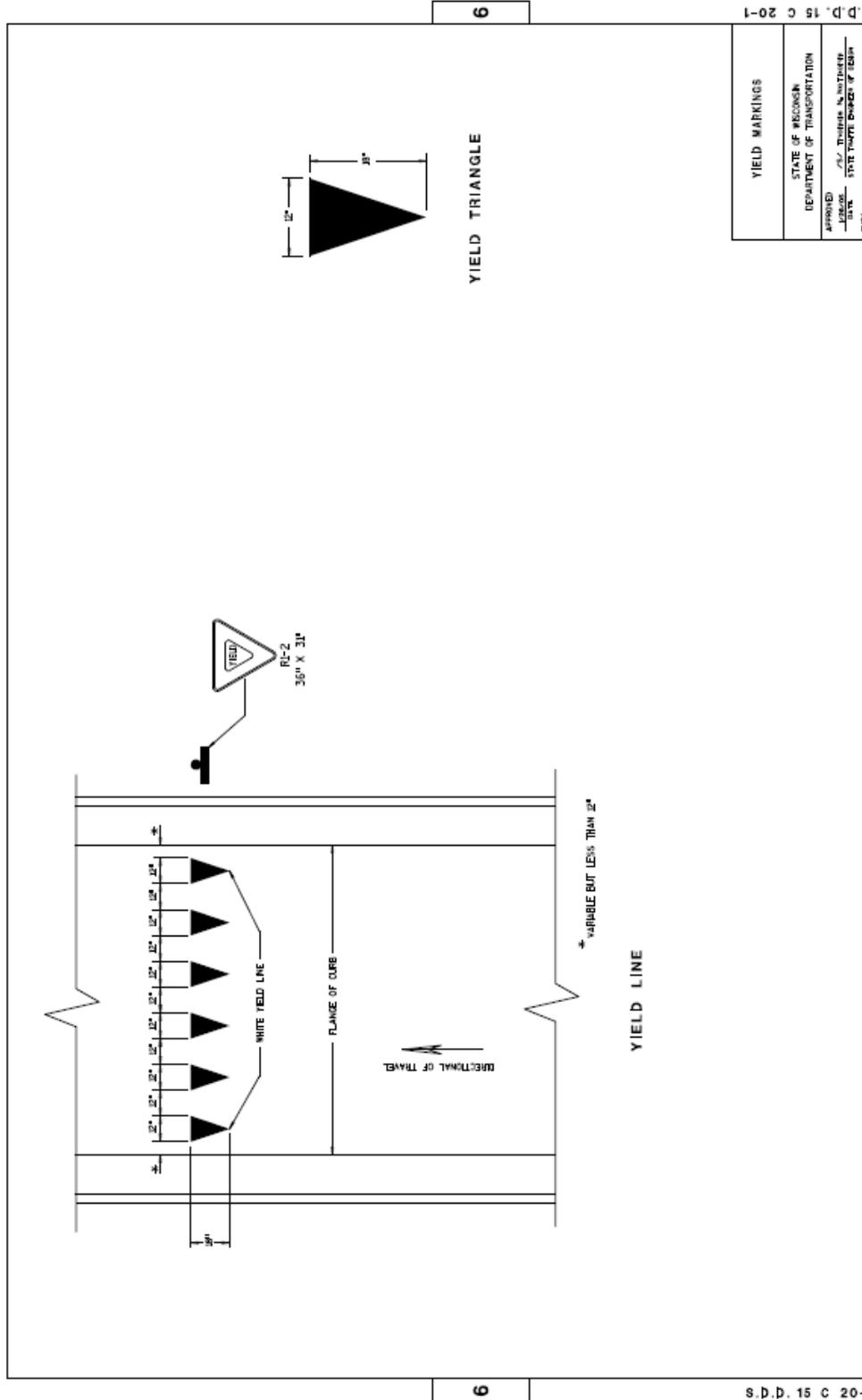
4.24 SDD 15C 19-2b – MOVING PAVEMENT MARKING OPERATIONS – MULTI – LANE UNDIVIDED ROADWAY



4.25 SDD 15C 19-2c - MOVING PAVEMENT MARKING OPERATIONS - MULTI-LANE DIVIDED ROADWAY



4.26 SDD 15C 20-1 – YIELD MARKING



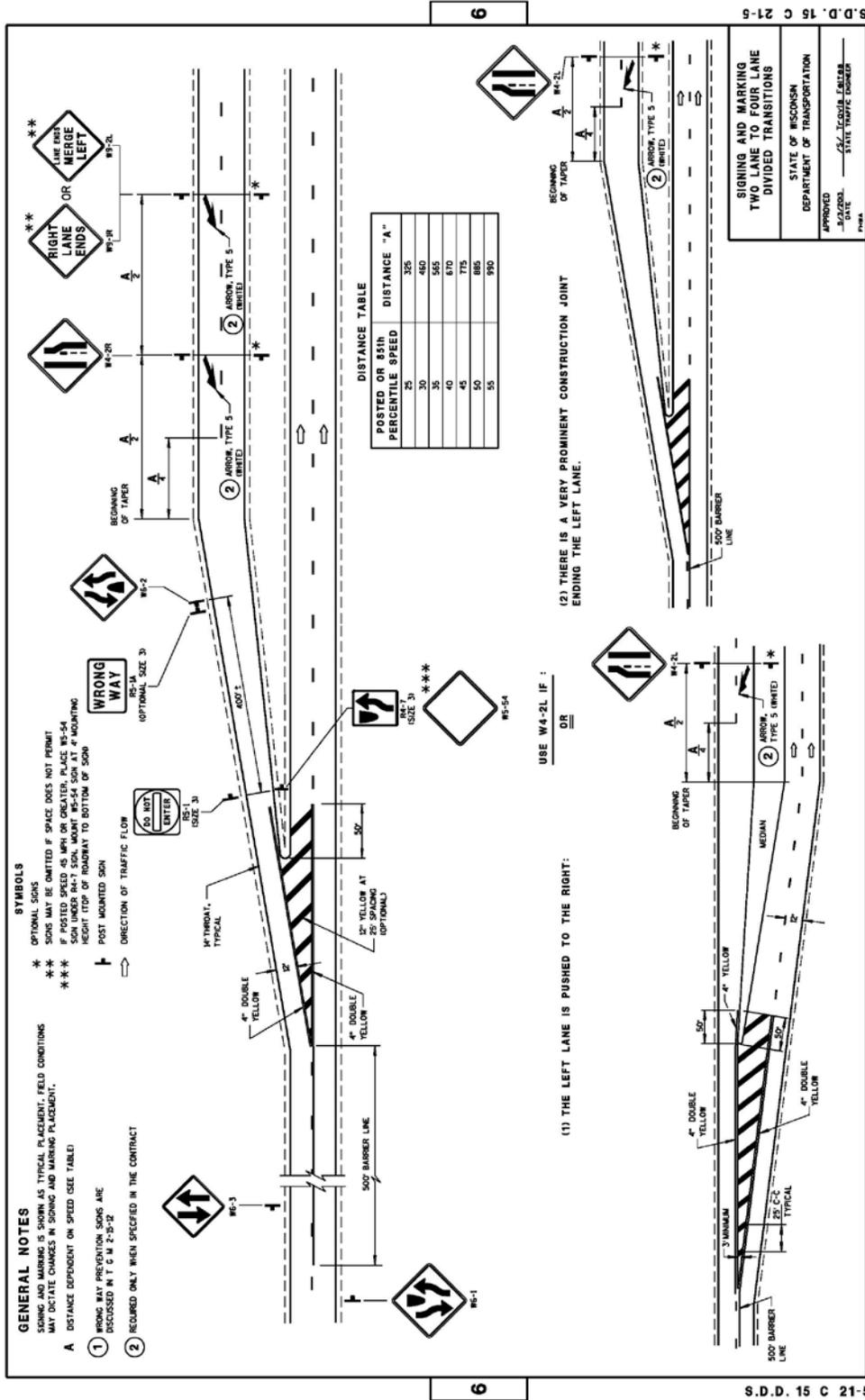
6

6

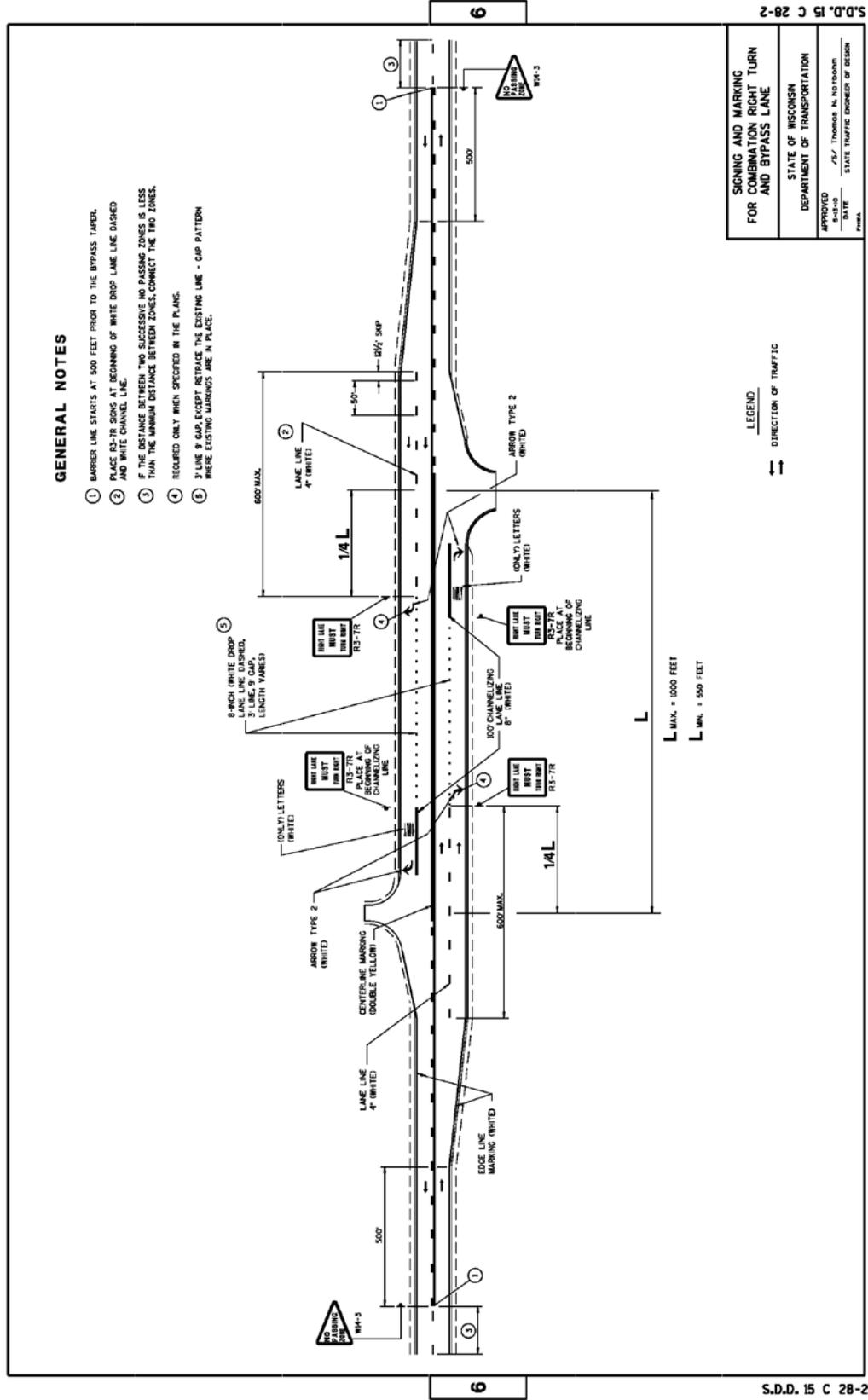
YIELD MARKINGS
STATE OF WISCONSIN DEPARTMENT OF TRANSPORTATION
APPROVED DATE: _____ BY: _____ FOR THE DIRECTOR OF TRANSPORTATION

S.D.D. 15 C 20-1

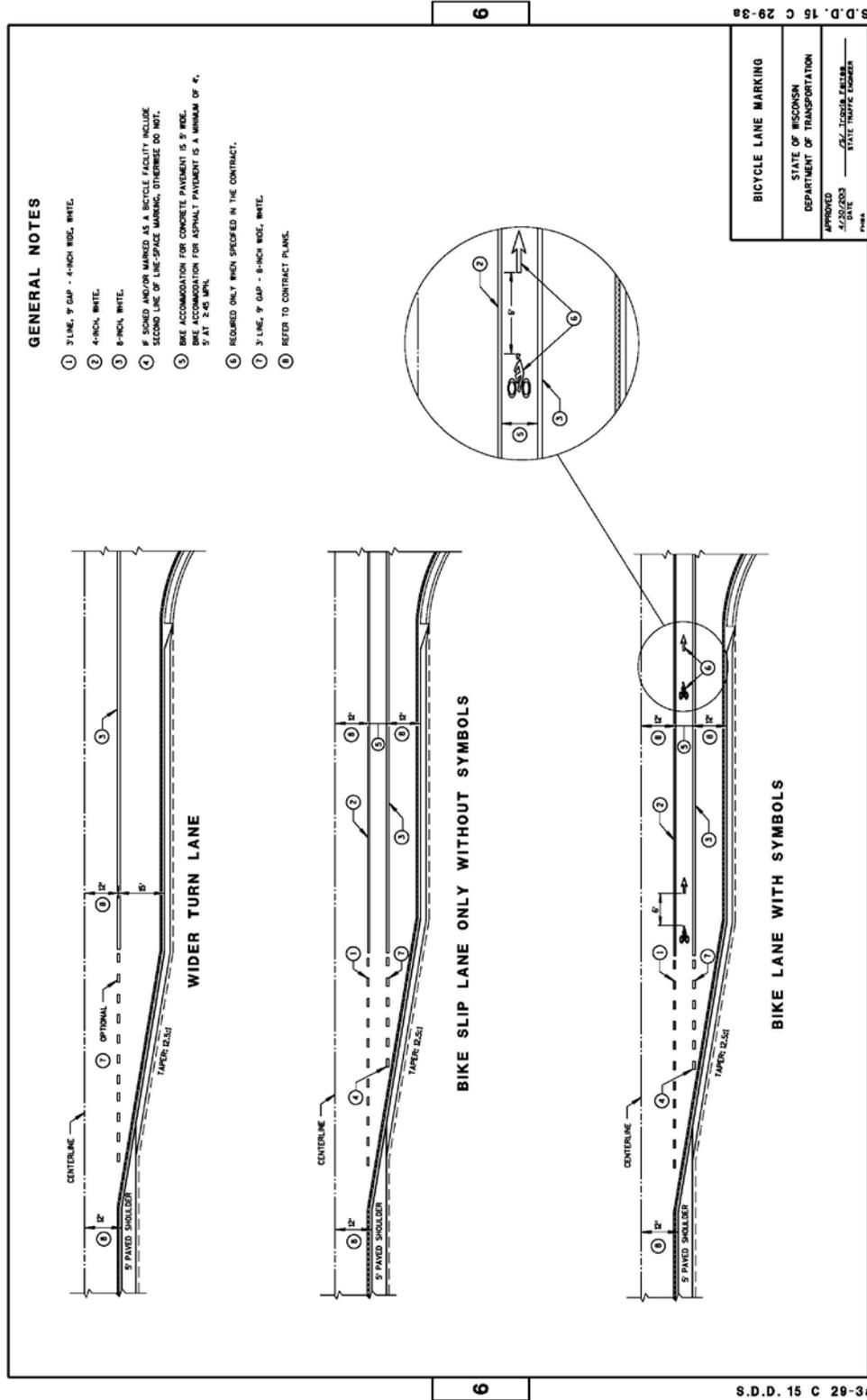
4.27 SDD 15C 21-5 – SIGNING & MARKING FOR TWO-LANE TO FOUR-LANE DIVIDED TRANSITION



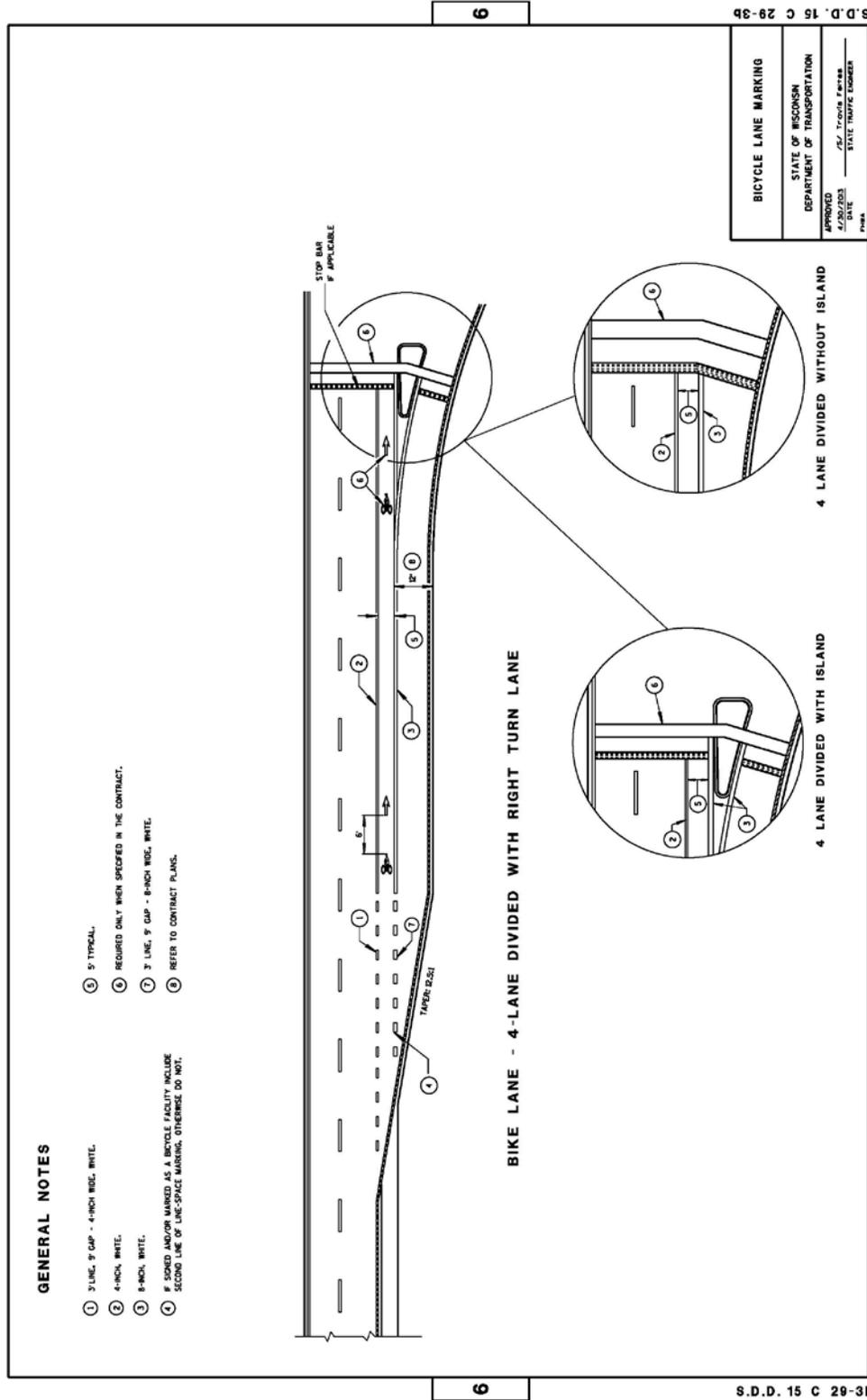
4.28 SDD 15C 28-2- SIGNING & MARKING FOR COMBINATION RIGHT TURN AND BYPASS



4.29 SDD 15C 29-3a – BICYCLE LANE MARKING

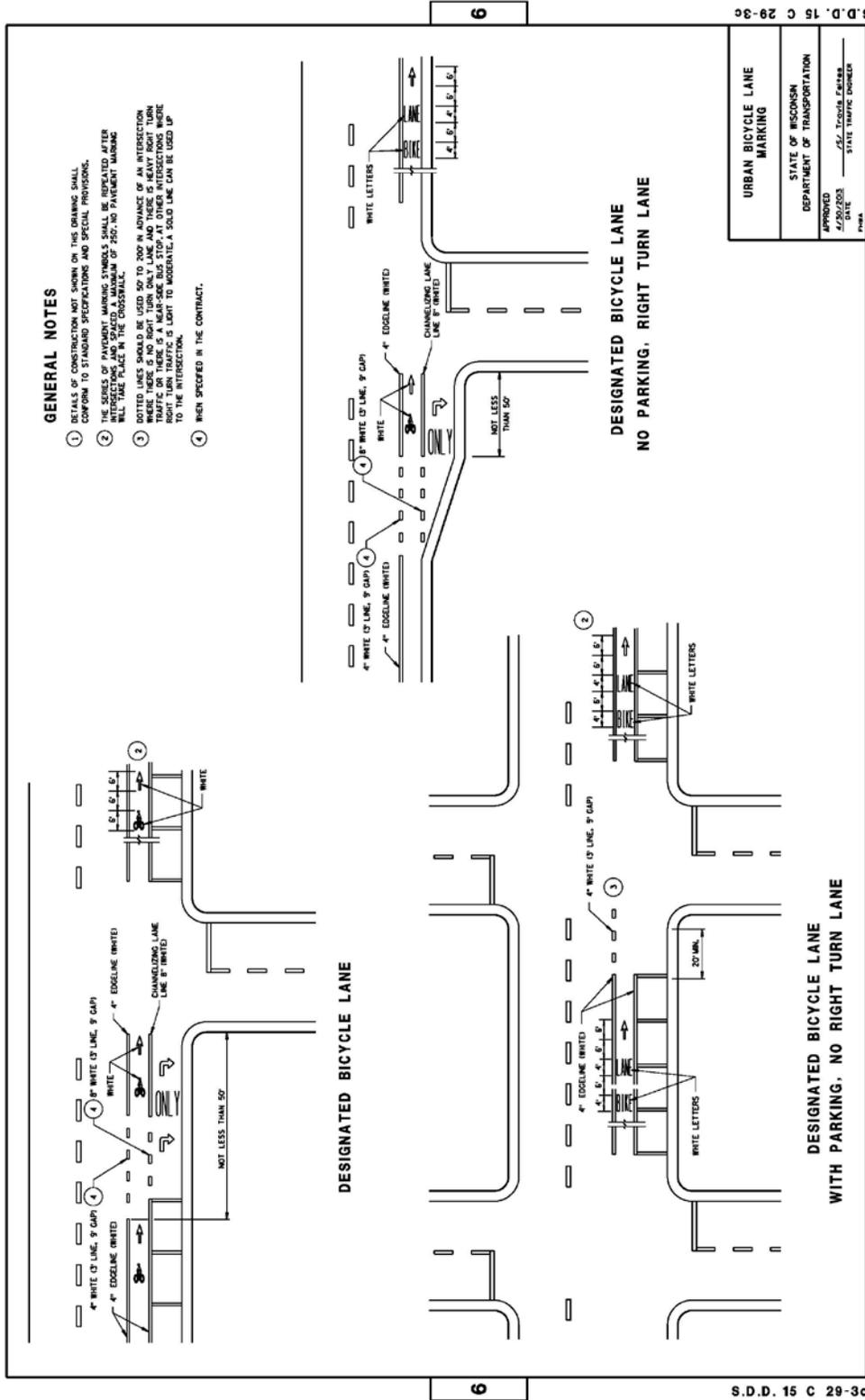


4.30 SDD 15C 29-3b - BICYCLE LANE MARKINGS



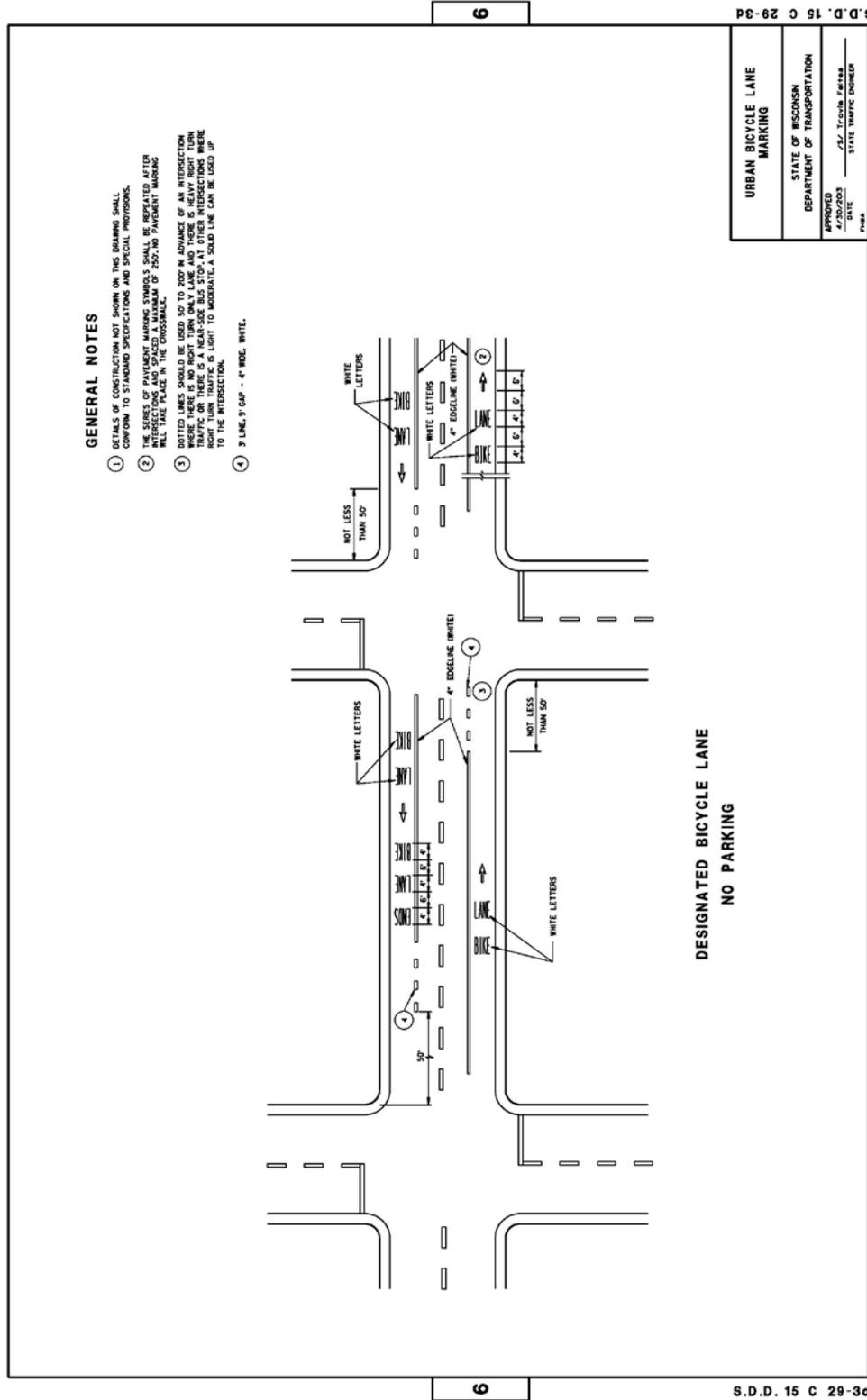
BICYCLE LANE MARKING
STATE OF WISCONSIN DEPARTMENT OF TRANSPORTATION
APPROVED DATE 4/20/2003
DESIGNED BY STATE TRAFFIC ENGINEER

4.31 SDD 15C 29-3c – URBAN BICYCLE LANE MARKING

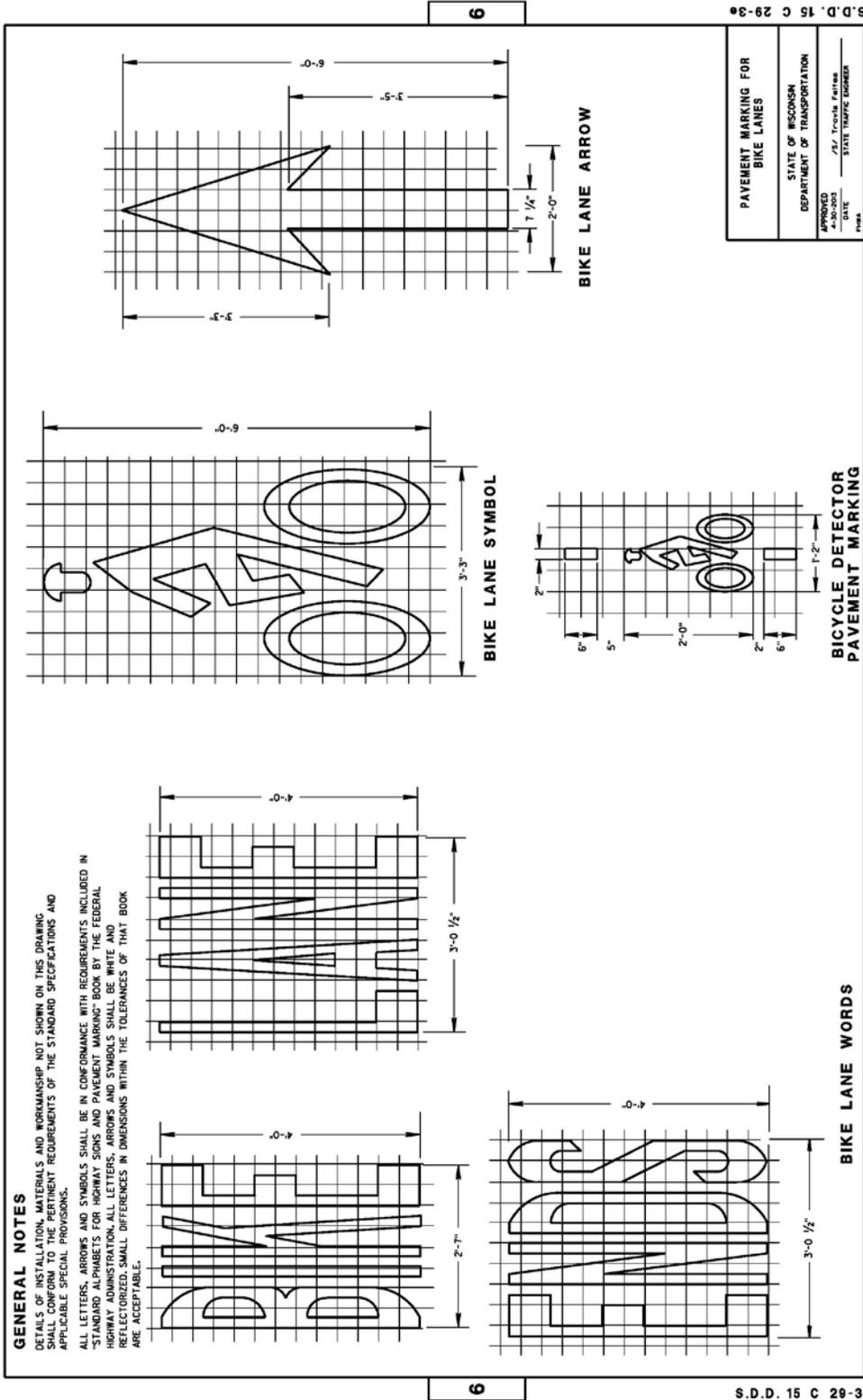


S.D.D. 15 C 29-3c
URBAN BICYCLE LANE MARKING
STATE OF WISCONSIN DEPARTMENT OF TRANSPORTATION
APPROVED: _____ DATE: 4/20/2003
DESIGNED BY: _____ STATE TRAFFIC ENGINEER
FIG. 4.31

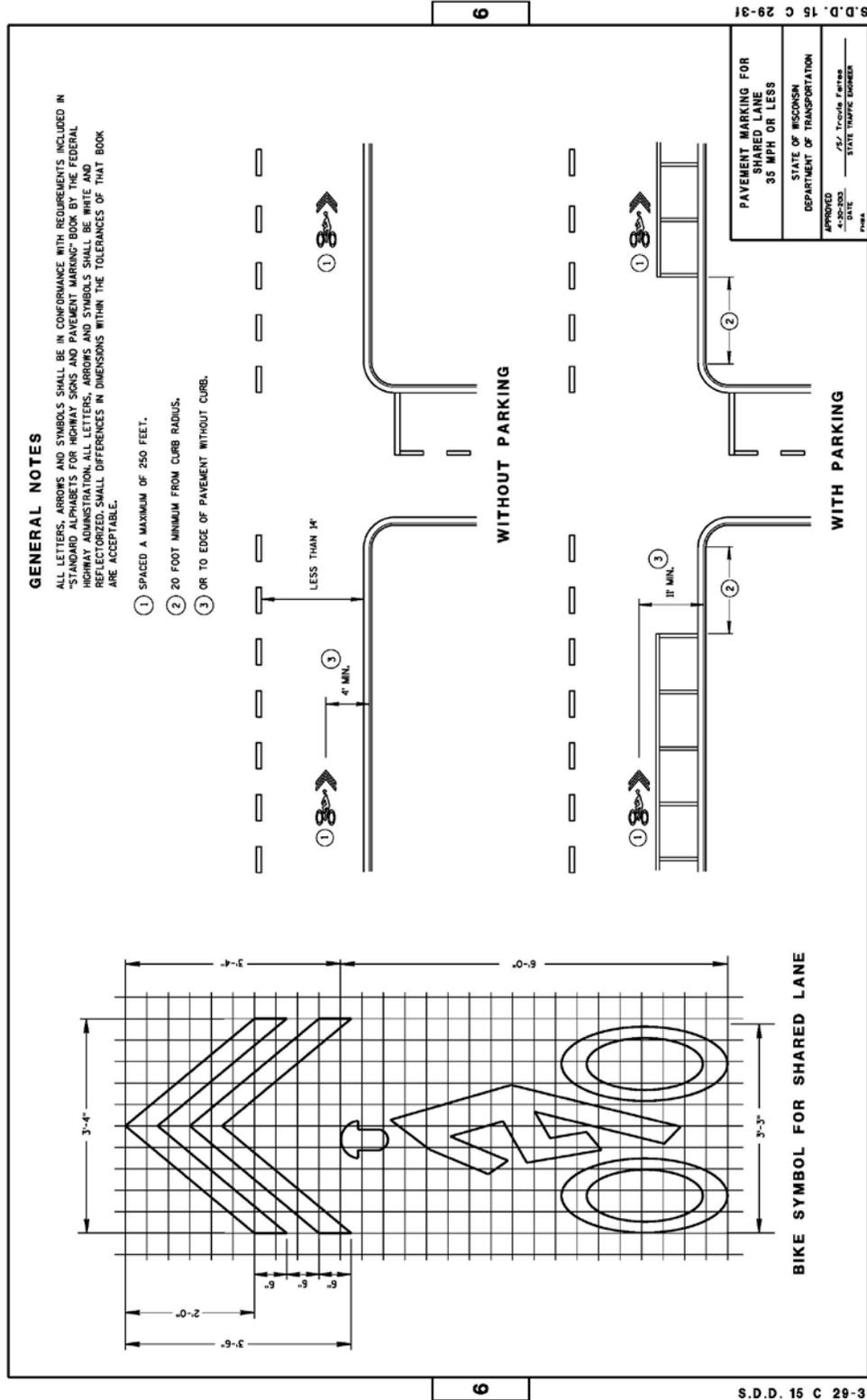
4.32 SDD 15C 29-3d – URBAN BICYCLE LANE MARKINGS



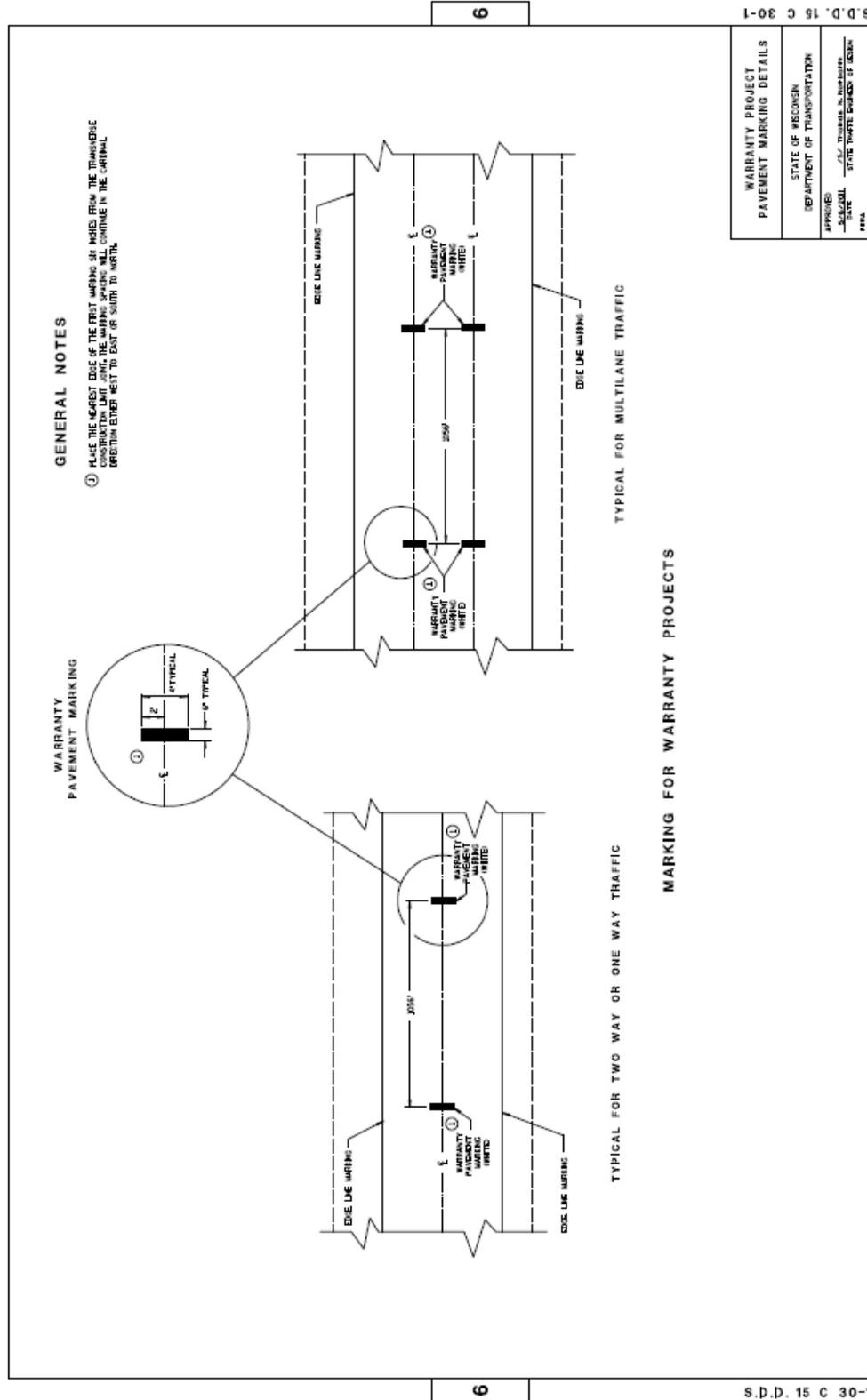
4.33 SDD 15C 29-3e – PAVEMENT MARKING FOR BIKE LANES



4.34 SDD 15C 29-3f – PAVEMENT MARKING FOR SHARED LANES



4.35 SDD 15C 30-1 – WARRANTY PROJECT PAVEMENT MARKING DETAILS

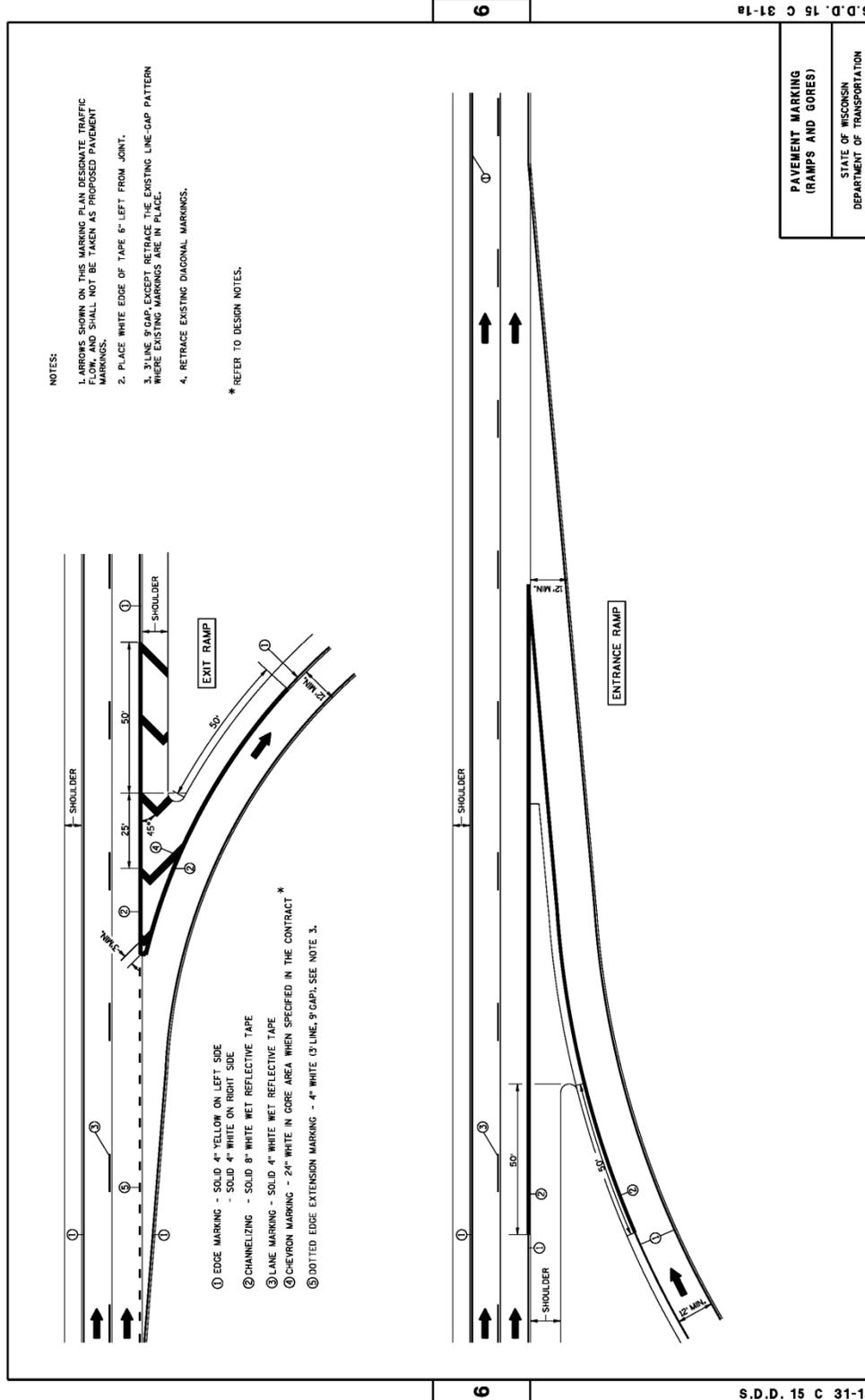


S.D.D. 15 C 30-1

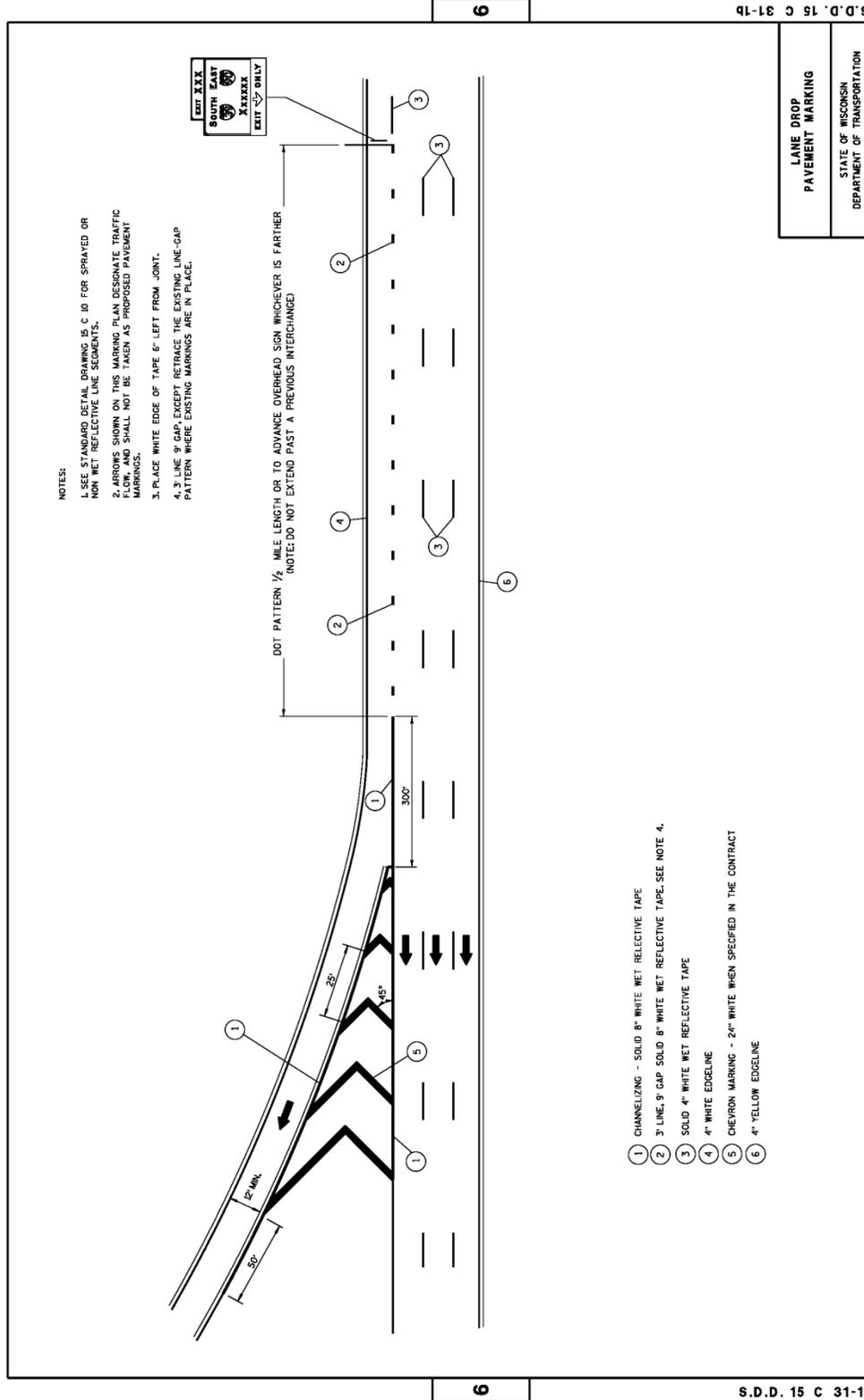
WARRANTY PROJECT PAVEMENT MARKING DETAILS
STATE OF WISCONSIN DEPARTMENT OF TRANSPORTATION
APPROVED: J. SAVAL STATE TRAFFIC ENGINEER OF DESIGN
DATE: 1/14/14

S.D.D. 15 C 30-1

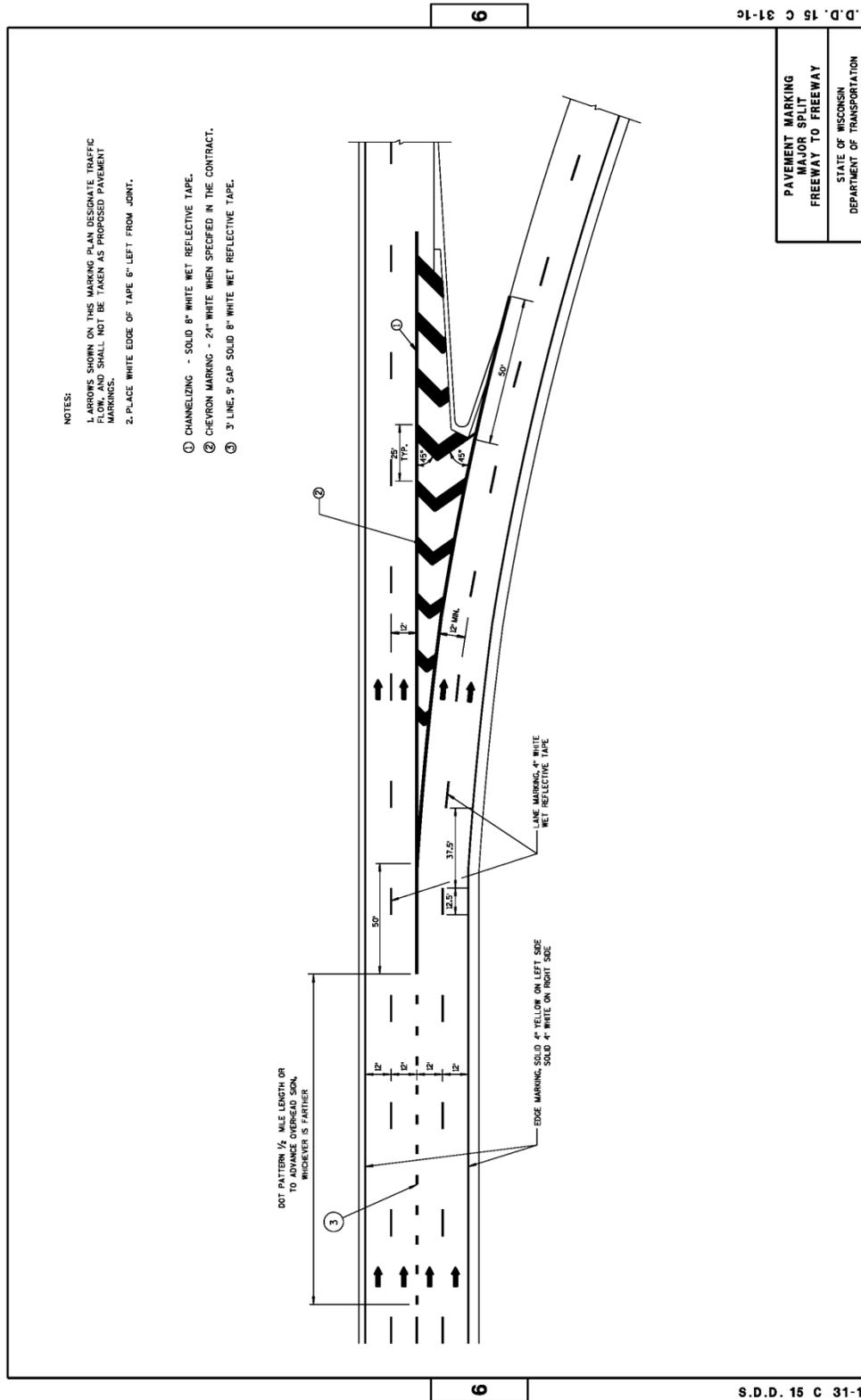
4.36 SDD 15C 31-1a – PAVEMENT MARKING (RAMPS & GORES)



4.37 SDD 15C 31-1b – LANE DROP PAVEMENT MARKING

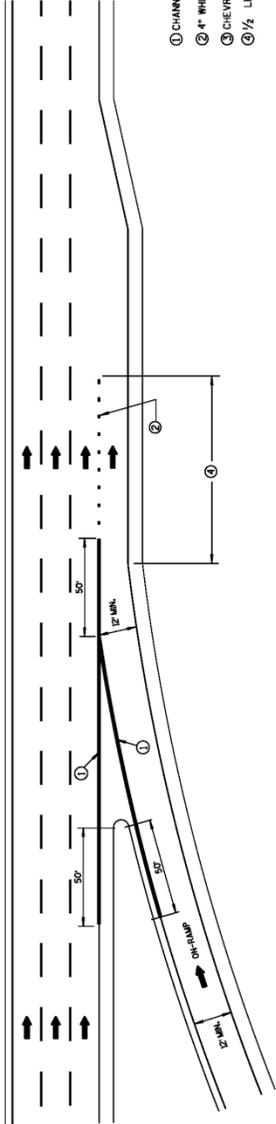


4.38 SDD 15C 31-1c -- PAVEMENT MARKING MAJOR SPLIT FREEWAY TO FREEWAY



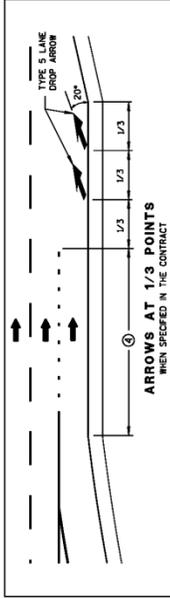
4.39 SDD 15C 31-1d - PAVEMENT MARKING FOR PARALLEL ON-RAMP AND PARALLEL OFF-RAMP

NOTES:
 1. AHEAD ARROWS SHOWN ON THIS MARKING PLAN DESIGNATE TRAFFIC FLOW, AND SHALL NOT BE TAKEN AS PROPOSED PAVEMENT MARKINGS.
 2. PLACE WHITE EDGE OF TAPE 6" LEFT FROM JOINT.
 3. RETRACE EXISTING DIAGONAL MARKINGS.



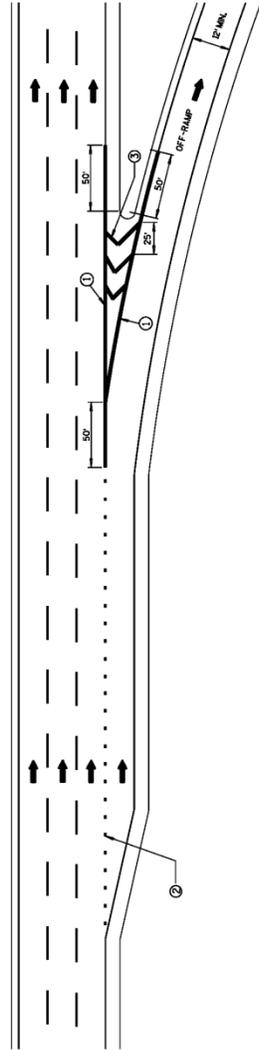
- ① CHANNELIZING - SOLID 8" WHITE MET REFLECTIVE TAPE IN GORE AREA.
- ② 4" WHITE (3" LINE, 9" GAP).
- ③ CHEVRON MARKING - 24" WHITE WHEN SPECIFIED IN THE CONTRACT.
- ④ 1/2 LENGTH OF FULL WIDTH ACCELERATION LANE.

SERVICE INTERCHANGE PAVEMENT MARKING FOR PARALLEL ENTRANCE-RAMP



6

6



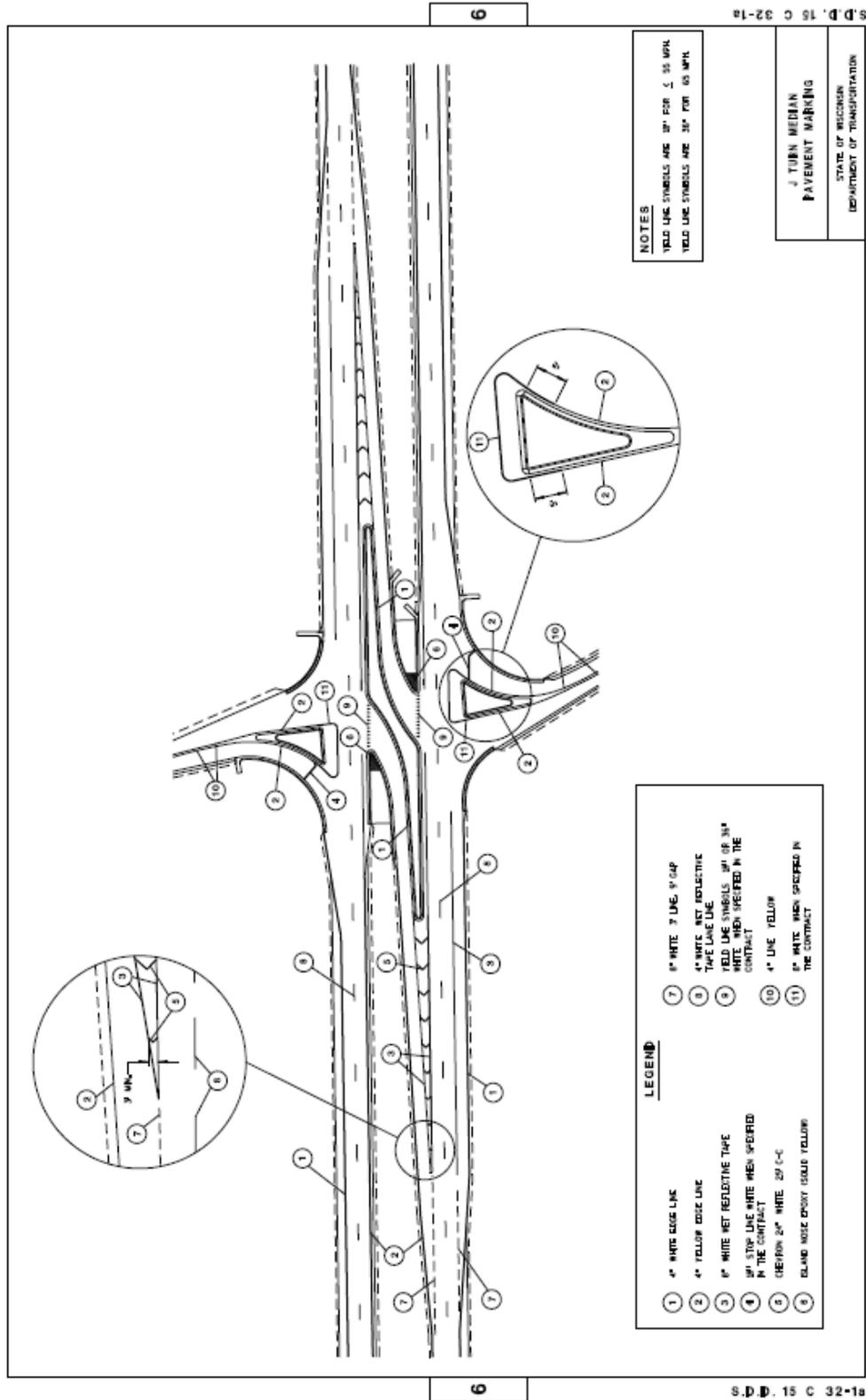
SERVICE INTERCHANGE PAVEMENT MARKING FOR PARALLEL EXIT-RAMP

PAVEMENT MARKING FOR PARALLEL ON-RAMP AND PARALLEL OFF-RAMP	
STATE OF WISCONSIN	
DEPARTMENT OF TRANSPORTATION	
APPROVED	DATE
BY: [Signature]	12/15/14
STATE TRAFFIC ENGINEER OF DESIGN	
P. [Signature]	

S.D.D. 15 C 31-1d

S.D.D. 15 C 31-1d

4.40 SDD 15C 32-1a – J TURN (MEDIAN) PAVEMENT MARKING



NOTES
 YIELD LINE SYMBOLS ARE 36" FOR ≤ 35 MPH
 YIELD LINE SYMBOLS ARE 36" FOR > 35 MPH

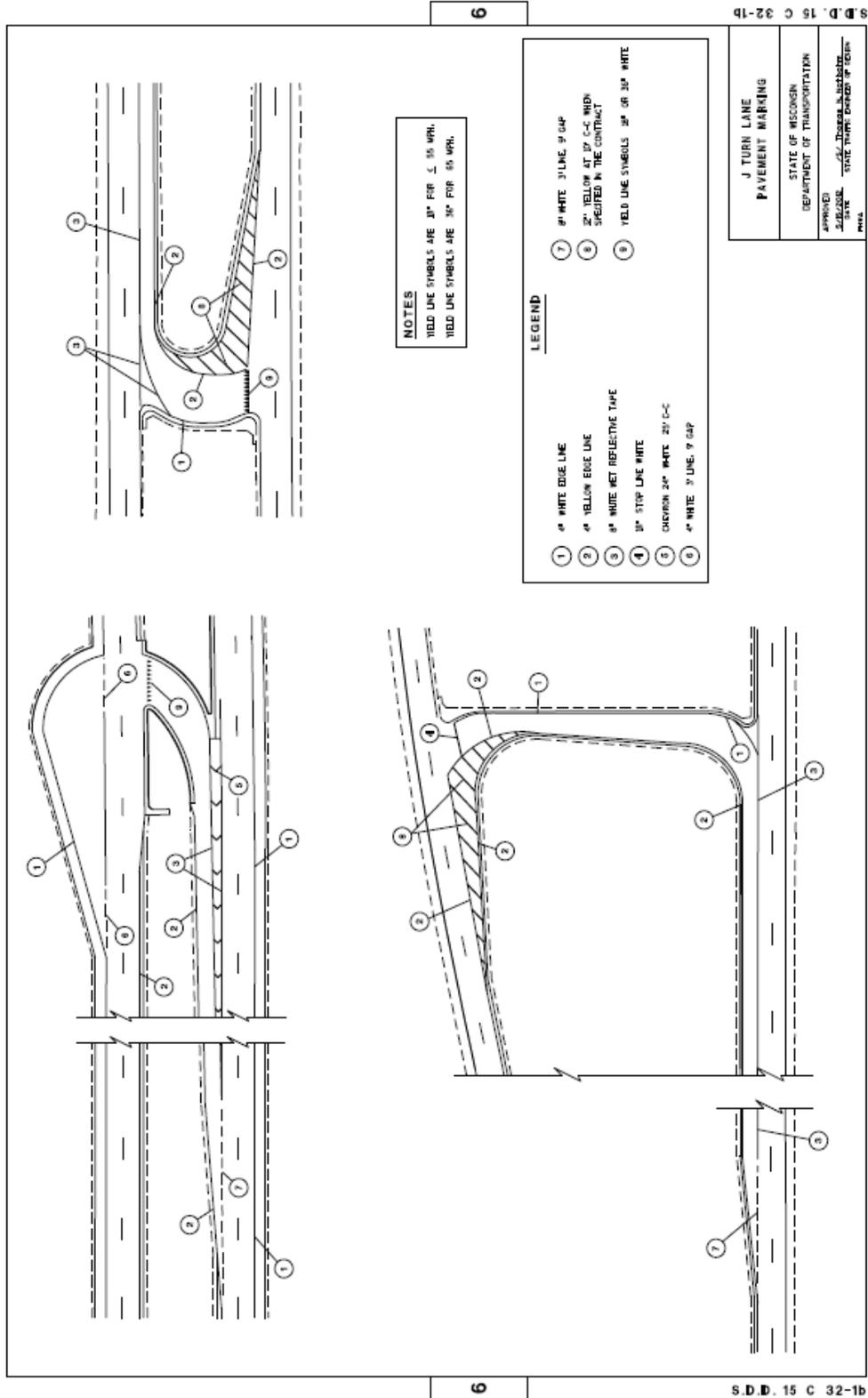
- LEGEND**
- ① 4" WHITE EDGE LINE
 - ② 4" YELLOW EDGE LINE
 - ③ 16" WHITE NET RELATIVE TIME
 - ④ 1/4" STIP LINE WHITE WHEN SPECIFIED IN THE CONTRACT
 - ⑤ 16" WHITE 20" WHITE 20" C-C
 - ⑥ ISLAND SIDE DRYOUT SOLID YELLOW
 - ⑦ 16" WHITE 3" LINE 3" GAP
 - ⑧ 4" WHITE NET RELATIVE TIME TAPE LINE LINE
 - ⑨ YIELD LINE SYMBOLS 36" OR 36" WHITE WHEN SPECIFIED IN THE CONTRACT
 - ⑩ 4" LINE YELLOW
 - ⑪ 16" WHITE WHEN SPECIFIED IN THE CONTRACT

J TURN MEDIAN
 PAVEMENT MARKING
 STATE OF WISCONSIN
 DEPARTMENT OF TRANSPORTATION

S.D.D. 15 C 32-1a

S.D.D. 15 C 32-1a

4.41 SDD 15C 32-1b - J TURN LANE PAVEMENT MARKING



4.42 SDD 15C 33-1 STOP LINE AND CROSSWALK PAVEMENT MARKING

6
S.D.D. 15 C 33-1

TYPICAL STOP LINE PAVEMENT MARKING WITH CURB AND GUTTER

TYPICAL STOP LINE PAVEMENT MARKING FOR SIDEROADS WITH CROSSWALK MARKING

TYPICAL STOP LINE PAVEMENT MARKING FOR SIDEROADS WITH RIGHT TURN LANE

TYPICAL STOP LINE PAVEMENT MARKING WITHOUT CURB AND GUTTER

GENERAL NOTES

- 1 8-INCH STOP LINES MAY BE DELETED OR ADDED BY THE PROJECT ENGINEER BASED ON VISIBILITY AND SIGHT LINES.
- 2 IF STOP SIGN IS LESS THAN OR EQUAL TO 40 FEET FROM THE EDGELINE THEN NO STOP LINE IS REQUIRED.
- 3 IF STOP SIGN IS LESS THAN OR EQUAL TO 30 FEET FROM THE EDGELINE EXTENSION THEN NO STOP LINE IS REQUIRED.
- 4 MARK CLOSER TO EDGE OF TRAVEL LANE AS NEEDED FOR VISIBILITY AND SIGHT LINES.

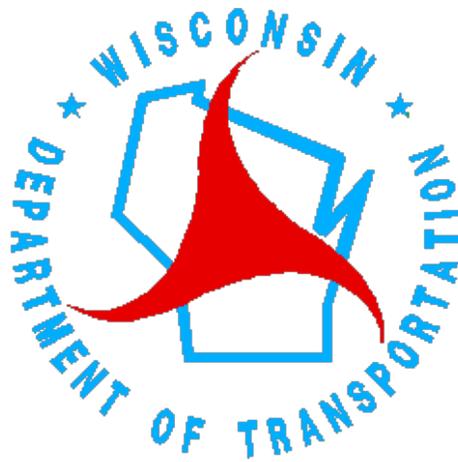
STOP LINE AND CROSSWALK PAVEMENT MARKING	STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION	APPROVED _____
DATE 4/20/2013	DRAWN BY _____
DATE _____	STATE TRAFFIC ENGINEER

6
S.D.D. 15 C 33-1

~~R R~~

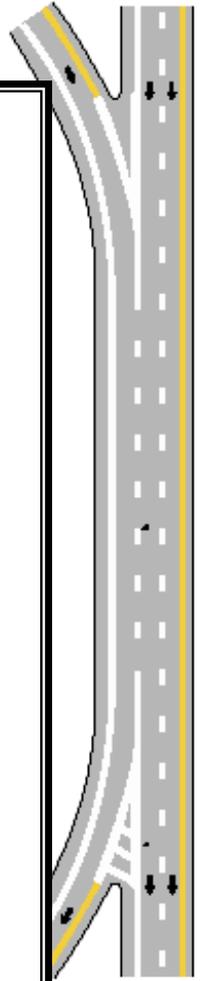
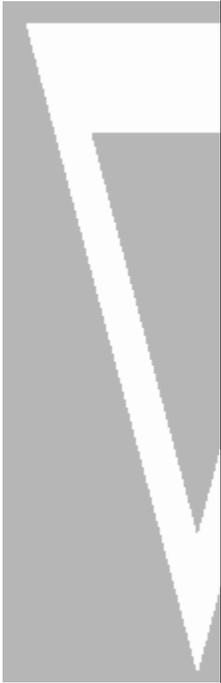
SECTION 5

EXHIBITS



January 2014 Edition

ONLY



SECTION 5 – LIST OF EXHIBITS

Exhibit 5.1 TAM SD30 Foot Protection..... 5-2
Exhibit 5.2 TAM SD36 Eye/Face Protection 5-3
Exhibit 5.3 TAM SD57 High Visibility Safety Apparel 5-5
Exhibit 5.4 DT 2130 Pavement Marking Daily Activity Report Form (Long Line) 5-7
Exhibit 5.5 DT 2131 Pavement Marking Daily Activity Report Form (Special Marking) ... 5-8

**WISCONSIN DEPARTMENT OF TRANSPORTATION
SAFETY DIRECTIVE SD30**

SUBJECT: FOOT PROTECTION

Issued: 06/01/12

**ORIGINATOR: Bureau of Business Services
Risk & Safety Unit**

**Supersedes: 02/15/95
07/09/02
06/23/05**

Authority	Administrative Code: SPS 332 and OSHA 1910.136 require the use of protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects, objects piercing the sole, and where such employee's feet are exposed to electrical hazards.
Training Requirements	Training on the use of and care for foot protection is required prior to use. A supervisor familiar with the equipment may do this. In addition, the Risk & Safety Unit offers a course in Personal Protective Equipment Basics.
When & Where Required	All field, shop and lab personnel shall wear the appropriate foot protection for the type of work conditions they are exposed to.
Types of Protective Footwear	<p>Protective footwear shall be selected for the type of job being performed and shall be designed and manufactured to protect the feet from injury and conform to ANSI Z41.1-1991. (See form DT1700 Employee Foot Protection Certification.)</p> <p>Most areas will require the use of a steel-toe boot or shoe; however, electricians shall wear a fiberglass-toe boot or shoe. Additional care should be taken into account when working on uneven, slippery or greasy surfaces.</p> <p>The Department shall provide strap-on metal foot guards for occasional use where steel-toe protection is required.</p> <p>Protective footwear shall be purchased by the employee and worn when required. Refer to applicable bargaining agreement or compensation plan for possible reimbursement.</p>
Program Responsibility	The Risk & Safety Unit is responsible for the administration and coordination of this program.
Employee Responsibility	All employees, including supervisory personnel who are exposed to foot hazards shall wear approved foot protection and be properly trained.
Supervisory Responsibility	Supervisors are to ensure that foot protection is worn at all times in areas where there are hazards that could cause injury to the feet and that training requirements are met and documented.

END OF DOCUMENT

**WISCONSIN DEPARTMENT OF TRANSPORTATION
SAFETY DIRECTIVE SD36**

SUBJECT: EYE/FACE PROTECTION **Issued: 06/01/12**

ORIGINATOR: Bureau of Business Services **Supersedes: 07/09/02**
Risk & Safety Unit **05/21/03**
06/23/05

Authority [Administrative Code: SPS 332](#) and [OSHA 1910.133](#) require the use of appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

Training Requirements Training on the use of and care for eye/face protection is required prior to use. A supervisor familiar with the equipment may do this. In addition, the Safety & Health Section offers a course in Personal Protective Equipment Basics.

When & Where Required Eye protection with attached side shields is required for, but not limited to, all employees whose job assignment exposes them to potential eye hazards (as stated in the "Authority" above).

Approved safety goggles must supplement non-approved prescription glasses or sunglasses when employees are exposed to eye hazards.

Eye protection is **not** required while riding in an enclosed vehicle.

Types of Eye/Face Protection Eye protection shall be selected for the type of job being performed and shall be designed and manufactured to protect the eyes from injury and conform to ANSI Z87.1-1989. All approved safety glasses will have the ANSI Z87.1 marking on the lens, frames and attached side shields.

Face/Splash Shields or Goggles shall be used when working with or around liquid chemicals, acids or caustic liquids, chemical gases or vapors. Goggles shall also be used in conjunction with prescription glasses while employee is awaiting delivery of prescription safety glasses and requires temporary eye protection.

Sunglasses with attached side shields that meet the ANSI Z87.1 may be worn by employees whose eyes are exposed to glare either from the sun or other external sources.

Safety sunglasses are **not** required while riding in an enclosed vehicle.

Program Responsibility The Risk & Safety Unit is responsible for the administration and coordination of this program.

Employee Responsibility All employees, including supervisory personnel who are exposed to eye/face injuries shall wear approved eye/face protection and be properly trained.
Supervisory Responsibility Supervisors are to ensure that eye protection is worn at all times in areas where there are hazards that could cause injury to the eyes and that training requirements are met and documented.

END OF DOCUMENT

**WISCONSIN DEPARTMENT OF TRANSPORTATION
SAFETY DIRECTIVE SD57**

SUBJECT:	HIGH VISIBILITY SAFETY APPAREL	Issued:	06/01/12
ORIGINATOR:	Bureau of Business Services Risk & Safety Unit	Supersedes:	10/22/98 07/01/01 07/09/02 06/23/05 08/01/06 07/29/11 09/01/11

Authority [Administrative Code: SPS 332.39, FHWA, *The Manual on Uniform Traffic Control Devices \(MUTCD\) Part 6*](#), ***Exposure to traffic*** requires that employees who work on highways; roads, streets or their easements shall wear a traffic safety vest.

Training Requirements Training on the use of and care for high visibility safety apparel is required prior to use. A supervisor familiar with the equipment may do this. In addition, the Risk & Safety Unit offers a course in Personal Protective Equipment Basics.

When & Where Required Only department approved **safety vests** are required to be worn by all employees working on the pavement, shoulder, and ditch or right-of-way of any roadway carrying traffic or under construction.

Approved **safety vests and pants** are required to be worn by employees during the hours of darkness (*½ hour before sunset & ½ hour after sunrise* or during low visibility.

Per ANSI/ISEA 107-2004, wearing high visibility pants in addition to the vest makes the Vest and Pant a Class 3 ensemble. Class 3 ensemble is required at all times for Flagging activities.

NOTE: Specialized WisDOT approved “Surveyor vests” are permitted to be worn by employees when they are not exposed to equipment and machinery. When working around machinery only WisDOT approved tear a way high visibility vests will be worn by DOT employees at all times.

Types of High Visibility Safety Apparel High Visibility Safety Apparel shall meet or exceed ANSI/ISEA 107-2004. It will also be WisDOT approved vest or vest and pants of a strong yellow-green material with patterns and material approved by the Safety Steering Committee (SSC).

State Patrol: per *The Manual on Uniform Traffic Control Devices (MUTCD) 2009*, the State Patrol (DSP) as Law enforcement shall wear department approved, High Visibility Safety Apparel that meet or exceed ANSI/ISEA 107-2004 while involved in directing traffic, investigating crashes, and handling lane closures, obstructed roadways and disasters within the right-

of-way of highways and roads or other Temporary Traffic Control zones (TTC).

In lieu of ANSI/ISEA 107-2004 apparel, law enforcement personnel within the TTC zone may wear high-visibility safety apparel that meets the performance requirements of the ANSI/ISEA 207-2006 publication entitled "American National Standard for High-Visibility Public Safety Vests" (see Section 1A.11) and labeled as ANSI 207-2006.

**Program
Responsibility**

The Risk & Safety Unit is responsible for the administration and coordination of this program.

**Employee
Responsibility**

All employees, including supervisory personnel who are involved in situations where high visibility is essential for personal safety shall wear approved safety apparel and be properly trained.

**Supervisory
Responsibility**

Supervisors are to ensure that high visibility safety apparel is worn at all times as required and that training requirements are met and documented.

END OF DOCUMENT

DT 2130 PAVEMENT MARKING DAILY ACTIVITY REPORT (Long Line)

An electronic version of this form can be obtained at <http://dotforms.n2public/BMS/FORMS/dt2130.xls>.

NOTE: RED OUTLINED CELLS WILL SELF-POPULATE WHEN INFORMATION IS ENTERED

DATE: (mm/dd/yyyy)		PROJECT ID:		REGION:		CONTRACTOR:		FOREMAN:	
1st HIGHWAY		EPOXY		VATERBORNE		COUNTY:		TAPE	
H/W #	REF #	Left Counter (ft.)	Right Counter (ft.)	Counters sub-total (ft.)	Paint (gal)	Rate of Application	Beeds (bs)		
ITEM (X one)				0					
4" YELLOW	4" WHITE								
8" YELLOW	8" WHITE								
REPAIRS (P)									
FROM:									
TO:									
2nd HIGHWAY		EPOXY		VATERBORNE		COUNTY:		TAPE	
H/W #	REF #	Left Counter (ft.)	Right Counter (ft.)	Counters sub-total (ft.)	Paint (gal)	Rate of Application	Beeds (bs)		
ITEM (X one)				0					
4" YELLOW	4" WHITE								
8" YELLOW	8" WHITE								
REPAIRS (P)									
FROM:									
TO:									
3rd HIGHWAY		EPOXY		VATERBORNE		COUNTY:		TAPE	
H/W #	REF #	Left Counter (ft.)	Right Counter (ft.)	Counters sub-total (ft.)	Paint (gal)	Rate of Application	Beeds (bs)		
ITEM (X one)				0					
4" YELLOW	4" WHITE								
8" YELLOW	8" WHITE								
REPAIRS (P)									
FROM:									
TO:									
WEATHER: (Start entries in box below)		# Vibriers		# Hours / Vibrier		Equipment		# Vehicles	
General Laborer:						Equipment Types			
Grinder:						Pavement Marking Vehicle:			
Other:						Pilot Vehicle:			
Pavement Marking Operator:						Shadow Vehicle:			
Pavement Marking Truck Driver:						Single Two Axis Truck:			
Pilot Vehicle Driver:						Three Axis Truck:			
Shadow Vehicle Driver:						Totals:		0.0	
Totals:		0		0.0		COMMENTS:		(Start entries in box below)	

(WisDOT) Contact Person

Name: _____
 City: _____
 Phone #: _____
 Cell #: _____
 Email: _____

Instructions:
 Fill out form electronically and then email to the WisDOT contact person above.

DT 2131 PAVEMENT MARKING DAILY ACTIVITY REPORT (Special Marking)

An electronic version of this form can be obtained at <http://dotforms.n2public/BMS/FORMS/dt2131.xls>.

NOTE: RED OUTLINED CELLS WILL SELF-POPULATE WHEN INFORMATION IS ENTERED

PAVEMENT MARKING DAILY REPORT - Special / Provision Marking

Wisconsin Department of Transportation
DT 2131 5/2012

DATE: (mm/dd/yyyy)		PROJECT ID:		REGION:			CONTRACTOR:			FOREMAN:			
HWY	LOCATION	COUNTY	Ref. #	Dir.	647.0156	647.0110	647.0156	647.0176	647.0188	647.0358	647.0726	647.0746	
					Pavement Marking Arrows Type 1 Epoxy White	Pavement Marking Railroad Crossing Epoxy White	Pavement Marking Arrows Type 2 Epoxy White	Pavement Marking Arrows Type 3 Epoxy White	Pavement Marking Arrows Type 4 Epoxy White	Pavement Marking Words Epoxy White	Pavement Marking Diagonal Epoxy White	Pavement Marking Diagonal Epoxy White	
					Each	Each	Each	Each	Each	Each	LF	LF	
					0	0	0	0	0	0	0	0	
Totals:					0	0	0	0	0	0	0	0	
PERSONNEL				EQUIPMENT									
Labor Classification	# Workers	# Hours / Worker	Equipment Type									# Vehicles	# Hours
General Laborer/Grinder/Other			Grinder/Other										
Pavement Marking Operator			Pavement Marking Vehicle										
Pavement Marking Truck Driver/Pilot Vehicle Driver/Shadow Vehicle Driver			Pilot Vehicle/Shadow Vehicle										
			Single / Two-Axle Truck/Three-Axle Truck										
Totals:	0	0.0	Totals:									0	0.0
WEATHER: (Start entries in box below)		COMMENTS: (Start entries in box below)											



(WisDOT) Contact Person
Name: _____
City: _____
Phone #: _____
Cell #: _____
Email: _____
Instructions:
Fill out form electronically and then email to the WisDOT contact person above.