Development of Best Practices for Portable Changeable Message Sign Use in Work Zones for Design and Construction Engineers

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Introduction

In Wisconsin, an average 1,600 work zone crashes occur per year. This number remains relatively steady while the number of injury or fatal crashes varies more. These numbers are likely under-reported as the policy for reporting a "work zone crash" may be different for each unit of government within Wisconsin. Preventing work zone crashes is a high priority as both drivers and construction workers are at a higher risk due to reduced roadway space and proximity of workers to the traffic lanes, as well as other factors.

Portable Changeable Message Signs (PCMS's) are one tool to provide roadway users with work zone information, which can reduce confusion, reduce vehicle speeds, and increase safety. PCMS use has continually increased in Wisconsin. PCMS's have been featured in Wisconsin Department of Transportation (WisDOT) construction projects since the 1990's and WisDOT has continually procured contractor-owned PCMS's by special provisions or standardized special bid item. In November 2011, PCMS's were added to the *State of Wisconsin Standard Specifications for Highway and Structure Construction* (Standard Specs) [1]. The introduction of the item into the Standard Specs demonstrates their increased use on Wisconsin's highways. A review of WisDOT's PCMS use on let construction projects was conducted to demonstrate the need for a revision to the existing PCMS guidelines in Wisconsin to ensure proper planning and use [2].

For WisDOT projects let in 2009, there were 27,616.5 days of PCMS use, which equates to 120 PCMS's daily on WisDOT construction projects during the typical construction season (April 1st to November 15th). With an average bid price of $68.42 per day, WisDOT spent $1.35M on PCMS's for projects let in 2009. For WisDOT projects let in 2013, there were 40,903 days of PCMS's use (178 PCMS's daily), an increase of 148 percent from 2009. The average bid price also increased to $77.76 per day, resulting in $2.51M spent on PCMS's for projects let in 2013. See Table 1 for the annual breakdown. Note that some projects let in previous years may still be ongoing, so the actual PCMS use and total dollars spent is likely to increase. With the number of PCMS's used in work zones increasing and the bid price per day increasing, guidelines for proper PCMS use for design and construction engineers should be developed to ensure WisDOT's funds are used wisely.

Table 1 WisDOT PCMS Use by let Year

Year Let	Estimated PCMS (Days)	Actual PCMS (Days)*	Average Price	Total Dollars Spent*
2009	40,246	27,617	$ 68.42	$ 1,350,959
2010	44,537	39,222	$ 75.54	$ 1,881,562
2011	51,636	36,024	$ 69.60	$ 1,841,156
2012	56,559	41,246	$ 72.33	$ 2,000,706
2013	51,220	40,903	$ 77.76	$ 2,513,926
2014	43,385	13,642	$ 95.82	$ 854,284

*As of December 2014

Wisconsin Standards and Guidelines

WisDOT developed the *Facilities Development Manual* (FDM) to aid in the design of highway facilities [3]. Section 11-50 is devoted to traffic control; however, nowhere in the FDM are PMCS's addressed or referenced. WisDOT has also developed a *Traffic Guidelines Manual* (TGM), containing more detailed design information on specific traffic control situations, such as railroad crossings, reduced speed limits, and emergency transportation operations [4]. Chapter 6 of the TGM includes guidance on work zone traffic control, with Section 6-2-55 titled *Portable Changeable Message Sign Use in Construction & Maintenance Projects*. This guideline was originally developed in September 2008 and was last updated in May 2009.

The TGM discusses PCMS's in general terms, providing one typical application (i.e. advanced warning of project start), and various example messages. The TGM states all PCMS's used on highway improvement projects will be supplied and maintained by the contractor and all messages displayed must be pre-approved by the project engineer. There is limited guidance to project engineers on message content. The *State of Wisconsin Standard Specifications for Highway and Structure Construction, 2015 Edition* describes the specifications for PCMS's, including: legend size, legibility, placement, and performance [5]. However, this guidance does not include any information about acceptable messages.

Within Wisconsin, no statewide PCMS guidance describing PCMS use or scenario-specific messages exists. In a diverse state with five different WisDOT regions, the consistency of messages drivers see displayed on PCMS's throughout the state varies greatly. Statewide guidance is needed to ensure all highway improvement projects throughout Wisconsin follow consistent guidelines on PCMS use. The development of typical PCMS applications and messages will help WisDOT, local highway agencies, and public works agencies, as well as potentially other state DOTs, provide clear and consistent messages to the traveling public.

National Standards and Guidelines

Nationwide, the *Manual on Uniform Traffic Control Devices* (MUTCD) contains standards and guidance for PCMS use [6]. Guidance is provided in Section 6F and Section 2L and includes items such as applications, legibility, visibility, appropriate abbreviations, and message content. The MUTCD does not provide guidance on when to use certain messages, on the duration messages should appear (i.e. the number of days), or on how messages should be worded. For is example, is it better to use "WED, 11/25" or "NOV 25"?

In addition to the MUTCD, the Federal Highway Administration (FHWA) developed the *Portable Changeable Message Handbook* (PCMS Handbook) in 2003 [7]. This handbook discusses different types of PCMS's, standard abbreviations, legibility, and field placement. Most recently, the American Traffic Safety Services Association (ATSSA) published the *Guidance for the Use of Portable Changeable Message Signs in Work Zones* (PCMS Guidelines) in 2013 [8]. Again, this

document discusses different types of PCMS's, including advantages and disadvantages, message content, field placement, and some typical applications.

Although these national guidelines provide a good baseline for basic PCMS principles, no current guidance document has compiled the vast amount of research on driver comprehension of messages on PCMS's. State guidelines and standards were reviewed for a number of states [9] [10] [11] [12] [13] [14] in addition to research evaluating PCMS message content [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26]. A compilation of the review is provided below based on different aspects of PCMS's, including: typical use, field placement, legibility, message content, and typical applications. The last section in this paper contains work zone PCMS recommendations and provides guidelines for both design and construction engineers to ensure consistent PCMS use throughout Wisconsin.

Typical PCMS Use

The MUTCD [6] defines general uses for PCMS's as: Incident management and route diversion, Warning of adverse weather conditions, Special event applications associated with traffic control or conditions, Control at crossing situations, Lane, ramp, and roadway control, Priced or other types of managed lanes, Travel times, Warning situations, Traffic regulations, Speed control, and Destination guidance.

PCMS's can also be used to display safety messages, transportation-related messages, emergency homeland security messages, AMBER alert messages, but cannot be used to display advertising messages [6] [15]. In Section 6F.60 of the MUTCD, typical work zone PCMS applications are provide and include: Speed differentials, Queuing and delays, Adverse environmental conditions, Changes in alignment or surface conditions, Advanced notice of closures, Crash and incident management, and Changes in the road pattern.

Other agencies have developed hierarchies of types of messages to display on work zone PCMS's. Indiana DOT (INDOT), Michigan DOT (MDOT), and Florida DOT (FDOT) have a priority list for the type of message to display [9][10][14].

PCMS Field Placement

The MUTCD [6] provides guidance on the placement of PCMS's. Additionally, FHWA's PCMS Handbook suggests putting the PCMS closest to the lane in which the message applies [7]. An example which conforms to the guidance in the PCMS Handbook but not to the MUTCD is "RAMP TO CLOSE" messages are usually placed within an interchange on the ramp that will be closed. If this message was placed in a different location, road users may be confused as to which ramp the message applies.

Horizontal Offset

PCMS's are not crashworthy devices and should be protected. If possible, PCMS's should be placed behind barrier or guard rail, placed outside the clear zone, or protected by traffic control devices [9] [11]. The horizontal offset needs to be considered as well. The PCMS needs to be in the driver's cone of vision to ensure there is enough distance to read the message. The cone of vision extends 10 degrees to the left and the right of the viewer [8]. As the distance from a PCMS increases, the offset also increases. For example, on a 6 lane divided facility, a driver in the left lane can comfortably view a sign on the right shoulder until about 200 feet from the sign (assuming 12-foot lanes, driver is centered in left lane, and the PCMS is 6 feet offset from the right lane). This makes the last 200 feet of visibility less useful to the driver, therefore reducing the amount of time they have to view the entire message. This is not typically considered in the placement or design of PCMS's. One study recommended placing PCMS's on both sides of the facility to ensure all drivers would receive the message [16].

Advanced Placement to Field Conditions

Advanced placement to the hazard or condition should also be considered to ensure drivers have adequate time to respond the message provided. FHWA's PCMS Handbook recommends [7]:

- Minimum 500 feet to the decision point for a minor action, regardless of speed
- 1000 feet for a major action for speeds 40 mph or less
- 1 mile for a major action upstream for speeds 45 mph or more

FDOT recommends placing PCMS's 500 to 800 feet in advance, if the PCMS is supplemental to conventional traffic control devices or 0.5 to 2 miles in advance of complex traffic schemes with new or unusual traffic patterns [14]. INDOT developed guidelines for PCMS placement on freeways and non-freeways [9]. The guidelines vary based on the event type and anticipated duration of the event. Other agencies rely on designers to determine the location and messages to be included on PCMS's. FDOT's *Plans Preparation Manual* states traffic control plans shall include the locations of PCMS's and the messages to be displayed [14].

PCMS Visibility and Legibility

The MUTCD provides guidance that PCMS's should be visible from 0.5 miles on facilities with speeds 55 mph or greater [6]. The message should be legible for 600 feet for nighttime conditions and 800 feet for daytime conditions [6]. At 65 mph, this results in a viewing time of 6.3 seconds and 8.4 seconds, respectively. WisDOT Standard Specs states that PCMS signs should be legible for 850 feet under both daytime and night time operations [5].

In addition, placement to existing signs should also be considered. Oregon Department of Transportation (ODOT) recommends [11]:

- At least 1000 feet from guide, warning or other critical signs on freeways
- At least 500 feet from guide, warning or other critical signs on non-freeways with posted speed of 45 mph or higher – Increase distance on multi-lane roadways
- At least 350 feet from guide, warning or other critical signs on multi-lane roads or arterials with posted speed of 40 mph or less
- At least 100 feet from guide, warning or other critical signs on urban roads with posted speed of 25 mph or less

Message Development

Messages on PCMS's need to be easily understandable as drivers have limited time to view, read, comprehend, and respond to the information provided. Message development includes the message's verbiage as well as the time to message is displayed, also known as phase length.

Phase Length

The MUTCD describes the method that should be used to determine the length of each phase [6]. The minimum time a phase should be displayed is determined by the lesser of one second per word or two seconds per bit of information. In direct contradiction to this, Duduk recommended using the greater of these two values to ensure drivers have time to read the entire message [7]. FHWA's PCMS Handbook recommends phases with 1 or 2 lines to be displayed for 1.5 seconds and phases with three lines to be displayed for 3 seconds [7]. Therefore, phase length typically is determined by the content of the message, and not by the available viewing time, which depends on the driver's speed. FDOT applies a different approach that requires signs to the legible at 900 feet and requires the driver be able to read the entire message twice when traveling 55 mph [14]; this results in a viewing time of 11.16 seconds and maximum phase duration of 2.79 seconds. Similarly, the TGM states it is desirable for the driver to be able to read the entire message twice as they pass by a PCMS [4]. Based on the desire for drivers to be able to read a PCMS twice while approaching the sign, Table 2 was developed to determine the distance traveled for two PCMS viewings, assuming the maximum message duration of 8 seconds and 2 phases [6]. Additionally, Table 2 shows the required legend height based on a legibility index of 40 feet of visibility for every inch of legend height.

One element of PCMS message design, which is typically disregarded, is the legend height, as an 18-inch legend height has become standard on PCMS's. Manufactures have been constructing PCMS's with line matrix and character matrix designs that restrict the legend height to the 18-inch minimum as required by the MUTCD [6]. WisDOT's Standard Spec reiterates this by stating "Provide a line matrix, character matrix, or full matrix sign message display…. displaying 3 lines sequentially with 8 or more 18 inch high by 11 inch wide characters per line" [5]. Therefore all PMCS's on all WisDOT projects will have a legend height of 18 inches. An 18-inch legend height and a legibility index of 40 ft/in impacts the

viewing time drivers have to read a PCMS. As shown in Table 2, an 18-inch legend is only adequate for speeds below 35 mph, if the message is displayed for 8 seconds.

Table 2 Required Legend Height by Speed and Display Time

Speed		Number of Phases	Phase Time (Max)	Distance Traveled (One Viewing)	Distance Traveled (Two Viewings)	Legend Height Required*
mph	fps		seconds	feet	feet	inches
65	95.33	2	4	762.67	1525.33	38.13
55	80.67	2	4	645.33	1290.67	32.27
45	66.00	2	4	528.00	1056.00	26.40
35	51.33	2	4	410.67	821.33	20.53
25	36.67	2	4	293.33	586.67	14.67

*Assumes a legibility of 40 ft / in

The shortcomings of the 18-inch legend height were described in FHWA's PCMS Handbook, where 18-inch legend is associated with a legibility distance of 720 feet, suitable for 40 mph [7]. These shortcomings have not been addressed in the various state and nationwide guidance that are currently available. A 2008 study confirmed the 40 ft/in legibility index by evaluating a number of PCMS signs based on legibility of word message and an "eye chart" message; the results are shown in Table 3 below [28]. This evaluation included three evaluators with corrected 20/20 vision driving towards the sign; however, their travel speeds were not recorded.

Table 3 Measured PCMS Legibility

PCMS Number	Legibility Distance (feet)			
	Day, Word	Day, Eye Chart	Night, Word	Night, Eye Chart
PCMS(2008)- 03	962	896	814	639
PCMS(2008)- 04	1031	751	918	804
PCMS(2008)- 05	702	559	611	519
PCMS(2008)- 06	712	621	582	455
PCMS(2008)- 07	1116	843	859	720
PCMS(2008)- 08	750	629	641	471
PCMS(2008)- 10	853	702	891	601
Average	875	714	759	601
Legibility (X ft /18 in)	48.6	39.7	42.2	33.4

Recommended guidance on the length of message and the phase time, based on a fixed legend height of 18 inches, is shown in Table 4. This recommendation will ensure drivers have adequate time to view and read the message provided for the varying speed limits. For speeds 55 mph or more, the two phases should be limited in text to ensure the message can be read in 3 seconds.

Using messages with varied phase lengths (i.e. three seconds and two seconds, etc.) can help ensure drivers have the maximum amount of time to read the entire message.

Table 4 PCMS Phase Recommendations for 18-inch Legend

Speed		WisDOT Legend Height	Maximum Viewing Time*	Max Number of Phases	Phase Time (Max)	Number of Phases Viewed
mph	*fps*	*inches*	*seconds*		*seconds*	
65	95.33	18	7.55	2	3	2.5
55	80.67	18	8.93	2	3	3.0
45	66.00	18	10.91	2	3	3.6
35	51.33	18	14.03	2	4	3.5
25	36.67	18	19.64	2	4	4.9

*Assumes a legibility of 40 ft / in

Message Verbiage

Message verbiage needs to be concise and readable in the allotted phase time. All messages displayed on PCMS's must be relevant [15]. Misleading or unreliable messages reduce the credibility of PCMS's. A proper message should be short and easily understandable. A number of sources discuss the content of a PCMS message, including the MUTCD [15], FHWA PCMS Handbook [7], and various state guidelines.

Units of Information

The MUTCD states the length of the message should not have more than 4 units of information [6]. Messages should be thought out and include useful information. The messages provided to drivers may covey the following four pieces of information: 1. What?, 2. Where?, 3. Who? and 4. Response?

Depending on the individual situation, the bits of information could be provided on one or two phases. All messages may not require all bits of information. ATSSA's PCMS Guidelines recommend keeping the message as short as possible to aid in driver readability and comprehension [8]. FHWA's PCMS Handbook provides recommendations on the content of phases based on the number of phases used [7].

The TGM recommends the first phase should describe the condition ahead that may be encountered, and the second phase would advise the driver of the appropriate action or response [4]. Note, the MUTCD does not allow three phase PCMS messages [6].

Message Content

In Wisconsin, the limited guidance on message content is provided in the TGM [4]. The TGM refers to the MUTCD abbreviation list and provides a list of messages that could be considered for use. ODOT has developed a number of

typical messages, and Texas Department of Transportation (TxDOT) developed a two page field guide with standard messages for field staff [19].

Additional message content guidance was developed in NCHRP 600 [15] [20]. Other studies have been completed and guidelines have been developed covering different aspects of PCMS messages. ODOT developed a policy for locations and distances [11]. For distances under 0.25 mile, "feet" should be used. For miles, fractions are acceptable, but the use of mile posts are not easily understood by the general public. ODOT also recommends using the 12 hour time format followed by AM or PM [11].

An additional study looked at flashing messages that included a two-phase message with three lines of text and one line changing between phases [24]. The study found drivers could recall the message; however, average reading times increased significantly. One common example of this scenario, as seen throughout Wisconsin, is "TRUCKS EXITING RIGHT / TRUCKS ENTERING RIGHT".

Sequential PCMS's

For freeways, a maximum of seven words is recommended, and for facilities with speeds less than 55 mph, a maximum of eight words is recommended [15]. If more information needs to be provided, the use of a sequential PCMS is recommended. The second PCMS should be placed 1000 feet from the first. One study looked at the comprehension of sequential PCMSs and found:

- Including five units of information between the two PCMS's results in low comprehension rates
- Using four units of information results in the same comprehension as the same information on a Dynamic Message Sign (DMS)
- Repeating one unit of information on both PCMS's can enhance comprehension [23].

Message Layout

The MUTCD provides the standard that a PCMS shall consist of no more than two phases, containing no more than three lines of text per phase. The message shall be understandable regardless of the order being read. The messages shall be centered within each line of the legend [6]. NCHRP Report 600 contradicts this recommendation by stating staircase justification enhances reader comprehension [15].

Graphics

A number of studies have looked at the addition of graphics to CMSs [24] [25] [26] [27]. Overall, well designed graphics can aid in comprehension of a message, especially for non-native language speakers and elderly drivers. Drivers prefer text over graphics that replace text; however, drivers responded quickly to graphic displays that replaced the text [26]. Graphics can also more easily describe complex situations that are hard to explain with text. Currently, Wisconsin does

not use graphical displays on DMS's or PCMS's. With the current installation of full matrix signs, the use of graphics should be explored in Wisconsin.

Typical Applications

Some state guidance and national research covers typical applications of PCMS use. Those that are currently documented are summarized and include inattentive driving, demand management, and advanced notice.

Inattentive Driving

Inattentive driving is a problem in work zones and can have severe consequences [8]. PCMS's demand higher attention than regular static work zone signage; therefore, they bring attention to the unique situation ahead. PCMS's should be considered as one method to reduce inattentive driving in work zones, if the work zone with the following characteristics: greater than one mile in length, locations of unexpected queues, challenging or unique situations, or easy to miss maneuvers, such as a temporary exit ramp [8].

Demand Management

PCMS's may be used in work zones for demand management; these situations typically include heavily traveled work zones (where peak demand exceeds capacity) or where queueing is expected that will impact traffic and/or the construction schedule [8]. One example of this strategy is showing real time travel times through the work zone.

California implemented this method by using existing roadway sensors to monitor traffic traveling through an I-15 work zone [16]. By providing users with information via CMS's in advance of decision points, the maximum delay was reduced from 90 minutes to 45 minutes during construction. The messages provided on the CMSs considered both the construction roadway as well as other routes. Detour information was only provided when available detour routes had additional capacity.

Advanced Notice

Advanced notice on PCMS signs involves making the public aware of a road, lane, or ramp closing in advance of the closure. ODOT recommends limiting the display of this information to drivers to two weeks before the closure takes place [11]. MDOT developed more specific guidelines based on the type of closure [10].

Work Zone PCMS Recommendations

This section presents recommendations for PCMS use in work zones. The recommendations are tailored to current practices in Wisconsin and can be used by design and construction engineers to ensure the State provides consistent

messages on their highways. Recommendations are provided for advanced notice of closures, advanced warnings, and queueing and delays.

Advanced Notice of Closures

Advanced notice of closures refers to the full or partial closure of a facility and includes: system ramps, service ramps, full closures, and lane closures.

System Ramp Closures

For system ramp closures, place the PMCS along the ramp in which the message applies.

Closure Type	Advanced Notice	Example Message		Phase Length (sec)
Continuous Closure 7 days or greater	14 days	RAMP TO CLOSE	APR 25 TO MAY 25	2 / 2
Continuous Closure 7 days or less	7 days	RAMP TO CLOSE	APR 25-29	2 / 2
Nightly or Daily Closures	7 days	RAMP TO CLOSE	NIGHTLY 9PM-5AM	2 / 3
Weekend Closures	10 days (begin Thursday before)	RAMP TO CLOSE	FRI 9PM TO MON 6AM	2 / 3

During the actual closure, a PCMS should be placed to alert drivers of the closure and provide alternative route information. If the detour is before the driver reaches the closed ramp, provide a PCMS ½ mile before the detour or alternative route exit. If the detour is after the closed ramp, place a PMCS near the closed entrance with the detour or alternative route exit.

Detour Type	Message		Phase Length (sec)
None Posted or Preferred	RAMP CLOSED	USE ALT ROUTE	2 / 2
Signed Detour (upstream of closure)	RAMP TO 10 EB CLOSED	USE CTH BB	3 / 2
Signed Detour (downstream of closure)	RAMP CLOSED	USE WIS 47	2 / 2

Service Ramp Closures

For service ramp closures, place the PMCS along the ramp in which the message applies. The number of days of notice can be based on the Annual Average Daily Traffic.

Closure Type	Advanced Notice	Message		Phase Length (sec)
Continuous Closure 7 days or greater	10 days	RAMP TO CLOSE	APR 25 TO MAY 25	2 / 3
Continuous Closure 7 days or less	3 to 7 days	RAMP TO CLOSE	APR 25-29	2 / 2
Nightly or Daily Closures	3 to 7 days	RAMP TO CLOSE	NIGHTLY 9PM-5AM	2 / 3

Detours may be provided for service ramp closures and can follow the guidelines under System Ramp Closures. For PCMS's on non-freeways, the sign should be placed in 500 to 100 feet advance of the preferred detour route.

Roadway Closures

For roadway closures, place the PCMS at the point of closure.

Closure Type	Advanced Notice	Message		Phase Length (sec)
Continuous Closure 7 days or greater	10 days	ROAD TO CLOSE	APR 25 TO MAY 25	2 / 3
Continuous Closure 7 days or less	3 to 7 days	ROAD TO CLOSE	APR 25-29	2 / 2
Nightly or Daily Closures	3 to 7 days	ROAD TO CLOSE	NIGHTLY 9PM-5AM	2 / 3

During the actual closure, a PCMS should be placed to alert drivers of the closure and provide alternative route information. Provide a PCMS 0.5 miles before the detour route. An additional PCMS may be placed further upstream if capacity is expected to be exceeded on the detour route and other alternative routes are available.

Sign Location	Example Message		Phase Length (sec)
At Closure	ROAD CLOSED	EXIT RIGHT ---->	2 / 2
Advance of Closure	ROAD CLOSED 1 MILE	FOLLOW DETOUR	3 / 2

Lane Closures

Under usual circumstances, PCMS's will not be used to give advanced notice of lane closures. Exceptions may include sporting events, holiday weekends, and other high traffic events in which some traffic may divert to alternative routes if they are aware of closures. These messages are covered under Queueing and Delays.

Advanced Warning

Advanced warning applies to a number of different situations. PCMS's can be used to enhance an existing static sign after a stage change, provide a time-specific warning, or provide a warning about an on-going event. PCMS messages, PCMS location, and applications are shown below.

Advanced Warning Type	Location of PCMS	Time Period to Display	Example Message		Phase Length (sec)
Traffic Pattern Change	500' to 1000' in advance	7 days	NEW TRAFFIC PATTERN		
Traffic Shift	500' to 1000' in advance	7 days	TRAFFIC SHIFTS RIGHT		
New Signal	Beyond expected queue	7 days	SIGNAL AHEAD X MILES	BE PREPARED TO STOP	3/2
Work in Lane Closure	500' to 1000' in advance	During Night Work	WORKERS IN ROAD AHEAD	SLOWDOWN IN WORKZONE	3 / 2
Paving in Adjacent Lane	500' to 1000' in advance	During Work	PAVING NEXT X MILES	WORKERS ON RIGHT	3 / 2
Flagging	Beyond expected queue	During Work	FLAGGER AHEAD	PREPARE TO STOP	2 / 3
Truck Egress/Access	500' to 1000' in advance	During Work	TRUCKS ENTERING RIGHT	ON RIGHT TRUCKS EXITING	3 / 3
Rough Road	Advance of alternative route	During Event	ROUGH ROAD 1 MILE		

Another advance warning situation is for rolling slowdowns. Typically, minimal advanced notice is given to the public before a rolling slowdown. A PCMS should be placed before the start of the rolling slowdown at a distance which encompasses the expected queue length. Other PCMS's should be placed along the route to ensure traffic is aware of the slowdown.

Sign Location	Example Message		Phase Length (sec)
Advance of Slowdown	SLOWED TRAFFIC AHEAD	XX MPH NEXT XX MILES	3 / 2
	SLOWED TRAFFIC	DO NOT PASS	2 / 2

Queuing and Delays

PCMS's can be used to display real time information about travel times, delays, queues, or other traffic impacts. These messages can be generated from a contractor-supplied system or from incorporation into the existing detection and program used to display the messages. Additionally, messages could be used as specific times of the day when queues are expected that would not be anticipated by road users. Typical message, PCMS location, and message duration is shown.

Message Type	Location of PCMS	Time Period to Display	Example Message		Phase Length (sec)
Real Time Travel Time Main Route	Advance of an alternative route	While delays are present or continuously	15 MINS TO I-94		
Real Time Travel Time Alt Route	Advance of an alternative route	While delays are present or continuously	15 MINS TO I-94 VIA 10	USE ALT ROUTE	3 / 2
Real Time Travel Time Comparison	Advance of an alternative route	While delays are present or continuously	25 MINS TO I-94	15 MINS TO I-94 VIA 10	3 / 3
Real Time Queuing	1 to 2 miles in advance of end of queue	During queueing	STOPPED TRAFFIC X MILES	EXPECT DELAYS	3 / 2
Anticipated Queuing	1 mile in advance of end of queue	During anticipated queueing	SLOWED TRAFFIC 1 MILE	LEFT LANE CLOSED	3 / 2
Slowed Traffic	½ to 1 mile in advance	During expected or measured	LFT LANE NARROWS 1500 FT	SLOWED TRAFFIC AHEAD	3 / 3
			RIGHT LN CLOSED 1 MILE	LFT LANE SLOWED AHEAD	
Event Traffic	Advance of alternative route	During Event	EVENT TRAFFIC 2 MILES	EXPECT DELAYS	3 / 2

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