4-2-1 Restricted Locations June 2004

GENERAL

When justified by a traffic engineering study, traffic control signals provide benefits to intersection traffic operations and *may* provide some types of safety improvements as well. While certain benefits can be realized, there *may* be potential trade-offs caused by the installation of traffic control signals including increased delay and reduced mobility on the major approaches, as well as an increase of rear-end type crashes at an intersection.

POLICY

Traffic control signals at isolated, single-source, private access points **shall not** be allowed on the STH system for the following reasons:

1. Signals at isolated, private access points disregard the public interest and investment in STH highway facilities.
2. Private access points are limited to a width of 35 feet (per Trans 231). This width *may* not be great enough to accommodate the geometry required for adequate signalized intersection operations.
3. Signal infrastructure (i.e. detection, signal bases, pull boxes, conduit) *may* need to be installed outside of the public right-of-way.

In lieu of installing traffic signals on the STH system at private access points, other alternatives *may* include:

1. Development of adjacent local street systems to concentrate traffic from other generators and/or direct traffic to intersections that are already controlled by traffic signals or roundabouts
2. Implementation of access restrictions (i.e. right-in/right-out or median modifications), or
3. Use of standard side-street stop control.

Private access point intersections that are aligned with public street connections are not the focus of this policy and are generally not considered to be in conflict with the points made above. However in these cases, it is desirable to locate signal infrastructure within public right-of-way.

The limited number of traffic control signals installed at private access points on the STH system prior to the adoption of this policy will continue to be operated by WisDOT until they are removed, replaced by other forms of intersection traffic control, or jurisdictionally transferred to local government agencies.

SUPPORT

In addition to a traffic engineering study that is performed to justify signal installations at a specific location, other factors *should* be considered. System and access issues also need to be considered when deciding whether signals are appropriate. Examples of these issues are indicated below:

1. Type of facility being proposed for signalization (i.e. it is generally not desirable to signalize expressways or high-speed bypasses around communities)
2. Signal spacing for progressive traffic flow along a corridor
3. Treatment of consolidated access points
4. Connectivity of the access point to the local roads network
5. Relative safety implications
6. Signal maintenance and operation implications.

Other guidance in this topic area *may* be found in the Traffic Impact Analysis (TIA) Guidelines Manual, Highway Access Management Reference Guide, Administrative Rules Trans 233 and Trans 231, State Highway Maintenance Manual Chapter 91, Facilities Development Manual Chapters 7 and 11, TRB Access Management Manual, and NCHRP Report 348 Access management Guidelines for Activity Centers.

If signals are to be installed at public street connections that are aligned with private access points, from a systems perspective, it *may* be desirable to have a portion or all of the private drive dedicated as a public street. There are several reasons for this:

- Provides system consistency for connectivity to local network
- Allows for access control on the subject approach, near the signalized intersection
- Signal infrastructure placement and signal maintenance considerations
- Will allow for greater control of features that *may* reduce sight distance (such as on-premise signing or landscaping)
- *May* provide greater design flexibility for intersection capacity.

When driveways are dedicated as public streets to meet the objectives of effective access and signal systems management, local agreements that are designed to cover or share the additional operations and maintenance costs for the additional infrastructure, *should* be considered.

4-2-4 Flashing Operations — May 2011

GENERAL

Reference is made to the MUTCD, Secitons 4D.28, 4D.29, 4D.30, and 4D.31, and Wisconsin State Statute 346.37, 346.39, and 346.40.

There are four types of flashing operations for traffic control signals: start-up flash, emergency flash, program flash, and manual override flash. Each of these conditions are described briefly below:

1. New signal start-up flash operation is used to acclimate motorists to the revised form of intersection traffic control at a given location prior to initiating steady stop-and-go mode operation.
2. Emergency flash operation *may* be caused by controller malfunction, utility service disruption, or physical damage to the installation (such as a pole knock-down).
3. Program (time-of-day) flash operation is generally limited to use at pre-timed signal installations where no actuation exists to detect vehicles and provide variable green time based on actual approach demand. This type of flash operation is used during off-peak hours (for example, from 10 PM to 6 AM) to reduce intersection delay at pre-timed signals.
4. Manual override flash operation *may* be used by law enforcement officers that assume intersection traffic control associated with special events or incidents.

In addition to flash operation, two flash modes are used: red-red or yellow-red flash.

POLICY

New Signal Installation Start-Up Flash Operation

At newly installed signals that have just become operational, consideration *should* be given to using flash-mode operations if the intersection was open to traffic during construction. This is used to acclimate motorists to the revised form of intersection traffic control at a given location prior to initiating steady stop-and-go mode operation.

Engineering judgment **shall** be used to determine the need for and duration of flash-mode operations. Consideration *should* also be given to the location of the signal and type of motorists that use the route. For example, along a commuter route, new signals *may* be flashed for a length of time between Monday and Friday. Similarly, new signals along a tourist route can be flashed during a weekend period.

Start-up flash for new signals *should* reflect the prior intersection traffic control condition. That is, if a signal is installed to replace a two-way STOP condition, a yellow-red flash mode *may* be used. If a signal is installed to replace an all-way STOP condition, a red-red flash mode *may* be used.

Program (Time-of-Day) Flash Operation

Pre-timed signals on the STH system *may* use program (time-of-day) flash operations but *should* be scheduled for upgrade to semi-actuation, at a minimum. Traffic signals on the STH system that are fully or semi-actuated **shall not** use program (time-of-day) flash operations. Actuated signals can detect and respond to actual demand on conflicting approaches; efficiencies gained by this type of operation at a pre-timed signal do not necessarily exist at an actuated signal. In addition, the transition out of flash operation to steady stop-and-go operations *may* be a time of potential confusion to motorists.

Traffic signals on the STH system that are interconnected with rail-grade crossing systems **shall not** use program (time-of-day) flash operations.

Emergency Flash Operation & Manual Override Flash Operation

Regardless of whether program flash operation is used at a particular installation, the flash mode must be determined for emergency and manual override situations. The bullet points below discuss these two modes:

1. Red-red (R-R) flash mode is prescribed for most signalized intersections, as this mode tends to reflect motorist expectancy. On multilane highways, this type of operation will benefit motorists on the side road since clearance distances can be large.
2. Yellow-red (Y-R) flash mode *may* be appropriate at signals where overall intersection volumes are relatively light and the proportions of mainline volumes significantly exceed those on the side road. This rule of thumb reflects a consideration for intersection delay and maintaining priority based on route significance. However, driver expectancy may be violated causing drivers to unnecessarily stop on yellow, thereby creating a potential safety hazard for other drivers and negating the potential delay reduction.

Even if an isolated intersection meets the broad volume criteria above for yellow-red flash mode, other signalized intersections along a corridor *may* dictate the type of flash mode that *should* be used. For example, if adjacent signalized intersections use a red-red flash mode, driver expectancy *may* determine that any additional signals in the immediate area operate in the same manner; regardless of this generalized volume criteria.

SUPPORT

Whether a signal is operating in steady stop-and-go mode, R-R or Y-R flashing mode, or non-operable (dark) mode, driver expectancy *should* be considered. Careful engineering judgment *should* be used to balance the needs of safety, efficiency and motorist expectancy.

4-2-5 Vehicle Clearance Intervals — May 2006

GENERAL

Reference is made to the MUTCD Section 4D.10.

According to State Statute 346.37(1)(b), "When shown with or following the green, traffic facing a yellow signal **shall** stop before entering the intersection unless so close to it that a stop *may not* be made in safety."

The purpose of the YELLOW vehicle clearance interval is to inform drivers of an impending change in right-of-way assignment. Yellow clearance intervals are normally three to six seconds in duration.

The purpose of the ALL-RED clearance interval is to allow vehicles to travel through an intersection that have lawfully entered during the yellow clearance interval. It *may* also provide a brief period of separation time between opposing movements. All-red clearance intervals normally do not exceed three seconds in duration.

POLICY

By the WisMUTCD, all traffic signal installations **shall** display a yellow indication following every green interval. In addition, by this policy, state-owned signal installations **shall** operate with an all-red clearance interval for mainline and side street intersection through-vehicle movements. All-red clearance intervals *may* be used for other intersection movements, such as protected left turns.

Fundamentally, there are three ways that yellow and all-red clearance intervals are developed: timing derived by kinematic principles, uniform timing, and rule of thumb. As a statewide organization, WisDOT routinely operates signals adjacent to various jurisdictions that *may* have differing perspectives about signal timing methodology. In the interest of providing uniform conditions to the extent possible, all methods are considered acceptable but *may* have greater applicability in certain situations or within specific areas of the state.

Kinematic Method

Develops a clearance interval duration based on driver behavior and physical principles. Clearance interval timing based on this method can be calculated for each intersection movement by using the following formula:

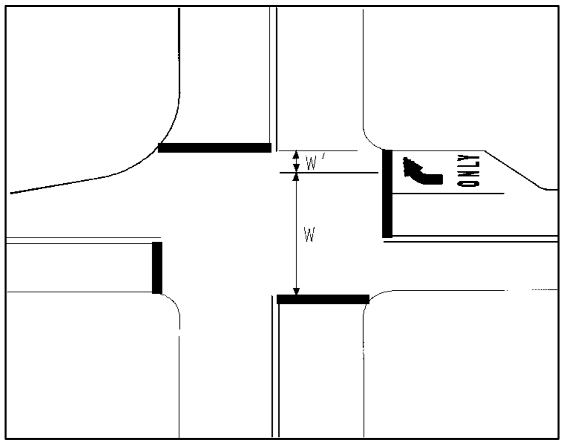
$$CT = prt + \frac{v}{2a+2Gg} + \frac{L+w}{v}$$

$$= \underbrace{prt + \frac{v}{2a+2Gg}}_{\text{yellow portion}} + \underbrace{\frac{L+w}{v}}_{\text{all-red portion}}$$

Where:

CT	=	clearance time (*may* be rounded up to nearest 0.5 second)
prt	=	driver perception-reaction time (usually 1.0 second)
v	=	vehicle approach speed (feet per second, vehicle approach speed *should* be based on the posted speed, or the 85-percentile speed if data is available)
a	=	average vehicle deceleration rate (usually 10 to 15 feet per second^2, 10 to 12 fps^2 recommended)
g	=	acceleration due to gravity (32 fps^2)
G	=	approach grade (expressed as decimal)
L	=	vehicle length (usually 20 feet)
w	=	intersection width (measured in feet from the near-side stop bar, see “w” diagram below)

Figure 1. Recommended Intersection Width (“w”) Determination



Intersection width measured from approach stop bar to center of conflicting vehicle lane on the far side of the intersection. Width *may* also include distance from center of far lane to the outside edge of the traveled way ($w + w^l$).

When used, variables within the formula above *may* need to be adjusted for various applications and for different intersection movements. For example, in the case of left-turns, driver perception-reaction times *may* be shorter and/or vehicle approach speeds lower.

As stated above, the upper limit of the yellow and all-red clearance intervals are typically 6 and 3 seconds, respectively. Longer clearance interval times *may* breed driver noncompliance that can actually degrade intersection safety benefits. Excessively long clearance interval times will also reduce the efficiency of signal operations. The lower limit of the yellow clearance interval is typically 3 seconds.

For isolated state-owned signals that can be considered outside the influence of established timing practices of adjacent jurisdictions (for purposes of driver expectancy), it is desirable to use the kinematic method of determining vehicle clearance intervals.

For given approach speeds and gradients, the table below indicates YELLOW CLEARANCE INTERVALS calculated by the equation above (considering a lower deceleration rate of 10 fps^2).

Table 1. Yellow Clearance Intervals at Deceleration Rate of 10 fps^2

Approach	Approach Grade								
Speed (mph)	+4%	+3%	+2%	+1%	0%	-1%	-2%	-3%	-4%
25	2.6	2.7	2.7	2.8	2.8	2.9	3.0	3.0	3.1
30	3.0	3.0	3.1	3.1	3.2	3.3	3.4	3.4	3.5
35	3.3	3.3	3.4	3.5	3.6	3.7	3.7	3.8	4.0
40	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.3	4.4
45	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.7	4.8
50	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.1	5.2
55	4.6	4.7	4.8	4.9	5.0	5.2	5.3	5.5	5.6
60	4.9	5.0	5.1	5.3	5.4	5.6	5.7	5.9	6.1
65	5.2	5.4	5.5	5.6	5.8	5.9	6.1	6.3	6.5

Gray-shaded values fall outside typical time intervals indicated. Use only as needed and at the direction of the regional traffic engineer.

For given approach speeds and gradients, the table below indicates YELLOW CLEARANCE INTERVALS calculated by the equation above (considering a higher deceleration rate of 15 fps^2)

Table 2. Yellow Clearance Intervals at Deceleration Rate of 15 fps^2

Approach	Approach Grade								
Speed (mph)	+4%	+3%	+2%	+1%	0%	-1%	-2%	-3%	-4%
25	2.1	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3
30	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.6	2.6
35	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.8	2.9
40	2.8	2.8	2.9	2.9	3.0	3.0	3.0	3.1	3.1
45	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	3.4
50	3.3	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7
55	3.5	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9
60	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.1	4.2
65	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.5

Grey-shaded values fall outside typical time intervals indicated. Use only as needed and at the direction of the regional traffic engineer.

For given intersection widths and approach speeds, the table below indicates ALL-RED CLEARANCE INTERVALS calculated by the equation above.

Table 3. All-Red Clearance Intervals

Approach	Intersection Width (ft)								
Speed (mph)	24	36	48	60	72	84	96	108	120
25	1.2	1.5	1.9	2.2	2.5	2.8	3.2	3.5	3.8
30	1.0	1.3	1.5	1.8	2.1	2.4	2.6	2.9	3.2
35	0.9	1.1	1.3	1.6	1.8	2.0	2.3	2.5	2.7
40	0.7	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
45	0.7	0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.1
50	0.6	0.8	0.9	1.1	1.3	1.4	1.6	1.7	1.9
55	0.5	0.7	0.8	1.0	1.1	1.3	1.4	1.6	1.7
60	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6
65	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.5

Gray-shaded values fall outside typical time intervals indicated. Use only as needed and at the discretion of the region traffic engineer.

Uniform Timing

Assigns a standardized duration for the clearance interval regardless of location. In this case, times *may* be based on the type of movement being made. For example, based on higher vehicle speeds, a through movement on a mainline approach *may* have a longer yellow clearance time then for a side street through movement or for a protected left-turn.

This method *may* be used when a state-owned signal is located in close proximity to signals operated in this manner by another jurisdiction. The purpose being, to address driver expectancy issues. However, assigning a single clearance interval value for all intersections and intersection movements is not recommended.

Rule of Thumb

Assigns a standardized duration for the clearance interval based on vehicle approach speed, the type of movement being made, or roadway classification. For example, mainline and side street movements *may* have the following yellow clearance interval durations:

Approach speed <30 mph = 3 seconds
Approach speed between 30-50 mph = 4 seconds
Approach speed >50 mph = 5 seconds
Protected left turns = 3 seconds

The interval times are for demonstrative purposes only. Similarly, though, all-red clearance times *may* be categorized.

This method *should* typically be used when a state-owned signal is located in close proximity to signals operated by another jurisdiction using this method to address driver expectancy issues.

SUPPORT

Even nationally, there is no clear consensus on appropriate methodology for determining vehicle clearance times ("Determining Vehicle Signal Change and Clearance Intervals", ITE, August 1994). According to ITE, "Divergent and strongly held positions are common when vehicle signal change interval lengths are discussed. Some believe that a common interval length is best, while others believe that uniform yellow change interval lengths are wrong….". This finding was verified more recently in an ITE document titled *Signal Timing Practices and Procedures – State of Practice* dated March 2004.

The kinematic methodology is typically the most desirable unless driver expectancy would be better served through the use of the other principals described above.

As stated above, since WisDOT signals routinely operate near locally owned installations, the intent *should* be uniformity across an appropriate area or along a specific corridor. As such, proper coordination with other jurisdictions *should* take place. If a crash or red light running problem exists, vehicle clearance intervals *should* be verified and, if needed, reasonably extended.

4-2-8 Battery Backup Systems May 2006

GENERAL

The recent application of LED traffic signal indications, which consume less power than conventional incandescent lamps, has made battery-powered energy backup systems feasible. However, it is recognized that, because of the cost of such systems, that gradual deployment at strategic signalized intersection locations is appropriate.

Factors that *may* influence the placement of battery backup systems are: proximity of other transportation systems, intersection geometry, traffic volumes, corridor (i.e. progressive movement) considerations, or safety considerations.

POLICY

<u>Location Criteria</u>

Signalized intersection locations that meet the criteria below **shall** be equipped with a battery backup system capable of maintaining signal operation, as defined and prioritized below:

1. RR interconnected installations, or
2. Single point urban interchanges, or
3. Intersections with triple-left turn lanes.

Signalized operations *should not* need to be modified in order to reduce energy requirements or extend service time. Rather than introducing modified signal operations or displays, signals that function with battery backup systems with low power reserves *may* go into flashing operation.

Intersections and roadway lighting **shall not** be connected to battery backup systems.

SUPPORT

Battery backup systems are expected to maintain safe and efficient traffic operations at critical signalized intersections during power outages. Of particular concern are intersections that are near railroad grade crossings (for preemption) and geometrically complex intersections.

Besides providing potential benefits to traffic safety and operations, the use of battery backup systems *may* allow increased response times by electrical personnel, which could provide an advantage in light of increased signal infrastructure and associated maintenance demands.

4-2-20 Emergency Vehicle Preemption February 2013

GENERAL

The following applies to the installation and operation of emergency vehicle preemption (EVP) systems involving traffic control signals owned and operated by the department.

POLICY

Statutory Provisions

347.255 Auxiliary lamps on emergency vehicles used to actiate traffic control signal preemption devices. (1) An authorized emergency vehicle described in ss.340.01 (3)(a), (c), (g) or (I) *may* be equipped and operated with lamps designed and used solely to activate official traffic control signal pre-emption devices. (2) The lamps authorized for use under this section *may* be any color and *may* be flashing, oscillating, rotating or pulsating. (3) No operator of an authorized emergency vehicle *may* use such lamps except when responding to an emergency call, when pursuing an actual or suspected violator of the law or when responding to, but not when returning from, a fire alarm.

The above does not preclude actuation by means of devices other than lamps.

Eligibility

Any local government unit, agency, or organization having responsibility for providing emergency services is eligible to request an EVP system.

Request Procedure

The local unit **shall** make the request in writing to the department. The following information *should* be included in the request:

1. Location of proposed EVP systems
2. Location of emergency facilities (fire station, police station, etc.) where vehicles will be departing from and description of the route to be provided with a preemption system
3. Listing or estimate of number of vehicles to be outfitted
4. Brand/model of equipment being requested.

Approval

1. The department **shall** review each request and respond in writing to the local unit as to the approval or denial of the request.
2. The department *may* deny any request that it deems would have an overall negative impact on the traveling public.
3. If the local agency is requesting a brand/model of EVP other than the department standard, the request must include a discussion about compatibility with neighboring agencies along the same corridor.
4. For approved requests, an official EVP System Agreement **shall** be prepared and approved by the department and the local unit. Template is included at the end of this policy. This policy **shall** be included as a supplement to the agreement. Any special terms or conditions beyond the scope of this policy **shall** be included as a supplement to the agreement. Any special terms or conditions beyond the scope of this policy **shall** be stipulated in the agreement.
5. The department *may* allow an indicator light that is intended to confirm o the driver of an emergency vehicle that the preemption signal has been received. The use of this device does not preclude the need of the vehicle operator to rely on the signal indications for assigned intersection right-of-way. Requests for EVP confirmation lights *should* be reviewed on a case-by-case basis, and are subject to the following conditions:
    a. The department *may* deny any request for confirmation lights that it deems would have an overall negative impact on traffic safety or operations.
    b. EVP confirmation lights **shall** only be installed at signalized intersections where:
        i. Signal(s) on the STH system are embedded in a locally-owned system that is also equipped with confirmation lights. This implies consideration for route continuity.
        ii. Or, multiple emergency vehicles have the potential to respond on conflicting

approaches to and from different points of origin. These conditions will typically exist in large urban areas where there are multiple precincts in the same municipality.

6. EVP equipment that has the ability to discriminate between individual responding vehicles **shall not** be used.
7. In the event that it comes to the attention of the department that the preemption is being misused, such as by unauthorized vehicles, or that the municipality is not using or intends to abandon the system, the department *may* notify the municipality of the situation. If the matter is not resolved and corrected, the department reserves the right to set about removing the equipment. The scheduled date of removal of the equipment is indicated in item 5 below.

Installation & Maintenance

1. Department forces **shall** perform the installation, maintenance, modification, or removal of the EVP system equipment that is located at the traffic signal. Generally, this equipment would include the receiving device (mounted on the mast arm or signal head), the phase selector (in the control cabinet), confirmation light, and any miscellaneous cables and wiring needed to operate and power the portion of the EVP system located at the signal.
2. The local unit will be responsible for the installation of the emitting devices in authorized vehicles.
3. The department **shall** maintain a reasonable inventory of spare parts for the department's selected standard equipment in order to service the EVP system equipment located t the traffic signal. If the local agency is requesting equipment other than the standard equipment, the local agency **shall** be responsible for maintaining and providing a reasonable inventory. Specify which in the agreement.
4. When notified, department forces will respond to correct suspected failures or breakdowns, or perform requested modifications in the EVP system equipment at the traffic signal.
5. Upon the department's request, the local unit will be responsible for verifying the working status of the EVP system by performing a field test using an emergency vehicle equipped with an EVP emitter device. The local unit is responsible for periodically checking the EVP equipment.
6. If used, the syle and type of confirmation lights on state- and locally-owned signals within each municipality **shall** be standardized. Confirmation lights **shall** be a LED 120 VAC white directional light that fits into a PAR 38 socket.
7. In the event of a construction project, EVP service **shall** be maintained at any intersection with permanent EVP agreements. In addition, EVP equipment may be installed, if requested by a local unit, at any additional signals within the construction project itself, or on a designated detour route in the event of a road closure.

Operation/Phase Timing

1. The department **shall** determine the phasing and timing of the preemption sequencing with input from the local unit. There are three key features that must be considered when determining how the preemption will operate:
   a. Left turn phasing (protected, protected/permissive, or permissive only)
   b. Signal head configuration for left-turning movement (shared vs. exclusive head)
      i. Shared heads: include both circular indications and arrow indications (used by through and turning vehicles)
      ii. Exclusive heads: arrow indications only (used solely by turning vehicles)
   c. Style of preemption sequencing (common greens vs. exclusive greens)
      i. Common greens: indicates opposing through phases both have a green ball. The corresponding left turn phases are permissive only.
      ii. Exclusive greens: indicates only one through movement and its corresponding left turn phase have the green ball/arrow.
2. The department offers the following operational guidance based upon the combination of those three key features identified above:
   a. Protected only left turns

        i. Exclusive head **shall** operate with exclusive greens for the safety and ease of turning of the preempting vehicle

    b. Permissive only left turns

        i. Shared head

            1. Common greens *may* be used

            2. Exclusive greens *may* be used if an all-red period is introduced or a W25-2 sign is installed.

        ii. Exclusive head:

            1. **Shall** operate with common greens since a green left turn arrow is not available for use with exclusive greens

    c. Protective/permissive left turns

        i. Shared head

            1. Common greens: *may* be used

            2. Exclusive greens *may* be used if an all-red period is introduced or a W25-2 sign is installed

        ii. Exclusive head

            1. Common greens *may* be used

            2. Exclusive greens *may* be used

3. Any exceptions to the guidance in item 2 above **shall** be included as part of the special terms or conditions of the agreement.

4. If used, the operation of confirmation lights on state- and locally-owned signals **shall** be standardized such that the approach being preempted has a steady indication. Approaches with secondary calls **shall** flash. The flash rate **shall not** be between 5 and 30 flashes per second to avoid frequencies that might cause seizures.

Driver Training

1. The local unit **shall** be responsible for training the emergency services personnel on the proper operation of the system.

2. This training *should* provide clear understanding of these items:

    a. The definition of an authorized emergency vehicle at the beginning of this policy

    b. The conditions when preemption *may* be used

    c. The use of preemption does not remove the responsibility of the vehicle operator from determining whether or not it is safe to enter the intersection

    d. The operator cannot assume that the preemption has gone into effect; the operator must rely on the traffic signal indication

    e. The proper operation of the activating device located on the vehicle.

Cost

1. The most common source of funding for a complete EVP system has been local funds or federal urban funds. However, EVP equipment at the traffic signal and installation may also be funded as part of an improvement project, provided it is incidental to the improvement. Please see Program Management Manual 3-25-5 to determine the most appropriate source of funding.

2. The local municipality **shall** be responsible for all costs associated with the emitting devices for is authorized vehicles.

3. The department **shall** be responsible for all material, equipment, labor, training, and incidental costs associated with maintaining, operating, modifying, or removing the EVP system at the traffic signal unless nonstandard EVP system equipment is used. When nonstandard equipment is installed, the local unit **shall** be responsible for maintaining and supplying spare inventory to the department.

4. Any cost associated with the continuance of service of an EVP system on temporary signals or aon a temporary route during a construction project **shall** be borne by the project.

WISCONSIN DEPARTMENT OF TRANSPORTATION

Emergency Vehicle Pre-emption (EVP) System Agreement

This is a binding agreement between the Wisconsin Department of Transportation and the

____

This agreement stipulates the terms and conditions for use of Emergency Vehicle Pre-Emption (EVP) systems at the state-owned traffic control signal located at the intersection of

____

in the ________________________ of ________________________

Description of route: ____

____

Listing of estimated number of vehicles to be outfitted: ________________________

____

Inventory of spare EVP equipment shall be provided by WisDOT/Local Agency.

The Department's Policy for *Use of Emergency Vehicle Pre-emption (EVP) Systems at State-Owned Traffic Control Signals is hereby* made a part of this agreement (copy attached). The following special terms or conditions also apply to this agreement:

ACCEPTED FOR THE ____
Local Government

BY ________________________ DATE ________________________

TITLE ________________________

APPROVED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION

BY ________________________ DATE ________________________

TITLE ________________________

4-2-34 Preemption of Traffic Signals Near Railroad Grade Crossings — October 2023

GENERAL

Reference is made to the WisMUTCD, Section 4D.27 and Section 8C.09.

POLICY

When to Preempt

Preemption *should* be provided for traffic signals within 200 feet of a grade crossing and *should* be considered for traffic signals more than 200 feet from a crossing. The determination on when to preempt any traffic signal located near a railroad grade crossing *should* be made based upon the likelihood of a queue extending across the tracks or through the intersection. Traffic engineering calculations, traffic simulation modeling, and field observations may be used to determine the queuing probability.

For all new traffic signals installed within at least 200 feet of a grade crossing, the signal investigation study (TSDM 2-1-1) **shall** include an analysis of the queueing between the signalized intersection and the grade crossing and provide a recommendation regarding railroad preemption. This recommendation **shall** be sent to the Railroads and Harbors Section for final determination.

For an existing traffic signal located within at least 200 feet of a grade crossing, a queueing analysis and/or review of the adequacy of the existing preemption, when appropriate, **shall** be performed as part of project scoping. The region **shall** send their analysis and recommendations to the Railroads and Harbors Section for final determination.

Preemption Timing

According to WisMUTCD Section 8C.09, if preemption is provided, the normal sequence of traffic control signal indications **shall** be preempted upon the approach of trains to avoid entrapment of highway vehicles on the highway-rail grade crossing.

Once it is determined that preemption is needed, WisDOT's Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings form (Figure 1) **shall** be completed and **shall** be included as an attachment to the railroad project submittal package (RPSP) (see FDM 17-20-10).

Section 2 of WisDOT's Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings covers Right-of-Way Transfer Time Calculations.

Right-of-Way Transfer Time

Right-of-way transfer time is the maximum amount of time needed prior to display of the preemption clearance interval. The amount of right-of-way transfer time required for any intersection can be reduced by utilizing different minimum green, walk and don't walk times during the transition to the track clearance phase. These values are programmed in the controller for use only during a railroad preemption.

Minimum green times *should* be at least five seconds to allow drivers time to perceive and react to green light and begin to move before the traffic signal turns yellow.

According to WisMUTCD Section 4D.27, during the transition into preempted control, the preemption sequence **shall not** shorten or omit the yellow change interval and any red clearance interval that follows.

Additionally, according to WisMUTCD Section 4D.27, pedestrian WALK and/or pedestrian change intervals *may* be shortened or omitted in order to begin the track clearance interval earlier. Omitting the WALK interval is standard practice, however omitting the pedestrian change interval (FLASHING DON'T WALK) is not recommended, and only done in rare, short-term circumstances. To reduce the right-of-way transfer time, FLASHING DON'T WALK may be reduced to a value equal to the crossing distance from face of curb to face of curb divided by a walking speed of 4 feet per second (fps).

Second Train Re-Service Considerations

Where a railroad crossing has more than one through track, special consideration must be given to operation of the warning devices and traffic signal when a second train follows the first train.

Preemption Circuitry

For all state-owned traffic signals operating with railroad preemption, the preemption circuitry **shall** be designed to, at a minimum, include a supervisory and gate down circuit in addition to the advance or simultaneous preemption. Additional circuits such as advanced pedestrian preemption and traffic signal health circuits may be used based on a case-by-case basis.

Joint Annual Railroad Preemption Inspection

Traffic signals with railroad preemption sequencing **shall** be inspected on an annual basis. Regional traffic engineers are responsible for ensuring that each state-maintained traffic signal is inspected.

At a minimum, the preemption inspection team *should* consist of an individual representing the traffic signal operating agency and an individual representing the railroad authority. This cooperative approach is critical to the success of the inspection because the operation of railroad preemption systems is dependent on both the railroad and highway equipment.

A copy of the completed WisDOT Railroad Preemption Inspection Form (Figure 2) **shall** be filed with the Office of the Commissioner of Railroads in their Joint Inspection Report portal.

SUPPORT

Additional guidance on the subject can be found in *Preemption of Traffic Signals Near Railroad Grade Crossings 2nd Edition – A Recommended Practice of the Institute of Transportation Engineers*.

Figure 1. WisDOT Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings (form)

Version 1.4
(Rev. 2/22)

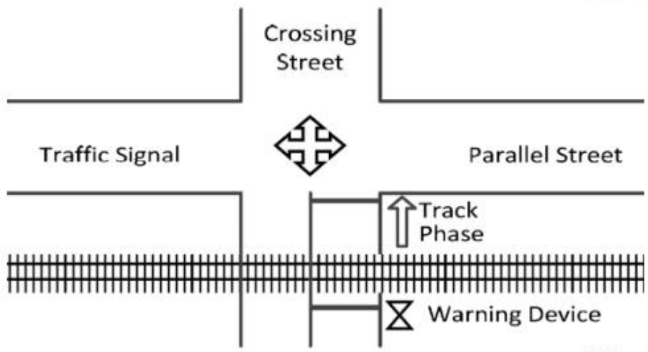
Wisconsin Department of Transportation

GUIDE FOR DETERMINING TIME REQUIREMENTS FOR TRAFFIC SIGNAL PREEMPTION AT HIGHWAY-RAIL GRADE CROSSINGS

City
County
Region

Date
Completed by
Region Approval

Select North Arrow:



Parallel Street Name

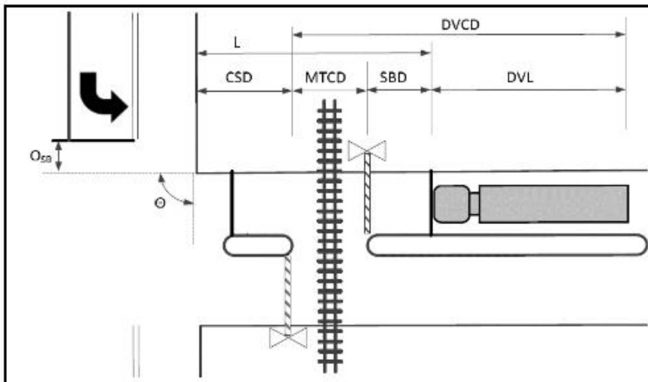
Crossing Street Name

Railroad
Crossing DOT #
M.P.

Railroad Contact
Phone

NOTE: After approval by the Region, a copy of this form, along with the traffic signal design sheets and the phasing diagrams for normal and preempted operation, shall be placed in the traffic signal cabinet. See Section 7 for traffic signal timings.

SECTION 1: GEOMETRY DATA & DEFAULTS



CSD = Clear storage distance (ft)
MTCD = Minimum track clearance distance (ft)
SBD = Stop bar setback distance (ft)
DVL = Design vehicle length (ft)
L = Queue start-up distance, also stop-line distance (ft)
DVCD = Design vehicle clearance distance (ft)
O_{SB} = Offset distance to Left-turn stop bar (ft)
B = Distance from curb line to center of nearest lane receiving left turns (ft)
Θ = Angle of turn (degrees)

GEOMETRIC DATA FOR CROSSING

			Remarks
1. Clear storage distance (CSD, feet)……	1.	0	
2. Minimum track clearance distance (MTCD, feet)……	2.	17	
3. Stop bar setback distance (SBD, feet)……	3.	8	Enter "0" if no stop bar is present
4. Width of receiving approach (B, feet)……	4.	0	
5. Offset distance of left turn stop bar (OSB, feet)……	5.	0	
6. Approach grade. % (0 if approach is on downgrade)……	6.	5.0%	
7. Angle of turn at Intersection (θ, degrees)……	7.	90	

DESIGN VEHICLE DATA

8. Select Design Vehicle from Dropdown		School Bus	
9. Default design vehicle length (feet)……	9.	40	Based on Selected Design Vehicle
a. Additional vehicle length, if needed (feet)……	9a.	0	Use only if "Other" Selected as Design Vehicle
10. Total design vehicle length (DVL, feet)……	10.	40	L9 + L9a
11. Centerline turning radius of design vehicle (R, feet)……	11.	35.4	Based on Selected Design Vehicle
12. Passenger car vehicle length (LV, feet)……	12.	19	Default Value

Page 1

SECTION 2: RIGHT-OF-WAY TRANSFER TIME CALCULATION

Preempt verification and response time

			Remarks
13. Preempt delay time (seconds)........	13.	0	Typically not used
14. Controller response time to preempt (seconds)........	14.	0.0	Manufacturer:
			Firmware Version:
15. Preempt verification and response time (seconds)........	15.	0.0	L13 + L14

Worst-case conflicting vehicle time

16. Minimum green time during right-of-way transfer (seconds)........	16.	7	Value abjustable to meet local conditions
17. Other green time during right-of-way transfer (seconds)........	17.	0	
18. Yellow change time (seconds)........	18.	0.0	
19. Red clearance time (seconds)........	19.	0.0	
20. Worst-case conflicting vehicle time (seconds)........	20.	7.0	Sum of L16 through L19

Worst-case conflicting conflicting time

			Remarks
21. Minimum walk time during right-of-way transfer (seconds)........	21.	0	0 is the default and recommended value
22. Pedestrian clearance time during right-of-way transfer (seconds)........	22.	0	
23. Vehicle yellow change time, if not included on line 22 (seconds)........	23.	0.0	
24. Vehicle red clearance time, if not included on line 22 (seconds)........	24.	0.0	
25. Worst-case conflicting pedestrian time (seconds)........	25.	0.0	Sum of L21 through L24

Worst-case conflicting vehicle or conflicting pedestrian time

			Remarks
26. Minimum walk time during right-of-way transfer (seconds)........	26.	7.0	maximum of L20 and L25
27. Right-of-way transfer time (seconds):	27.	7.0	L15 + L26

SECTION 3: QUEUE CLEARANCE TIME CALCULATION

			Remarks
28. Are there left-turns towards the tracks? (Select Yes/No)........	28.	No	
29. Distance traveled by truck during left-turn (LTL, feet)........	29.	0	LTL = πRθ/180
30. Travel speed of left-turning truck (SLTT, mph)........	30.	10	Default Value
31. Distance required to clear left-turning truck from travel lanes on track clearance approach (feet)........	31.	0	Eqn: (L4 + L5 + L12 - L11) + L29 + L1C
32. Additional time required to clear left-turning truck from travel lanes on track clearance approach (seconds)........	32.	0.0	Eqn: [(L31 * 3600) / (L30 * 5280) - L18 - L19
33. Worst-case Left Turning Truck time (seconds)........	33.	0.0	If L28 = 'Yes', use L32; otherwise use C
34. Queue start-up distance, L (feet)........	34.	25	L1 + L2 + L3
35. Time required for design vehicle to start moving (seconds)........	35.	3.3	2 + (L34 ÷ 20)
36. Design vehicle clearance distance, DVCD (feet)........	36.	65	L2 + L3 + L10
37. Time for design vehicle to accelerate through DVCD (seconds)........	37.	11.9	Find value using Figure 3, given L36 & L8
38. Factor to account for slower acceleration on uphill grade........	38.	1.000	Table 2 interpolation
39. Time for design vehcle to accelerate through DVCD (seconds)........	39.	11.9	Adjusted for grade
40. Queue clearance time (seconds)........	40.	15.2	L33 + L35 + L39

SECTION 4: MAXIMUM PREEMPTION TIME CALCULATION

			Remarks
41. Right-of-way transfer time (seconds)........	41.	7.0	Line 27
42. Queue clearance time (seconds)........	42.	15.2	Line 40
43. Desired minimum separation time (seconds)........	43.	4.0	Typical Value
44. Maximum preemption time for Queue Clearance (seconds)........	44.	26.2	L41 + L42 + L43

Page 2

SECTION 5: SUFFICIENT WARNING TIME CHECK

			Remarks
45. Required minimum time, MT (seconds): per regulations	45.	30	Default Value
46. Clearance time, CT (seconds)	46.	0	(L2-35)/10 (rounded up to nearest second)
47. Total minimum warning time, MWT, needed (seconds)	47.	30.0	L45 + L46 (excludes BT and ERT)
48. Required advance preemption time (APT) from railroad (seconds)	48.	0	L44 - L47 (rounded up to nearest full secor
49. APT currently provided by railroad (seconds)	49.		Enter "0" if new crossing or signal

If the required advance preemption time (line 48) is greater than the amount of advance preemption time currently provided by the railroad (line 49), additional warning time must be requested from the railroad. Alternatively, the maximum preemption time (line 48) may be decreased after performing an engineering study to investigate the possibility of reducing the values on lines 13, 16, 17, 21, 22 and 43.

Remarks:

SECTION 6: TRACK CLEARANCE GREEN TIME CALCULATION (IF NO GATE DOWN CIRCUIT PROVIDED) (NOT TYPICALLY USED)

Preempt Trap Check

			Remarks
50. Warning Time Variability (Select One)	50.	Consistent Warning Times	
51. APT required or provided (seconds)	51.	0	See Instructions for details (max of 48/49)
52. Multiplier for maximum APT due to train handling	52.	1.00	
53. Maximum APT (seconds)	53.	0	multiply L51 and L52
54. Minimum duration for the track clearance green interval (seconds)	54.	15	Default Value
55. Track Clearance Green Time to avoid Preempt Trap (seconds)	55.	15.0	L53 + L54

Clearing of Clear Storage Distance

56. Time waiting on left-turn truck (seconds)	56.	0.0	Line 33
57. Time required for design vehicle to start moving (seconds)	57.	3.3	Line 35
58. Design vehicle clearance distance (DVCD, feet)	58.	65	Line 36

59. If CSD < DVL, you must clear the design vehicle through the entire CSD during the traffic clearance phase; however, if CSD > DVL, you should consider providing enough time to clear the design vehicle from the crossing.

a. Is the clear storage distance (CSD) less than or equal to the design vehicle length (DVL)?

YES. The design vehicle MUST clear through the entire CSD. (CSD will be entered in Line 59).

b. Do you want to clear the design vehicle through the entire CSD? (Select Yes/No)

<Select One>

Portion of CSD to clear during track clearance phase (feet)	59.	0	
60. Design vehicle relocation distance (DVRD, feet)	60.	65	L58 +L59
61. Time required to accelerate design vehicle through DVRD (seconds)	61.	12.1	Find value using Figure 3, given L60 & L8
62. Factor to account for slower acceleration on uphill grade	62.	1.284	interpolation
63. Time required to accelerate design vehicle through DVRD (seconds)	63.	15.5	Adjusted for Grade - multiply L61 & L62
64. Time to clear portion of clear storage distance (seconds)	64.	18.8	L56 + L57 + L63
65. Track clearance green interval (seconds)	65.	19.0	max of L55 and L64 (rounded up)

Maximum Duration of Track Clearance Green after gates are down (in absence of a gate down circuit)

66. Total time to complete track clearance green (seconds)	66.	26	L27 + L65
67. Total time before gates are down (seconds)	67.	21.2	L44 - 5 seconds (per AREMA Manual)
68. Maximum Duration of Track Clearance Green after gates are down	68.	4.8	(seconds): L66 - L67

Page 3

ιECTION 7: SUMMARY OF CONTROLLER PREEMPTION SETTINGS

'reempt Trap Check

			Remarks
69. Duration Time (seconds)…	69.	0	Default Value
70. Preempt Delay Time (seconds)…	70.	0	Line 13

Right of Way Transfer Phase

			Remarks
71. Minimum Green Interval (seconds)…	71.	7	Line 16
72. Pedestrian Walk Interval (seconds)…	72.	0	Line 21
73. Pedestrian Clearance Interval (Flashing "DON'T WALK", seconds)…	73.	0	Line 22
74. Yellow Change Interval (seconds)…	74.	-	Not typically overriden for preemption
75. All Red Vehicle Clearance (seconds)…	75.	-	Not typically overriden for preemption

Track Clearance Phase

			Remarks
76. Green Interval (seconds) (in the absence of gate down circuit)…	71.	26	
77. Green Interval (seconds) with gate down circuit…	72.	16	Line 40
78. Yellow Change Interval (seconds)…	73.	-	Not typically overridden for preemption
79. All Red Vehicle Clearance (seconds)…	74.	-	Not typically overridden for preemption

Exit Phase

			Remarks
80. Dwell/Cycle Minimum Green Time (seconds)…	71.	0	Default Value
81. Yellow Change Interval (seconds)…	72.	-	Not typically overridden for preemption
82. All Red Vehicle Clearance (seconds)…	73.	-	Not typically overridden for preemption

Remarks:

Figure 2. WisDOT Railroad Preemption Inspection Form

WisDOT RAILROAD PREEMPTION INSPECTION FORM

1. REVIEW TEAM

TRAFFIC SIGNAL INSPECTION COMPLETED BY:		INSPECTION DATE:	
RAILROAD INSPECTION COMPLETED BY:		DATE OF LAST INSPECTION:	

2. LOCATION DATA

HIGHWAY INTERSECTION:		MUNICIPALITY:	COUNTY:
TRAFFIC SIGNAL OPERATING AGENCY:	SIGNAL ID: (ex. S1056)	SIGNAL CONTACT:	SIGNAL CONTACT PHONE:
RAILROAD OPERATING COMPANY:	RR CROSSING ID: (ex. 391768X)	RR CONTACT:	RR CONTACT PHONE:
TRAFFIC SIGNAL EMERGENCY CONTACT NUMBER:		RAILROAD EMERGENCY CONTACT NUMBER:	

3. RAILROAD DATA

ACTIVE WARNING DEVICES: ☐ 3 or 4-Quadrant Gates ☐ 2-Quadrant Gates ☐ Flashers	
MAXIMUM TRAIN SPEED (MPH):	SPEED RANGE OVER XING (MPH):
NUMBER OF TRAINS PER DAY:	NUMBER OF TRACKS:
AVAILABLE CIRCUITS: ☐ APPT ☐ APT ☐ GD ☐ HC ☐ Sup ☐ XR	
USED CIRCUITS: ☐ APPT ☐ APT ☐ GD ☐ HC ☐ Sup ☐ XR	

CIRCUIT NOTES:
APPT = Advanced Pedestrian Preemption
XR = Island Circuit
APT = Advance Preemption
GD = Gate Down
HC = Health Circuit
Sup = Supervisor

4. TRAFFIC SIGNAL DATA

CABINET TYPE: ☐ TS1 ☐ TS2	CONTROLLER MAKE & MODEL:
TYPE OF SIGNAL PREEMPTION: ☐ Advanced ☐Simultaneous	BLANKOUT SIGNS PRESENT? ☐ Yes ☐ No
OTHER TYPES OF PREEMPTION: ☐ Emergency Vehicle ☐ Bus/Transit	DOES RR PREEMPT HAVE PRIORITY? ☐ Yes ☐ No
BATTERY BACKUP PRESENT? ☐ Yes ☐ No	BATTERY BACKUP COMMUNICATION? ☐ Yes ☐ No
AVAILABLE CIRCUITS: ☐ APPT ☐ APT ☐ GD ☐ HC ☐ Sup ☐ XR	
USED CIRCUITS: ☐ APPT ☐ APT ☐ GD ☐ HC ☐ Sup ☐ XR	
VEHICULAR PHASES PRESENT: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8	
PEDESTRIAN PHASES PRESENT: ☐ 2 ☐ 4 ☐ 6 ☐ 8	OTHER PHASES PRESENT:

5. RAILROAD EQUIPMENT TIMERS

RAILROAD SETTINGS	DESIGNED	MEASURED	NOTES
Equipment Reaction Time (ERT):	sec.		
Advanced Pedestrian Preemption Time (APPT):	sec.	sec.	
Advanced Preemption Time (APT):	sec.	sec.	
Minimum Warning Time (MWT):	sec.		
Additional Clearance Time (CT): (overspeed tolerance, wide/angled crossings)	sec.		
Buffer Time (BT):	sec.		
Total Warning Time (MWT + CT + BT):	sec.		

6. DESIGN RAILROAD PREEMPTION PHASING SEQUENCE

WORST CASE CONFLICTING PHASES	TRACK CLEARANCE PHASE(S)	PREEMPT DWELL PHASES	PREEMPT CYCLE PHASES
Vehicle: Pedestrian:			

Page 1 of 2

7. TRAFFIC SIGNAL TIMINGS

CONTROLLER SETTINGS	DESIGNED	PROGRAMMED	MEASURED	NOTES
Preempt Delay:	sec.	sec.		
Entrance Min Green:	sec.	sec.	sec.	
Entrance Walk + Ped Clear:	sec.	sec.	sec.	
Entrance Yellow + Entrance Red:	sec.	sec.	sec.	
Maximum RWTT (Delay + Min G + Y + R or Delay + Walk + Ped Clear + Y + R):	sec.	sec.		
Track Clear Min Green:	sec.	sec.	sec.	
Track Clear Ext Green:	sec.	sec.	sec.	
Track Clear Max Green:		sec.		
Min Dwell:		sec.	sec.	
Dwell Preemption Ext:		sec.	sec.	

8. FIELD TESTING AND INSPECTION

		NOTES
DO THE RAILROAD FLASHERS OPERATE AS EXPECTED?	☐ Yes ☐ No	
DO THE RAILROAD GATES OPERATE AS EXPECTED?	☐ Yes ☐ No	
ARE THE BLANK OUT SIGNS WORKING PROPERLY?	☐ Yes ☐ No ☐ NA	
DOES A PREEMPT CALL TRIGGER RIGHT OF WAY TRANSFER?	☐ Yes ☐ No	
DOES A PROTECTED ARROW COME UP FOR TRACK CLEARANCE?	☐ Yes ☐ No	
DOES GATE DOWN RELEASE TRACK CLEAR PHASE?	☐ Yes ☐ No ☐ NA	
PROPER DWELL/CYCLE PHASES OPERATE?	☐ Yes ☐ No ☐ NA	
IS THE PREEMPT CALL RELEASED AT BEGINNING OF GATE ASCENT?	☐ Yes ☐ No	
DOES THE SIGNAL EXIT TO THE PROPER PHASE UPON RELEASE OF PREEMPT?	☐ Yes ☐ No	
DOES PREEMPT RESERVICE ACTIVATE?	☐ Yes ☐ No	
ARE EXEMPT SIGNS POSTED AT THE CROSSING?	☐ Yes ☐ No	
ARE EMERGENCY CONTACT STICKERS IN SIGNAL CABINET AND BUNGALOW?	☐ Yes ☐ No	

9. OTHER INFORMATION / NOTES

Page 2 of 2

- Railroad Preemption Inspection form
- WisDOT Railroad Preemption Inspection form