1-5-1 Subject Numbering System — June 2005

DEFINITIONS

Chapter: A main divisional unit of this manual, addressing one of the major functions of traffic engineering or supporting functions.

Section: A grouping of related subjects within a chapter.

Subject: A specific guideline, policy or procedure.

SUBJECT NUMBERING

The manual is divided into topical chapters with each chapter having one or more sections that are divided into specific treatments of material, called subjects.

Chapters, sections and subjects are all numbered.

Chapter numbers are numbered consecutively, generally without gaps. Sections and subjects are numbered consecutively or sometimes with gaps--5, 10, 15, 20--to allow for future insertions of material at the most appropriate locations within the chapter or to follow the MUTCD numbering system.

Chapters 2 through 10 are allotted to subjects related to traffic control devices covered in the corresponding Parts 2 through 10 of the MUTCD.

1-5-5 Table of Contents — April 2025

4-1-1 Traffic Signal Glossary April 2025

This section offers terms and definitions used throughout Chapter 4. For other definitions, refer to WMUTCD Chapter 4A, Definition of Terms.

ACCESSIBLE PEDESTRIAN SIGNAL (APS): A device that communicates information about pedestrian timing in non-visual format such as audible tones, verbal messages, and/or vibrating surfaces.

ACTUATED CONTROLLER: A traffic signal controller that receives information from vehicle and/or pedestrian detectors and provides signal timing accordingly.

ADA: Americans with Disabilities Act (42 U.S.C. 12181).

ADAPTIVE MODE: A system operation that adjusts when phases start and end based on current traffic data as input by vehicle sensors within the network.

ANSI: American National Standards Institute.

ARTERIAL: A major urban roadway.

ASTM: The American Society for Testing and Materials.

AWG: American Wire Gauge. The standard measurement of wire size. It is based on the circular mil system. 1 mil equals .001 inch.

BACKPLATE: A strip of thin material extending outward parallel to the signal face on all sides of a signal housing to provide a suitable background for the signal indications.

BATTERY BACKUP: A battery-powered energy backup system capable of maintaining power for signal system operation. These devices are encouraged to be placed at railroad interconnected systems, single point urban interchanges and intersections with triple-left turn lanes.

CABLE: A group of separately insulated wires wrapped together.

CALL: A registration of a demand for right-of-way by traffic at a controller unit (NEMA). The call comes to the controller from a detector that is outputting an actuation.

CALLING DELAY: An adjustable feature used on a specific detector amplifier that does not issue an output until the detection zone has been occupied for a period.

CAPACITANCE: That property of a system of conductors and dielectrics which permits the storage of electricity separated charges when potential differences exist between the conductors. Its value is expressed as the ratio of an electric charge to a potential difference.

CHANNEL: Electronic circuitry which functions as a loop detector unit (NEMA).

CHANNELIZING ISLAND: Curbed or painted area outside the vehicular path that is provided to separate and direct traffic movement, which *may* also serve as a refuge for pedestrians.

CIRCUIT: A closed path followed by an electric current.

CONDUCTOR: A medium for transmitting electrical current. A conductor usually consists of copper or other materials.

CONDUIT: A raceway or tubing for protecting electrical wires or cables.

CONFLICTING PHASES: Two or more traffic phases which will cause interfering traffic movements if operated concurrently.

CONTROLLER: A device that controls the sequence and duration of indications displayed by traffic signals.

COORDINATION: The establishment of a definite timing relationship among adjacent traffic signals.

CYCLE: In a pretimed controller unit, a complete sequence of signal indication. In an actuated controller unit, a complete cycle is dependent on the presence of calls on all phases.

CYCLE LENGTH: The time period in seconds required for a complete cycle.

DEMAND: The need for service, e.g., the number of vehicles desiring to use a given segment of roadway during a specified unit of time.

DENSITY: A measure of the concentration of vehicles, stated as the number of vehicles per mile per lane.

DESIGN SPEED: The speed used as typical by the designer of the detector/controller scheme in their kinematic analysis of the scheme under free traffic flow conditions (typically 85% speeds).

DESIGN VEHICLE: The longest vehicle permitted by the State on that roadway. Refer to FDM 11-25 for further guidance.

DETECTION: The process used to identify the presence or passage of a vehicle at a specific point or to identify the presence of one or more vehicles in a specific area.

DETECTION ZONE: That area of the roadway within which a vehicle will be detected by a vehicle detector (NEMA). Also called "ZONE OF DETECTION" or "SENSING ZONE."

DETECTOR: A device for indicating the presence or passage of vehicles or pedestrians (NEMA). This general term is usually supplemented with a modifier indicating type (e.g., loop detector, magnetic detector, etc.), operation (e.g., point detector, presence detector, etc.), or function (e.g., calling detector, extension detector, etc.).

DETECTOR DISCONNECT: A controller function which when used allows detection to be ignored by the controller during a specific phase.

DETECTOR FAILURES: The occurrence of detector malfunctions, including non-operation, chattering, or other intermittently erroneous counting.

DETECTOR SYSTEM: The complete sensing and indicating group consisting of the detector unit, transmission lines (lead-ins), and sensor.

DETECTOR UNIT: The portion of a detector system other than the sensor and lead-in, consisting of an electronics assembly.

DILEMMA ZONE: A distance or time interval related to the onset of the yellow interval. Originally the term was used to describe that portion of the roadway in advance of the intersection within which a driver can neither stop prior to the stop line nor clear the intersection before conflicting traffic is released. That usage pertained to insufficient length of timing of the yellow and/or all red intervals. More recently the term has been used also to describe that portion of the roadway in advance of the intersection within which a driver is indecisive regarding stopping or clearing, although the signal timing is long enough to permit either. That portion of the roadway in advance of the intersection within which a driver is indecisive regarding stopping prior to the stop line or proceeding into or through the intersection. *May* also be expressed as the increment of time corresponding to the dilemma zone distance.

DILEMMA-ZONE PROTECTION: Any method of attempting to control the end of the green interval so that no vehicle will be in the dilemma zone when the signal turns yellow.

EMERGENCY VEHICLE PREEMPTION (EVP): The transfer of the normal control of signals to a special control mode for emergency vehicles.

EXTENDED CALL DETECTOR: A detector with carryover output. It holds or stretches the call of a vehicle for a period of seconds that has been set on an adjustable timer incorporated into the detector. It can be designed to begin the timing of that period when the vehicle enters the detection area, or when it leaves. See STRETCH DETECTOR.

EXTENSION DETECTOR: A detector that is arranged to register actuations at the controller only during the green interval for that approach to extend the green time of the actuating vehicles (NEMA).

EXTENSION STRETCH: Feature used in detector operations which *may* add green time to the current phase allowing a vehicle to pass from a point of detection to some other position.

FDM: *Facilities Development Manual*, published by The Wisconsin Department of Transportation.

FREQUENCY: The number of times an alternating current repeats its cycle in 1 second.

GAP: The time interval between the end of one vehicle actuation and the beginning of the next actuation.

GAP OUT: Terminating of green due to an excessive time interval between the actuations of vehicles arriving on the green, so green *may* be served to a competing phase.

GREEN EXTENSION SYSTEM: Hardware assembly of extended call detectors and auxiliary logic. The logic can monitor the signal display, enable, or disable the selected extended call detectors, and hold the controller in artery green.

HEADWAY: The time (in seconds) between two successive vehicles as they pass a point on the roadway, measured from the same common feature of both vehicles (e.g., the front axle or the front bumper)

HSIP: Highway Safety Improvement Program

HOLD: A command to the controller which causes it to retain the existing right-of-way.

INDUCTANCE: That property of an electric circuit or of two neighboring circuits whereby an electromotive force is generated in one circuit by a change of current or in the other. The ratio of the electromotive force to the rate of change of the current.

INITIAL INTERVAL: The first timed interval actuated controller unit:

1. Fixed Initial Interval - A preset initial interval that does not change. (See MINIMUM GREEN INTERVAL)
2. Added Initial Interval – An increment of time in response to each vehicle actuation during red that extends the green. Added initial times concurrently with the minimum green.
3. Maximum Initial Interval - The limit of the added or computed initial.

INTERCONNECT: The communication network usually consisting of electrical or fiber optic cable connecting the system master with local intersection controllers and intersection controllers to networks.

INTERVAL: A discrete portion of the signal cycle during which the signal indications remain unchanged.

JUNCTION BOX: A container that is typically placed within bridge parapets and on wingwalls with a removable cover. Splices between cabling is located here.

LEAD-IN CABLE: The electrical cable which serves to connect the loop detector wire to the input of the loop detector unit (NEMA). Sometimes called "home-run" cable or transmission line.

LOCAL CONTROLLER: A controller supervising the operating of traffic signals at a single intersection.

LOOP DETECTOR: A detector that senses a change in inductance of its inductive loop caused by the passage or presence of a vehicle near the sensor (NEMA).

LOOP DETECTOR WIRE: Wire used for the inductive loop detector and lead-in (between loop and pull box).

LOOP-LEAD WIRE: The portion of the loop wire that is not a part of the loop but is in the conduit or saw slot connecting the loop to the edge of the roadway, where is it carried in conduit to the controller or to a pull box and connected to the lead-in cable.

LOS: Level of service per Highway Capacity Manual.

LUMINAIRE: A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps and to connect the lamps to the power supply.

MAST ARM: A structural support extending over the roadway from a pole, for supporting signal heads.

MASTER (PRIMARY): A control device for supervising a system of secondary controllers, maintaining definite time interrelationships, and/or accomplishing other supervisory functions.

MEMORY:

a. Locking Memory: A controller memory mode used to trigger a call for service with the first actuation received by the controller during the red (or yellow) interval. Typically, only used when there is no stop-bar detection.
b. Non-Locking Memory: A mode of actuated-controller unit operation which does not require memory (NEMA). In this mode of operation, the call of a vehicle arriving on the red (or yellow) is forgotten or dropped by the controller as soon as the vehicle leaves the detection area.

MINIMUM GREEN INTERVAL: The shortest green time of a phase. If a time setting control is designed as "minimum green," the green time **shall not** be less than that setting.

NEMA: The National Electrical Manufacturers Association.

OVERLAP: An overlap is a set of outputs associated with two or more phase combinations. In some instances, right-turn movements operating in exclusive lanes can be assigned to more than one phase that is not conflicting. The overlap forms a separate movement that derives its operation from its assigned phases (also called parent phases).

PASSAGE TIME: A phase timer that ends a phase when the time from the last detector output to the controller exceeds the timer setting.

PEDESTRIAN COUNTDOWN TIMER: A dynamic display that supplements standard pedestrian signal indications within the same section. The display is used to indicate the time remaining during the pedestrian clearance interval.

PEDESTRIAN DETECTOR: A detector that is responsive to operation by or the presence of a pedestrian (NEMA). This traditionally has been of the push-button type, installed near the roadway and operated by hand.

PEDESTRIAN PHASE: A traffic phase allocated to pedestrian traffic which *may* provide a right-of-way indication either concurrently with one or more vehicular phases, or to the exclusion of all vehicular phases.

PHASE: A part of the cycle allocated to any traffic movements receiving the right-of-way or to any combination of traffic movements receiving the right-of-way simultaneously during one or more intervals.

PHASE SEQUENCE: The order in which a controller cycles through all phases.

POINT DETECTION: The detection of a vehicle as it passes a point or spot on a street or highway.

PORKCHOP: A type of channelizing island that separates right turning traffic from through traffic on the same approach. (See CHANNELIZING ISLAND).

PREEMPTION: The term used when the normal signal sequence at an intersection is interrupted and/or altered in deference to a special situation such as the passage of a train, bridge opening, or the granting of the right-of-way to an emergency or mass transit vehicle.

PRESENCE DETECTION: The sensing of a vehicle passing over a detector. True presence is when the pulse duration is equal to the actual time the vehicle remains in the detector field of influence.

PRESENCE MODE: Detector output continues for a limited period if vehicles remain in field of influence (NEMA).

PROBE: The sensor form that is commonly used with a magnetometer-type (microloop) detector (NEMA).

PROGRESSION: Coordinated movement along an arterial at a given speed.

PULL BOX: A container, usually at least 1 cubic foot in size, that is placed underground with a removable cover flush with the ground surface. As an example, splices between lead-in cable and loop-lead wire are located here.

PULSE MODE: Detector produces a short output pulse when detection occurs (NEMA). The pulse lasts only about 100 ms, even if the vehicle remains in the detection zone for a longer time.

QUADRUPOLE: A loop configuration that adds a longitudinal saw slot along the center of the rectangle, so that the wire can be installed in a figure-eight pattern, thereby producing four electromagnetic poles instead of the normal two. The design improves the sensitivity to small vehicles and minimizes adjacent lane pick up.

QUEUE DETECTOR: Component of a traffic control system which senses the presence (or number) of vehicles waiting in a queue. Once the detector has reached a maximum time, or input is removed, the detector will no longer call the phase until corresponding green has been terminated.

QUEUE LENGTH: Number of vehicles that are stopped or slowly moving in a line where the movement of each vehicle is constrained by that of the lead vehicle.

RADAR DETECTOR: A vehicle detector installed above or adjacent to the roadway capable of being activated by the passage of a vehicle through its field of emitted microwave energy.

RECALL: A call is placed for a specified phase each time the controller is serving a conflicting phase. This ensures that the specified phase will be served again. Types of recalls include maximum, minimum, pedestrian, and soft.

RED CLEARANCE INTERVAL: The period of time following a yellow change interval, indicating the end of a phase and allowing additional time before the beginning of conflicting traffic.

SENSITIVITY: As it relates to a loop system the change in total inductance of a system caused by a vehicle at one loop, expressed as a percentage of the total inductance. As it relates to a detector, is the minimum inductance change in percent required at the input terminals to cause the detector to actuate.

SPI: Single Point Interchange; Turning movements are arranged around a single point with fewer conflict points. This allows for safer and smoother traffic movement with more efficient signal timing.

SPLIT: The time assigned to a phase during coordinated operations. *May* be expressed in seconds or as a percentage.

SPLIT PHASE: The assignment of the right-of-way to all movements of an approach, followed by all the movements of the opposing approach.

SYSTEM DETECTOR: Detector located to provide information to central control computers selecting appropriate control programs to meet the traffic demands.

TRAFFIC DETECTOR: A device by which vehicles, streetcars, trolley buses, or pedestrians are enabled to register their presence with a traffic-actuated controller (Institute of Transportation Engineers, ITE).

TRAFFIC PHASE: A timing unit associated with the control of one or more movements. Phases are often assigned to vehicular and pedestrian movements.

TRAFFIC RESPONSIVE MODE: A system operation wherein the selection of signal timing programs is based on current traffic data as input by vehicle sensors within the network.

TURNS: Used to describe the placement of loop wire around a detector. One turn is equivalent to one complete revolution around the loop

TWISTED PAIR: Two insulated conductors twisted together and coded.

VARIABLE INITIAL INTERVAL: An interval that times concurrently with the minimum green interval and increases by each vehicle actuation received during the initial period. This time cannot exceed the maximum variable initial.

VEHICULAR PHASE: A traffic phase allocated to vehicular traffic.

VIDEO DETECTION SYSTEM: A detection system which analyzes a video image of an approach and identifies and classifies (optional) vehicles in that approach.

WEC: *Wisconsin Electrical Code*, published by the Wisconsin Electrical Manufacturers Association. This manual consists of a supplement to the *National Electrical Code* (NEC), and the Wisconsin supplement.

WMUTCD: *Wisconsin Manual on Uniform Traffic Control Devices*, published by the Wisconsin Department of Transportation.

YELLOW CHANGE INTERVAL: An indication warning users that the green, flashing yellow, or flashing red indication has ended, and the red indication will begin.

ZONE OF DETECTION (SENSING ZONE): That area of the roadway within which a vehicle is detected by a vehicle detector system (NEMA).

4-1-2 Alternatives to Signals — April 2025

The decision to install a traffic signal at an intersection resides in the Regional traffic unit and **shall** be made based on an intersection control evaluation (ICE) study at that location. The warrants stated in the WMUTCD *should* be viewed as guidelines to help the traffic engineering staff decide whether a traffic signal *may* be installed, not as a legal requirement for their installation. The decision to install a traffic signal is not based solely on the satisfaction of warrants; rather, it is also based on the need for operational improvements at the intersection.

As with all traffic control device analysis procedures, the adequate trial of less restrictive remedies *should* be undertaken, prior to the installation of a traffic signal. If these remedies fail to reduce the crash frequency and/or improve operations at the intersection, a warrant analysis **shall** be completed. Such less restrictive improvements *may* cost less and *may* result in less overall delay than the installation of a traffic signal. These improvements include but are not limited to:

- Addition of exclusive right or left turn lane(s)
- Intersection lighting
- Improvement to pavement markings (left turn arrows, stop lines, etc.)
- Acceleration/deceleration lanes
- Channelization to eliminate certain movements (access restrictions)
- Sight distance improvements
- All-way STOP control
- Installation of rumble strips on STOP sign controlled approaches

- Improved signing (doubling up STOP AHEAD signs, larger STOP signs or route markers)
- Hazard beacons
- Roundabouts
- Grade separations
- Geometric improvements
- Demand management (control of trip arrival times)
- Signal timing changes at nearby intersections

4-1-3 Signal Development Process April 2025

The signal development process is outlined below.

STATE MAINTAINED HIGHWAYS

Intersection Control Evaluation (ICE)

- ❑ Need for an ICE study identified or Local Agency/Constituent contacts region traffic unit to request signal
- ❑ Regional Traffic Unit notifies constituent on procedure, eligibility, agreements, etc.
- ❑ Regional Traffic Unit or consultant preparation of ICE study as detailed in FDM 11-25-3.
- ❑ Formal submittal to Regional Traffic Unit (if study is prepared by consultant)
- ❑ Regional Traffic Unit review (if study is prepared by consultant) and recommendation
- ❑ Central Office review and approval of ICE study.
- ❑ If a signal is recommended through a completed ICE study, Regional Traffic Unit preparation of Central Office cover letter and two copies of Traffic Control Signal Approval Request Form DT 1199 to be submitted for BTO approval.

Project Definition Phase

- ❑ Region/consultant prepares capacity analysis, assess proposed/existing geometric considerations, cost estimations, etc.
- ❑ Coordinate with existing/future highway needs
- ❑ Coordination within other Regional functional areas and municipalities as needed.

Signal Design

- ❑ Region/consultant prepares signal plan
- ❑ Region/consultant prepares signal timing/system coordination
- ❑ Regional Traffic Unit performs plan reviews at the Design Study Review Meeting and Plans, Specification & Estimates (PS&E) Meeting approval prior to submitting to Central Office
- ❑ PS&E package (including signal plans) submitted to BTO

Traffic Impact Analysis (TIA)

- ❑ For signals that are proposed on a state maintained highway through a TIA, the TIA Guidelines Manual **shall** be followed.

CONNECTING HIGHWAYS

Intersection Control Evaluation (ICE)

- ❑ Need for an ICE study identified or Local Agency contacts Regional Traffic Unit to request signal
- ❑ Region notifies constituent on procedure, eligibility, agreements, etc.
- ❑ Local agency or consultant preparation of ICE study as detailed in FDM 11-25-3.
- ❑ Formal submittal to Regional office
- ❑ Regional review and recommendation
- ❑ Central Office review and approval of the ICE study.
- ❑ If signal recommended, Regional preparation of Central Office BTO cover letter and three copies of Traffic Control Signal Approval Request Form DT 1199 to be submitted for BTO approval.

Project Scoping Process

- ❑ Local agency/consultant prepares capacity analysis, assess proposed/existing geometric considerations, cost estimations, etc.
- ❑ Coordinate with existing/future highway needs
- ❑ Coordination within other Region functional areas and municipality.

Signal Design

- ❑ Local agency/consultant prepares signal plan
- ❑ Local agency/consultant prepares signal timing/system coordination
- ❑ Region *may* perform cursory plan review for WMUTCD compliance

- ❑ Plan approval by local maintaining agency
- ❑ PS&E package (including signal plans) submitted to Central Office DTSD

<u>Traffic Impact Analysis</u>

- ❑ Signals that are warranted by a TIA on a connecting highway are subject to the approval process outlined in the above signal investigation study section.

LOCAL SIGNALS

<u>Signal Investigation Study</u>

- ❑ No study required by the Department

<u>Project Definition Phase</u>

- ❑ Local agency/consultant prepares capacity analysis, assesses proposed/existing geometric considerations, cost estimations, etc.
- ❑ Coordinate with existing/future highway needs
- ❑ Coordination within other jurisdictions

<u>Signal Design</u>

- ❑ Local agency/consultant prepares signal plan
- ❑ Local agency/consultant prepares signal timing/system coordination
- ❑ If state administered project, Region *may* perform cursory plan review for WMUTCD compliance
- ❑ Plan approval by local maintaining agency
- ❑ PS&E package (including signal plans) submitted to Central Office DTSD

4-1-4 Funding — April 2025

Funding of a traffic signal installation typically is provided five ways:

- Improvement Program,
- Highway Safety Improvement Program (traffic signal items required to be incidental to construction, see PMM 04-01-01),
- Congestion, Mitigation & Air Quality (CMAQ) Program (generally only available in counties adjacent Lake Michigan, see PMM 02-20-01),
- Standalone ITS & Traffic Signals Program (Operations Allocation) funding,
- Permit Projects (TIA process -- non-State funded).

Contact the Regional Traffic Signal Engineer for appropriate funding mechanisms at specific locations.

4-2-1 Capacity Analysis **April 2025**

INTERSECTION CAPACITY ANALYSIS

In cases where the Signal Investigation Study indicates a traffic signal is warranted, the maintaining authority or its agents **shall** compute the capacity and level of service for the future signalized intersection during the peak hour periods for construction, as well as design or horizon year volumes. If no projection information is readily available, reasonable assumptions *should* be made to extrapolate turning movement volumes to the design/horizon year levels. It is typically assumed that traffic growth increases at a rate of 2 percent per year.

Capacity analysis *should* be based on actual turning movement volume counts and projected turning movement volumes. Only turning movement counts conducted within the previous three years *should* be used for capacity analysis. Refer to FDM 11-5-2 for information related to requesting traffic volume forecasts.

The purpose of the analysis is to determine proper intersection geometric design, and to begin to develop appropriate signal phasing and timing plans. If the signal is to be located on the STH system, an electronic version of the intersection capacity analysis **shall** be shared with the Regional Traffic Signal staff for review.

The analysis of the unsignalized vs. signalized intersection provides additional information for the review of the study, the design of the signal, and the need for possible geometric improvements. Signals that are a part of, or adjacent to, a coordinated system **shall** be studied as part of a systems analysis. In these cases, a traffic simulation model *may* also need to be developed, particularly when developing signal timing plans.

Computer software **shall** be used to determine the intersection capacity and using current versions of software as identified by FDM 11-05-03, section 3.7.

Capacity analyses that are performed for state-maintained signals **shall** be supplemented with a technical memorandum summarizing analysis results using existing and/or proposed geometrics and recommending preferred phasing and timing alternatives. The technical memorandum and capacity analysis **shall** be provided to Regional Traffic Signal Engineers in electronic and hard copy form.

BASIC PARAMETERS FOR CAPACITY ANALYSIS

GENERAL SIGNAL TIMING ANALYSIS PARAMETERS

Note: The Signal Timing Analysis Parameters below are recommended guidelines for general analysis of state-owned signals at typical at-grade intersections. For analysis that is conducted to determine actual design parameters (such as turn bay lengths) or for analysis of complex signals (such as at an interchange), contact the appropriate Region to check for additional regional guidance prior to submitting the analysis.

Minimum Green Values:

Mainline Through Phases (2 & 6) – 10 to 15 secs

Side Street Through Phases (4 & 8) – 7 to 10 secs

Mainline & Side Street Left Turn Phases (1,3,5,7) – 5 or 6 secs for single lanes, 8 secs for dual lanes.

Maximum Green Values:

Mainline Through Phases (2 & 6) – 35 to 70 secs

Side Street Through Phases (4 & 8) – 25 to 40 sec.

Note: At intersection of two STHs, on the lower volume STH a lower max time may be used.

Mainline & Side Street Left Turn Phases (1,3,5,7) – 15 to 35 sec.

Clearance Intervals:

Use ITE's kinematic formula for determining clearance intervals for signal installations on the STH system. Refer to TEOpS 4-7-5, Clearance Intervals.

Pedestrian Phase Times:

Walk Time – 7 sec.

Ped Clearance Time – [(Distance from curb to curb)/(3.5 ft/sec)].

Note: If it is known that Children or Elderly use the intersection, a walking speed of less than 3.5 ft/sec may be considered.

Ped Check – Walk Time + Ped Clearance Time ≥ the amount of time it takes for a person walking 3 ft/sec to cross from the pedestrian detector to the far side of the traveled way being crossed. Any additional time that is required to satisfy this condition *should* be added to the Walk Time.

Isolated Signal Cycle Lengths:

Typically Range from 60 secs – 120 sec.

Coordinated Signal Cycle Lengths:

Typically Range from 80 secs – 130 sec.

Interchanges:

Typically Range from 100 – 130 sec.

GENERAL SIGNAL ANALYSIS REVIEW PARAMETERS

1. PHF – Verify that the correct PHF is used.
2. % Heavy Vehicles – Verify that correct % Heavy Vehicles are used.
3. RTOR – Refer to TEOps 16-15-5.
4. Ideal Saturation Flow Rate – Ideal Saturation Flow Rate used for left-turn and through movements **shall** be 1900. If any other Ideal Saturation Flow Rate is used it must be supported by a study performed in a comparable location, with similar characteristics, and same geographical area.
5. Phasing –Verify that sequence of operation (phasing) is correct for existing conditions and that changes to existing phasing for future conditions are reasonable and *should* consider any necessary geometric changes. Split phasing on the mainline **shall** only be considered as last resort in extreme cases.
6. Geometric Design – Verify dimensions of turn bay lengths and that the existing/proposed lane configuration is appropriate and corresponds between field conditions, signal plan information and sequence of operations sheets.
7. Turning movement Volumes – Verify that the input volumes used in the analyses are correct.
9. Left Turn Requirements – Verify that under existing or future conditions that left turn movements are accounted for by signal phasing. A protected/permissive or protected only left turn phase **shall** be considered in accordance with the Left-turn Conflict Analysis.
10. Coordinated Signal System Analysis – When signals are in a coordinated system and pedestrian phases are present, verify that minimum green time given to through phase is enough time to cross pedestrians curb to curb unless pedestrian actuation is used.

4-2-2 Intersection Geometrics — April 2025

BASIC GUIDELINES FOR INTERSECTION DESIGN

The following is a set of guidelines used by Regional Traffic Engineers for the review process of intersection geometrics submitted by Project Development and Consultants. These standards **shall** be followed when designing an intersection that *may* be signalized in the next 5 to 10 years or revising an existing signalized intersection. The guidelines contained in this chapter are a supplement to those found in the FDM 11-25.

The Regional Traffic Engineer *should* review the recommended queue length storage for left and right turns based on the capacity analysis. Intersection design *should not* be based solely on capacity analysis but also based on operation requirements. Additional considerations are listed below.

- When designing an intersection keep in mind that even if traffic signals are not an immediate design criteria, signals *may* be needed in the future.
- It is very important to include Traffic Operations personnel early in the scoping of a project. Volumes, storage, geometric, and R/W needs *should* be addressed. It can then be determined if further involvement of Traffic Operations is needed.
- Verify that the intersection design meets these criteria before R/W becomes an issue or is purchased.
- For proposed or reconstructed intersections, use desirable design criteria, not minimum. R/W restrictions are taken into consideration on modifications to existing intersections.
- Intersections *should* not be located on curves (horizontal or vertical). Experience has shown that motorists don't handle these situations well even if adequate sight distance is provided.
- Design of any signalized intersection **shall** consider applicability of heavy vehicles. All right turns and both opposing left turn movements *may* need to accommodate WB-67 vehicles. This includes two WB-67 vehicles making opposing left turns at the same time. Higher consideration for Oversized/Overweight vehicle turning movements *should* be given at locations within five miles along long-truck routes. Refer to FDM 11-25-2, Intersections at Grade – Design Criteria & Guidelines.
- Intersection geometrics **shall** be designed using turning templates. The intersection plan with turning template overlay **shall** be submitted to the Regional Traffic Unit for review.

Refer to FDM 11-25-1, *Intersections At Grade – General*

- Selection of Intersection Criteria
- Rural Intersections
- Urban Intersections

RIGHT-OF-WAY

Public right-of-way at STH intersections needs to accommodate design geometrics (for existing & future conditions), operations-related infrastructure, and adequate sight distance. All WisDOT maintained signal & electrical equipment **shall** be located within the public right-of-way. Such signal equipment typically includes cabinet bases, signal/lighting bases, vehicle detection, associated conductor runs, and *may* also include temporary signal support guy lines.

As a last resort when equipment cannot be located within the public right-of-way (i.e., far loops in mall entrances), it **shall** be necessary to have an established permitted limited easement (PLE) to access private lands before electrical staff can perform associated maintenance activities. Note: This could be problematic if it is necessary to install additional equipment or if repairs are time sensitive.

Consideration *should* also be given to future capacity expansion. Examples of this *may* include right- & left-turn lanes, widened medians, sidewalk, bike lanes, roundabouts or interchanges. Because of these issues, Regional Traffic Engineering staff **shall** be involved in identifying required right-of-way at signalized intersections early in the design process.

CORRIDOR CONSIDERATIONS

The design of an individual intersection will not only need to provide a safe environment with adequate capacity but will also need to reflect the needs of adjacent intersections and the corridor. As such, isolated intersection designs *may* need to include features not dictated by capacity alone. These features *should* be coherent with the overall facility, examples of which *may* include turn lanes, separation of turn lanes from adjacent through lanes, raised medians, islands, and separated bicycle facilities. Right-of-way *may* also need to be preserved for future corridor-based improvements.

The proximity of adjacent intersections to locations that are or *may* be signalized *should* be maintained at a minimum of 1200-ft. The distance to adjacent private driveways also need to be considered, especially as to how traffic along the corridor and at various access points interact.

Refer to FDM 11-30-1, Interchange – Design Elements regarding ramp terminal spacing and FDM 11-5-5, Access Control – Attachment 5.1 for access spacing guidelines.

DESIGN VEHICLE AND TRUCK TURNING

The design vehicle used to determine intersection geometrics at locations that *may* be signalized **shall** be at least a WB-62. If the area being designed is known to have WB-65 or WB-67s, that design vehicle *should* be used. Using the appropriate sized design vehicle has significant impacts on intersection operation and signal efficiency.

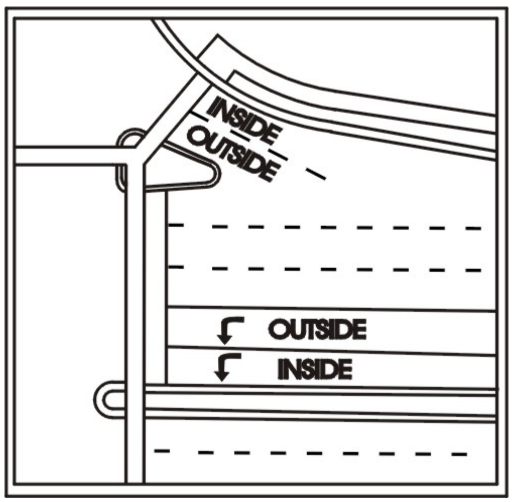
Movements *should* allow for the appropriate design vehicle~~s~~ to turn with a smooth continuous radius. Opposing left turns require a minimum of 3' clearance at the center of the intersection as they pass the opposing vehicle.

Dual lefts are typically designed for the truck (WB-62) using the outside lane a single unit using the lane. There *should* be a minimum of 3' between the vehicles as they turn with each other. Refer to Figure 2.1 for clarification on outside and inside lane terminology for dual left turn lanes.

Dual rights are designed for the truck (WB-62) using the outside lane and a single unit using the inside lane. There *should* be a minimum of 3' between the vehicles as they turn with each other.

Refer to FDM 11-25-2, *Intersections at Grade – Design Criteria & Guidelines*.

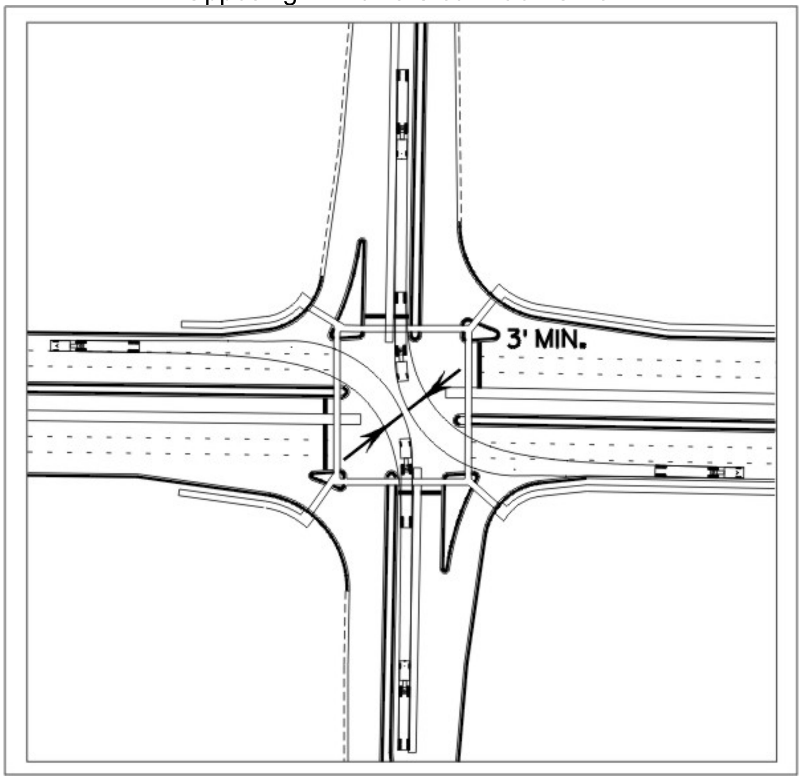
Figure 2.1. Outside and Inside Lanes for Left and Right dual turn lanes.



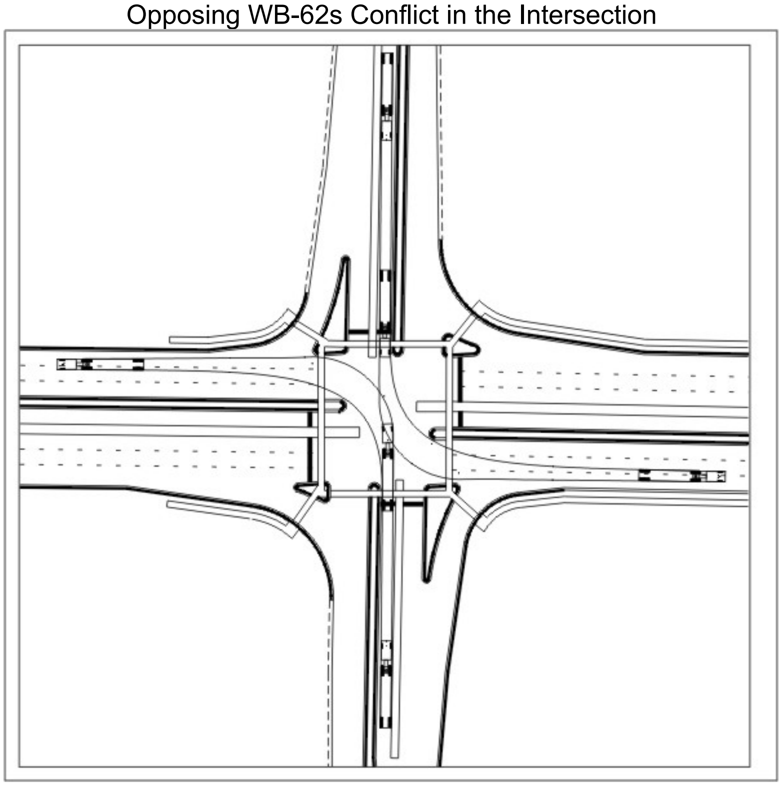
Left turning trucks *should not* encroach on the left turn lane for the approach that they are entering when making their left turn. Trucks need not be restricted to the nearest lane when making a turn. Trucks *may* encroach into other lanes on multiple lane roadways (not across the centerline for trucks making a right turn movement, in this case the stop line *may* be pulled back). Parking *may* need to be restricted at intersections to aid in truck turning movements.

Specific routes along the state-system have been established to accommodate either Over-sized/Over-weight (OSOW) and/or Over-height (OH) vehicles. Check with the Region Traffic Engineer to determine appropriate design requirements that *may* be needed for specific locations.

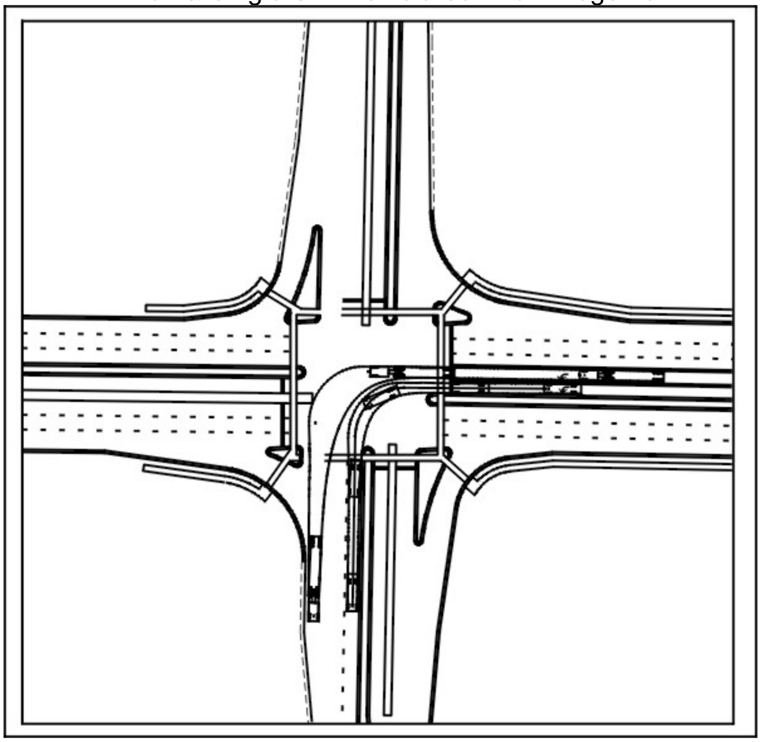
CORRECT
Opposing WB-62's Clear Each Other



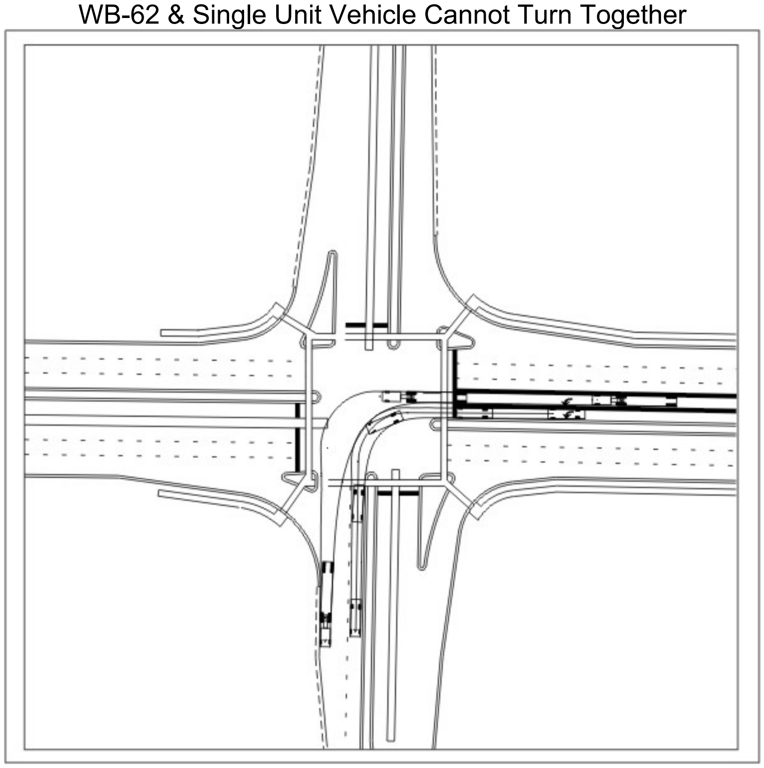
INCORRECT
Opposing WB-62s Conflict in the Intersection



CORRECT
WB-62 & Single Unit Vehicle Can Turn Together



INCORRECT
WB-62 & Single Unit Vehicle Cannot Turn Together



LEFT TURN LANES

Refer to FDM 11-25-5, Intersections at Grade – Left Turn Lanes

The width of a left turn lane *should* desirably be the same as the width of the through lane. A left turn lane width of 12 feet *should* be used on rural and suburban arterial highways.

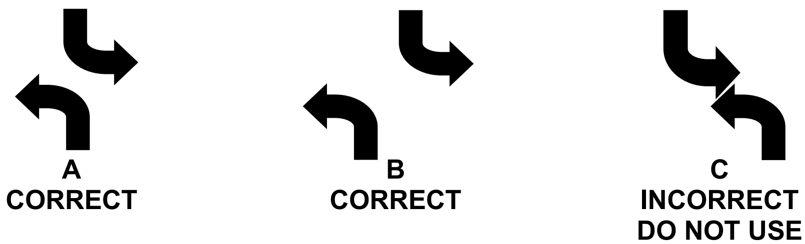
With the general exception of interchange ramp terminals, it is desirable to separate left turn lanes from the adjacent through movement at intersections on the STH system. Separation *may* be accomplished by the following different ways:

- Raised median including slotted left turn lanes
- Pavement Marking
- Corrugated median (generally not desirable)

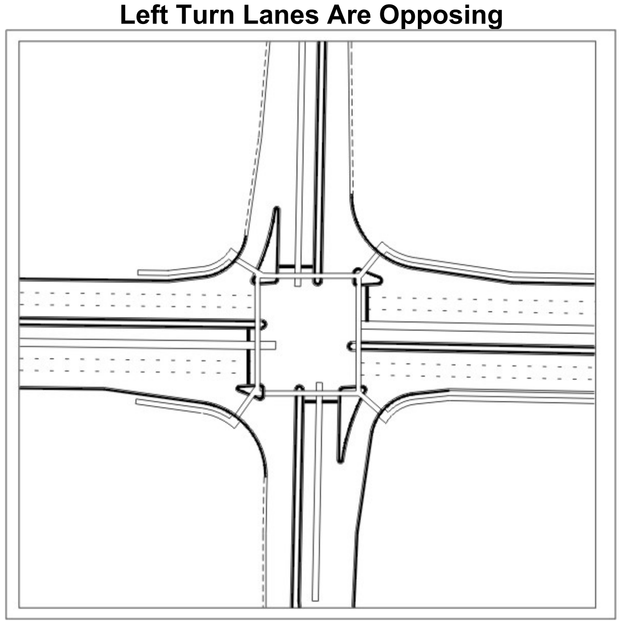
The Regional Traffic Engineer **shall** be consulted when selecting proper channelization methods.

The ideal alignment of left turn lanes is to have opposing left turns directly opposite (head-to-head) of each other (A) or to positively offset them as shown in (B). For visibility and safety reasons, the alignment shown in (C) *should not* be used.

- Alignment of left turn lanes is critical to enable turning vehicles to see past opposing left turners and view opposing through vehicles to allow them to pick an adequate gap to complete their maneuver.
- If there is poor alignment, Traffic Operations *may* be faced with prematurely adding protected left turn arrows for low volume left turn movements due to crashes that occur due to poor visibility. This will increase the delay at the intersection. See the Incorrect and Correct left turn design figures.
- It is sometimes advantageous to “hook” the ends of the left turn lane, which enables better sight around left turners in a “tight” intersection.



CORRECT
Left Turn Lanes Are Opposing



When designing dual left turn lanes, it is extremely important that opposing left turns complete their movements simultaneously. Dual left turn lanes do not need to be designed to accommodate two WB-62 vehicles, or larger, turning side by side since the chance of this occurring is quite remote, but rather a single unit vehicle in the inside turn lane and a truck (WB-62) in the outside turn lane.

1. Left turn lanes *should* be provided at signalized intersections wherever the turns are permitted.

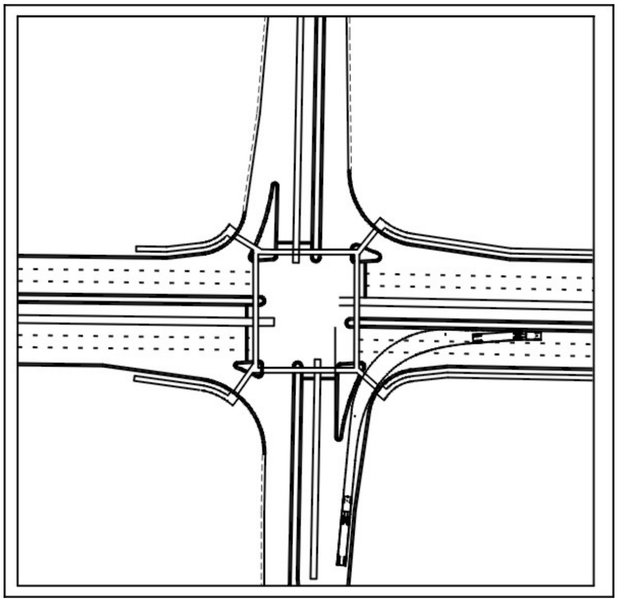
2. Shared left turn lanes are not desirable and *should* only be allowed along minor low-speed streets or where it is physically impossible to develop protected lanes. If allowed, their crash history *should* be monitored, especially along principal roads.
3. Dual left turn lanes are desirable and *should* be considered where left turn volumes exceed 300 vph (depends on opposing volumes). These lanes require sufficient width on the receiving roadway to accommodate design vehicles running side-by-side. The receiving roadway **shall** carry two through lanes a sufficient distance to allow both lanes to be utilized effectively (typically 1000 feet minimum).

RIGHT TURN LANES

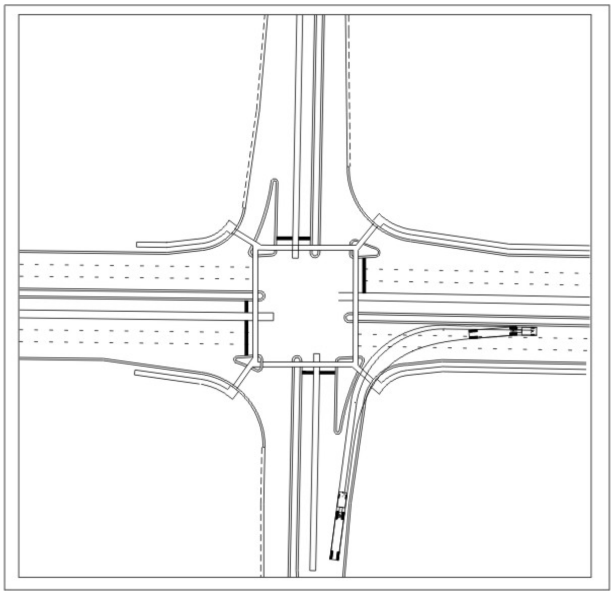
Refer to FDM 11-25-10, Intersection at Grade, Right Turn Lanes and FDM 11-25-15, Intersection at Grade, Turning Roadways (Channelized Right)

- Exclusive right turn lanes *should* always be considered on all approaches.
  - A right turn lane provides refuge for safe deceleration outside a high speed through lane and provides storage for right-turning vehicles to assist in optimizing traffic signal phasing.
- When the design of the radius is quite flat (i.e., > 70'), this creates a traffic signal design problem when locating the near right traffic signal. The preferred solution is to design a small pork chop island (minimum of 150 square feet) to place the traffic signal and lighting bases, pull box, pedestrian pushbuttons, pedestrian walkways, and to facilitate channelization of the right turn movement.
- Improperly designed right turn radii most likely will result in traffic signal knockdowns.
- For speeds more than 40 mph, the island *should* be offset 8-10 feet from the adjacent through lane.
- Consideration *should* be given for the type of controls to use for channelized right turns. Typically, it is preferred to use a least restrictive method and increase the degree of control as volumes, safety, and geometric conditions dictate.
- Channelized right turns *should* be brought in as near as perpendicular as possible for vision to the left.
- Adequate R/W width *should* be provided for future right turn lane expansion.

CORRECT
Truck Does Not Travel Over Curb



INCORRECT



MEDIANS AND ISLANDS

The desired minimum width for a median at a signalized intersection is 8 feet face to face, the absolute minimum width is 6 feet face to face. This width is required for signal and sign/structure placement, and pedestrian refuge. In addition, this minimum is wider than the wheelbase of a typical passenger vehicle and therefore if in an accident a vehicle traverses the median it *may* knock down the traffic signal standard but will not damage the bolts in the concrete base.

Right turn pork chop islands are typically needed for delineation, pedestrian refuge, and traffic signal placement at intersections with flat radii. This island *should* be no smaller than 150 square feet in area. It is inevitable revisions at a signalized intersection will need to be made at some point in the future. Therefore, the construction of islands is very important. Islands constructed as in Figure 2.2 are not desired because to install a pull box or base would require removal of 12”, + of concrete. The detail shown in Figure 2.3 is the preferred construction. Pork chop islands *should* be skewed to improve visibility for approaching vehicles.

Slotted left-turn islands *should* be set back for clarity of turning movement as shown in Figure 2.4.

Figure 2.2. Non-desirable island design

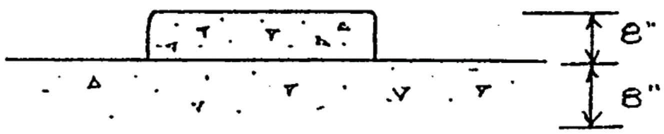
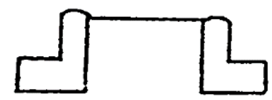


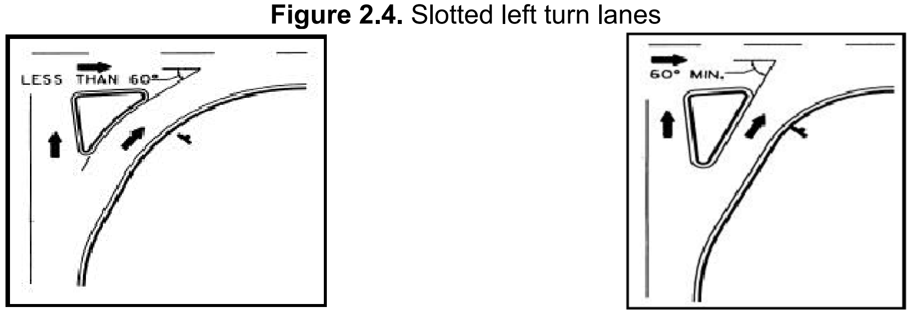
Figure 2.3. Desirable island design



Plowable noses *may* be an issue with pedestrian crossings. A cut-through *may* be necessary for pushbuttons to be pedestrian accessible. Coordination with design staff *should* take place to ensure proper placement of pedestrian crossing and signal bases.

Designers *should* be aware of the hazards that develop when right turn lanes separated by islands having intersecting angles less than 60 degrees with the cross street. These layouts require the driver to look back over their left shoulder to view oncoming traffic; this is particularly difficult for older drivers. Designers are encouraged to design all right turn islands in urban/suburban areas with the right-turn lane at an angle of 60 degrees or greater. 10:1 tapers on the approach to the right-turn lane *should* be used to allow the driver adequate time to decide and maneuver their vehicle in the direction of choice.

Figure 2.4. Slotted left turn lanes



Not Recommended Recommended

PEDESTRIANS

Intersections *should* be designed to accommodate pedestrian traffic whenever required. The surrounding area *should* be surveyed for schools, development which *may* lend towards pedestrian traffic, elderly housing, group homes, etc. to determine if pedestrian indications *should* be included. Pedestrian provisions need to include signal infrastructure design requirements and pushbutton placement that are ADA compliant. For more information on accessible design requirements refer to FDM 11-46-10, Curb Ramps or go to www.access-board.gov.

Traffic signal standards/poles *should* be located to accommodate the addition of pedestrian signals and pushbuttons in the future. To accomplish this the standards/poles must be located within 2 feet of the sidewalk and or crosswalk. Be sure the button is placed on the correct side of the pole.

It is recommended to place a pedestrian crossing on the right side of a T-intersection to prevent left turning vehicles from queuing due to pedestrians in the crosswalk. Refer to Figure 2.5 for typical layouts of crosswalks at a signalized intersection.

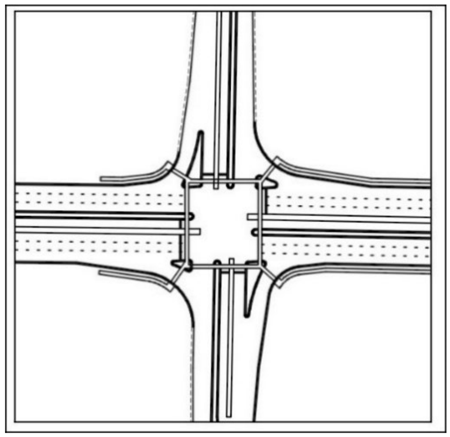
If there is no channelized right turn, the preferred design incorporates Type 2 curb ramps. These are particularly desirable in locations where visually impaired pedestrians *may* use the intersection. A Type 2 curb ramp will properly align pedestrians with the correct crosswalks whereas a Type 1 curb ramp will orient the pedestrian into the middle of the intersection.

If there is a channelized right turn, the preferred curb ramp design incorporates a Type 1 curb ramp that will direct pedestrians to the channelizing island (porkchop). Pedestrians *should* then be directed to cross the mainline or side street accordingly. This method implies that the channelizing island (porkchop) is large enough (150 ft^2 minimum) to accommodate space for pedestrians/bicycle cut-throughs, pull boxes, signal bases, and curb ramps.

Crossing pedestrians to a channelizing island, as described above has several advantages:

1. It reduces pedestrian crossing time,
2. It reduces the number of conflicting traffic turning maneuvers that pedestrians will need to negotiate,
3. This design will typically accommodate larger design vehicles and heavy turning movements with less intersection delay.

Figure 2.5. Typical crosswalk placement at a signalized intersection



ADJACENT ACCESS/INTERSECTIONS

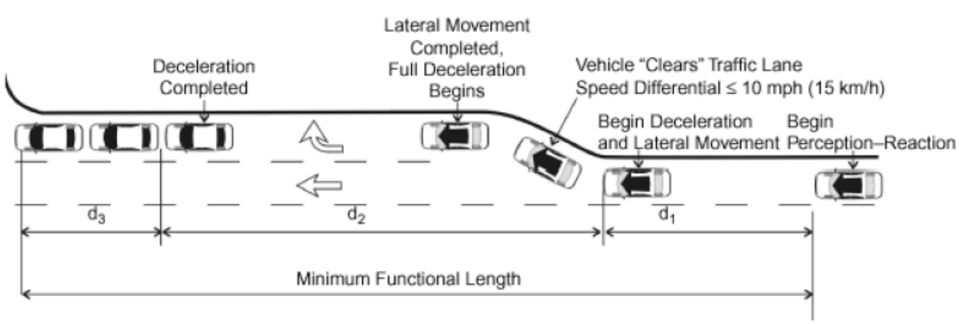
Access points located immediately near any intersection are generally problematic. Typically, vehicle turning movements at the intersection and the adjacent access further complicates driver decision making. This effect *may* cause safety problems. At a minimum, close access will affect operations.

Consideration *should* be given to the impacts of access points located immediately near signalized intersections. It *may* be necessary to close, move or restrict driveways so overall safety and operations can be effectively maintained at acceptable levels. The functional area of the intersection, as described below, *should* be considered relative to adjacent access. Typically, this functional area *should* include areas that experience routine queuing. Median openings in the intersection functional area *should* be avoided. According to FHWA's "Signalized Intersections: Informational Guide," (2nd Ed, 2013), the functional area has four parameters for which it is defined:

- Distance *d1*: Distance traveled during perception-reaction time as a driver approaches the intersection, assuming 1.5 seconds for urban and suburban conditions and 2.5 seconds for rural conditions.
- Distance *d2*: Deceleration distance while the driver maneuvers to a stop upstream of the intersection.
- Distance *d3*: Queue storage at the intersection.
- Distance immediately downstream of the intersection so that a driver can completely clear the intersection before needing to react to something downstream (stopping sight distance is often used for this).

Figure 3.6 illustrates the functional area distances. Refer to FDM 11-25-1, Intersections At Grade for additional information for determining the intersection distances for WisDOT projects.

Figure 2.6. Elements of upstream functional intersection area



The Regional Access Management Coordinator *should* be consulted prior to making changes to access points. Guidance regarding access management concepts *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, *FDM* Chapters 7 and 11, TRB *Access Management Manua*l, and NCHRP Report 348 *Access Management Guidelines for Activity Centers*.

Detection for signalized intersections *should* be placed such that vehicles entering or exiting adjacent driveways do not activate loops and subsequently interfere with signal operations.

FUTURE TRAFFIC SIGNALS

The Regional Traffic Unit needs to be involved during the scoping of a project. The installation of traffic signals as part of an improvement project can have an impact on the amount of right-of-way needed to accommodate signal equipment. Geometric configurations *may* be driven by the need for lane requirements, medians, islands, etc.

All intersections within project limits **shall** be evaluated to determine if traffic signals are warranted and *should* be included with the project.

If traffic signals are not currently warranted, it *may* be feasible to install conduit and pull boxes for future use. Factors that *may* or *may not* support installation of underground features are the timeline for future geometric changes, how close the intersection is to meeting warrants, and known future developments.

The installation of underground conduit systems *should* be considered when:

- It is apparent that signals will someday be located prior to the next project on a roadway.
- Project timing and location is appropriate.
- Post improvement project installation will not readily accommodate future installation (i.e., breaker run roadway base, conduit crossing structures, etc.).
- Impacts to adjacent land use and/or underground utilities necessitate the early placement of an underground system.

RIGHT TURN CONTROL

Right turn control at signalized intersections *should* be studied very thoroughly considering such factors as the volume of right turning vehicles, queue length, number of pedestrians, turn radii, cross street geometrics, channelizing islands, vehicular speeds, etc. Typically, it is preferred to use a less restrictive method and increase the degree of control as volumes, safety, number of pedestrians, and geometric conditions dictate.

FREE FLOW (No control)

- Right turn lane **shall** be channelized. The higher the right turn speed, the larger the channelizing island.
- The receiving approach **shall** have a designated traffic lane (acceleration lane) to be used exclusively for the right turning vehicles. It is recommended to extend the channelizing island to separate the right turn acceleration lane from the adjacent through lanes.
- Use only when no to very low volume of pedestrians crossing the right turn movement.
- Requires larger amount of right of way and is typically used in rural areas where continuous flow is preferred.

YIELD CONTROL

- Right turn lane **shall** be channelized.
- Channelized right turns *should* be brought in as near as perpendicular as possible for vision to the left.
- Recommended when no to very low volume of pedestrians crossing the right turn movement.
- Typically, is the preferred control type, unless more control is required.

STOP CONTROL

- Right turn lane **shall** be channelized.
- Channelized right turns **shall** be brought in as near as perpendicular as possible for vision to the left.
- Periodic enforcement *may* be needed to ensure drivers are obeying the stop sign.

SIGNAL CONTROL

Unchannelized right turn only lanes

- No channelizing island (porkchop). This layout is not the most desirable if there is a significant volume of conflicting pedestrians.
- Generally, a 3-section head (red, yellow and green ball) *should* be used.
- A 5-section head (red, yellow and green ball, yellow right arrow and green right arrow) configuration for the near and far right indications *may* be used, if considering the use of overlaps.
- The right turn arrow **shall not** be displayed at the same time as a conflicting pedestrian interval.
- Right turn FYA *may* be used with engineering judgement.

Channelized right turn lanes

- Per the WMUTCD, two signal faces **shall** be installed.
- A 3-section head configuration (red ball, yellow right arrow, and green right arrow) *should* be used when there is an opposing protected left turn.
- A 5-section head (yellow right arrow and green right arrow) *may* be used when there is an opposing permissive left turn.
- For control of dual right-turn movements, refer to State Statute 346.37(1)(c)3 regarding right turn on red from left most right-turn lane.
- In cases of multiple right turn lanes, “NO TURN ON RED” signing *may* be required at the discretion of the Regional Traffic Engineer. Red right arrows *may* only be used in conjunction with the “NO TURN ON RED” sign.
- Pedestrian crossings *should* be designed to direct the pedestrians from the radius to the channelizing islands (porkchops) and not to the median. This will allow for the possibility of utilizing a right turn overlap situation.

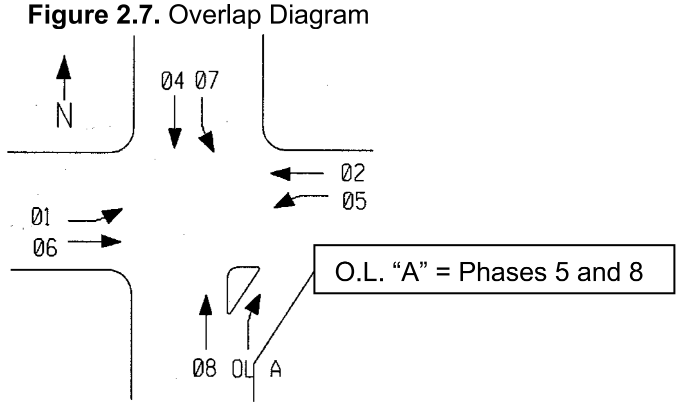
For geometric guidance for right turn lanes, refer to FDM 11-25-10, Right Turn Lanes.

VEHICLE OVERLAPS

An overlap is a vehicle movement that operates with more than one parent phase. Overlap movements will display a green when the phase to which the overlap is initially assigned within the cycle is green. Clearance (yellow and red) timings for the overlap signal indications are determined by the last parent phase of the overlap within the cycle. For example, if an overlap is assigned to phases 2 and 3, its green will begin timing with phase 2. The overlap will continue and then terminate with phase 3 yellow and all-red clearance intervals.

To distinguish from the basic vehicle and pedestrian phases, overlaps are designated alphabetically by letters (i.e., A, B, C, etc.). The overlap chart is located on the Sequence of Operations Sheet. The overlap *should* only be shown if it contains two (2) or more phases. The chart *should* indicate which phases the overlap times concurrently.

Figure 2.7. Overlap Diagram



In the example above, overlap “A” is a right-turn movement operating in conjunction with the complementary left turn movement (Phase 5) and will also operate with the adjacent through movement (Phase 8). Under this scenario, time given to the right turn overlap is governed by the associated left turn demand or the adjacent through movement depending on which phase is operating, not the right turn demand.

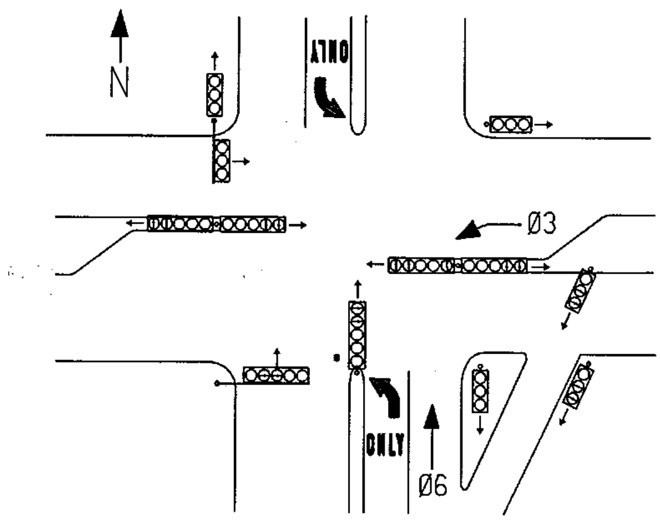
Figure 2.8. Overlap Chart

O.L. “A” =	O.L. “E” =
O.L. “B” =	O.L. “F” =
O.L. “C” =	O.L. “G” =
O.L. “D” =	O.L. “H” =

Geometrics

Right turn overlaps are best utilized at locations where there is an exclusive right turn lane, a complementary left turn lane and a left turn phase on the crossing street. Refer to figures 2.9 and 2.10 below for examples of typical signal head layouts with overlaps.

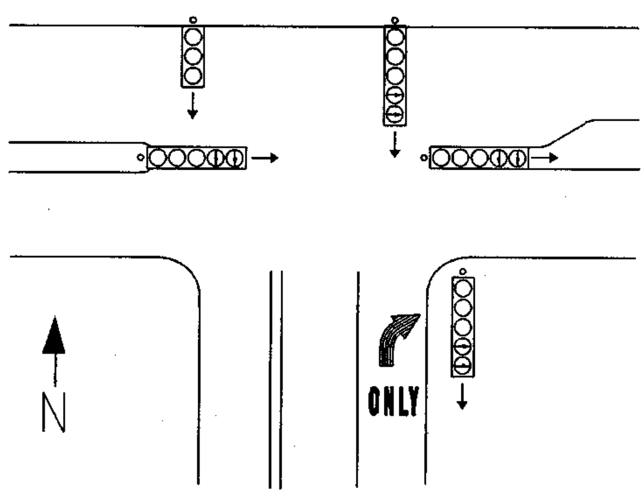
Figure 2.9. Right Turn Overlap with 3-Section Heads



NOTE: Signal heads only shown for EB/WB/SB left-turns and NB right-turn indications.
5-section heads are normally not recommended on right-turn bypasses, and may be dependent on opposing left-turn volumes. See Regional Traffic Engineer for guidance.
•If no median, then the signal head should be placed in far-left channelizing island.

The use of a protected only versus a permissive left turn for the southbound left turn movement (Phase 5) is dependent on receiving approach geometrics and intersection turning movement volumes. The Regional Traffic Signal Engineer **shall** be consulted.

Figure 2.10. Right Turn Overlap at T-intersection



NOTE: Signal heads only shown for EB/WB left-turns and NB right-turn indications

For information about flashing yellow arrow overlaps, see TEOpS 4-7-1.

Interchanges

At interchanges, overlaps are commonly used in conjunction with the ramp phases and the through phases between the ramps when one controller is used.

Figure 2.11. Single Controller – Dual Ring

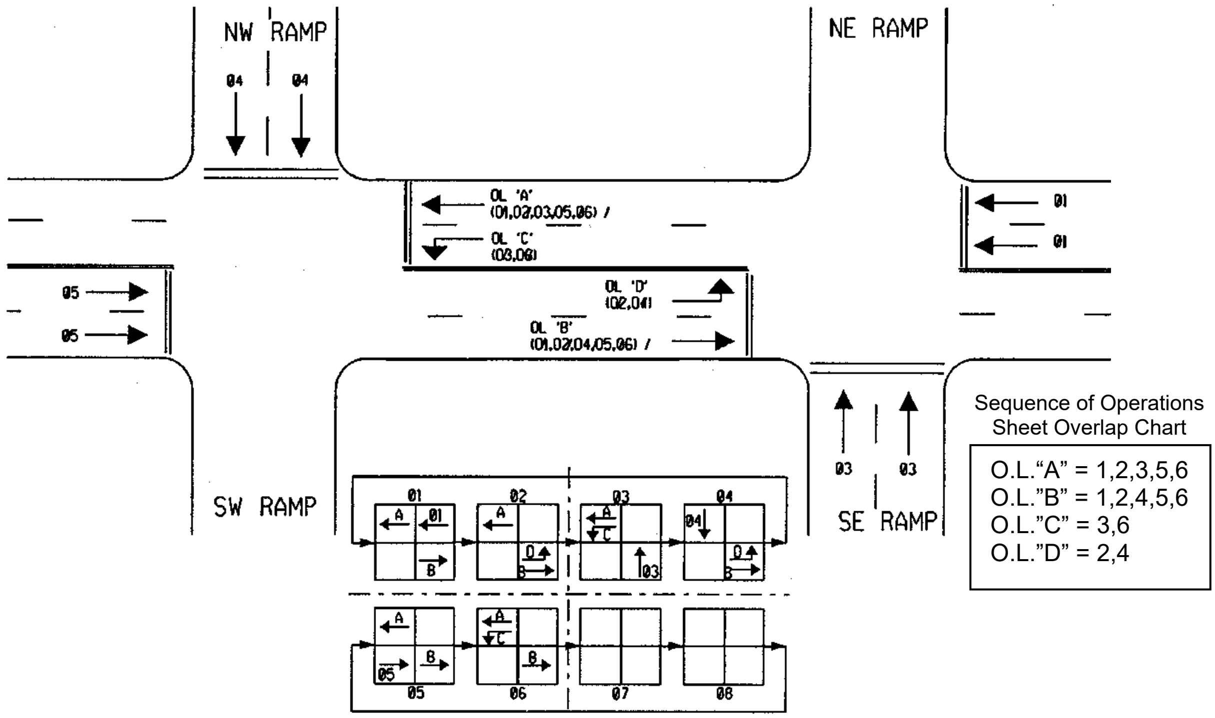
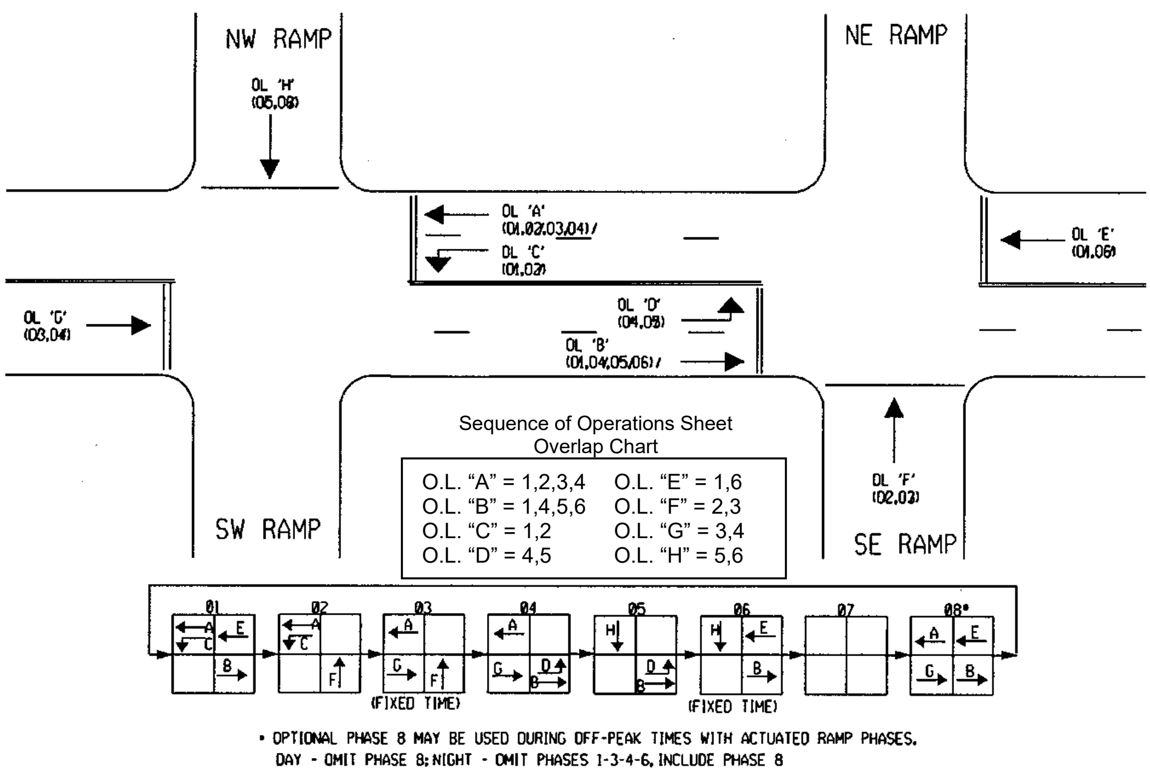


Figure 2.12. TTI Lead – Sequential Interchange



Pedestrian Considerations

In areas where pedestrian demands are high, particularly in central business districts, school crossings, or locations associated with special events, the use of right turn overlaps *should* be carefully evaluated with respect to pedestrian safety.

RESTRICTED LOCATIONS

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 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 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-premises 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.

TEMPORARY SIGNALS

Temporary traffic signals are typically installed for traffic control, when an existing signalized intersection is partially or totally reconstructed, as part of construction staging, detours, diversions or as part of a bridge rehabilitation project. Consult with the regional traffic section as to the type of temporary signal installation (partial or full) that *may* be needed for the project. The Regional Traffic Unit **shall** make the final decision regarding the installation, design, and operation of temporary traffic control signals.

The type of temporary signal installation is based on how much of the project work impacts the signalized intersection. The temporary signal could be as minor as overhead cable drops to the existing signal poles or standards or a complete overhead span wire signal head installation. When the signal heads are span wire mounted, the road work *may* require the signal heads to be moved on the plans for the different stages. If the scope of the project includes several stages, the temporary signal plan **shall** show the placement of the span wire signal heads for the various construction stages including temporary pavement markings, temporary signing, and placement of any work zone traffic control devices.

Before the temporary signal plan is developed, a field site review *should* be conducted to determine constructability. Additionally, all utilities *should* be located by contacting Diggers Hotline. Any utilities that are not on Diggers **shall** require a call directly to that utility to get their facilities located.

- Conduct a site review after all the utilities have been located.
- Check for any overhead facilities such as fiber optic, telephone, cable TV, and electrical lines both primary and secondary voltages that could conflict with any signal poles, light poles, and temporary wood poles for the temporary traffic signal.
- Maintain span length less than 200 feet. If length exceeds 200 feet, an additional median wood pole is required.
- Consult the utility for their clear zone working clearances when working around their utilities.
- Place temporary signal wood poles free of overhead utility conflicts and free from any new utility installations that *may* be installed as part of the project. The proposed signal equipment **shall** also be taken into consideration so that temporary head remain visible throughout construction. Sufficient right-of-way (or temporary limited easements) must be available to install down guys, Temporary wood poles *should* be located away from the vehicular traffic or adequately protected from vehicle traffic.
- Determine the cabinet location during the site visit if the installation will be installed and maintained by WisDOT. Factors to consider for the cabinet location are the accessibility of the electrical service, good sight vision of the intersection from the cabinet, avoid low areas where the cabinet could be flooded, and located in an area to avoid being struck by vehicles.
- Provide for temporary lighting.
- Determine if coordinated signal operations need to be developed or maintained with adjacent signals. Typically, time-based coordination is used.

Temporary left turn phasing during construction needs to be considered and approved by the Regional Traffic Signal Unit prior to the project. Sight limitations and limited turning movements *may* require the use of split phasing or the use of protected left turn phases in place of a protected/permissive phase. Provide adequate turn lane storage and channelization during the project to avoid vehicles queuing into the adjacent thru lanes for turning movements. If appropriate turning accommodations cannot be made, consider restricting the turning movement at the intersection.

Temporary signals operated in the pretimed mode *should* consider time of day plans for efficient operations. Temporary signals *may* use non-intrusive vehicle detectors as staging allows. Typically providing detection for vehicles, pedestrians and emergency vehicles is constrained during construction. Detection can be accommodated and **shall** be discussed with the Regional Traffic Unit. Requirements *may* include:

- Show the type/placement of vehicular detection on the plan (temporary detection (video, microwave, radar)
- Provide adequate refuge for pedestrian storage.
- Provide unrestricted access to pedestrian push button detectors.
- Show the placement of the EVP detector heads on the temporary signal plan.
- Show the EVP operation on the temporary signal sequence sheet.
- Refer to WMUTCD 6L.01, Temporary Traffic Control Signals.

The temporary signal plan set will include construction staging plan, temporary pavement marking and signing plan, temporary timing plan, placement of work zone traffic control devices (barrel or wands), a temporary signal plan, and a sequence of operation sheet for the temporary signal.

Section 661 of the *State of Wisconsin Standard Specifications for Highway and Structure Construction* and SDD 9g1 sheets a through g (Span Wire Temporary Traffic Signal) provide additional information about temporary traffic signal installations. These specifications define:

- Equipment to be furnished for temporary signals,
- Electrical service requirements, and
- Required working clearance is 17 to 19 feet for the signal heads and lower tether wire above the roadway.

The Regional Traffic Signal Unit **shall** determine the need for signal controller cabinets of full or partial temporary signal.

- Full temporary signals typically require the use of a separate (contractor furnished) traffic signal cabinet and/or controller, remote communications and non-intrusive detection during the construction project. The use of a temporary control cabinet allows for a safe transition from the temporary signal operation to the permanent signal operation.
- Partial temporary signals *may* use existing controller cabinets if state maintained during construction.

Responsibility for developing temporary signal timing plans *should* be clearly established. For temporary signals within WisDOT jurisdiction, the Regional Traffic Unit will develop temporary signal timing plans. If the timing plan is consultant developed, the Regional Traffic Signal Unit **shall** review and accept the plan.

INTERCHANGES

Selection of interchange signal operations

A common question relating to the design of signals at diamond interchange ramp terminals is whether to use one or two controllers. There *may* be advantages or disadvantages to either alternative. This subject presents typical applications and some of the differences between these alternatives.

When deciding how many controllers and what type of phasing *should* be used, consider the following general factors: required flexibility in signal operation/timing plan, physical interchange size, nature/volume of ramp traffic, mainline coordination with adjacent signals, vehicle storage requirements, and motorist expectancy. In any case, the Regional Traffic Engineer **shall** make the final determination regarding the type of operation at signalized interchanges.

Table 2.1 indicates some of the advantages and disadvantages of various interchange operations discussed below.

SINGLE CONTROLLER INTERCHANGE APPLICATIONS

Single controllers are typically used at interchanges with tightly spaced ramp terminals (less than 500 ft) where vehicle storage *may* be an issue. Signals at interchange ramps that use a single controller will generally use the following types of phasing options:

- TTI phasing is commonly used at interchanges with relatively consistent, heavy ramp volumes. When this type of phasing is used, right-of-way is assigned to a single mainline approach which is followed up with the ramp on the same side of the interchange. Next, right-of-way is assigned to the opposing mainline approach which is then followed up with the ramp movement on that side of the interchange. Put differently, the mainline approaches (followed up by their "complimentary" ramp movement) are alternated.

Vehicles will store on the outside of the ramp terminals; this will eliminate queuing on the roadway between the ramps. Phasing is appropriate for tightly spaced interchanges. It is advantageous because mainline movements will only be stopped once in the interchange area, due to leading protected left turn phasing on the mainline approach of the interchange.

- <u>Dual Ring with Overlaps</u> phasing *may* be preferred over TTI Phasing particularly if ramp volumes are more variable or unbalanced. External mainline movements are assigned to phases 1 and 5. Ramp movements are assigned to phases 3 and 4. Internal mainline through and left turn movements are assigned to overlaps within phases 1 through 6. Like a standard four-legged intersection, any non-conflicting phases that have demand can be serviced simultaneously. Also, within these phases multiple movements that have been assigned to overlaps can be serviced.

  Ramp spacing *should* be great enough to accommodate queuing between ramp terminals. As such, a queue analysis *should* be performed.

- <u>Simultaneous Ramp Release</u> *may* be either leading or lagging relative to the mainline through movements. With this type of phasing, traffic on opposing ramps are released at the same time and stored within the interchange. Next opposing interior through and left turn movements are released. This interval is followed by opposing exterior mainline through movements. Exterior mainline through vehicles that want to access the freeway by turning left at the opposite ramp terminal will also need to store within the interchange while the opposing through movement times out concurrently. This *may* necessitate multiple stops within the same interchange.

  This phasing requires that ramp spacing be great enough to accommodate queuing of the ramp traffic between terminals. As such, this phasing will not typically be appropriate for interchanges with tightly spaced ramp terminals and moderate to heavy ramp traffic. Even locations with relatively light ramp volumes would need to be analyzed carefully. As with the Dual Ring phasing alternative above, a queue analysis *should* be performed.

Splice Cabinets at Single Controller Interchanges

When a single controller is used to operate both terminals, a splice cabinet *may* be located on the opposite side of the interchange at the discretion of the Regional Traffic Engineer. A splice cabinet is a controller cabinet shell that houses the consolidated signal cable conductors from the separate indications for each phase. Once wiring splices have been made in the splicing cabinet, then a multi-conductor signal cable is run back to the controller cabinet on the opposite side of the interchange. Otherwise, a single conductor per indication type and per phase is required to run back to the controller cabinet for each of these phases. Installing a splice cabinet allows electrical personnel to pull only one cable instead of many.

The splice cabinet *should* be placed in a location where electrical service is accessible. This will allow for placement of a full signal control cabinet in the future, if necessary.

<u>TWO CONTROLLER INTERCHANGE APPLICATIONS</u>

In some situations, it *may* be more appropriate to use a controller for each interchange ramp terminal. This type of arrangement will typically be applied at interchanges with ramp spacing greater than 500 ft. In large part, this is due to the long distances to far detection that *may* be on the opposite side of the interchange from the signal cabinet and the ability for those devices to function effectively.

The use of two controllers will likely necessitate the need for coordination. One advantage of dual controller interchange operation is that a conduit crossing the interchange *may* not be necessary unless interconnected coordination is desired.

In some cases, two controller arrangements have flexibility for interchange signal operations due to the opportunity to program offsets. However, they are more labor intensive, in terms of coordination, maintenance, and cost when compared to single controller arrangements.

It is essential that two controller interchanges are accurate and remain in step with each other for coordination purposes.

These concepts will apply to standard diamond interchanges or modified interchange configurations, such as Diverging Diamond Interchanges (DDI's).

Table 2.1. General Signalized Interchange Alternative Considerations

Operation or Phasing	Key Factors	Advantages	Disadvantages
Single Controller Applications (ramp terminal spacing < 500 ft)			
TTI	Heavy, consistent volumes at isolated location or where there is a relatively high percentage of left turning movements.	▪ Eliminates queuing within the interchange ▪ Works well in areas of high-demand ▪ Relatively straight-forward, consistent operation -- one movement occupies the interchange at any time ▪ *May* require only one stop within the interchange	▪ *May* not provide ideal conditions for coordination with adjacent signals ▪ *May* impose higher delay on users during periods of low use ▪ Forces queue outside of interchange ramps ▪ Basically, a pre-timed operation
Dual Ring w/Overlaps	Desire to provide progression on the mainline with more variable/unbalanced ramp volumes.	▪ Can provide improved conditions for coordination with adjacent signals ▪ Ability to provide leading-lagging left-turn phasing ▪ Omits phases 2 & 6 and recalls phases 3 & 4 ▪ Efficient	▪ Inconsistent operation, (penalized ramps (phase 3) must stop)
Simultaneous Release	Desire to provide high throughput on the mainline. Lower left-turning ramp volumes.	▪ Provides improved conditions for coordination with adjacent signals	▪ Requires storage of left-turning ramp traffic within the interchange ▪ Left-turns off the mainline *may* be delayed due to phasing sequence
Single Point	High volume interchanges in a tight, urban environment	▪ Improved operation and safety due to fewer conflict points ▪ Controlled by a single signal	▪ Higher cost due to needing a larger bridge ▪ Large areas of pavement needed ▪ Not pedestrian friendly ▪ Difficult to clear snow
Two Controller Applications (ramp terminal spacing > 500 ft)			
Coordinated Ramps	Desire to provide progression on the mainline & need to provide maximum flexibility for future operational alternatives.	▪ Provides improved conditions for coordination with adjacent signals ▪ Can be made to mimic the phasing alternatives above. ▪ Provides greatest opportunity for operational flexibility	▪ Identifying & implementing maximized operational/timing plan using multiple controllers is more complex than using a single controller ▪ Both controllers must be coordinated ▪ Increased maintenance & capital ▪ *May* require additional detection

VEHICLE DETECTION

In the cases where a single controller is used, large ramp spacing can impact the effectiveness of inductance loops used for vehicle detectors.

To operate properly, the differential between the inductance of the loop *should* exceed that of the lead-in cable by a factor of 2:1. There are two ways to compensate for the increased spacing.

The first method is to decrease the physical distance between the detection amplifiers that reside in the controller cabinet and the far loops. At diamond interchanges, the preferred location for the controller cabinet is inside the interchange footprint and adjacent to either off-ramp. Placement adjacent to either off-ramp is acceptable if sight-distance from the controlled approach is not impeded.

The second method is to increase inductance within the loop relative to the lead-in cable. This is done by using a larger number of turns within the loop or increasing the loop size. In general, the maximum number of turns a loop can contain is six.

RAMP METERING CONSIDERATIONS

In highly urbanized locations, future or pending ramp metering capabilities *may* need to be considered. Additional capacity treatments *may* include extension of right- and left-turn lanes used to access metered on-ramps, and additional lanes (at appropriate length) on the ramp itself to store vehicles.

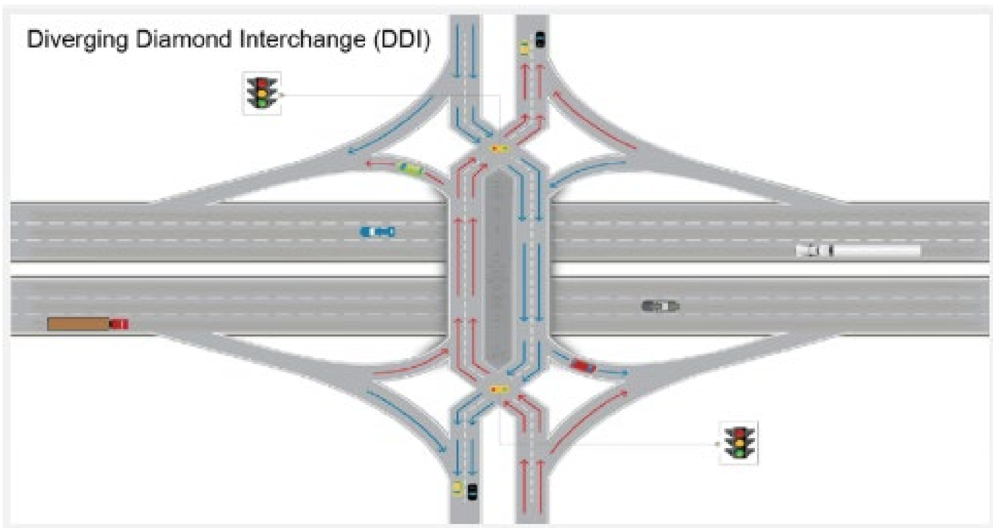
OTHER ELECTRICAL FACILITIES

Other facilities such as continuous roadway lighting or ITS elements (such as ramp meters and DMS), **shall** be contained within their own systems for maintenance and operational reasons.

ALTERNATIVE INTERCHANGE DESIGNS

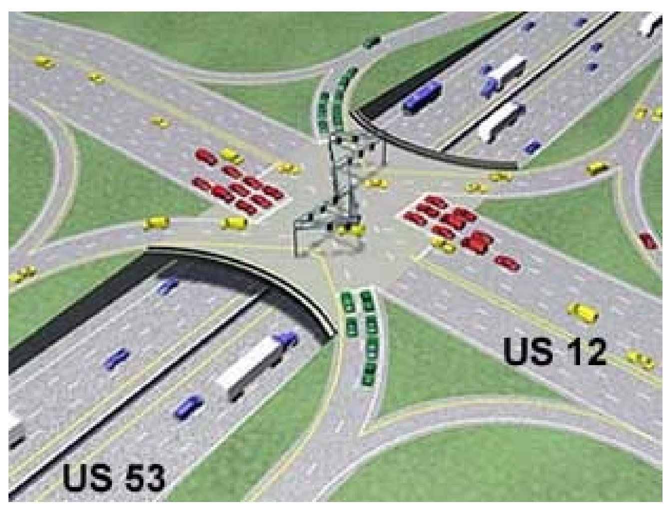
Diverging Diamond Interchanges (DDI's) are a modified version of the standard diamond where vehicles entering the interchange, cross over to the opposite roadway through the interchange area. The advantage of this configuration is that ramp volumes are less impeded, similar to right-turn movements at standard intersections. Whether a DDI or stand diamond, the concepts discussed above regarding single- or dual controller operations, still apply. DDI's will typically use 2-phase operation.

Figure 2.13. Diverging Diamond Interchange



Single Point Interchanges (SPI's) consist of a distinct geometric design, such that all interchange movements converge at a single point within the interchange and left-turns phases are eliminated. SPI's are also a proper application for single controllers and will typically use 3-phase operation.

Figure 2.14. Single Point Interchanges



In the illustration on the right, vehicular movements served by individual phases are distinguished by color.

PEDESTRIAN APPLICATIONS/WARRANTS

Reference is made to the WMUTCD Sections 4C.05, 4C.06, 4D.03, and 4I.

The design and operation of traffic control signals **shall** take into consideration the needs of pedestrian as well as vehicular traffic. The decision to signalize pedestrian movements *should* be a collaborative decision between the regional signal engineer and the regional bicycle/pedestrian safety coordinator and *should* be based upon the warrants and other criteria provided hereafter.

POLICY

Sidewalk and curb ramps **shall** be provided at locations where pedestrian signal heads are to be installed.

Per WMUTCD 4I.01:

"Pedestrian signal heads **shall** be used in conjunction with vehicular traffic control signals under any of the following conditions:

A. If a traffic control signal is justified by an engineering study and meets either Warrant 4, Pedestrian Volume or Warrant 5, School Crossing (see WMUTCD 4C.05 and 4C.06);

B. If an exclusive signal phase is provided or made available for pedestrian movements in one or more directions, with all conflicting vehicular movements being stopped;

C. At an established school crossing at any signalized location; or

D. Where engineering judgment determines that multi-phase signal indications (as with split-phase timing) would tend to confuse or cause conflicts with pedestrians using a crosswalk guided only by vehicular signal indications."

"Pedestrian signal heads *should* be used in conjunction with vehicular traffic control signals under any of the following conditions:

A. If it is necessary to assist pedestrians in deciding when to begin crossing the roadway in the chosen direction or if engineering judgment determines that pedestrian signal heads are justified to minimize vehicle-pedestrian conflicts;

B. If pedestrians are permitted to cross a portion of a street, such as to or from a median of sufficient width for pedestrians to wait, during an interval but are not permitted to cross the remainder of the street during any part of the same interval; and/or

C. If no vehicular signal indications are visible to pedestrians, or if the vehicular signal indications that are visible to pedestrians starting a crossing provide insufficient guidance for them to decide when to begin crossing the roadway in the chosen direction, such as on one-way streets, at T-intersections, or at multi-phase signal operations."

In addition to the guidance provided above, there are a few other items to consider when deciding whether to install pedestrian signal indications:

1. Is a pedestrian with a visual disability requesting the accommodation? (It is WisDOT's policy to accommodate pedestrians with visual disabilities by installing pedestrian heads and APS devices, so long as the pedestrians with visual disabilities are the ones requesting it).
2. What is the land use adjacent to the intersection? Does the intersection serve as a connection between businesses? To a school? To a parking lot? To a transit/bus stop?

At locations where, pedestrian heads and push buttons are not initially installed, the designer *should* locate all signal poles with future pedestrian accommodations in mind. This way the intersection can be easily retrofitted with pedestrian heads and push buttons once the sidewalk and curb ramps have been installed.

SUPPORT

In Wisconsin, pedestrians can legally cross a roadway at a traffic signal even if that traffic signal does not have pedestrian signal heads.

Wisconsin State Statute 346.37 (1)(a)2: "Pedestrians, and persons who are riding bicycles or electric personal assistive mobility devices in a manner which is consistent with the safe use of the crosswalk by pedestrians, facing the (green) signal *may* proceed across the roadway within any marked or unmarked crosswalk."

Wisconsin State Statute 346.37 (1)(c)2: "No pedestrian, bicyclist, or rider of an electric personal assistive mobility device facing such signal (red) **shall** enter the roadway unless he or she can do so safely and without interfering with any vehicular traffic.

Also, Wisconsin State Statute 346.23 addresses motorists' responsibility at intersections relative to pedestrians:

(1) At an intersection or crosswalk where traffic is controlled by traffic control signals or by a traffic officer, the operator of a vehicle **shall** yield the right-of-way to a pedestrian, or to a person who is riding a bicycle or electric personal assistive mobility device in a manner which is consistent with the safe use of the crosswalk by pedestrians, who has started to cross the highway on a green or "Walk" signal and in all other cases pedestrians, bicyclists, and riders of electric personal assistive mobility devices **shall** yield the right-of-way to vehicles lawfully proceeding directly ahead on a green signal. No operator of a vehicle proceeding ahead on a green signal *may* begin a turn at a controlled intersection or crosswalk when a pedestrian, bicyclist, or rider of an electric personal assistive mobility device crossing in the crosswalk on a green or "Walk" signal would be endangered or interfered with in any way. The rules stated in this subsection are modified t intersections or crosswalks on divided highways or highways provided with safety zones in the manner and to the extent stated in sub. (2).

(2) At intersections or crosswalks on divided highways or highways provided with safety zones where traffic is controlled by traffic control signals or by a traffic officer, the operator of a vehicle **shall** yield the right-of-way to a pedestrian, bicyclist, or rider of an electric personal assistive mobility device who has started to cross the roadway either from the near curb or shoulder or from the center dividing strip or a safety zone with the green or "Walk" signal in the favor of the pedestrian, bicyclist, or rider of an electric personal assistive mobility device.

CONTROL FOR EMERGENCY VEHICLE ACCESS

Reference is made to the WMUTCD, Section 4F, and Wisconsin State Statute 346.455

POLICY

The following conditions describe various forms of traffic control associated with emergency vehicle access as well as general installation, design, and operational criteria.

Condition 1: Warning Device with No Traffic Control

Prescribed practice is to use the warning sign W11-8, Fire Station Truck, with or without a flashing beacon used to supplement the sign. Use of this type of warning is intended for use only at locations with restricted sight distances. If used with a flashing beacon, the beacon *should* be activated by a control in the firehouse for a preset period for the emergency vehicle to enter the highway.

An alternate method is to use a W11-8 at the emergency vehicle access with a yellow flashing beacon, and install an advance warning sign, W54-60, Fire Trucks (Emergency Vehicles) Enter when Signal Flashes.

On the state trunk highway system, signing will be furnished, installed, and maintained by the department. The municipality *may* have an option to install a flashing beacon subject to obtaining a permit from the regional office and accepting responsibility for operating and maintaining the beacon in accordance with the permit.

Condition 2: Emergency Vehicle Hybrid Beacons and Mid-Block Access

Under this condition, the emergency vehicle access is at mid-block and controlled by a hybrid beacon.

Application

Emergency vehicle hybrid beacons **shall not** be installed mid-block on two-lane roadways. In addition to guidance provided in the WMUTCD 4F, emergency vehicle hybrid beacons *may* be considered on multilane highways when the following volume criteria is met:

1. Traffic volume on the adjacent roadway exceeds 18,000 vehicles per day, or
2. Traffic volume on the adjacent roadway exceeds 1,800 vehicles during the peak hour of the day.

In addition to the volume criteria above, a specialized study **shall** be conducted by the agency requesting the beacons to demonstrate the need for control at emergency vehicle access points. Minimally, k=the study will consider adjacent roadway geometry (to include sight distance criteria), traffic volumes and characteristics, relative emergency vehicle exposure, and related vehicular conflicts (to include crash history). The study *should* also include a traffic capacity analysis to evaluate the effects of such an installation on the adjacent roadway. Such an installation *may* be denied if the study determines that a substantial, negative impact will be created by the installation of an emergency vehicle hybrid beacon.

Design and Operation

All design and operation requirements for an emergency vehicle hybrid beacon can be found in WMUTCD 4F.

Maintenance and Funding

Since emergency vehicle hybrid beacons are installed to serve a defined community, it is reasonable to assign maintenance responsibilities to the community being served. However, for installations outside connecting highway limits, communities *may not* have resources available to manage such systems. As such, this function will likely need to be fulfilled by WisDOT. In that case, an agreement with the community *may* be developed that will establish a means to reimburse WisDOT for any time and materials spent maintaining these installations. This agreement *may* address costs to install traffic control hybrid beacons as well.

Other Traffic Control Methods for Emergency Vehicle Access

Devices used to control traffic on the STH system, including connecting highways, at locations of emergency vehicle access are subject to Wisconsin State Statute 346.455, the WMUTCD, and this policy. Forms of traffic control outside of these standards are not permitted. Examples of this include using red flashing beacons with signs indicating “WHEN FLASHING – STOP FOR FIRE TRUCKS” or similar messages.

SUPPORT

Regardless of the reason traffic control devices are installed, they need to convey a purposeful, clear, and consistent message to motorists.

In addition to providing these types of devices on the STH system to promote safety, drivers of emergency vehicles *should* be properly trained regarding the proper operation of emergency vehicle hybrid beacons, and the concept that use of emergency vehicle hybrid beacons does not remove the responsibility of the vehicle operator from determining whether it is safe to enter the highway.

The local municipality **shall** be responsible for such training programs.

4-2-3 Other Considerations — April 2025

LOCAL COORDINATION

Coordination with Local Municipalities

When evaluating a location for traffic signal control, consideration *should* be given to the proximity of other types of intersection traffic control, including those in other jurisdictions. Despite ownership of traffic control devices, route continuity, intersection spacing, and traffic volumes *may* dictate the need to place signals in coordination if adjacent to other signals.

In the case of multi-jurisdictional coordinated systems, timing plans need to be developed collaboratively. Consideration *should* also be given to agreements that define roles of responsibility relative to maintenance of the system (i.e. interconnect demarcation for locates or repairs), and/or use of equipment that keeps signal controllers in step (i.e. GPS clocks).

More complex multi-jurisdictional systems, such as Traffic Responsive or Adaptive signal control, require central control of individual intersections. In this case, a Memorandum of Agreement (MOA) is strongly suggested to address jurisdictional authority, financial responsibilities (i.e. ongoing utility costs, sharing of software maintenance contracts), as well as operational and maintenance roles. In these cases, the Region Traffic Signal Engineer **shall** be contacted.

State-owned Equipment Located on Private Property

State-owned signal equipment **shall** be placed in public right-of-way. In the unusual case that equipment needs to be located on private property, a Permanent Limited Easement (PLE) is required to allow state personnel to routinely access this portion of the property for signal maintenance purposes and to install detection and other equipment. To establish a PLE, the Regional Real Estate Unit **shall** be contacted.

Specialty Equipment – Locally owned/maintained signals

Local municipalities/agencies *may* request decorative or ornamental signal equipment for poles, standards or mast arms. Cost of decorative or ornamental signal hardware **shall** be borne by the jurisdiction requesting the specialty items and is subject to standard project cost-sharing practices.

Specialty Equipment – State owned/maintained signals

Local municipalities/agencies *may* request standard signal equipment (i.e. poles, standards or mast arms) that have been manufacturer painted (or anodized) black. Requests **shall** be made in writing and submitted to the appropriate Region. The Region maintains discretion over the approval of such requests. If approved, the local municipality/agency **shall** sign an agreement with the state.

The specifics of this agreement are also at the discretion of the region and will cover items such as inventory management, delivery of spare equipment, and the billing of additional costs incurred outside of regular maintenance work back to the local municipality/agency. In addition, initial installation cost of black painted signal equipment **shall** be borne by the jurisdiction requesting the specialty items and is subject to standard project cost-sharing practices.

JURSIDICTIONAL TRANSFER CONSIDERATIONS

Signals and signal systems need to be considered when highways are transferred between agencies. The ownership of traffic signal installations *may* be jurisdictionally transferred several reasons:

- Jurisdictional transfer of a segment of highway due to a change to the route (i.e. bypass of a community),
- Establishing or changing the limits of connecting highway segment, or
- Reallocation to a specific agency for traffic management or operational benefits (i.e. establishing alternate routes during construction projects and/or coordinated systems).

Since many of the jurisdictional transfers/connecting highway changes take effect upon completion of a state let construction project which *may* include installation of new signals or rehab of existing signals, the transfer of any existing or new signal(s) *should* be a part of the highway jurisdictional process initiated by Regional Planning staff.

Regional Traffic and Planning staff, as well as the local municipality, *should* be involved in discussions relating to the details associated with the signal transfer. There are many key signal operation and maintenance issues to consider <u>early</u> in the highway jurisdictional process.

Ideally, the transfer of traffic signal installations will be addressed via the jurisdictional transfer agreement for the subject roadway. In some cases, the transfer agreements have been approved and signed by both agencies, however the actual transfer of the signal has been detained for several years after the transfer of the roadway due to various issues ranging from warranties to interconnect.

For any signal transfer it is important to remember that the utility costs *should* be transferred on the date the signal transfer is effective.

The lists of items below *should* be considered when jurisdictionally transferring signal installations between agencies. Items include, but are not limited to, the following:

<u>PROPOSED SIGNALS THAT WILL BE TRANSFERRED UPON COMPLETION OF INSTALLATION</u>

- Who is designing the signal (e.g. local municipality, consultant or DOT)?
- Will the signal be designed to DOT standards or to municipal standards?
- If designed to DOT standards, who will provide the signal equipment?
- Who will do the final electrical inspection and turn on the signal (i.e. DOT electricians, contractor or local municipality's electricians or contractor)?
- What conditions are to be met prior to the transfer to take place? Ideally, the signal will become jurisdiction of the local municipality upon signal turn on as opposed to completion and acceptance of the associated roadwork, which *may* occur several months after signal turn on.
- What agency (DOT, local municipality or consultant) will be responsible for initial signal timing required at turn on?
- Is signal in coordination with other state maintained or locally maintained signals? (If yes, see EXISTING OR PROPOSED COORDINATED SIGNALS)
- A key situation to address early, is if the signal(s) to be transferred operates in coordination with another agency's signal(s). In this case the following needs to be addressed, mutually agreed upon, and spelled out in the transfer agreement*:*
    - Type of coordination (TBC, closed loop, fiber, etc.)?
    - If multiple agencies will be involved, who will locate and maintain the interconnect conduit? Specific maintenance limits **shall** be defined in the agreement.
    - Who will review, update and pay for changes to timing to maintain or improve coordination?
    - Who will pay to change controllers in the future for compatibility reasons?
    - Who will respond to communication/network issues?

EXISTING SIGNALS THAT WILL BE TRANSFERRED

If an existing signal is being transferred, then the following issues need to be addressed, mutually agreed upon, and spelled out in the transfer agreement:

- Is the signal being transferred in "AS IS" condition, i.e. the signal equipment is in proper working condition or will upgrades be required?
- Condition/age of the existing controller?
- Coordination with other state maintained or locally maintained signals? (If yes, see EXISTING COORDINATED SIGNALS, above)
- What conditions *should* be met for the transfer to take place (e.g. inspection by local municipality)?
- Warranties **shall not** be used.
- A key situation to address early is the signal coordination status. The following issues *should* be addressed, mutually agreed upon and spelled out in the transfer agreement:
- Specify the signals in a coordinated system that are maintained by individual agencies.
    - Type of coordination (TBC, closed loop, fiber, etc.)?
    - Multiple Agencies:
    - Who will maintain the interconnect conduit? Specific maintenance limits **shall** be defined in the agreement.
    - Who will review, update and pay for changes to timings to maintain or improve coordination?
    - Who will pay to change controllers in the future for compatibility reasons?
    - Who will respond to communication/network issues?

SIGNAL TRANSFER CHECKLIST

When transferring an existing state owned/maintained traffic signal to another agency there are several associated issues to remember to take care of approximately two weeks prior to transfer:

- ❑ Request inspection of signal by WisDOT electricians, i.e., check loop functionality, lamp outages, etc.
- ❑ Notify electric utility of impending change in ownership.
- ❑ Remove WisDOT decals or other identification from control cabinet
- ❑ Send letter to receiving municipality to remind of pending transfer.

The text of the letter *should* include transfer date and a reminder to establish account with electrical utility (See sample letter). Copies of the following *should* be included with the letter:

- ❑ Latest timing
- ❑ Latest signal plan and sequence sheet
- ❑ Signed documentation for signal transfer
- ❑ Notify impacted law enforcement agencies including state patrol.
- ❑ Notify pertinent regional staff including:
    - ❑ Other pertinent regional staff who are responsible for the operation of the signals, paying the electrical service bill, and maintaining pavement marking and signing, if applicable.
    - ❑ Electricians
    - ❑ Planning staff who are responsible for manual traffic counts and updating STN log
    - ❑ Digger's Hotline
    - ❑ Roadway Maintenance
    - ❑ Pertinent Bureau of Traffic Operations staff who are responsible for maintaining asset management tools and signal cabinet wiring diagrams.

SIGNAL TRANSFER SAMPLE LETTER

June 20, 2005

City Engineer

City XYZ

1234 Drive

City XYZ, Wisconsin 53200

Dear :

SUBJECT: STH XX & CTH XX

XX County

This letter is a reminder, that effective June 30, 2005, the subject traffic signal will become the maintenance and operational responsibility of the City of XYZ per the enclosed agreement.

We have informed the utility company of the pending transfer. They request that you contact them to provide the applicable billing information.

For your use you will find copies of the existing signal plan, sequence of operations sheet and timing.

If you have any questions, please feel free to contact me (XXX) XXX-XXXX.

Sincerely,

Regional Traffic Signal Engineer

UTILITIES, CULTURAL AND ENVIRONMENTAL ISSUES

Early in the design process, existing above- and below-ground utilities must be identified to determine if there is a potential conflict that will affect the placement of signal equipment and particularly for monotube signal bases that *may* require wing walls.

Underground facilities *should* be located and marked in the field prior to a field investigation. Examples of such facilities include:

- electric
- utility vaults
- high pressure gas lines
- fiber optic packages
- telecommunication
- cable
- water
- sewer lines
- municipal communication duct packages, etc.

Overhead electrical facilities *may* have proximity requirements regarding signal monotube and/or mast arm clearances.

Guidelines for historical boundaries and cemeteries are found in FDM Chapter 26, Cultural Resource Preservation.

Guidelines regarding required Environmental processes and documentation are found in FDM Chapter 20, Environmental Documents, Reports and Permits.

COMMUNITY SENSITIVE DESIGN (CSD)

According to FDM 11-3-1, Community Sensitive Design, CSD is a collaborative interdisciplinary approach that includes early involvement of all stakeholders to ensure that transportation projects not only provide safety and mobility, but are also in harmony with communities and the natural, social, economic, and cultural environments.

When requests are made for non-standard WisDOT signal equipment (i.e., decorative hardware), consideration *should* be given to establishing connecting highway limits so local jurisdictions can own and maintain signals that incorporate special equipment.

When decorative pavement is used near state owned and maintained intersections, the location of signal equipment *should* be considered. Decorative pavement *should not* be used near signal bases, pull boxes or in-pavement detection for maintenance and replacement reasons.

4-3-1 Field Investigation Introduction — April 2025

Prior to commencement of plan preparation, a field investigation **shall** be conducted at the location proposed to be signalized, or at the site of the existing signal to be modified. The purpose of the field investigation **shall** be to verify and/or collect data on existing field conditions to facilitate plan preparation and identify potential utility conflicts prior to actual construction. In addition, the field investigation will enable the proposed electrical service location to be identified early on, which *may* or *may not* affect the location of the controller cabinet.

State-Owned Signal (either State Administered or Permit) Project

The signal designer **shall** coordinate with the Regional Traffic Unit prior to the field investigation. The Regional Traffic Unit will work with the local utility company and signal designer to determine the most appropriate location for the traffic signal control cabinet for state owned signal projects.

Locally Owned Signal (State Administered Project) (i.e., municipality, county, connecting highway)

The signal designer **shall** coordinate with the local agency that owns the signal prior to the field investigation.

4-3-2 Intersection Inventory — April 2025

GEOMETRICS

Existing intersection and approach geometrics **shall** be verified in the field, including but not limited to:

- Approach grade
- Lane usage
- Lane widths
- Parking
- Left- and right-turn channelization
- Sight distance restrictions
- Sidewalks
- Bike paths
- Posted speed limit
- Other related information

Furthermore, information regarding right of way and drainage **shall** be checked. Right of way restrictions *may* require permanent easements to be obtained for the placement and maintenance of traffic signal equipment. Drainage characteristics *should* be taken into consideration to avoid placement of signal equipment, particularly controller cabinets in low points or flow lines.

Further investigation *may* be necessary to address certain special conditions, which could include the need for emergency pre-emption, signal interconnection, and accommodation of handicapped persons.

UTILITY CONFLICTS

Diggers Hotline (1-800-242-8511 or 811) **shall** be contacted during the design stage to determine the location of existing utilities. Marked locations for state-owned electrical facilities will need to be arranged through the Diggers Hotline.

Information regarding existing utilities from locates **shall** be incorporated into the preliminary signal plan. The utility information **shall** be verified during the field investigation and potential conflicts noted. Utility conflicts *may* consist of both underground and aboveground conflicts. Attention **shall** be given to underground utilities that could conflict with foundations for mast arm poles. At grade and aboveground utilities such as manholes and overhead lines **shall** be checked to avoid conflicts with proposed mast arms, pull boxes, concrete bases, and detection.

Signal poles and mast arms **shall** be a minimum of 10 feet from all overhead utilities. The designer **shall** contact the local utility companies for specific guidelines.

CONTROL CABINET LOCATION

Generally, electrical service disconnect *should* be located at or near the control cabinet.

For state-owned signals, the Regional Traffic Unit **shall** determine the placement of the control cabinet based on safety, visibility and aesthetics (i.e., to avoid placement on residential properties, etc.), not necessarily on service location. The electrical service provider **shall** be contacted prior to plan preparation to verify the location of the electrical service relative to the control cabinet, and what, if any, charges *may* apply.

For locally owned signals on state administered projects (i.e., municipality, county, connecting highway), the signal designer **shall** coordinate with the local agency who owns the signal prior to the plan preparation for the control cabinet and service location.

CHECKLIST

The field investigation **shall** include a thorough investigation of the location to familiarize the designer with the characteristics unique to that location. To facilitate the field investigation and design of the traffic signal, the designer *should* follow the guidelines listed below. In addition, the field investigation checklist *should* be completed during the investigation and filed with other project documentation.

1. A topographic survey of the location *should* be obtained prior to conducting the field investigation. The information represented on the survey *should* be verified for accuracy and include discrepancies noted during the field investigation. Information not included on the survey but observed in the field, *should* be added.
2. A photographic log of the location *should* be taken which could include photos of all approaches and photos of all the quadrants, at the intersection. This information could be used for the Signal Investigation Study and is useful during the design of the traffic signal installation.
3. The field investigation *should* be conducted when weather conditions are favorable.

The following field investigation checklist has been created by the Department for use during field visits. This list is a general checklist of items which *should*, as a minimum, be documented during the field investigation.

FIELD INVESTIGATION CHECKLIST

Intersection Geometrics

- ☐ Angles of intersecting streets
- ☐ Approach grades
- ☐ Physical features (pavement type, streetscaping, curb & gutter, loading zone, sidewalks, bike paths, shoulders, etc.)
- ☐ Distance to bridge approaches
- ☐ Corner radii (evidence of wheel tracking behind curb/median)
- ☐ Right turn movements (yield/stop conditions)
- ☐ Width of streets and travel lanes
- ☐ Lane usage and dimensions
- ☐ Turning lane storage length
- ☐ Roadway entrances within 500 feet on minor approaches and 1000 feet on Major approaches (driveways)
- ☐ One way streets
- ☐ Bus stops and loading zones
- ☐ Turning restrictions
- ☐ Future street connections at T-intersections

Pavement

- ☐ Existing pavement markings (stop bar locations, crosswalks, lane assignments)
- ☐ Concrete to asphalt joint locations
- ☐ Areas of extreme pavement distress (pavement rutting, alligator cracking)

Traffic Control Devices

- ☐ Location and message of roadside signs
- ☐ Railroad preemption/battery back-up system and/or potential preemption for emergency centers in vicinity
- ☐ Location and operation of existing signals and/or adjacent signals of state or another agency
- ☐ Existing speed limits
- ☐ Existing traffic signal standard/pole, controller, detector, etc. locations
- ☐ Potential locations for proposed underground signal facilities (potential bridge crossing for conduit)

Utilities
- ☐ Existing municipal lighting
- ☐ Utility locations including possible service location
- ☐ Overhead restrictions (phone/electrical lines, height restrictions)

Adjacent Land Use
- ☐ Right of way or property lines
- ☐ Current land use (schools, trucking, elderly housing)
- ☐ Existing site distance obstructions (buildings, trees, fences, outdoor advertising)
- ☐ Emergency use (fire station, police station, hospital, etc.)

Other
- ☐ Drainage features (culverts, catch basins, manholes, ditch bottoms, etc.)
- ☐ Parking restrictions

4-4-1 Signal Investigation Study — April 2025

For traffic signals to be considered on the STH-system, a Signal Investigation Study **shall** be developed to document its need.

All supporting discussion, information, and evaluation worksheets **shall** be presented in a standard format. This format will create uniformity in the presentation/review of the Signal Investigation Study for the intersection being evaluated.

The format of the signal investigation study is detailed below:

I. The cover letter **shall** include:
- A recommendation and brief discussion of the study.
- Any/All exceptions to the standards referenced in this manual and the WMUTCD.
- A discussion of remedial actions tried, or, if none, explanation of need for signal.
- Related agreements (i.e. railroad, maintenance).
- Formal correspondence (letters from governmental officials, elected or non-elected, brief mention of local petitions, if any).
- The local jurisdiction's recommendation and why rural warrants were used (if used).

II. DT1199 Traffic Control Signal Approval Request **shall** be completed by the Region and submitted with the investigation study to Central Office.

III. Analysis or signal investigation study stating reason for recommendation, to include statements regarding:
   a. Reasons / Justification for Signal Request
   b. Existing Physical Conditions and Control Devices
   c. Traffic Conditions
   d. Crash History
   e. Warrants met

IV. Appendices:
   a. Intersection Location Map
   b. Hourly Intersection Turning Movement Traffic Volume Counts
   c. Signal Warrant Analysis Worksheets
   d. Intersection Plan Sheets
   e. Signalized Intersection Capacity Analysis
   f. 3-yr Intersection Crash History Data Extract
      - Crash Reports
      - Collision Diagram (if available)

4-4-2 Data Collection — April 2025

VEHICULAR/PEDESTRIAN VOLUMES

Vehicular traffic counts and pedestrian volumes **shall** include the periods of the average day when signal control is expected to provide the greatest benefit. The traffic counts **shall** be at least 8 hours in duration; however, 16-hour counts are recommended. The traffic counts **shall** contain the greatest percentage of 24-hour traffic and *should* include 15-minute counts during the A.M. and P.M. peak hour to determine the peak-hour factor (PHF). Typical hourly volume counts are collected from 6:00AM to 6:00PM, however, if volumes remain steady after 6:00PM, counts *should* continue until volumes decrease significantly.

When vehicular volume data is unobtainable during the time when signals *may* be warranted, vehicular volumes *may* be factored to represent peak periods. Traffic volume factors are different in various regions of the state. These factors (seasonal, monthly, daily, or hourly) *may* be available from WisDOT Planning Section in some cases. When volume factors are used, they must be supported and fully explained as to why they are being used in lieu of actual turning movement counts.

Vehicular volume counts **shall** be recorded for each traffic movement by approach. Vehicles *may* be classified by type: heavy trucks, passenger cars, and buses. Refer to Figure 2.1 for an example of the "Vehicle Volume Summary" form.

When pedestrian volumes are significant, the pedestrian volume counts on each crosswalk **shall** be recorded during the same periods as the vehicular volume counts or during hours of highest pedestrian volume. Bicyclists using pedestrian crosswalks *should* be counted as pedestrians and bicyclists using the roadway *should* be counted as vehicles.

A summary of the vehicle and/or pedestrian count information *should* be prepared, using the Department form DT 1902 which can be obtained by contacting the Regional traffic unit or an equivalent summary (i.e., volume counting software). This form and the actual counts summarized hourly *should* be submitted with the signal investigation study. In some cases, it *may* be necessary to break the hourly volumes down into 15-minute intervals, although this is not a requirement.

For proposed developments, projected traffic volumes can be used to determine whether signals *may* be warranted. Volume projection methods *should* be documented, including the trip generation rates and source. Projected traffic volumes *should* be added to existing traffic counts for the location if traffic exists. The analysis of projected traffic volumes must follow all criteria as stated in this manual. A traffic signal installed, based on projected volumes, *should* have a follow-up study completed at the time of expected build-out to determine if actual volumes meet warrants.

Figure 2.1. Vehicle Volume Summary Example

Intersection Traffic Volume Report

15-Minute Motor Vehicle Data

Count Basics		*Page 5 of 13*
Start Date: Thursday, January 10, 2019	Weekday	Schools in Session
Total Number of Hours Counted: 13	Non-Holiday	No Special Events

Schoenhaar Drive and STH 33 - Washington Street

All Motor Vehicles

15-Minute Motor Vehicle Data

	15-Minute Time Period	From North (↓) Schoenhaar Drive					From East (←) STH 33 - Washington Street					From South (↑)					From West (→) STH 33 - Washington Street					15-Min	Hourly	
	Start Time	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Totals	Sum	PHF
AM Peak Period	6:00 AM	5	0	5	0	10	2	66	0	0	68	0	0	0	0	0	0	64	7	0	71	149	870	0.78
	6:15 AM	7	0	5	0	12	10	101	0	0	111	0	0	0	0	0	0	76	3	0	79	202	974	0.87
	6:30 AM	7	0	8	0	15	2	130	0	0	132	0	0	0	0	0	0	87	6	0	93	240	1072	0.89
	6:45 AM	12	0	2	0	14	6	171	0	0	177	0	0	0	0	0	0	69	19	0	88	279	1175	0.86
	7:00 AM	11	0	4	0	15	3	108	0	0	111	0	0	0	0	0	0	111	16	0	127	253	1245	0.89
	7:15 AM	12	0	8	0	20	8	156	0	0	164	0	0	0	0	0	0	103	13	0	116	300	1254	0.90
	7:30 AM	18	0	0	0	18	9	199	0	0	208	0	0	0	0	0	0	110	7	0	117	343	1193	0.85
	7:45 AM	10	0	3	0	13	6	206	0	0	212	0	0	0	0	0	0	101	23	0	124	349	1035	0.74
	8:00 AM	15	0	2	0	17	4	126	0	0	130	0	0	0	0	0	0	102	13	0	115	262	897	0.86
	8:15 AM	9	0	3	0	12	3	127	0	0	130	0	0	0	0	0	0	78	19	0	97	239	809	0.85
	8:30 AM	10	0	1	0	11	3	89	0	0	92	0	0	0	0	0	0	68	14	0	82	185	741	0.88
	8:45 AM	10	0	3	0	13	6	105	0	0	111	0	0	0	0	0	0	74	13	0	87	211	744	0.88
	9:00 AM	7	0	1	0	8	3	95	0	0	98	0	0	0	0	0	0	59	9	0	68	174	748	0.87
	9:15 AM	9	0	1	0	10	7	85	0	0	92	0	0	0	0	0	0	59	10	0	69	171	772	0.90
	9:30 AM	15	0	3	0	18	1	74	0	0	75	0	0	0	0	0	0	85	10	0	95	188	795	0.92
	9:45 AM	12	0	7	0	19	2	112	0	0	114	0	0	0	0	0	0	67	15	0	82	215	801	0.93
Midday Peak Period	10:00 AM	14	0	0	0	14	4	87	0	0	91	0	0	0	0	0	0	81	12	0	93	198	772	0.97
	10:15 AM	16	0	1	0	17	2	85	0	0	87	0	0	0	0	0	0	83	7	0	90	194	763	0.98
	10:30 AM	10	0	2	0	12	3	85	0	0	88	0	0	0	0	0	0	88	6	0	94	194	772	0.95
	10:45 AM	4	0	2	0	6	1	98	0	0	99	0	0	0	0	0	0	74	7	0	81	186	796	0.91
	11:00 AM	6	0	2	0	8	4	78	0	0	82	0	0	0	0	0	0	91	8	0	99	189	810	0.93
	11:15 AM	10	0	3	0	13	4	100	0	0	104	0	0	0	0	0	0	78	8	0	86	203	890	0.83
	11:30 AM	5	0	1	0	6	4	88	0	0	92	0	0	0	0	0	0	110	10	0	120	218	937	0.87
	11:45 AM	8	0	3	0	11	3	86	0	0	89	0	0	0	0	0	0	85	15	0	100	200	959	0.89
	12:00 PM	37	0	4	0	41	5	104	0	0	109	0	0	0	0	0	0	107	12	0	119	269	984	0.91
	12:15 PM	13	0	7	0	20	5	97	0	0	102	0	0	0	0	0	0	101	27	0	128	250	909	0.91
	12:30 PM	9	0	2	0	11	3	107	0	0	110	0	0	0	0	0	0	105	14	0	119	240	897	0.93
	12:45 PM	23	0	4	0	27	6	94	0	0	100	0	0	0	0	0	0	86	12	0	98	225	903	0.92
	1:00 PM	7	0	4	0	11	9	79	0	0	88	0	0	0	0	0	0	78	17	0	95	194	910	0.92
	1:15 PM	13	0	1	0	14	2	101	0	0	103	0	0	0	0	0	0	108	13	0	121	238	973	0.95
	1:30 PM	14	0	4	0	18	3	86	0	0	89	0	0	0	0	0	0	123	16	0	139	246	984	0.96
	1:45 PM	14	0	3	0	17	6	90	0	0	96	0	0	0	0	0	0	108	10	1	119	232	1123	0.73
PM Peak Period	2:00 PM	16	0	3	0	19	2	96	0	0	98	0	0	0	0	0	0	125	15	0	140	257	1184	0.77
	2:15 PM	15	0	4	0	19	6	111	0	0	117	0	0	0	0	0	0	105	8	0	113	249	1224	0.79
	2:30 PM	30	0	5	0	35	6	138	0	0	144	0	0	0	0	0	0	183	23	0	206	385	1320	0.86
	2:45 PM	10	0	1	0	11	4	116	0	0	120	0	0	0	0	0	0	134	28	0	162	293	1296	0.90
	3:00 PM	25	0	4	0	29	4	115	0	0	119	0	0	0	0	0	0	123	26	0	149	297	1321	0.91
	3:15 PM	14	0	4	0	18	5	156	0	0	161	0	0	0	0	0	0	148	18	0	166	345	1393	0.94
	3:30 PM	33	0	5	0	38	10	117	0	0	127	0	0	0	0	0	0	176	20	0	196	361	1407	0.95
	3:45 PM	12	0	5	0	17	9	128	0	0	137	0	0	0	0	0	0	146	18	0	164	318	1455	0.89
	4:00 PM	17	0	8	0	25	5	124	0	0	129	0	0	0	0	0	0	192	23	0	215	369	1538	0.94
	4:15 PM	20	0	1	0	21	5	130	0	0	135	0	0	0	0	0	0	180	23	0	203	359	1603	0.92
	4:30 PM	27	0	6	0	33	6	150	0	0	156	0	0	0	0	0	0	188	32	0	220	409	1600	0.92
	4:45 PM	12	0	3	0	15	7	148	0	0	155	0	0	0	0	0	0	210	21	0	231	401	1518	0.87
	5:00 PM	23	0	4	0	27	14	155	0	0	169	0	0	0	0	0	0	219	19	0	238	434	1423	0.82
	5:15 PM	13	0	4	0	17	2	148	0	0	150	0	0	0	0	0	0	177	12	0	189	356	1277	0.90
	5:30 PM	19	0	10	0	29	5	133	0	0	138	0	0	0	0	0	0	143	17	0	160	327	1162	0.89
	5:45 PM	10	0	3	0	13	2	109	0	0	111	0	0	0	0	0	0	173	9	0	182	306	1027	0.84
	6:00 PM	5	0	2	0	7	1	120	0	0	121	0	0	0	0	0	0	142	18	0	160	288	881	0.76
	6:15 PM	11	0	7	0	18	4	107	0	0	111	0	0	0	0	0	0	99	13	0	112	241		
	6:30 PM	4	0	1	0	5	4	88	0	0	92	0	0	0	0	0	0	86	9	0	95	192		
	6:45 PM	6	0	0	0	6	1	57	0	0	58	0	0	0	0	0	0	83	13	0	96	160		
	7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	7:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	7:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	7:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	8:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	8:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	8:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	9:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	9:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	9:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Totals		694	0	179	0	873	241	5861	0	0	6102	0	0	0	0	0	0	5851	756	1	6608	13583		

Peak Hour All Vehicle Volume Summary

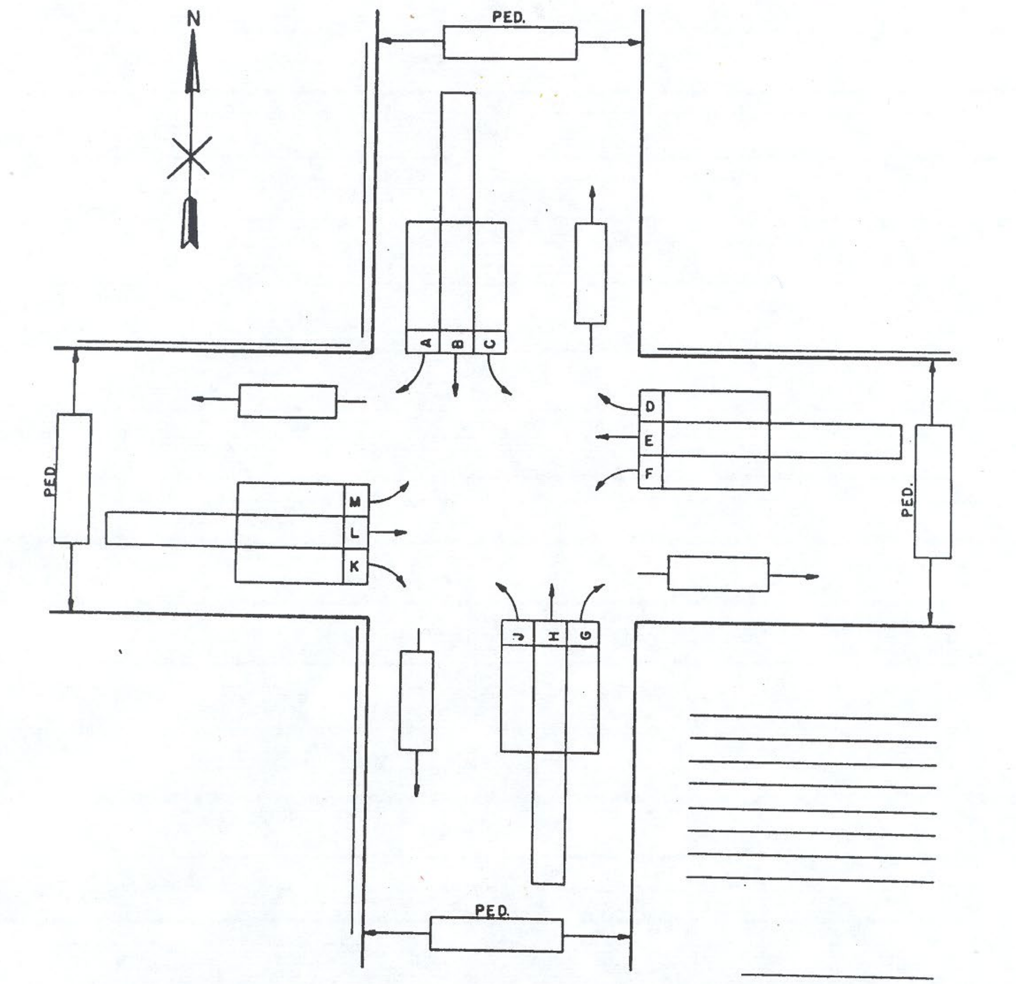
	Hourly Time Period	From North (↓) Schoenhaar Drive					From East (←) STH 33 - Washington Street					From South (↑)					From West (→) STH 33 - Washington Street					Total Hourly	
	Start Time	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Volume	PHF
AM	7:00 AM	51	0	15	0	66	26	669	0	0	695	0	0	0	0	0	0	425	59	0	484	1245	0.89
MD	12:00 PM	82	0	17	0	99	19	402	0	0	421	0	0	0	0	0	0	399	65	0	464	984	0.91
PM	4:30 PM	75	0	17	0	92	29	601	0	0	630	0	0	0	0	0	0	794	84	0	878	1600	0.92

Figure 2.2. Form DT1902

TRAFFIC SURVEY VEHICLE VOLUME COUNT
GRAPHIC SUMMARY SHEET
DT1902 2002 (Replaces ET704)

Wisconsin Department of Transportation

Date	Day	Time To	Sheet Of
District	County	Rural	City
Intersection		And	
Weather	Road Condition		Observers



CRASH RECORDS/ANALYSIS

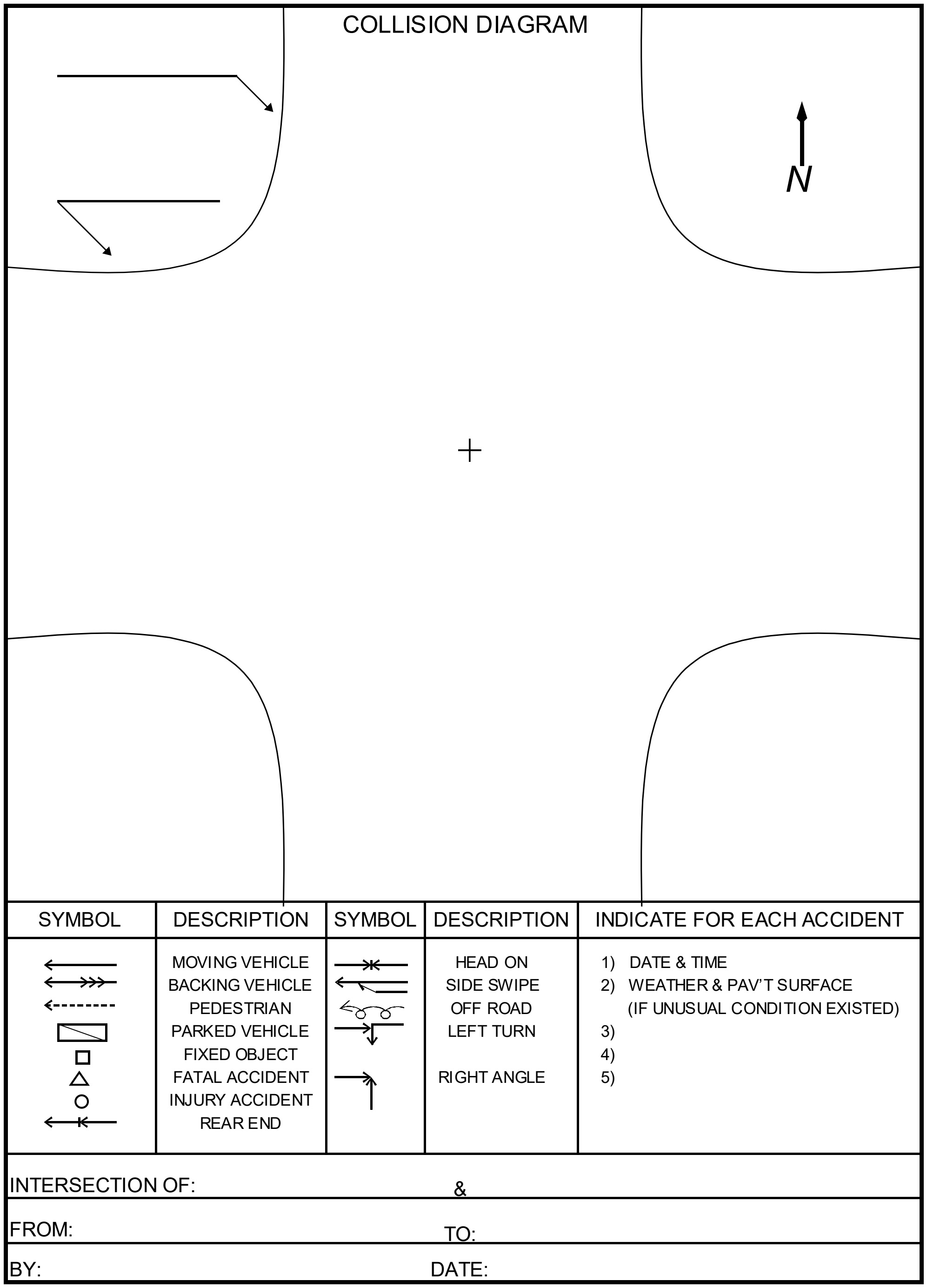
Crash reports provide an indication of relative intersection safety. Intersection crash history **shall** be reviewed for a minimum of a three-year period. To help determine trends, crash data *should* be summarized on a collision diagram or an as-built plan. Show crash experience by type, location, direction of movement, severity, pavement condition, time of day, date, and day of week.

To evaluate Warrant 7, Crash Experience, the most recent 12-month period **shall** be investigated prior to any other years. If the crashes at the intersection appear to form a pattern, these findings **shall** be documented in the Investigation Study.

Actual police crash reports *should* be reviewed to determine the driver's intention just prior to the crash. This is important in determining which crashes are susceptible to correction by a traffic signal.

Any improvements or changes to the intersection, which have been completed during or after the three-year period in which crashes are reported, **shall** be fully documented. It is important to note that a change *may* include "negative" improvements such as a driveway addition or new traffic generator. A comparison **shall** be made to the crashes before and after any such improvement or change to determine its effects.

Figure 2.3. Collision Diagram



INTERSECTION CHARACTERISTICS

Data collection *should* include the creation of an Intersection Geometric Condition Sketch. This *may* be developed by obtaining an as built plan of the intersection and verifying the intersection layout with a field investigation. Any differences *should* be shown in the Intersection Geometric Condition Sketch. The Condition Sketch *should* show geometry, access point locations, nearest intersections, lane configurations, channelization, parking conditions, sight-distance restrictions, etc.

If aerial imaging is used, lane geometry **shall** be clearly visible.

The geometrics of the intersection **shall** be fully described in the Signal Investigation Study.

4-4-3 Traffic Signal Warrants April 2025

STANDARD INVESTIGATION PRACTICES

The analysis of intersection data **shall** proceed in the order indicated below unless intersection characteristics predicate specific warrant analysis. This order permits the most commonly used warrants to be evaluated first and the more difficult, data intensive (staff time and cost) warrants last, and only if added justification is needed or no other warrants are met. The Department has prepared Warrant worksheets for both urban and rural conditions. These worksheets are based upon the guidance provided in WMUTCD Section 4C and **shall** be utilized to determine whether existing/future intersection characteristics satisfy the warrants outlined in this text.

1. The traffic volumes **shall** be evaluated against the requirements for Warrant 1, (Conditions A, B and C), and Warrant 2.
2. The traffic volumes *may* be evaluated against the requirements for Warrant 3. Meeting Warrant 3 alone is not justification for the installation of a traffic signal. At least one additional warrant *should* also be met.
3. The crash history for the intersection(s) covering at least the past 3 years *should* be used to determine any trends. Any 12-month period (not a 3-year average) is evaluated against the requirements for Warrant 7. Only crash types susceptible to correction by a traffic signal **shall** be included in the Warrant 7 evaluation.
4. The existing and/or projected pedestrian volumes **shall** be evaluated for Warrant 4.
5. If an established school crossing is being investigated, Warrant 5 **shall** be evaluated.
6. The existing intersection characteristics and traffic volumes **shall** be evaluated against the requirements for Warrants 6 and 8. These warrants are used when it is necessary to properly control arterial or system flow. Warrant 6, Coordinated Signal System, is based upon the speed-distance relationship with adjacent signals. Warrant 7, Roadway Network, is used to complete networks on major routes.
7. If traffic signal warrants are expected to be met within 5 years of the completion of an improvement project, signals *may* be installed as a part of the project at the location being analyzed.
8. For T-intersections being analyzed for signals, side street traffic volume warrant thresholds *may* be inflated to 150 percent of the values indicated in the WMUTCD to reflect the lack of turning movements associated with a typical full access intersection, at the discretion of the Region Traffic Engineer.

If new signals are proposed at an intersection that will be reconstructed as part of an improvement project, a signal warrant analysis **shall** be completed using the proposed intersection geometrics.

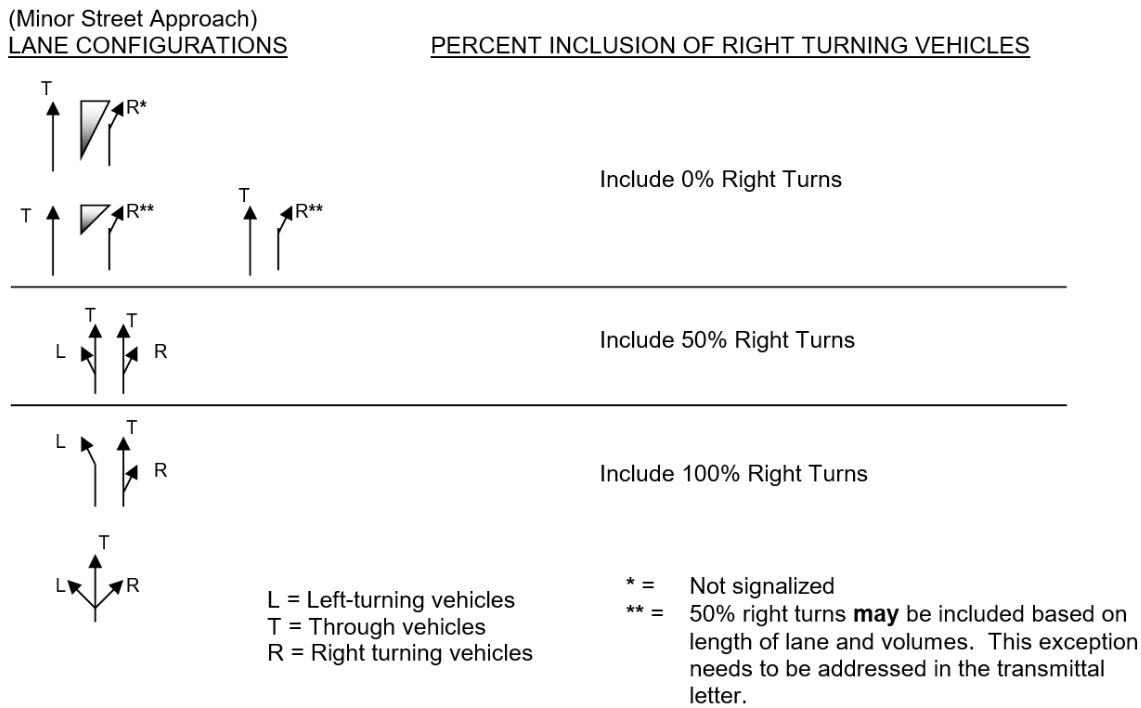
Guidelines for traffic signal warrants based on average daily traffic (ADT) can be found in the FDM 11-50-50, Tables 50.1 & 50.2. These *should not* be used as a justification for signals but rather *should* be used as a preliminary tool in determining if a site investigation study is needed.

RIGHT-TURN INCLUSIONS

Before evaluating traffic volumes against warrant criteria, inclusions of right turn vehicles **shall** be considered. The number of right turn vehicles included in the intersection analysis plays an important role in the overall operation of the intersection. The traffic control for the right turning vehicles *should* be known prior to determining the percentage of inclusion. The Department uses three right turn inclusion percentages based on the impact of the right turns on operation of the intersection. Figure 3.4 shows lane configurations and the corresponding percentages. These percentages *should* be applied to the minor street volumes in accordance with the WMUTCD 4C-1.

All mainline right turn traffic **shall** be included in the evaluation, unless there are unusual conditions, such as the subject mainline right turn lane being drastically displaced from the intersection. Provide justification for adjustments due to unusual conditions.

Figure 3.4. Right Turn Inclusion Percentages



4-4-4 Documentation — April 2025

The following study has been prepared as a sample for this manual.

- Sample cover letter (Consultant to Region)
- Sample memorandum (Region to Central Office)
- Sample Investigation Study
  - DT1199 Traffic Control Signal Approval Request
  - Report Outline
    - a. Reason/Need for Study
    - b. Existing Physical Conditions and Control Devices
    - c. Traffic Conditions
    - d. Crash History
    - e. Warrants Met
  - Appendix
    - Site Map
    - Hourly Traffic Volume Counts
    - Vehicle Volume Count Graphic Summary Sheet
    - Warrant Analysis Worksheets
    - Intersection Plan Sheet (Intersection Geometric Condition Sketch)
    - Signalized Intersection Capacity Analysis
    - Crash Record Extract
    - Collision Diagram (If Available)

SAMPLE COVER LETTER
(CONSULTANT TO REGION)

Date

(Region Office)

Re: Signal Investigation Study
S.T.H. XX and C.T.H. YY
Town of Somewhere
Here County

Dear XXXXXX:

Attached for your review and approval is a signal investigation study for the intersection of S.T.H. XX and C.T.H. YY. The proposed installation is requested due to an increase in traffic, accidents, and congestion. In addition, there have been several requests from area residents to consider a traffic signal at this location.

In the fall of 1993 acceleration and deceleration tapers were installed on STH XX. This was an interim improvement prior to a signal being installed.

Traffic signal warrants 1, 2, 3 and 7 as stated in the *Wisconsin Manual on Uniform Traffic Control Devices (WMUTCD)*, are satisfied for the required number of hours for this location.

A signal capacity analysis was performed based on common signal phasing and timing parameters, existing turning movement counts, and current intersection geometrics. Results of the analysis (included in the appendix) have determined that the intersection will operate with acceptable levels-of-service, and the expected queues will not exceed intersection storage currently provided or planned for.

We recommend approval of this installation.

Sincerely,
Private Consultant

SAMPLE MEMORANDUM

(REGION TO BUREAU OF HIGHWAY OPERATIONS)

Date:

To: (State Traffic Signal Engineer)

From: (Regional Traffic Engineer)

Subject: Signal Investigation Study
Project ID (number)
S.T.H. XX and C.T.H. YY
Town of Somewhere
Here County

Attached for your review and approval is a signal investigation study for the intersection of S.T.H. XX and C.T.H. YY. The proposed installation is requested due to an increase in traffic, accidents, and congestion. In addition, there have been several requests from area residents to consider a traffic signal at this location.

In the fall of 1993 acceleration and deceleration tapers were installed on STH XX. This was an interim improvement prior to a signal being installed. Additional lane capacity with existing control is not possible due to local conditions, therefore a traffic signal is justified.

Traffic signal warrants 1, 2, 3, and 7, as stated in the (WMUTCD), are satisfied for the required number of hours for this location.

A signal capacity analysis was performed based on common signal phasing and timing parameters, existing turning movement counts, and current intersection geometrics. Results of the analysis (included in the appendix) have determined that expected queues will not exceed intersection storage currently provided, and the level of service for each movement will be satisfactory. Based on the analysis, left turn phasing will not need to be provided at this time.

Contracted forces will complete aboveground and underground work. Operations and maintenance of the installation will be at the expense of the Department.

The total estimated cost is $__, ___. __.

The project will be funded through (state funding source(s)).

We recommend approval of this installation.

Figure 4.5. DT 1199 Traffic Control Signal Approval Request

TRAFFIC CONTROL SIGNAL APPROVAL REQUEST
DT1199 8/2012 s.86.32(1) Wis. Stats.

Wisconsin Department of Transportation

Municipality	County
State Trunk Highway	Intersecting Road

☐ Check if connecting highway – Requires authorized municipal and departmental approval below. Approval of installation on the connecting highway system is required under s.86.32(1) Wis. Stats.

The Region requests approval of a traffic control signal at the location indicated above. Traffic volumes, crash experience and physical conditions at the described intersection have been reviewed. A traffic control signal is justified.

Approval Recommended ______________________________
(Regional Traffic Engineer) (Date)

Approval Granted ______________________________
(Bureau of Traffic Operations) (Date)

TRAFFIC CONTROL SIGNAL INSTALLATION, OPERATION AND MAINTENANCE AGREEMENT

The municipality identified above agrees to install, operate and maintain a traffic control signal at the specified intersection for the purpose of controlling the flow of traffic.

The following conditions precedent to approval of the signal are acknowledged and accepted by the municipality:

1. The design, installation and operation of the signal will comply with the Wisconsin Manual on Uniform Traffic Control Devices.
2. The cost of maintenance and operation of the signal will be the responsibility of the municipality or in any case will not be an obligation of the Wisconsin Department of Transportation.
3. Parking will be restricted by the municipality at locations on the identified intersecting streets in accordance with the need to provide adequate capacity and normal flow of traffic. Specific restrictions, if needed, are as follows:
4. The municipality, with the approval or at the request of the Department of Transportation, and at the municipality's expense, shall make such adjustments in the equipment and manner of operation of these signals as are deemed necessary for public safety and facilitation of traffic movement.

☐ Yes ☐ No Further provisions are stated on the back of this document.
☐ Yes ☐ No Attachments

Agreed on behalf of the Municipality

X ______________________________
(Signature of Authorized Representative for Municipality) (Date)

Agreed on behalf of the Department

X ______________________________
(Signature of Bureau of Traffic Operations) (Date)

SIGNAL INVESTIGATION STUDY
MAIN LINE (STH XX) & SIDE ROAD (CTH YY) INTERSECTION

a. REASON/NEED FOR STUDY

The traffic volume in this area has tended to increase rapidly over the last few years. In addition, we have received numerous requests (letters attached), mostly from area residents, to consider the installation of a traffic control signal at the intersection of STH XX and CTH YY. Accidents and congestion are increasing along with the increase in area development and traffic.

b. EXISTING PHYSICAL CONDITIONS AND CONTROL DEVICES

Each of these roadways is a two-lane road with 10-foot shoulders on STH XX and a minimal of 2 to 4-foot shoulders on the CTH YY. The Main Line (STH XX) has 150-ft left-turn bays at the intersection. STH XX has a 55-mph speed limit while CTH YY has 35 mph limits on each side of the intersection. Existing traffic control at the intersection consists of two-way STOP control for CTH YY. New acceleration and deceleration tapers were installed September of 2002 on STH XX as an interim operational improvement prior to a signal being installed. Additional lane capacity is not possible due to local conditions; therefore, congestion cannot be reduced on CTH YY if the Stop Signs remain.

c. TRAFFIC CONDITIONS

A 16-hour manual traffic count was conducted at this intersection on Tuesday, October 21, 2003 and Wednesday, October 22, 2003. The results of this traffic count are summarized in Figure 1 and included in the Appendix along with the actual count data.

d. CRASH HISTORY

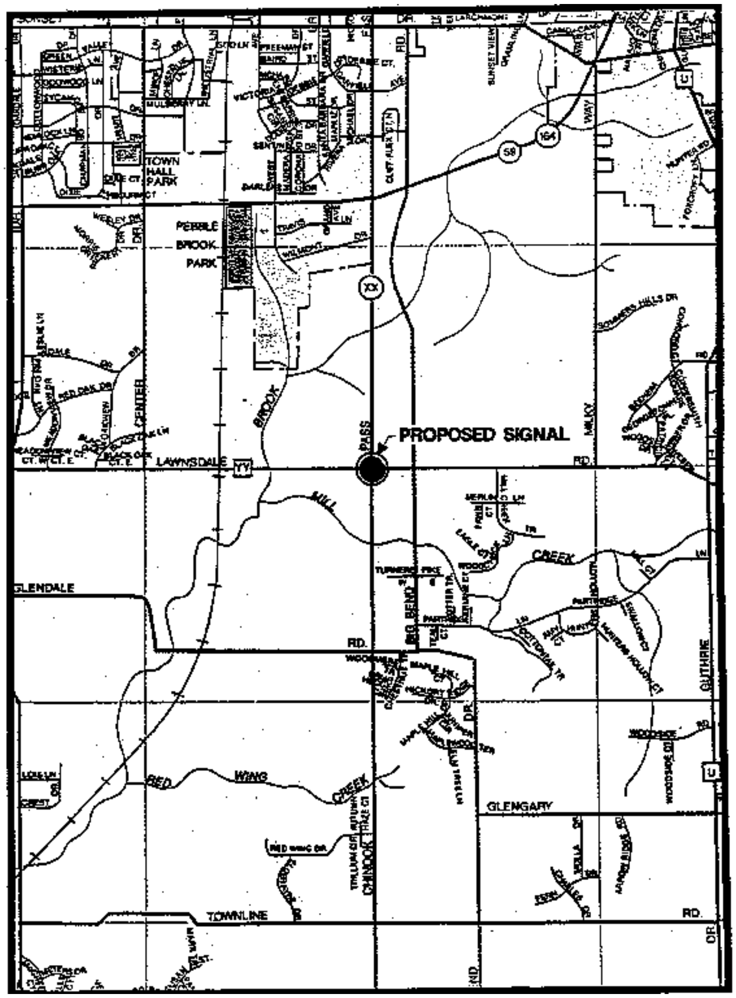
The crash history shows an increase in crashes and a minimum of 5 crashes in a 12-month period which are correctable by installation of a traffic control signal. There was one fatality crash at the intersection.

e. WARRANT MET

The following signal warrants are met and are summarized on the Warrant sheets:

Warrant #1 – Eight-Hour Vehicular Volume	
Condition A - Minimum Vehicular Traffic:	8 hours
Condition B - Interruption of Continuous Traffic:	14 hours
Condition C - Combination of Warrants:	9 hours
Warrant #2 - Four Hour Warrants:	9 hours
Warrant #3 - Peak Hour Warrant:	7 hours
Warrant #7 - Accident Experience:	8 hours

SITE MAP EXAMPLE



TRAFFIC VOLUME REPORT EXAMPLE

Intersection Traffic Volume Report

Count Basics		Version 2011.M3	Page 1 of 13
Start Date:	Wednesday, March 10, 2021	Weekday	Schools in Session
Total Number of Hours Counted: 13		Non-Holiday	No Special Events

Base Information, Observed (13) Hour and Estimated (24) Hour Volume Summaries

Intersection of: STH 164 & Lindsay Road

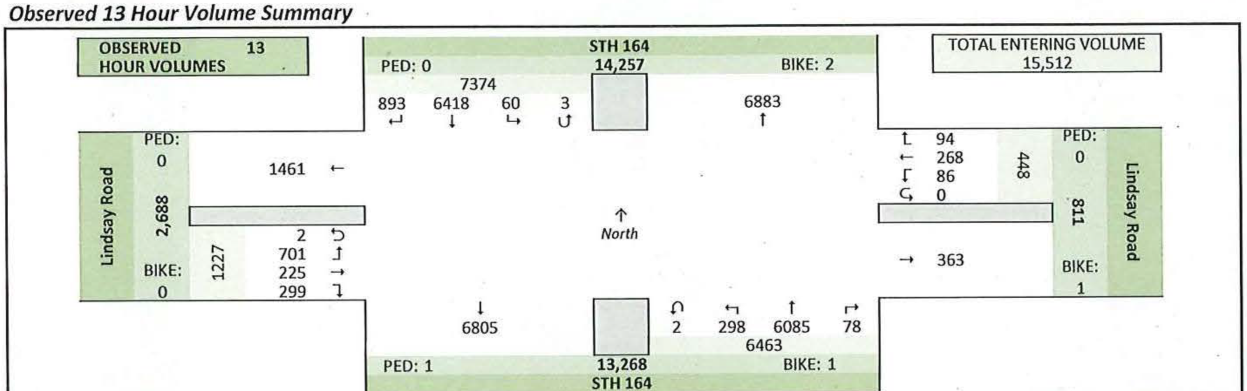
Site Information

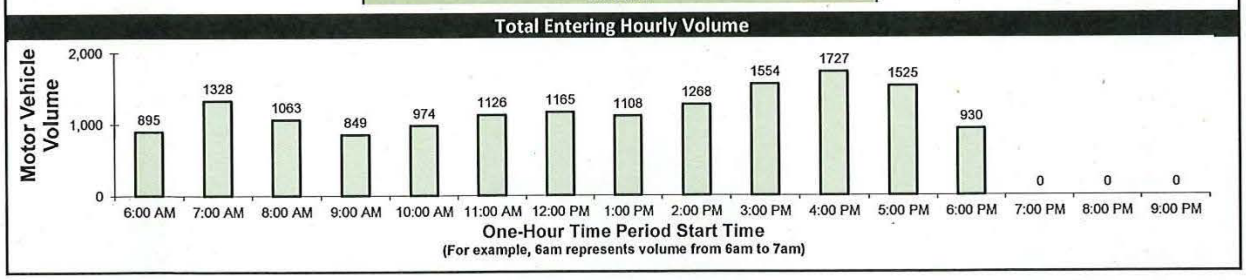
Municipality	Village of Pewaukee		
County	Waukesha	WisDOT Region	SE
Traffic Control	Partial Stop Control		
Roadway Names		North Direction	↑
North Leg	STH 164		
East Leg	Lindsay Road		
South Leg	STH 164		
West Leg	Lindsay Road		
Special Considerations			
Schools	In Session		
Holidays	None		
Special Events	None		
Special Pedestrians Observed			
Pre-school children	None		
Elementry school age children	None		
Visually impaired (white cane/helper dog)	None		
Elderly/disabled (except wheelchairs)	None		
Wheelchairs/electric scooters	None		
Other (describe)	None	None	

Count Information

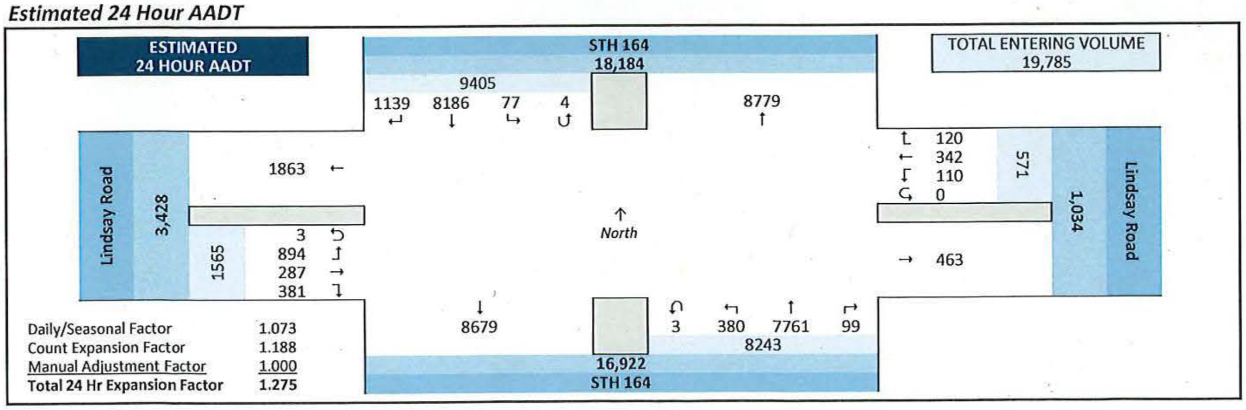
Hrs Counted:	6:00 AM-7:00 PM		
1st Day of Count	Wednesday, March 10, 2021	Weather	
AM Peak Period	Wednesday, March 10, 2021	Clear & Dry	
Midday Peak Period	Wednesday, March 10, 2021	Clear & Dry	
PM Peak Period	Wednesday, March 10, 2021	Clear & Dry	
Calculated Peak Hours			
AM 7:00-8:00am	MD 11:30-12:30am	PM 4:15-5:15pm	
Peak Hours Selected for Analysis			
AM 7:00-8:00am	MD 11:30-12:30am	PM 4:15-5:15pm	
Daily/Seasonal Adjustment Group	(4) Rural Arterials & Collectors		
Count Expansion Group	(4) Rural Arterials & Collectors		
Daily/Seasonal Adjustment Factor	1.073	Count Expansion Factor	1.188
Company Name	TranSmart, Inc.	Manual Adj.	1.000
Observers	AM Peak Period	Miovision Video Recording	
	Midday Peak Period	Miovision Video Recording	
	PM Peak Period	Miovision Video Recording	
Comments	2019 DOT Seasonal Factors		

Observed 13 Hour Volume Summary





Estimated 24 Hour AADT



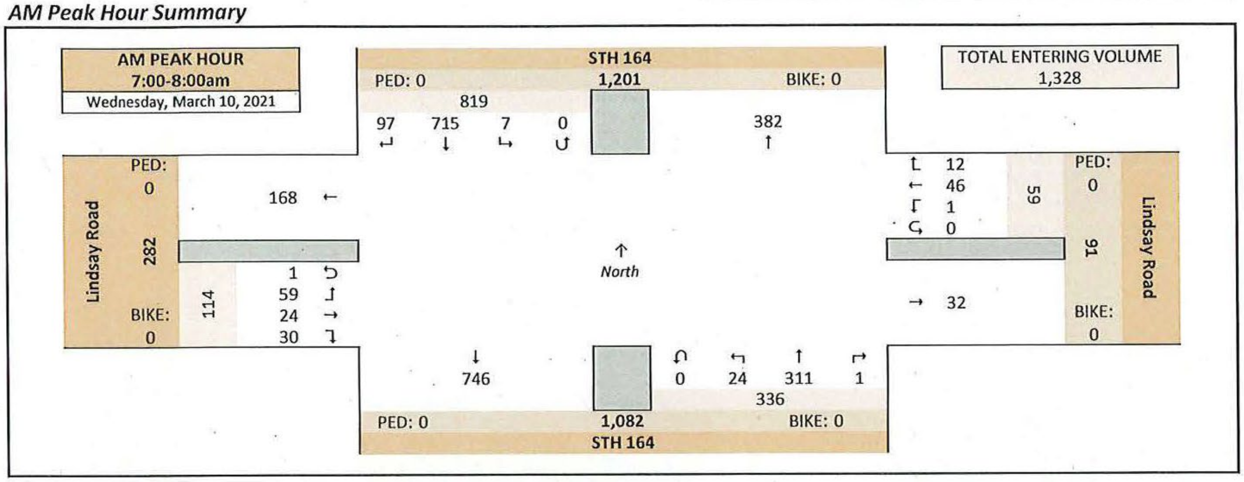
Intersection Traffic Volume Report

Count Basics			Page 2 of 13
Start Date:	Wednesday, March 10, 2021	Weekday	Schools in Session
Total Number of Hours Counted: 13		Non-Holiday	No Special Events

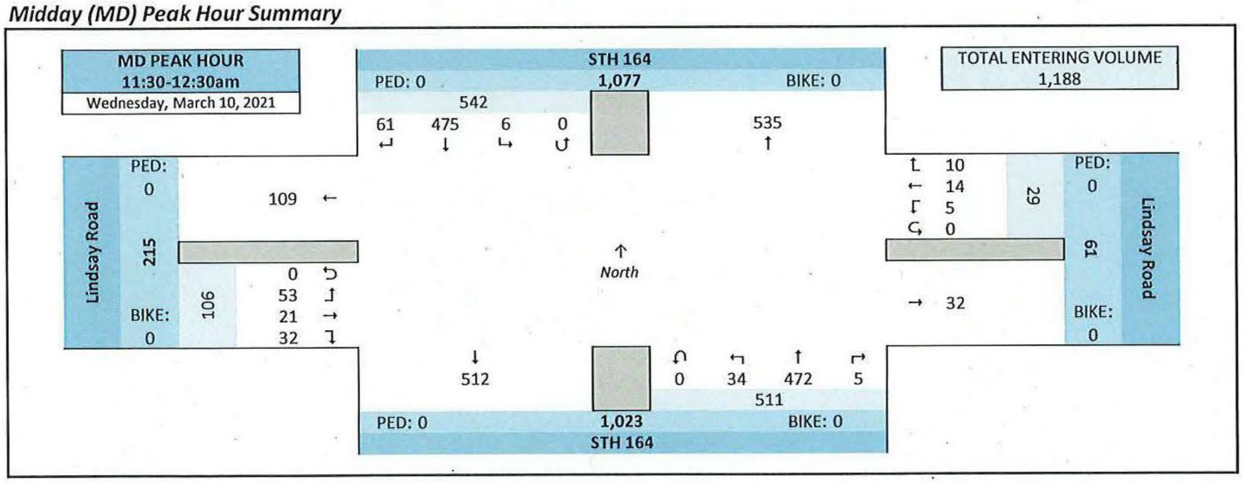
Peak Hour Volume Graphical Summary

STH 164 & Lindsay Road

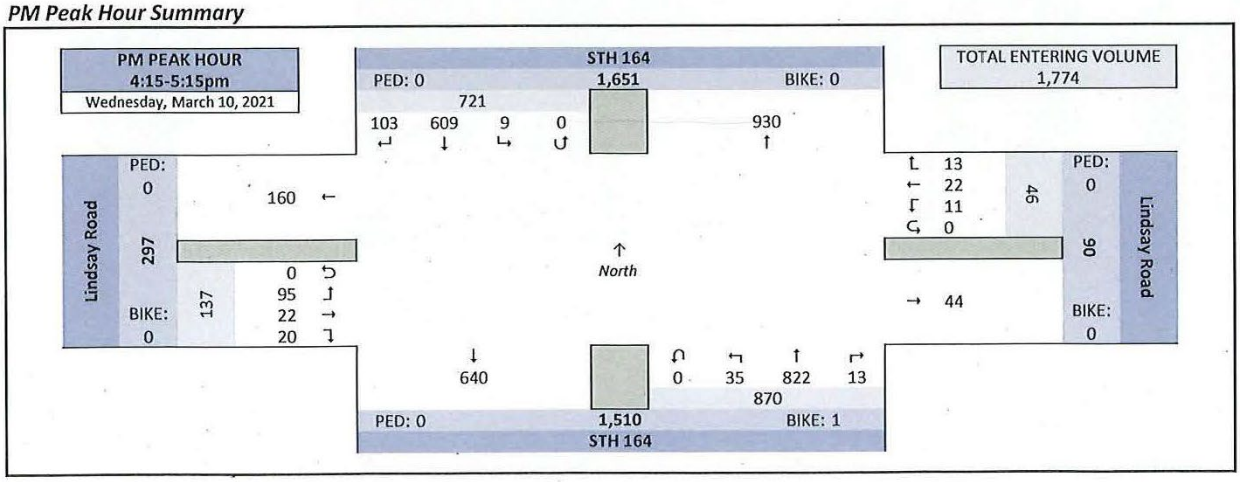
AM Peak Hour Summary



Midday (MD) Peak Hour Summary



PM Peak Hour Summary



Intersection Traffic Volume Report

Count Basics			Page 5 of 13
Start Date:	Wednesday, March 10, 2021	Weekday	Schools in Session
Total Number of Hours Counted: 13		Non-Holiday	No Special Events

15-Minute Motor Vehicle Data

STH 164 & Lindsay Road

All Motor Vehicles

15-Minute Motor Vehicle Data

15-Minute Time Period		From North STH 164					From East Lindsay Road					From South STH 164					From West Lindsay Road					15-Min	Hourly	
	Start Time	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Totals	Sum	PHF
AM Peak Period	6:00 AM	8	76	1	0	85	1	0	0	0	1	0	26	0	0	26	1	5	7	0	13	125	895	0.78
	6:15 AM	8	97	0	0	105	2	2	1	0	5	0	67	1	0	68	0	1	20	0	21	199	1071	0.89
	6:30 AM	16	175	3	0	194	5	1	0	0	6	1	72	1	0	74	5	1	6	0	12	286	1195	0.92
	6:45 AM	29	153	0	0	182	4	10	1	0	15	0	64	4	0	68	5	1	14	0	20	285	1298	0.83
	7:00 AM	20	144	0	0	164	0	10	1	0	11	0	95	3	0	98	4	7	16	1	28	301	1328	0.85
	7:15 AM	30	168	1	0	199	4	9	0	0	13	0	75	4	0	79	8	9	15	0	32	323	1314	0.84
	7:30 AM	25	222	3	0	250	5	17	0	0	22	0	82	10	0	92	4	6	15	0	25	389	1259	0.81
	7:45 AM	22	181	3	0	206	3	10	0	0	13	1	59	7	0	67	14	2	13	0	29	315	1126	0.89
	8:00 AM	26	146	1	1	174	0	4	1	0	5	0	80	6	0	86	5	6	11	0	22	287	1063	0.93
	8:15 AM	19	144	0	0	163	1	5	2	0	8	0	70	1	0	71	8	1	17	0	26	268	976	0.91
	8:30 AM	17	121	0	0	138	0	4	4	0	8	2	89	2	0	93	3	2	12	0	17	256	917	0.90
	8:45 AM	15	129	0	0	144	0	6	0	0	6	0	73	2	0	75	12	5	10	0	27	252	880	0.87
	9:00 AM	14	87	1	0	102	1	4	1	0	6	0	72	1	0	73	5	1	13	0	19	200	849	0.96
	9:15 AM	16	89	1	0	106	1	6	2	0	9	1	81	3	0	85	3	2	4	0	9	209	868	0.98
	9:30 AM	4	111	0	0	115	3	5	2	0	10	2	76	4	0	82	2	6	4	0	12	219	885	0.98
	9:45 AM	11	99	2	0	112	2	1	3	0	6	4	81	3	0	88	5	1	9	0	15	221	937	0.86
Midday Peak Period	10:00 AM	8	121	0	0	129	1	0	3	0	4	2	62	5	0	69	4	2	11	0	17	219	974	0.90
	10:15 AM	12	109	0	0	121	0	2	1	0	3	1	84	4	0	89	4	1	8	0	13	226	1025	0.95
	10:30 AM	9	122	2	0	133	2	8	3	0	13	2	96	3	0	101	8	4	12	0	24	271	1060	0.98
	10:45 AM	13	107	0	0	120	0	3	5	0	8	2	97	4	1	104	7	4	15	0	26	258	1078	0.93
	11:00 AM	11	127	0	0	138	2	2	1	0	5	2	98	7	0	107	4	2	14	0	20	270	1126	0.92
	11:15 AM	16	96	0	0	112	1	4	0	0	5	1	114	5	0	120	4	4	16	0	24	261	1161	0.95
	11:30 AM	25	125	1	0	151	1	4	1	0	6	2	100	5	0	107	8	5	12	0	25	289	1188	0.97
	11:45 AM	11	114	2	0	127	6	3	2	0	11	0	127	5	0	132	14	6	16	0	36	306	1168	0.95
	12:00 PM	16	124	1	0	141	1	2	1	0	4	3	122	13	0	138	6	5	11	0	22	305	1165	0.95
	12:15 PM	9	112	2	0	123	2	5	1	0	8	0	123	11	0	134	4	5	14	0	23	288	1141	0.94
	12:30 PM	13	107	1	0	121	2	5	5	0	12	0	114	4	0	118	5	1	12	0	18	269	1122	0.93
	12:45 PM	14	129	1	0	144	1	3	0	0	4	1	124	4	0	129	8	3	15	0	26	303	1118	0.92
	1:00 PM	11	118	1	0	130	1	3	1	0	5	3	115	4	0	122	9	3	12	0	24	281	1108	0.95
	1:15 PM	17	108	0	0	125	2	2	4	0	8	1	114	6	1	122	2	5	7	0	14	269	1117	0.95
	1:30 PM	22	119	1	0	142	1	4	0	0	5	0	96	3	0	99	6	3	10	0	19	265	1164	0.92
	1:45 PM	12	110	0	0	122	2	6	2	0	10	2	122	7	0	131	7	6	17	0	30	293	1209	0.96
PM Peak Period	2:00 PM	12	134	1	0	147	1	3	1	0	5	2	115	4	0	121	7	1	9	0	17	290	1268	0.90
	2:15 PM	13	107	2	0	122	2	6	1	0	9	1	147	11	0	159	7	5	14	0	26	316	1361	0.89
	2:30 PM	16	119	2	0	137	2	7	1	0	10	2	118	9	0	129	7	14	13	0	34	310	1412	0.92
	2:45 PM	25	106	0	0	131	0	11	0	0	11	1	179	11	0	191	4	3	12	0	19	352	1525	0.90
	3:00 PM	22	120	3	0	145	1	12	1	0	14	2	184	11	0	197	4	7	16	0	27	383	1554	0.92
	3:15 PM	7	126	0	1	134	1	4	3	0	8	3	181	10	0	194	7	4	20	0	31	367	1566	0.93
	3:30 PM	22	158	1	0	181	2	5	1	0	8	3	190	6	0	199	11	6	17	1	35	423	1626	0.95
	3:45 PM	26	130	2	0	158	2	7	4	0	13	2	171	5	0	178	5	9	18	0	32	381	1647	0.93
	4:00 PM	31	135	3	0	169	1	5	3	0	9	2	173	11	0	186	7	8	16	0	31	395	1727	0.94
	4:15 PM	26	141	0	0	167	5	3	1	0	9	2	206	7	0	215	2	7	27	0	36	427	1774	0.96
	4:30 PM	27	161	3	0	191	1	8	4	0	13	2	193	4	0	199	7	4	30	0	41	444	1746	0.95
	4:45 PM	26	142	3	0	171	6	6	3	0	15	6	224	9	0	239	7	7	22	0	36	461	1698	0.92
	5:00 PM	24	165	3	0	192	1	5	3	0	9	3	199	15	0	217	4	4	16	0	24	442	1525	0.86
	5:15 PM	28	130	3	1	162	4	6	1	0	11	2	192	9	0	203	6	4	13	0	23	399	1370	0.86
	5:30 PM	27	124	0	0	151	1	9	1	0	11	0	195	8	0	203	9	6	16	0	31	396	1231	0.78
	5:45 PM	18	112	0	0	130	1	7	2	0	10	2	120	8	0	130	2	5	11	0	18	288	1034	0.90
	6:00 PM	18	110	3	0	131	2	5	2	0	9	2	121	3	0	126	5	5	11	0	21	287	930	0.81
	6:15 PM	10	97	1	0	108	1	6	3	0	10	2	113	5	0	120	3	6	13	0	22	260		
	6:30 PM	5	55	1	0	61	3	3	3	0	9	3	98	6	0	107	8	2	12	0	22	199		
	6:45 PM	11	56	1	0	68	0	0	0	0	0	3	96	4	0	103	3	3	7	0	13	184		
	7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	7:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	7:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	7:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	8:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	8:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	8:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	9:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	9:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	9:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Totals		893	6418	60	3	7374	94	268	86	0	448	78	6085	298	2	6463	299	225	701	2	1227	15512		

Peak Hour All Vehicle Volume Summary

Hourly Time Period		From North STH 164					From East Lindsay Road					From South STH 164					From West Lindsay Road					Total Hourly	
	Start Time	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Volume	PHF
AM	7:00 AM	97	715	7	0	819	12	46	1	0	59	1	311	24	0	336	30	24	59	1	114	1328	0.85
MD	11:30 AM	61	475	6	0	542	10	14	5	0	29	5	472	34	0	511	32	21	53	0	106	1188	0.97
PM	4:15 PM	103	609	9	0	721	13	22	11	0	46	13	822	35	0	870	20	22	95	0	137	1774	0.96

Intersection Traffic Volume Report

Count Basics			*Page 4 of 13*
Start Date:	Wednesday, March 10, 2021	Weekday	Schools in Session
Total Number of Hours Counted: 13		Non-Holiday	No Special Events

Hourly Volume Summary - Motor Vehicle Data

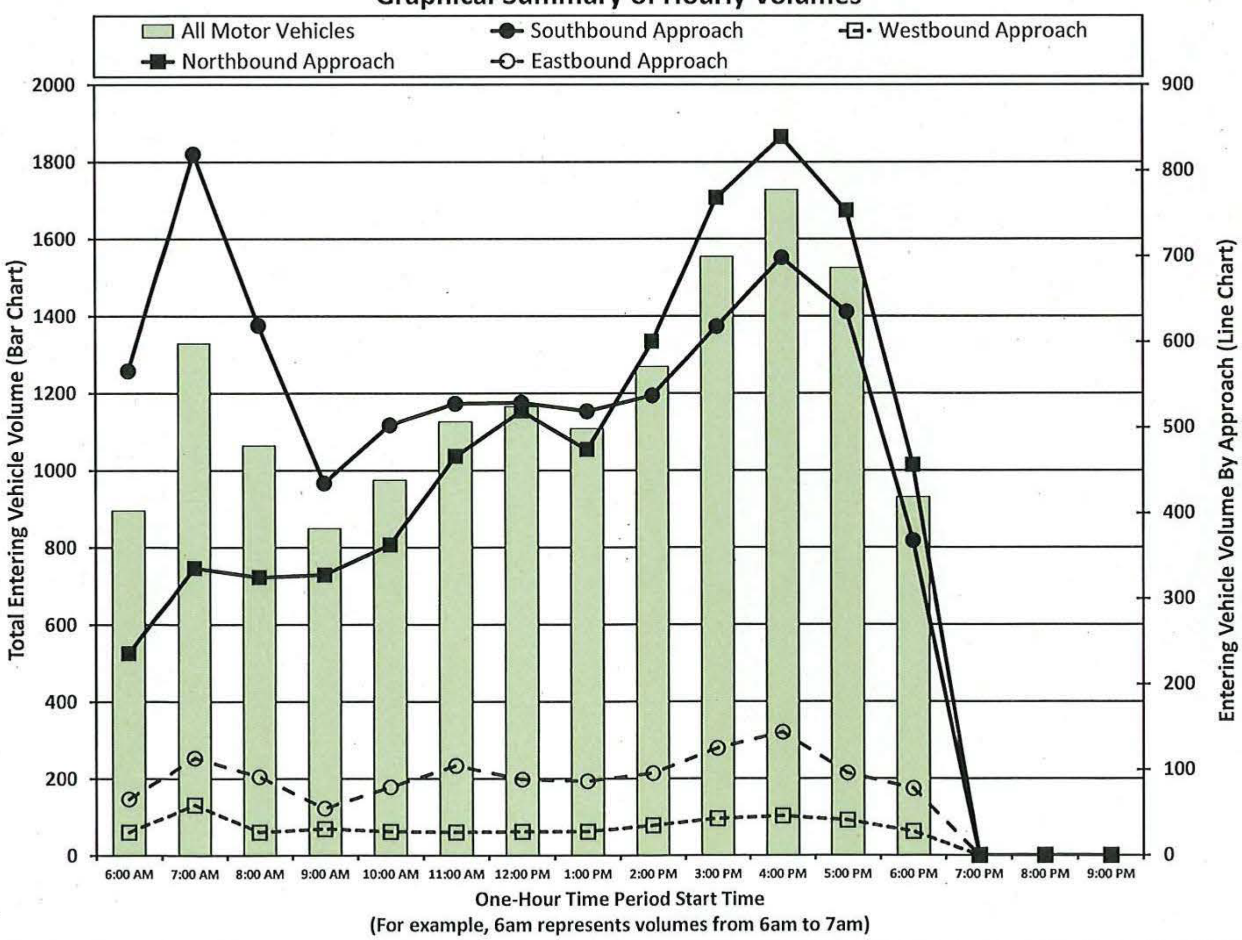
All Motor Vehicles

STH 164 & Lindsay Road

One-Hour Motor Vehicle Data

One-Hour Time Period Start Time		From North (↓) STH 164					From East (←) Lindsay Road					From South (↑) STH 164					From West (→) Lindsay Road					Total Vehicle Volume	Directional Volume Totals	
		Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total	Right	Thru	Left	U-Tn	Total		E/W	N/S
AM	6:00 AM	61	501	4	0	566	12	13	2	0	27	1	229	6	0	236	11	8	47	0	66	895	93	802
	7:00 AM	97	715	7	0	819	12	46	1	0	59	1	311	24	0	336	30	24	59	1	114	1328	173	1155
	8:00 AM	77	540	1	1	619	1	19	7	0	27	2	312	11	0	325	28	14	50	0	92	1063	119	944
	9:00 AM	45	386	4	0	435	7	16	8	0	31	7	310	11	0	328	15	10	30	0	55	849	86	763
MD	10:00 AM	42	459	2	0	503	3	13	12	0	28	7	339	16	1	363	23	11	46	0	80	974	108	866
	11:00 AM	63	462	3	0	528	10	13	4	0	27	5	439	22	0	466	30	17	58	0	105	1126	132	994
	12:00 PM	52	472	5	0	529	6	15	7	0	28	4	483	32	0	519	23	14	52	0	89	1165	117	1048
	1:00 PM	62	455	2	0	519	6	15	7	0	28	6	447	20	1	474	24	17	46	0	87	1108	115	993
PM	2:00 PM	66	466	5	0	537	5	27	3	0	35	6	559	35	0	600	25	23	48	0	96	1268	131	1137
	3:00 PM	77	534	6	1	618	6	28	9	0	43	10	726	32	0	768	27	26	71	1	125	1554	168	1386
	4:00 PM	110	579	9	0	698	13	22	11	0	46	12	796	31	0	839	23	26	95	0	144	1727	190	1537
	5:00 PM	97	531	6	1	635	7	27	7	0	41	7	706	40	0	753	21	19	56	0	96	1525	137	1388
	6:00 PM	44	318	6	0	368	6	14	8	0	28	10	428	18	0	456	19	16	43	0	78	930	106	824
	7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals		893	6418	60	3	7374	94	268	86	0	448	78	6085	298	2	6463	299	225	701	2	1227	15512	1675	13837

Graphical Summary of Hourly Volumes



WARRANT ANALYSIS WORKSHEETS

Wisconsin Department of Transportation Traffic Signal Warrant Summary Worksheet

100%

The Worksheet(s) attached are provided as an attachment to the Engineering Investigation Study for:

Intersection:
County:
Select one:

Major Street:		Minor Street:	
Critical Approach Speed:	mph	Critical Approach Speed:	mph
Lanes:		Lanes:	

% Right Turns Included
From North (SB) 0%
From East (WB) 0%
From South (NB) 0%
From West (EB) 0%

In built-up area of isolated community of < 10,000 population?
Total number of approaches at intersection?
If it is a "T" intersection, inflate minor threshold to 150%?
Manually set volume level?

Analysis based on **volume data.**

		Time (HH:MM)			
		From	AM / PM	To	AM / PM

Warrant Evaluation Summary	Warrant Met:
Warrant 1: Eight - Hour Vehicular Volume	**N/A**
Condition A: Minimum Vehicular Volume	
Condition B: Interruption of Continuous Traffic	
Condition C: Combination: 80% of A and B	
Warrant 2: Four-Hour Volume	**N/A**
Warrant 3: Peak Hour Volume	**N/A**
Warrant 4: Pedestrian Volume	**N/A**
Criterion A: Four-Hour	
Criterion B: Peak-Hour	
Warrant 5: School Crossing	**N/A**
Warrant 6: Coordinated Signal System	**N/A**
Warrant 7: Crash Experience	**N/A**
Warrant 8: Roadway Network	**N/A**
Warrant 9: Intersection Near a Grade Crossing	**N/A**

Warrant Analysis Conducted By:
Name:
Agency:
Date:

1

Warrant 1: Eight - Hour Vehicular Volume 100%

Warrant Evaluated? **Warrant Satisfied? N/A** **Manually Set To:**

Condition A :		
Min. Veh. Volume		
Volume Level	100%	80%
Major Rd. Req		
Minor Rd. Req		
Number of Hours	0	0

Satisfied?

Condition B:		
Interruption of Continuous Traffic		
Volume Level	100%	80%
Major Rd. Req		
Minor Rd. Req		
Number of Hours	0	0

Satisfied?

Condition C:
Combination of A & B at 80%

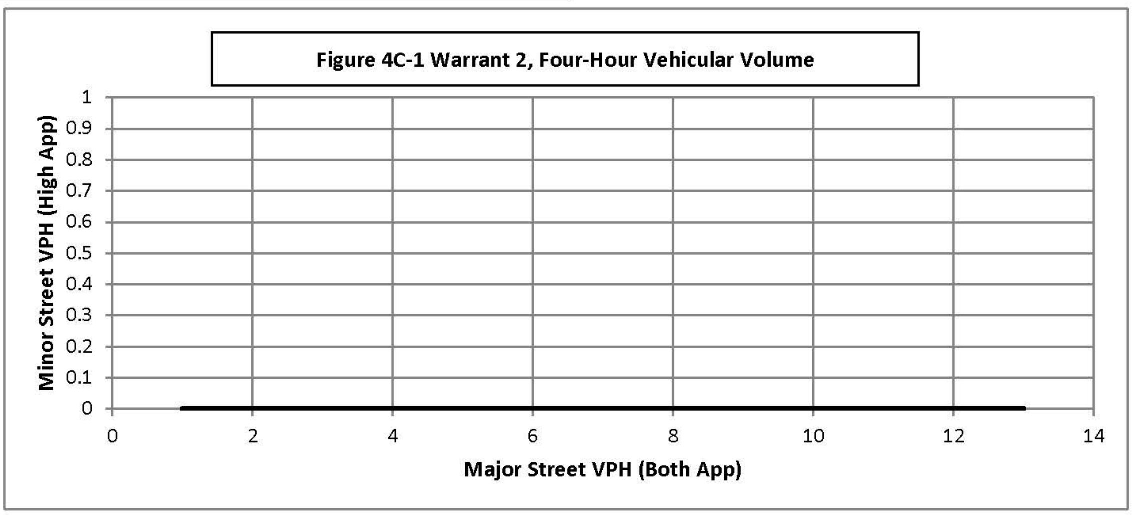
Satisfied?

6:00 AM	Enter Start Time (Military Time) (HH:MM)				
Time Period	**From**	**To**	**Major Road: Both App. (VPH)**	**Minor Road: High App. (VPH)**	**Total**
1	6:00	7:00			
2	7:00	8:00			
3	8:00	9:00			
4	9:00	10:00			
5	10:00	11:00			
6	11:00	12:00			
7	12:00	13:00			
8	13:00	14:00			
9	14:00	15:00			
10	15:00	16:00			
11	16:00	17:00			
12	17:00	18:00			
13	18:00	19:00			
14	19:00	20:00			
15	20:00	21:00			
16	21:00	22:00			

Warrant 2: Four-Hour Volume 100%

Warrant Evaluated?
Warrant Satisfied? N/A
Manually Set To:

Hour Start	#N/A	#N/A	#N/A	#N/A
Major Road Vol.	#N/A	#N/A	#N/A	#N/A
Minor Road Vol.	#N/A	#N/A	#N/A	#N/A



2

Warrant 3: Peak Hour Volume

100%

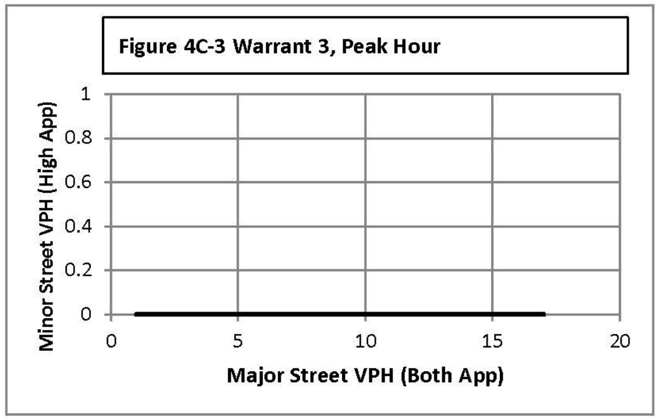
Warrant Evaluated? **Warrant Satisfied? N/A** **Manually Set To:**

Condition justifying use of warrant:

Criteria		Met?
Delay on Minor Approach		
Volume on Minor Approach		
Total Entering Volume (veh/h)		

Manually Set Peak Hour?

Peak Hour	Major Road Vol. (Both App.)	Minor Road Vol. (High App.)
#N/A	#N/A	#N/A



Warrant 4: Pedestrian Volume

100%

Warrant Evaluated? **Warrant Satisfied? N/A** **Manually Set To:**

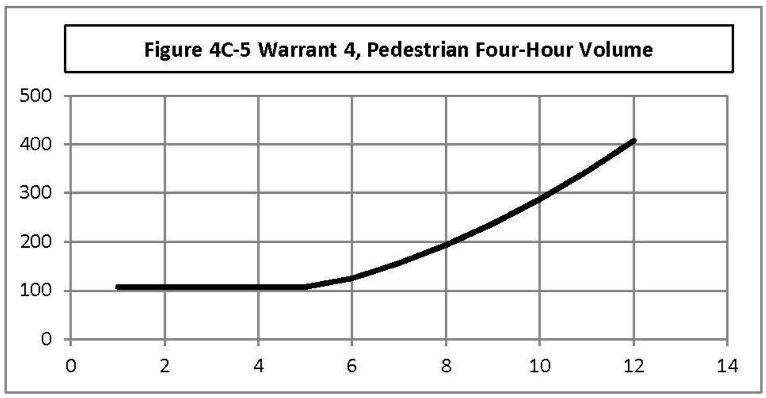
Criterion A: Four Hour

Hour (Start)	Pedestrian Volume	Major Road Vol.
		0
		0
		0
		0

Manually Set Major Rd Vol?

Avg. walk speed less than 3.5 ft/s?

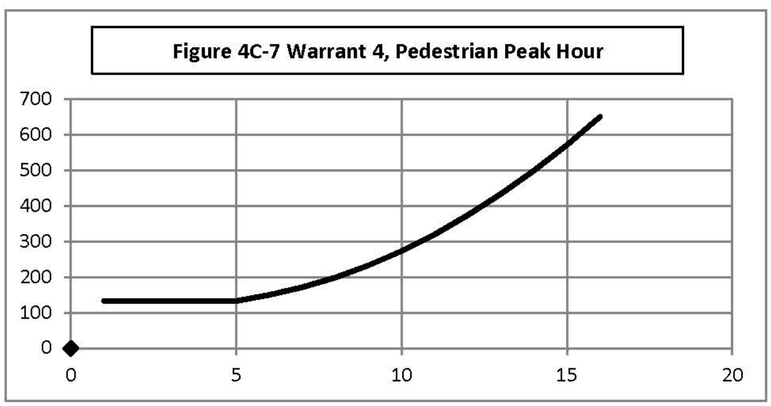
Criterion A Satisfied?



Criterion B: Peak Hour

Peak Hour	Pedestrian Vol.	Major Road Vol.
0:00	0	0

Criterion B Satisfied?



3

Warrant 5: School Crossing — 100%

Warrant Evaluated? **Warrant Satisfied?** **N/A** **Manually Set To:**

Criteria

		Fulfilled?
1	There are a MINIMUM of 20 school children during the highest crossing hour.	
2	There are fewer adequate gaps in the major road traffic stream during the period when the school children are using the crossing than the number of minutes in the same period.	
3	The nearest traffic signal along the major road is located more than 300 ft away. Or, the nearest traffic signal is within 300 ft but the proposed traffic signal will not restrict the progressive movement of traffic.	

Warrant 6: Coordinated Signal System — 100%

Warrant Evaluated? **Warrant Satisfied?** **N/A** **Manually Set To:**

Criteria

		Fulfilled?
1	Signal spacing > 1000 ft	
2	On a one-way road or a road that has traffic predominantly in one direction, the adjacent signals are so far apart that they do not provide the necessary degree of vehicle platooning.	
3	On a two-way road, adjacent signals do not provide the necessary degree of platooning and the proposed and the adjacent signals will collectively provide a progressive operation.	

Warrant 7: Crash Experience — 100%

Warrant Evaluated? **Warrant Satisfied?** **N/A** **Manually Set To:**

Criteria

			Met?	Fulfilled?
1	Adequate trial of other remedial measures has failed to reduce crash frequency.			
	Measures Tried:			
2	Five or more reported crashes, of types susceptible to correction by signal, have occurred within a 12 month period.	# of crashes per 12 months		
3	Warrant 1, Condition A (80%)		No	Yes
	Warrant 1, Condition B (80%)		No	
	Warrant 4, Criterion A (80%)		No	
	Warrant 4, Criterion B (80%)		Yes	

Warrant 8: Roadway Network — 100%

Warrant Evaluated? **Warrant Satisfied?** **N/A** **Manually Set To:**

Criteria

							Met?	Fulfilled?
1	Total entering volume of at least 1,000 veh/h during typical weekday peak hour					#N/A	#N/A	#N/A
	Five-year projected volumes that satisfy one or more of Warrants 1, 2, or 3.						No	
2	Total entering vol. of at least 1,000 veh/h for each of any 5 hrs of non-normal business day (Sat. or Sun.)							
		Hour						
		Volume						

Characteristics of Major Routes - Select yes if all intersecting routes have characteristic

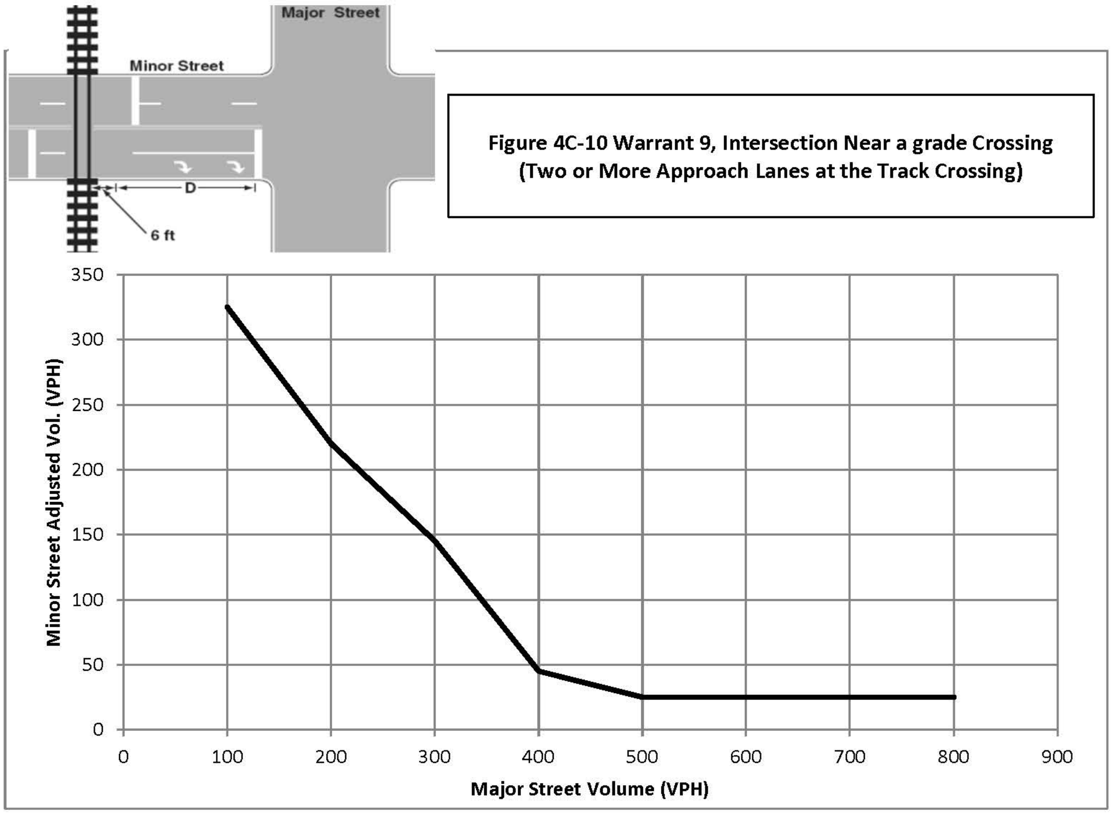
		Fulfilled?
1	Part of the road or highway system that serves as the principal roadway network for through traffic flow	
2	Rural or suburban highway outside of, entering, or traversing a city	
3	Appears as a major route on an official plan	

4

Warrant 9: Intersection Near a Grade Crossing 100%

Warrant Evaluated? **Warrant Satisfied? N/A** **Manually Set To:**

Adjustment Factors			Manually Set Peak Hour?				
Rail Traffic per Day	% High Occupancy Buses on Minor Road	% Tractor-Trailer Trucks on Minor Road	D	Peak Hour	Major Road Vol.	Minor Road Vol.	Adjusted Minor Vol.
1	0	0% to 2.5%	660	#N/A	#N/A	#N/A	#N/A



Conclusions/Comments:

Updated: 12/6/2017

5

Example Intersection Plan Sheet

Conceptual Design
Traffic Signal Installation
WIS 164 & Lindsay Road

Lanes, Volumes, Timings
3: WIS 164 & Lindsay Road

AM Peak
01/11/2024

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	81	30	38	1	58	19	30	414	1	10	943	129
Future Volume (vph)	81	30	38	1	58	19	30	414	1	10	943	129
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	250		210	250		200
Storage Lanes	0		0	0		0	1		1	1		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt		0.965			0.967				0.850			0.850
Flt Protected		0.974			0.999		0.950			0.950		
Satd. Flow (prot)	0	1717	0	0	1817	0	1671	3343	1495	1770	3539	1583
Flt Permitted		0.974			0.999		0.950			0.950		
Satd. Flow (perm)	0	1717	0	0	1817	0	1671	3343	1495	1770	3539	1583
Link Speed (mph)		35			35			45			45	
Link Distance (ft)		1442			1336			1442			1508	
Travel Time (s)		28.1			26.0			21.8			22.8	
Peak Hour Factor	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Heavy Vehicles (%)	4%	4%	4%	1%	1%	1%	8%	8%	8%	2%	2%	2%
Adj. Flow (vph)	95	35	45	1	68	22	35	487	1	12	1109	152
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	175	0	0	91	0	35	487	1	12	1109	152
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Sign Control		Stop			Stop			Free			Free	

Intersection Summary

Area Type: Other

Control Type: Unsignalized

Intersection Capacity Utilization 47.8% ICU Level of Service A

Analysis Period (min) 15

HCM 6th TWSC
3: WIS 164 & Lindsay Road

AM Peak
01/11/2024

Intersection	
Int Delay, s/veh	7

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥		↰	↑↑	↱	↰	↑↑	↱
Traffic Vol, veh/h	81	30	38	1	58	19	30	414	1	10	943	129
Future Vol, veh/h	81	30	38	1	58	19	30	414	1	10	943	129
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	250	-	210	250	-	200
Veh in Median Storage, #	-	2	-	-	2	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	85	85	85	85	85	85	85	85	85	85	85	85
Heavy Vehicles, %	4	4	4	1	1	1	8	8	8	2	2	2
Mvmt Flow	95	35	45	1	68	22	35	487	1	12	1109	152

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1481	1691	555	1153	1842	244	1261	0	0	488	0	0
Stage 1	1133	1133	-	557	557	-	-	-	-	-	-	-
Stage 2	348	558	-	596	1285	-	-	-	-	-	-	-
Critical Hdwy	7.58	6.58	6.98	7.52	6.52	6.92	4.26	-	-	4.14	-	-
Critical Hdwy Stg 1	6.58	5.58	-	6.52	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.58	5.58	-	6.52	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.54	4.04	3.34	3.51	4.01	3.31	2.28	-	-	2.22	-	-
Pot Cap-1 Maneuver	~ 85	90	470	154	75	760	516	-	-	1071	-	-
Stage 1	213	272	-	485	513	-	-	-	-	-	-	-
Stage 2	636	505	-	460	235	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	~ 55	83	470	116	69	760	516	-	-	1071	-	-
Mov Cap-2 Maneuver	178	230	-	269	179	-	-	-	-	-	-	-
Stage 1	199	269	-	452	478	-	-	-	-	-	-	-
Stage 2	493	471	-	358	232	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	61.9	32.4	0.8	0.1
HCM LOS	F	D		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	516	-	-	224	221	1071	-	-
HCM Lane V/C Ratio	0.068	-	-	0.783	0.415	0.011	-	-
HCM Control Delay (s)	12.5	-	-	61.9	32.4	8.4	-	-
HCM Lane LOS	B	-	-	F	D	A	-	-
HCM 95th %tile Q(veh)	0.2	-	-	5.6	1.9	0	-	-

Notes

~: Volume exceeds capacity $: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon

CRASH REPORT EXAMPLE

MAPPED	DOCTNMBR	ACCDDATE	NTFYHOUR	REGION	COUNTY	MUNICIPALITY	MUNITYPE	ONHWYRP	ONHWYDIR	ONHWY	ONSTR	ATHWY	ATSTR	ATNMBR	INTDIR	INTDIS
Y	75L0P4K13N	6/4/2019	16	SE	WALWORTH	BLOOMFIELD	T	120	S	120			N BLOOMFIELD RD			0
Y	75L0V3XHJW	2/13/2019	7	SE	WALWORTH	BLOOMFIELD	T	120	S		N BLOOMFIELD RD	120			W	1
Y	B8L0NLHJNL	10/10/2017	16	SE	WALWORTH	BLOOMFIELD	T	120	S	120			N BLOOMFIELD RD			0
Y	B8L0NLHJQ6	10/31/2018	15	SE	WALWORTH	BLOOMFIELD	T	120	S	120			N WELLS ST		E	34
Y	B8L0NLHJQ7	10/30/2018	18	SE	WALWORTH	BLOOMFIELD	T	120	S	120			N BLOOMFIELD RD		E	0
Y	B8L0XTDXVT	5/29/2017	11	SE	WALWORTH	BLOOMFIELD	T	120	S		N BLOOMFIELD RD	120			W	1
Y	B8L0Z7RB01	1/27/2019	10	SE	WALWORTH	BLOOMFIELD	T	120	S		N BLOOMFIELD RD	120			W	1
Y	B8L0Z7RB0Q	11/13/2019	19	SE	WALWORTH	BLOOMFIELD	T	120	S	120			N BLOOMFIELD RD		S	1
Y	B8L0Z90C3S	1/11/2020	9	SE	WALWORTH	BLOOMFIELD	T	120	S		N BLOOMFIELD RD	120			W	2
Y	B8L0Z90C3T	1/11/2020	12	SE	WALWORTH	BLOOMFIELD	T	120	S		N BLOOMFIELD RD	120			W	2
Y	B8L0ZCGFBN	1/23/2020	15	SE	WALWORTH	BLOOMFIELD	T	120	S	120		120				0
Y	B8L0ZCGFC0	6/2/2020	18	SE	WALWORTH	BLOOMFIELD	T	120	S	120			N BLOOMFIELD RD		S	0
Y	B8L12XVNB8	1/17/2020	16	SE	WALWORTH	BLOOMFIELD	T	120	S		N BLOOMFIELD RD	120			W	2
Y	CNL097RB05	6/4/2018	16	SE	WALWORTH	LAKE GENEVA	C	120	N	120			N WELLS ST		E	36
Y	CNL0990C7C	11/7/2019	8	SE	WALWORTH	LAKE GENEVA	C	120	S	120			N BLOOMFIELD RD		N	1
Y	CNL09PBQ7H	9/5/2018	21	SE	WALWORTH	BLOOMFIELD	T	120	S		N BLOOMFIELD RD	120			W	1
Y	KR6KSW1	8/1/2016	16	SE	WALWORTH	BLOOMFIELD	T	120	N		N BLOOMFIELD RD	120				0
Y	LWJLK2R	4/15/2016	22	SE	WALWORTH	LAKE GENEVA	C	120	N	120	NB		N BLOOMFIELD RD			0
Y	LWMLXD9	11/23/2016	15	SE	WALWORTH	LAKE GENEVA	C	120	S	120			N BLOOMFIELD RD			0

DOCTNMBR	ACCDTYPE	MNRCOLL	RLTNRDWY	ACCDLOC	HWYCLASS	TRFCWAY	ROADCOND	WTHRCOND	LGTCOND	ROADHOR	ROADVERT	ACCDSVR	INJSVR	INJTRNS	TOTFATL	TOTINJ	CONSZONE	ALCFLAG	BIKEFLAG	CYCLFLAG	PEDFLAG	TOTVEH
75L0P4K13N		ANGL	ON	I	R STH	ND		CLR				INJ	B	Y	0	3						3
75L0V3XHJW		ANGL	ON	I	R TOWN	ND	ICE	WIND				PD			0	0						3
B8L0NLHJNL		ANGL	ON	I	R STH	D/WO	WET	RAIN				INJ	B	Y	0	1						2
B8L0NLHJQ6		ANGL	ON	I	R STH	D/WO		CLDY				PD			0	0						2
B8L0NLHJQ7		ANGL	ON	I	R STH	ND	WET	RAIN	DUSK			INJ	C	Y	0	1						2
B8L0XTDXVT	CULVRT	NO	RTSH	I	R TOWN	ND		CLR				INJ	A	Y	0	3						1
B8L0Z7RB01		ANGL	ON	I	R TOWN	ND	WET	CLR				PD			0	0						2
B8L0Z7RB0Q		REAR	ON	N	R STH	D/WO	WET	SNOW	LIGT			PD			0	0						2
B8L0Z90C3S		ANGL	ON	N	R TOWN	ND	WET	RAIN				PD			0	0						2
B8L0Z90C3T		ANGL	ON	N	R TOWN	ND	WET	RAIN				PD			0	0						2
B8L0ZCGFBN		ANGL	ON	I	R STH	D/WO	WET	CLDY				PD			0	0						2
B8L0ZCGFC0		ANGL	ON	I	R STH	ND		CLR				INJ	C	Y	0	1						2
B8L12XVNB8		ANGL	ON	I	R TOWN	D/WO	SNOW	SNOW	DAWN			PD			0	0						2
CNL097RB05		ANGL	ON	I	U STH	D/B		CLR				INJ	B		0	1						2
CNL0990C7C		ANGL	ON	I	U STH	ND	ICE	CLR				INJ	C		0	1						2
CNL09PBQ7H		ANGL	ON	I	R TOWN	ND	WET	RAIN	LIGT			PD			0	0						2
KR6KSW1		ANGL	ON	I	R TOWN	D/WO		CLR				PD			0	0						2
LWJLK2R	TFSIGN	NO	MED	I	U STH	D/WO		CLDY	LIGT			PD			0	0						1
LWMLXD9		ANGL	ON	I	U STH	D/WO	WET	RAIN	DUSK			PD			0	0						2

DOCTNMBR	VEHTYPE1	VEHDMG1	TRVLDIR1	DRVRDO1	TRFCNTL1	POSTSPD1	AGE1	SEX1	INJSVR1	SAFETY1	DRVRPC1	STNM11	STNM12
75L0P4K13N	CAR	SVR	W	GO STR	SS	35	66	F	B	SH/LP	FTY	346.06	
75L0V3XHJW	CAR	MNR	N	STOPED	SS	25	49	F		SH/LP			
B8L0NLHJNL	CAR	MNR	E	LT TRN	SS FL	45	38	M		SH/LP	FTY	346.32	
B8L0NLHJQ6	CAR	MNR	E	GO STR	SS FL	45	17	M		SH/LP	FTY	346.18(3)	
B8L0NLHJQ7	CAR	MNR	E	GO STR	SS	45	44	M		UNKN	FTY	344.62(1)	346.18(3)
B8L0XTDXVT	TRK UT	SVR	W	BLNK	SS	35	49	F	A	SH/LP	OTHR		
B8L0Z7RB01	CAR	MOD	S	RT TRN	NONE	45	23	F		SH/LP	TFC,FVC	346.57(3)	
B8L0Z7RB0Q	TRK UT	MNR	S	GO STR	NONE	45	56	M		SH/LP			
B8L0Z90C3S	CAR	MNR	W	RT TRN	SS	35	67	F		SH/LP	TFC	346.57(3)	
B8L0Z90C3T	CAR	SVR	W	RT TRN	SS	35	31	F		SH/LP	TFC	346.57(3)	
B8L0ZCGFBN	CAR	MNR	S	GO STR	NONE	45	62	F		SH/LP			
B8L0ZCGFC0	CAR	SVR	W	GO STR	SS	45	24	F		UNKN	FTY	346.18(3)	
B8L12XVNB8	CAR	MNR	S	RT TRN	NONE	45	46	M		SH/LP	TFC,FVC		
CNL097RB05	CAR	SVR	W	GO STR	SS	45	25	M		SH/LP	FTY	346.18(3)	
CNL0990C7C	CAR	BLNK	E	LT TRN	SS	35	35	M		UNKN	FTY		
CNL09PBQ7H	CAR	MOD	E	GO STR	SS	30	27	M		SH/LP		346.18(3)	
KR6KSW1	CAR	SVR	E	GO STR	SS	35	61	F		SH/LP	FTY	346.18 3	
LWJLK2R	CAR	MOD	N	GO STR	NONE	45	63	M		UNKN	FVC		
LWMLXD9	CAR	SVR	W	GO STR	SS	35	33	F		SH/LP	FTY	346.18 3	344.62 1

DOCTNMBR	VEHTYPE2	VEHDMG2	TRVLDIR2	DRVRDO2	TRFCNTL2	POSTSPD2	AGE2	SEX2	INJSVR2	SAFETY2	DRVRPC2	STNM21	STNM22
75L0P4K13N	CAR	SVR	S	GO STR	NONE	45	61	M	C	SH/LP			
75L0V3XHJW	CAR	MNR	N	STOPED	SS	25	58	M		SH/LP			
B8L0NLHJNL	CAR	SVR	S	GO STR	SS FL	45	55	M	B	SH/LP			
B8L0NLHJQ6	CAR	MNR	S	GO STR	NONE	45	19	F		SH/LP			
B8L0NLHJQ7	CAR	SVR	S	GO STR	NONE	45	17	M		SH/LP			
B8L0XTDXVT													
B8L0Z7RB01	TRK UT	MNR	E	GO STR	SS	25	23	M		SH/LP			
B8L0Z7RB0Q	CAR	MNR	S	CHG LN	NONE	45	23	F		SH/LP	FVC,FVC,IO		
B8L0Z90C3S	CAR	MNR	E	GO STR	SS	35	39	M		SH/LP			
B8L0Z90C3T	CAR	SVR	E	OTHR	SS	35	29	M		SH/LP			
B8L0ZCGFBN	CAR	BLNK		BLNK	BLNK	45	0	N		NONE			
B8L0ZCGFC0	CAR	SVR	S	GO STR	NONE	45	18	M	C	SH/LP			
B8L12XVNB8	CAR	MNR	E	SL/ST	SS	35	17	F		SH/LP			
CNL097RB05	CAR	SVR	N	GO STR	NONE	45	70	F	B	SH/LP			
CNL0990C7C	CAR	MOD	N	LT TRN	SS	45	63	M	C	SH/LP			
CNL09PBQ7H	CAR	SVR	S	GO STR	NONE	45	30	M		SH/LP			
KR6KSW1	TRK UT	MOD	N	GO STR	NONE	45	54	M		SH/LP			
LWJLK2R													
LWMLXD9	CAR	SVR	S	GO STR	NONE	45	36	M		SH/LP		344.62 1	

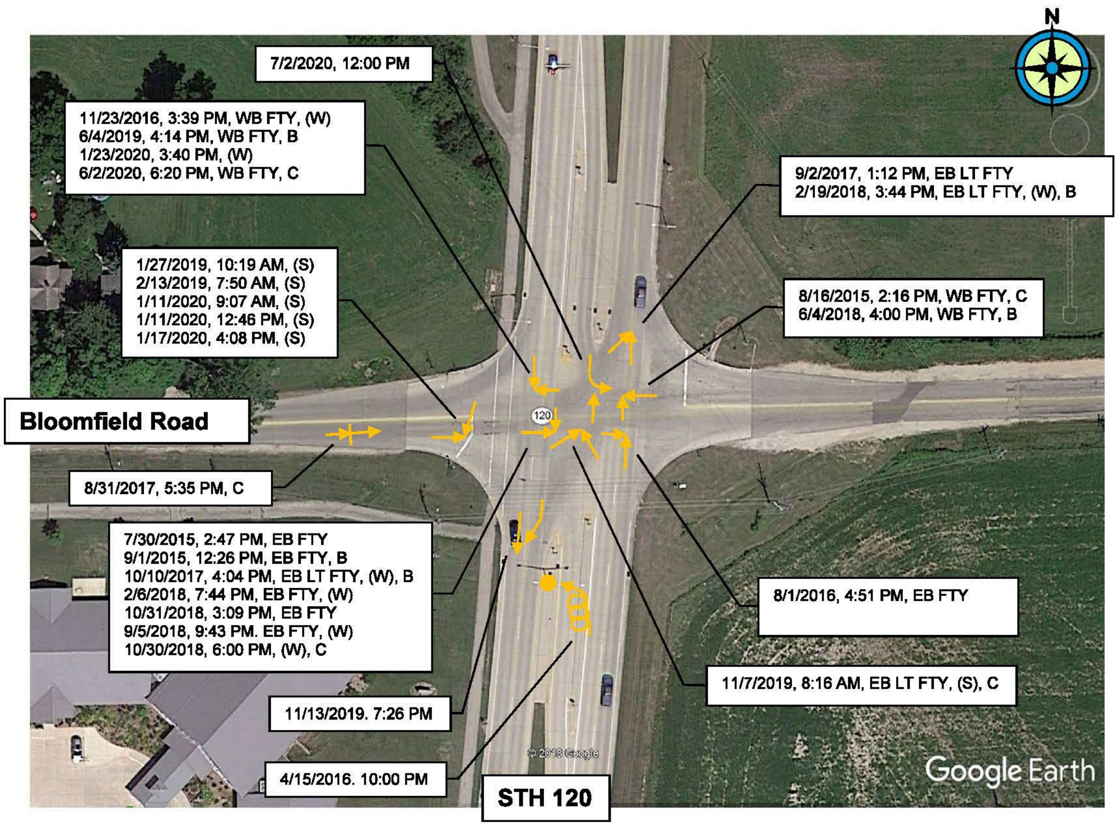
Attachment 3: Crash Diagram

DTSD – SE Region

Intersection Safety Evaluation

STH 120 & N. Bloomfield Road

Walworth County **January 2015-Preliminary 2020**



LEGEND									
	Signal/Sign Post		Bicycle		Right Angle		Out of Control	(S) = SNOW-ICE	K = FATAL
	Tree/Utility Pole		Pedestrian		Left Turn		Rear-End	(W) = WET	A = SUS. SERIOUS INJURY
	Non-Fixed Object		Non-Contact Vehicle		Right Turn		Head-On	(F) = FOG-MIST	B = SUS. MINOR INJURY
	Fixed Object		Backing Vehicle		Sideswipe-Same		Overtake	(DUI) = ALCOHOL	C = POS. INJURY
	Parked Vehicle		Moving Vehicle		Sideswipe-Opp.		Overturn	OR DRUG USE	BLANK = PROPERTY

Traffic Engineering, Operations & Safety Manual

Chapter 4 Signals

Section 5 Signal Plan Format

4-5-1 Permanent Signal Plan Format — April 2025

GENERAL

Preparation of signal plans involves preparing a set of detailed drawings showing location, geometric configuration, quantities, and details of work to be performed on a project. The objective of this section is to present standards that will meet the requirements of the Department.

Preparation of traffic signal plan sheets **shall** follow base sheets that have been developed in the FDM Chapter 15, Plan Preparation. The signal plan sheet set **shall** be in one design file. The number and type of sheets are dependent on the type of traffic signal installation. As a minimum, the signal plan set **shall** include:

1. Plan Sheet(s)
2. Sequence of Operations Sheet
3. Cable routing sheet

And if applicable:

1. Temporary signal plan
2. Temporary Sequence of Operations Sheet
3. Miscellaneous quantities for electrical items
4. Engineering estimate for electrical items
5. Special provisions pertaining to electrical items
6. Signal Removal plans
7. Details of non-standard items
8. List of SDDs, general construction notes, and construction details pertaining to electrical items

To obtain a signal number (e.g., S 18-1006), the Regional Traffic Signal Unit will assign the signal number once the DT1199 form has been approved by the Bureau of Traffic Operations. In rare cases, a T-number *may* be assigned instead of an S-number due to the temporary nature of the signal.

The Sequence of Operations Sheet comes in three variations: 1) TS1; 2) Econolite TS2; and 3) Eagle TS2.

Consultants' logos **shall not** be included on the signal plans. These two sheets, along with the plan sheet and cell libraries, are available from the Department for CADD usage.

Consultant prepared plans **shall** be signed and sealed by a Professional Engineer registered in Wisconsin and submitted to the Regional Traffic Signal Engineer for approval. Electronic CADD files **shall** be submitted in accordance with the FDM.

An original, 11”X17” signal plan signed by the Regional Traffic Signal Engineer Professional Engineer (refer to Wis. State Statute 443) or delegate, needs to be submitted by the Regions to Central Office, Bureau of Traffic Operations for all new signal plans and for signal plan revisions.

All signal plan sets, including those in a PS&E submittal or permit application, must be submitted to the Regional Traffic Unit for approval. If the signal plan is part of a PS&E, the signal plan must be submitted to the Region at least one month prior to the draft PS&E date. Upon approval by the Regional Traffic Signal Engineer, it is the responsibility of the Region to submit the signal plan to the Bureau of Traffic Operations for approval. If a signal plan is to be included in a permit application, the permit coordinator will submit the signal plan to the Regional Traffic Signal Engineer for approval. Upon approval by the Region, it is the responsibility of the Region to submit the signal plan to the Bureau of Traffic Operations for approval.

PLAN SHEET

1. Signal plans **shall** have a signature block in the lower right hand corner showing approvals and revision history. Use the appropriate signature block on the signal plan to distinguish between connecting highways and state-owned signals.
   a. Page 1 Signature block for state owned signals (see Figure 1.1a)
   b. Page 1 Title block for connecting highways and locally owned streets (see Figure 1.1b)
   c. Signal plan page 2 identification block, if required (see Figure 1.1c)
   d. Page 1 Revision block, if required (see Figure 1.1d)
   e. Sequence of operations block (see Figure 1.1e)

Figure 1.1a. Traffic Control Signal Plan Page 1 Signature Block for State-owned Signals

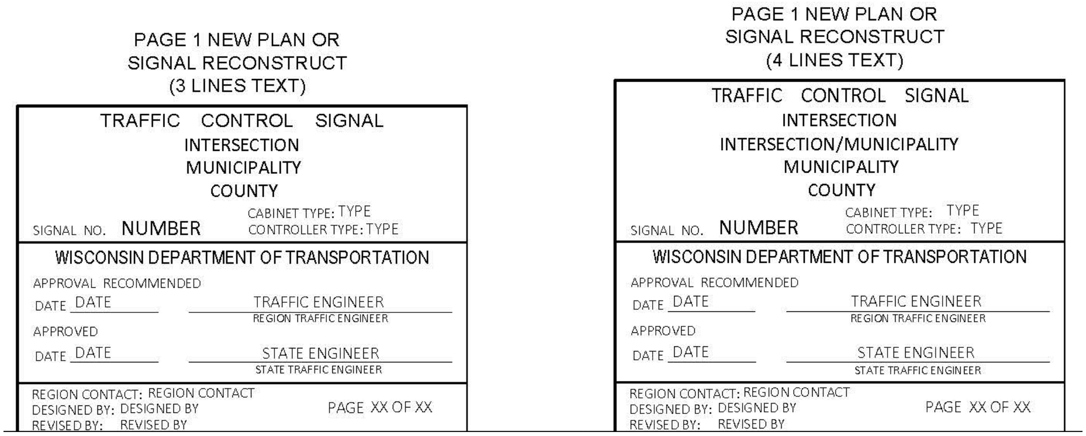


Figure 1.1b. Traffic Control Signal Plan Page 1 Title Block for Connecting Highway and Local Signals

Figure 1.1c. Traffic Control Signal Plan Page 2, 3, 4, etc. Block for state-owned signals

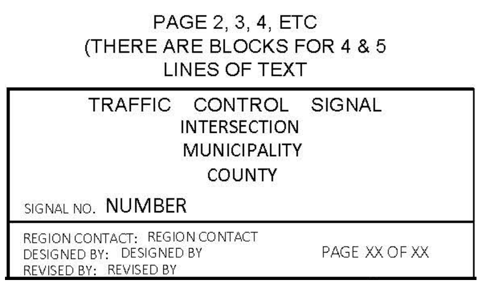


Figure 1.1d. Traffic Control Signal Plan Page 1 Revision Block for state-owned signals

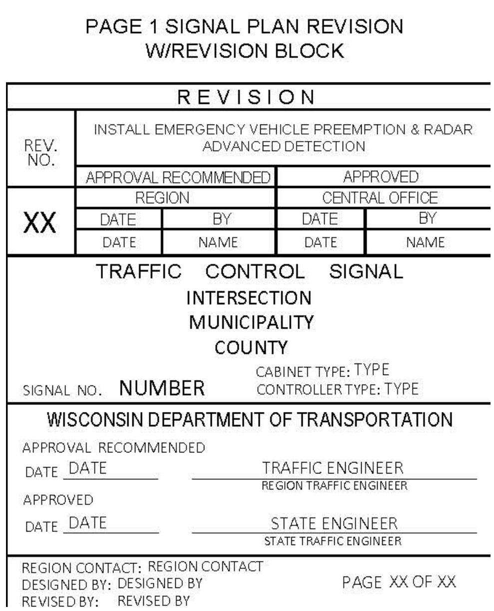


Figure 1.1e. Traffic Control Signal Plan Sequence of Operations Block

INTERSECTION MUNICIPALITY COUNTY			
SIGNAL NO.	NUMBER		
CABINET:	TS2	CONTROLLER:	ASC3
DATE:	DATE	PAGE NO. 2 OF 2	

According to state statute 443.08(4)(b), final signal plans **shall** bear the signature of a professional engineer. In addition, PS&E plans not developed by WisDOT staff **shall** bear the stamp of the consultant designer.

1. Show North arrow on all sheets.
2. The mainline roadway *should* be oriented horizontally on the plan sheet. Typically, the STH *should* be designated as the mainline.
3. Matchlines **shall** be used instead of breaklines. Matchlines are helpful for indicating utility locates, approach geometries, intermediate access points, and signal infrastructure placement.
4. NEMA phasing convention **shall** be used. Typically, NEMA phase 6 is in the Cardinal direction (Northbound/Eastbound).
5. Show curb cuts, ramps, sidewalks, crosswalks and stop bars due to their influence on signal base and detection placement.
6. Pavement markings **shall** be shown on the signal plan. Lane lines need to be shown due to their effect on detector placement past the far loops. Informational lane designation arrows *may* be shown on complicated designs. If the pavement marking plan is not incorporated into the plan sheet, and arrows are shown for lane designation purposes, supply the symbols and a note in the legend saying, “Arrows shown are for lane designation and are for information only”.
7. Show posted speed limits on each approach.
8. Show right-turn control. STOP or YIELD if separated by an island and not controlled by the signal.
9. The Department has created a CADD cell library specifically to aid in the creation of signal and lighting plans. The State signal cell library **shall** be used for signal design. Each signal and pedestrian head **shall** have a number.
10. Show and label asphalt-to-concrete-pavement joints. Loop detectors *should not* cross these joints; therefore, they are important for detector placement.
11. Show municipal lighting, if any, and state lighting. It is the policy of the Department to light signalized intersections.
12. All signal plans **shall** show utilities, including overhead lines.
13. Show mast arm lengths for mast arm installations. Show monotube arm lengths for monotube arm installations.
14. Each detector **shall** be a two-digit number, the first digit of the number being the phase number with which it is associated.
15. Signal plans **shall** be drawn and printed at 1”=40’ scale on an 11”x17” (D-size) number 2 tab plan sheet. For signal plans to be included in a PS&E submittal, refer to FDM Chapter 15, Plan Preparation.
16. Show Right-of-way gray shaded.
17. Show reference line.
18. Show access points.
19. Existing geometrics on fully reconstructed intersections **shall not** be shown.

The Regional Traffic Signal Unit will assign an intersection signal number (“S”, “M”, “T” or “U” number) as required for proper identification & future reference.

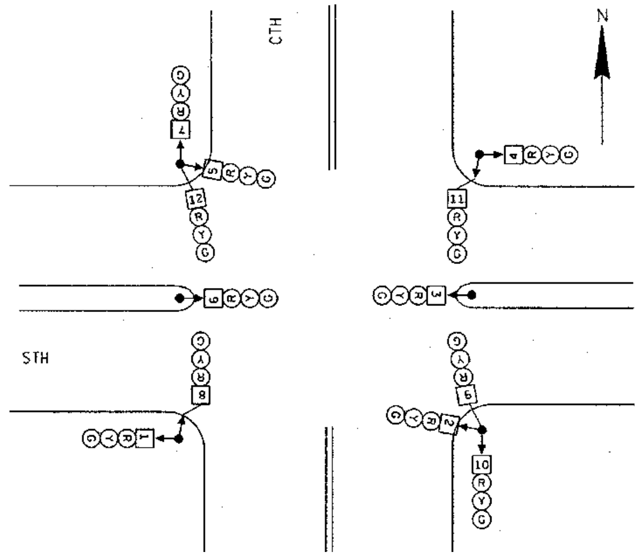
Signal equipment to be installed in the field are identified on the plan and quantity sheets by the schemes described below, these schemes *should* be applied on a per signalized intersection basis. In the case where multiple signal plans exist along a corridor within the same plan set, these numbering schemes **shall** apply to individual signal locations.

Signal Head Numbering

Individual signal heads **shall** be uniquely numbered. Head numbering is arbitrary, but typical practice is to number signal heads by approaches.

Pedestrian head numbers **shall** also be numbered. When using the same numbering scheme for both signal and pedestrian heads, first number all vehicular signal indications, then label pedestrian heads starting with the next consecutive number.

Figure 1.2. Signal Head Numbering



Detection Numbering

Loops **shall** be designated by two numbers (NEMA phase + consecutive numbering systems as described below). Detection associated with an overlap **shall** be designated with the NEMA phases that it accompanies. Dimensions and number of turns **shall** be included on the traffic signal plan sheet or in the case of a TS1 cabinet, the sequence of operation sheet.

Number loops starting at advanced detection to near stop bar detection, then right lane to left lane. If left turns phases are added, left turn loops do not influence renumbering of other detection.

Signal Base Numbering

Signal base numbers **shall** be prefixed with an “SB” and numbered consecutively in the clockwise direction starting at the signal cabinet.

Light Base Numbering

Lighting bases that only have lighting equipment on them **shall** be prefixed with an “LB”.

Cabinet Numbering

The main cabinet base **shall** be called “CB1”, a splice cabinet **shall** be called “CB2” and temporary cabinets **shall** be called “TCB1”.

Pull Box Numbering

Pull box numbers **shall** be prefixed with a “PB” and numbered consecutively in the clockwise direction starting at the signal cabinet.

SEQUENCE OF OPERATIONS SHEET

The standardized Sequence of Operations Sheet is in the State standard cell library.

The guidelines listed below **shall** be followed when preparing the Sequence of Operations Sheet.

1. Show North arrow. It **shall** be oriented the same as the plan sheet. The arrows in the boxes on the sequence of operations **shall not** be rotated and **shall** remain oriented up and down or left and right. The north arrow *may* be rotated up to 45 degrees in either direction to accomplish this.
2. NEMA phasing **shall** be used for uniform phase numbering. Use phases 2 & 6 for the mainline and phases 4 & 8 for the cross street. Phase 6 **shall** be for the northbound or eastbound phase and phase 8 **shall** be counterclockwise from phase 6 (the phasing and directions can be changed only in special phasing situations, such as interchanges, T-intersections, or split-phase operations).
3. The pedestrian movements are shown with half arrow heads.

4. If the word "phase" is listed in a column, the symbol "Ø" does not need to be shown. Using just the number is sufficient.
5. In the controller logic box, the phase-recall column *should* be listed as "MIN", "MAX", "PED", and/or "SOFT". The remaining columns *should* have either a number or an "X."
6. Overlaps can be shown in one of two ways:
    a. A movement is active or allowed to be on with 2 or more phases.
    b. A Flashing Yellow Arrow.

SIGNAL CABLING

For all new or reconstructed state-owned signals installed under contract, a Cable Routing Schedule **shall** be included, and reviewed by the Regional Electrical staff and the Regional Traffic Signal Engineer as part of the signal plan review process.

The Cable Schedule assures the maintaining electrical staff that the standard WisDOT wiring scheme is followed. Electrical staff *should* be contacted prior to preparing the Cable Routing Schedule to discuss proper wiring practices. Additionally, it is important that this plan sheet correctly identifies the wiring scheme as installed at the intersection. A sample of the chart is provided.

The cable routing sheet is also used by the electrical contractor as a blueprint for the routing of the signal feeder cables and field connections. This sheet will also aid the signal designer when determining miscellaneous quantities.

This section presents information, some of which has been previously printed in such documents as the State of Wisconsin Standard Specifications for Highway and Structure Construction (Specification 655), Standard Detail Drawings, and the Wisconsin Electrical Code.

<u>COMPLETION OF THE CABLE ROUTING SCHEDULE</u>

At the top left of the cable routing sheet, insert the project identification number followed by the intersection name and signal number.

The color-coding chart provides identification of each conductor within the signal feeder cables. The conductor colors and sequence for cables can be found in the International Municipal Signal Association, Inc. (IMSA) specification No. 20-1. Base colors **shall** consist of colored insulation. Tracers **shall** be colored stripes or bands along the surface of the insulation. The color-coding chart utilizes the use of a three-letter abbreviation for each conductor color. Examples: RED=red, ORG=orange, GRN=green and for the tracer colors: WHT/BLK=white/black, RED/WHT=red/white, etc.

There are six tables placed in the cable routing sheet, which are:

- SIGNAL FEEDER CABLES
- EQUIPMENT GROUNDING CONDUCTOR
- CONDUCTIVE PULL BOX BONDING JUMPERS
- LIGHTING CABLES
- EMERGENCY VEHICLE PREEMPTION CABLES
- NON-INTRUSIVE DETECTION

To fill in the cable routing sheet from the example Second Revision Plan, the signal feeder cable goes from the cabinet base (i.e. CB1) to each signal base (i.e. SB1). For SB1, the minimum number of conductors needed is 7 and a maximum will typically be 15 conductors. The following concepts apply to the example chart provided: head no. 18 requires 3 conductors, head no. 23 requires 2 conductors, 1 conductor is needed for the pedestrian push button (in some cases loop lead-in cable *may* be used instead), and 1 conductor is used for the grounded conductor. This example used a 12 conductor as a feeder cable. A 15 conductor could also be used, in either case this will provide some additional spare conductors to meet future needs.

<u>Signal Cable, IMSA-20-1, Ungrounded Conductors</u>

During emergency situations, it is imperative that the maintenance staff knows the wiring at the intersection. For this reason, the Signal Cable, IMSA-20-1, Ungrounded Conductors (wiring table) is very important. The wiring table identifies the signal cable path and wiring scheme for all signal and pedestrian indications at the intersection it is important that a copy of this be located inside the controller cabinet for use during maintenance. Wiring color schemes vary among Regions and local jurisdictions. Prior to beginning the wiring table, the maintaining electrician *should* be contacted to determine the proper routing procedure.

<u>Signal Feeder Cables Table</u>

The preferred method for installing signal feeder cable is to run a separate home run cable from the control cabinet base to each individual signal base. When selecting the number of conductors needed in each signal feeder cable, future signal expansion *should* be considered such as adding pedestrian heads, pedestrian push buttons, turn arrows, etc. Consideration *should* also be given to minimize the number of different sized cables to be used as feeder cables. For intersection wiring, it is easier to provide a few standard size cables like a 12-conductor cable instead of providing 7, 9, or 10 conductor cables.

The next entry on the chart is the signal head number and the phase the head is associated with as shown on the signal plan. In the example, Head 18 is a phase 4 head, head 23 is a phase 6 pedestrian head, and the push button is for the phase 6 ped.

To complete the entries for SB 1, the signal indication wire color section needs to be entered. Across the top of the chart are the signal indications. We start with the circular indications of red, yellow, and green followed by the arrow indications, the pedestrian signal indications, the pedestrian push buttons, and other. For each indication used, a signal feeder conductor is assigned to the signal indication. These colors are entered as shown in the signal wire color-coding section. Head # 18, RED = red, ORG = yellow, and GRN = green. Head #23 the DON'T WALK = BLK and the WALK = BLU. The push button needs 2 conductors. One conductor will be the WHT/BLK and the other side of the button will be connected to the grounded conductor (neutral) in the signal feeder cable. If loop lead-in cable is to be used for the pedestrian push buttons refer to the pedestrian push button chart.

Cable Routing Schedule Example

PROJECT ID:	
INTERSECTION:	

SC1 TO	CABLE (AWG 14)	HEAD NO.	SIGNAL INDICATION WIRE COLOR									
			RED	YELLOW	GREEN	FLASHING YELLOW	<RED>	<YELLOW>	<GREEN>	<FLASHING YELLOW>	DON'T WALK	WALK
SB1	12/C	81	RED	ORG	GRN	-	-	-	-	-	-	-
		72	-	-	-	-	RED/BLK	ORG/BLK	GRN/BLK	BLUE/BLK	-	-
SB2	12/C	42,43	RED	ORG	GRN	-	-	-	-	-	-	-
		71	-	-	-	-	RED/BLK	ORG/BLK	GRN/BLK	BLUE/BLK		
SB3	12/C	21	RED	ORG	GRN	-	-	-	-	-	-	-
		12	-	-	-	-	RED/BLK	ORG/BLK	GRN/BLK	BLUE/BLK	-	-
SB4	12/C	62,63	RED	ORG	GRN	-	-	-	-	-	-	-
		11	-	-	-	-	RED/BLK	ORG/BLK	GRN/BLK	BLUE/BLK	-	-
ESB307	12/C	41	RED	ORG	GRN	-	-	-	-	-	-	-
		32	-	-	-	-	RED/BLK	ORG/BLK	GRN/BLK	BLUE/BLK	-	-
		P62	-	-	-	-	-	-	-	-	BLK	BLUE
ESB308	12/C	31	RED	ORG	GRN	BLUE	-	-	-	-	-	-
		73	-	-	-	-	RED/BLK	ORG/BLK	GRN/BLK	BLUE/BLK	-	-
SB8	12/C	82,83	RED	ORG	GRN	-	-	-	-	-	-	-
		P82	-	-	-	-	-	-	-	-	BLK	BLUE
			-	-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-	-

To complete the wiring chart, an entry is added for each signal base and associated signal heads and pedestrian push buttons. The OTHER column is used for any shadow box signs, time of day signs, etc., fed out of the signal feeder cable.

<u>Equipment Grounding Conductor</u>

The equipment grounding conductors provide grounding for the physical elements at the intersection (i.e. controller cabinet, signal poles, pull boxes, light poles powered from signal cabinet). As with signal cable, the maintaining electrician *should* be contacted to determine the correct routing for the equipment grounding conductors.

<u>Equipment Grounding Conductor Table</u>

The equipment-grounding conductor is a stranded 10 AWG XLP insulated conductor used for grounding purposes. This wire **shall** have an insulation that is green. The conductor starts at the cabinet base and is jumpered in and out of each signal base and returning to the cabinet base. This creates a loop around the intersection. A stranded 10 AWG conductor is used due to the mechanical strength of the conductor. The use of a spare conductor from the signal feeder cable to be used as permitted. In the example, the equipment-grounding conductor starts at CB1 runs to SB20, to SB1, in and out of the signal bases to SB 19 and from SB 20 terminating back at CB1.

EQUIPMENT GROUNDING CONDUCTOR 10 AWG GRN XLP	
FROM	TO
CB 1	SB 1
SB 1	SB 2
SB 2	SB 3
SB 3	SB 4

SB 4	SB 5
SB 5	SB 6
SB 6	SB 7
SB 7	SB 8
SB 8	SB 9
SB 9	SB 10
SB 10	SB 11
SB 11	SB 12
SB12	SB 13
SB 13	SB 14
SB 14	SB 15
SB 15	SB 18
SB 19	SB 16
SB 16	SB 17
SB 17	SB 19
SB 19	SB 20
SB 20	CB 1

Conductive Pull Box Bonding Jumper Table

The pull box bonding jumper **shall** be in accordance with Specification 655.2.5. The purpose of this conductor is to bond all metal pull boxes and metal pull box covers that are used as a raceway for cables that carry voltages of 50 volts or more to ground. The pull box bonding jumper extends from the pull box to the nearest signal base or cabinet.

PULL BOX BONDING JUMPER 10 AWG GRN XLP	
FROM	TO
CB 1	PB 1
SB 2	PB 4
SB 3	PB 2
SB 4	PB 5
SB 6	PB 6
SB 6	PB 7
SB 8	PB 10
SB 10	PB 11
SB 11	PB 12
SB 11	PB 13
SB 13	PB 16
SB 14	PB 17
SB 16	PB 22
SB 18	PB 18
SB 18	PB 19
SB 19	PB 24
SB 20	PB 23
CB 1	PB 25

Lighting

The Lighting Chart identifies the routing for the lighting wire/cable. Since some Regions provide separate conduit for lighting systems, the cable routing *may* have been previously discussed with the maintaining engineer or electrician during the design; nevertheless, the wire/cable routing **shall** be included in the plans. Refer to Specification 655.3.4.

Lighting Table

Lighting fed from a signal cabinet is line to neutral (120V) or line to line (240V) Individual lighting feeder cables could be run to each light pole. Typically, a 12 AWG 2 conductor UF cable with ground feeds the intersection. For higher lighting loads and to maintain minimal voltage drops a larger conductor *may* be required. A maximum 5% voltage drop for a branch circuit is recommended according to the NEC. It is preferred to design up to a 3.5% maximum voltage drop, which would allow for some limited expansion of the lighting system in the future.

LIGHTING UF 12 AWG W/GROUND	
FROM	TO
CB 1	SB 21
SB 21	SB 5
SB 5	SB 6
SB 6	SB 9
CB 1	SB 20
SB 20	SB 18
SB 18	SB 15
SB 15	SB 11

When the load of the luminaires exceeds 16 amps, a separate lighting cabinet is required.

When separate traffic signal and street lighting systems are used, the systems **shall** be electrically isolated from each other. Each system would have a separate cabinet and underground conduit system. Examples would include signals and street lighting fed from two different power sources, lighting branch circuit loads exceeding 16 amperes, and/or lighting systems maintained by different governmental agencies.

Emergency Vehicle Preemption Table

The EVP cable and confirmation light cable (if applicable) **shall** be installed as shown on the plan and in accordance with the manufacturer's specifications. The cable(s) **shall** be installed from the control cabinet to the EVP detector head and to the confirmation light (if applicable) in one continuous non-spliced length. The EVP detector cable **shall** be terminated at the detector head and control cabinet. The confirmation light cable **shall** be terminated at the confirmation light and control cabinet. The cable(s) **shall** be routed through the underground conduit system using the shortest route.

EVP CABLE	
FROM	TO
CB1	HEAD 'C'
CB1	HEAD 'A'
CB1	HEAD 'D'
CB1	HEAD 'B'

Loop Detector Lead-in Cable & Loop Wire Table

Although loop detector lead-in cables are not shown on the chart, a separate loop detector lead-in cable **shall** be provided for each individual loop. This cable **shall** run from the cabinet base (CB) to the loop pull box used as the splice point. The detector lead-in cable **shall** be pulled thru each pull box without any additional loops or coils in each pull box. Excessive coils of detector lead in cables *may* affect the loop detector amplifier or detector card operation. At the splice point pull box, the detector cable **shall** extend 3 feet above the pull box cover for splicing purposes. At the control cabinet, the detector cable **shall** extend 3 feet above the top of the control cabinet to allow for future landing of the detector cables on the associated loop panel. Splices are made between the loop detector wire and the lead-in cable at the pull box at the side of the road.

Non-Intrusive Detection Cable Table

Non-Intrusive Detection cable **shall** be installed as shown on the plan and in accordance with the manufacturer's specifications. The cable **shall** be installed from the control cabinet to the device. The cable **shall** be routed through the underground conduit system using the shortest route. The type of cable along with the use of splices, signal repeaters/extenders, etc. **shall** be used according to manufacturer's specifications.

PROJECT ID:	0000-00-00
INTERSECTION:	STH XX and CTH XX

Signal Wire Color Coding			
	BLK - black	RED - red	GRN - green
	WHT - white	BLU - blue	ORG - orange

			SIGNAL INDICATION WIRE COLOR										
CB1 TO	AWG14 # OF CONDUCTORS	HEAD NO.	RED	YELLOW	GREEN	<RED>	<YELLOW>	<GREEN>	<FLASHING YELLOW>	D/WALK	WALK	PED BUTTON	OTHER
SB1	12	1	RED	ORG	GRN								

Equipment grounding conductor 10 AWG Green XLP	
From	TO

Pull Box Bonding Jumper 10 AWG Green XLP	
From	To

Lighting UF #12 w/ground	
From	To

EVP CABLE	
From	To

VIDEO DETECTION CABLE	
From	To

*Use the white conductor in the cable assembly as the grounded conductor for all traffic signal indications
*Ensure the grounded conductor in the feeder cable and the pole cables are both 18" longer than the ungrounded conductors.
*At the signal bases, connect one terminal from the pedestrian push buttons to the color indicated in the chart. Connect the other terminal to the grounded conductor.
*Reconnect the grounding conductors wherever the circuit has been interrupted to ensure the grounding circuit is complete.
*Reserve the Blue/Black conductor in the cable assembly as the APS conductor for all push buttons

UNDERGROUND PLAN FOR FUTURE SIGNALS

If during the design of an improvement project, especially on reconstruction projects, an intersection is deemed to be close to meeting warrants in the next several years, then the underground conduit system and pull boxes *may* be installed under the improvement project. The signal designer *should* obtain a U number (e.g., U-XX-1004) from the regional traffic unit for identification purposes, i.e., diggers hotline locates, etc.

If breaker run is used in the construction of the roadway, it is recommended that conduit be installed for future signal installations due to the inability to bore through breaker run. In addition, consideration *should* be given to installation of signal bases and pull boxes in medians and islands when breaker run is used.

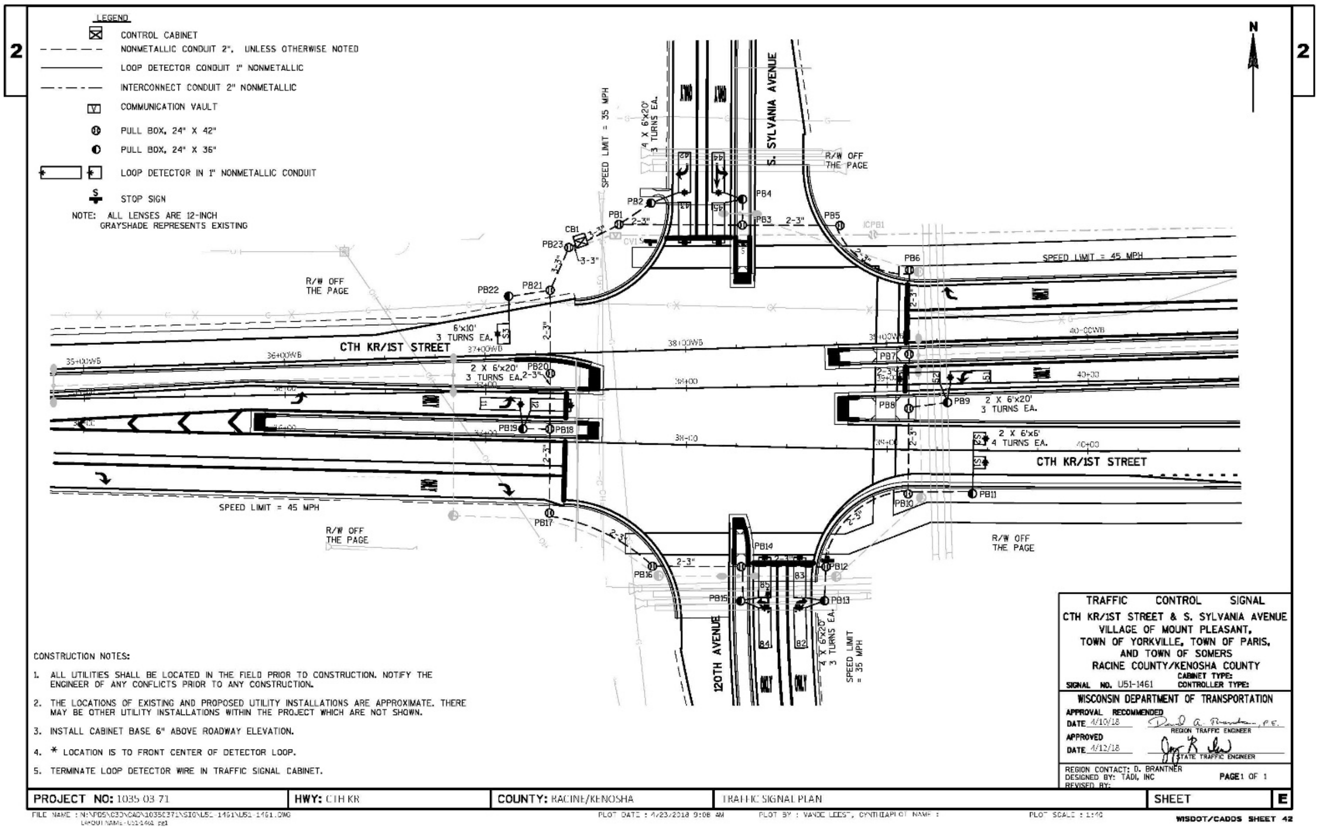
The conduit *should* be installed in an underground system around the complete intersection, not just under the roadway. The 24” diameter pull boxes *should* be installed at all angle points, medians and islands. Loop detector conduit *may* be installed at this time under the new concrete. If several adjacent intersections are being constructed, conduit for the interconnection of the future signals *may* also be installed. Additionally, according to standard specifications, a continuous pull wire **shall** be installed in all underground conduits for locate purposes. Loop detector wire *should* be installed in the loop detector conduit during construction with the number of turns indicated in the construction plans. Locate wire in loop conduit **shall** be accessible off the roadway.

The underground conduit system *should* be installed at a sufficient distance along the intersection approach to accommodate for future expansion of the intersection and installation of the future signals. Contact the Regional Traffic Signal Engineer for other considerations, such as possible future geometrics, i.e., turn lanes, radii, etc.

In concrete-capped medians and islands, box-outs *may* be added for future signal base placement. Box-outs *should* be sized so they will accommodate a standard concrete base. Conduits from the adjacent pull box *should* be stubbed and capped to the box-out.

Shown below is an example of an underground plan for a future signal.

Figure 1.3. Underground plan for a future signal



MISCELLANEOUS QUANTITIES

Plans **shall** be developed including the miscellaneous quantities according to the FDM 15-1-1, General Plan Preparation. The Regional and Central Office Traffic Signal staff will determine which specific plan type is required for each signal installation. Revisions to a plan that are not part of a let or permit project that will be performed by WisDOT forces, such as adding a left turn phase or right turn overlap, etc., do not require a miscellaneous quantities sheet, but will require a plan revision.

Let projects require a significant amount of information regarding the quantities. Discussions of these types of plans can be found in the FDM Chapter 19, PS&E.

MISCELLANEOUS QUANTITIES SHEET

The purpose of these sheets is to indicate specific types, sizes, and locations for the signal equipment at the intersection. The following are common items found in the electrical miscellaneous quantities sheet:

- SIGNAL HEADS
- SIGNAL POLES, LUMINARE POLES, MAST ARMS, BASES
- PULL BOXES
- CONDUIT, SPECIAL
- CONDUIT
- CONCRETE BASES
- MAJOR ITEMS REQUIRED FOR TRAFFIC DETECTORS
- CONCRETE CONTROL CABINET BASE
- CABLE, WIRE

Like items *should* be combined into one table to avoid several small tables. The item reference (i.e. signal base number, head number, pull box number, etc.) **shall** be included for all items labeled on the plan sheet of the signal installation. Station and offset reference *should* be linked only to items installed into the ground (i.e. pull boxes, concrete bases, detector loops, and control cabinet bases). Although not required, a solid line *may* be placed around each table to avoid confusion.

QUANTITY TAKE-OFF PROCEDURES

Methods used to estimate plan quantities follow standard engineering practices, which, for the most part, are self-explanatory. The following points *should* be reviewed prior to computing the final quantities.

Items must use same terminology as stated in the Standard Specifications, Supplemental Specifications, and Special Provisions.

Items appearing in the Miscellaneous Quantities Sheets (as part of the lump sum) **shall** be so noted.

All plan sheet item references (i.e. signal base number, head number, pull box number, etc.) **shall** be tied to the appropriate quantity.

All pay items must be shown in the Miscellaneous Quantities Sheet.

Station and offset references **shall** be used to locate pull boxes, concrete bases, detector loops, and control cabinet bases.

DETERMINING ELECTRICAL CABLE QUANTITIES

Tables 1.1, 1.2, and 1.3 show suggested cable measurements for poles, light poles, and monotubes that can be used to determine electrical cable quantities.

Table 1.1. Suggested cable measurements for poles

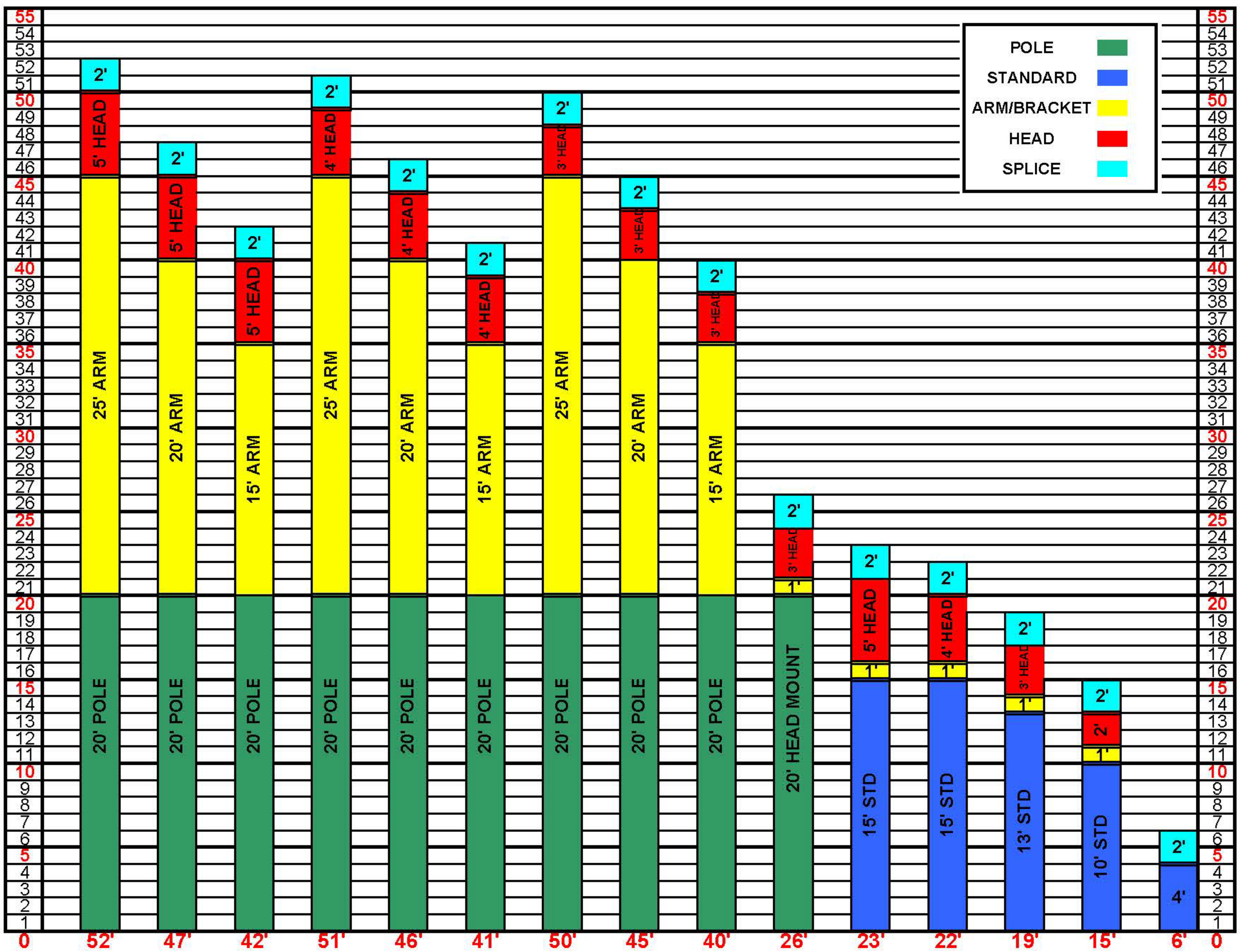


Table 1.2. Suggested cable measurements for light poles

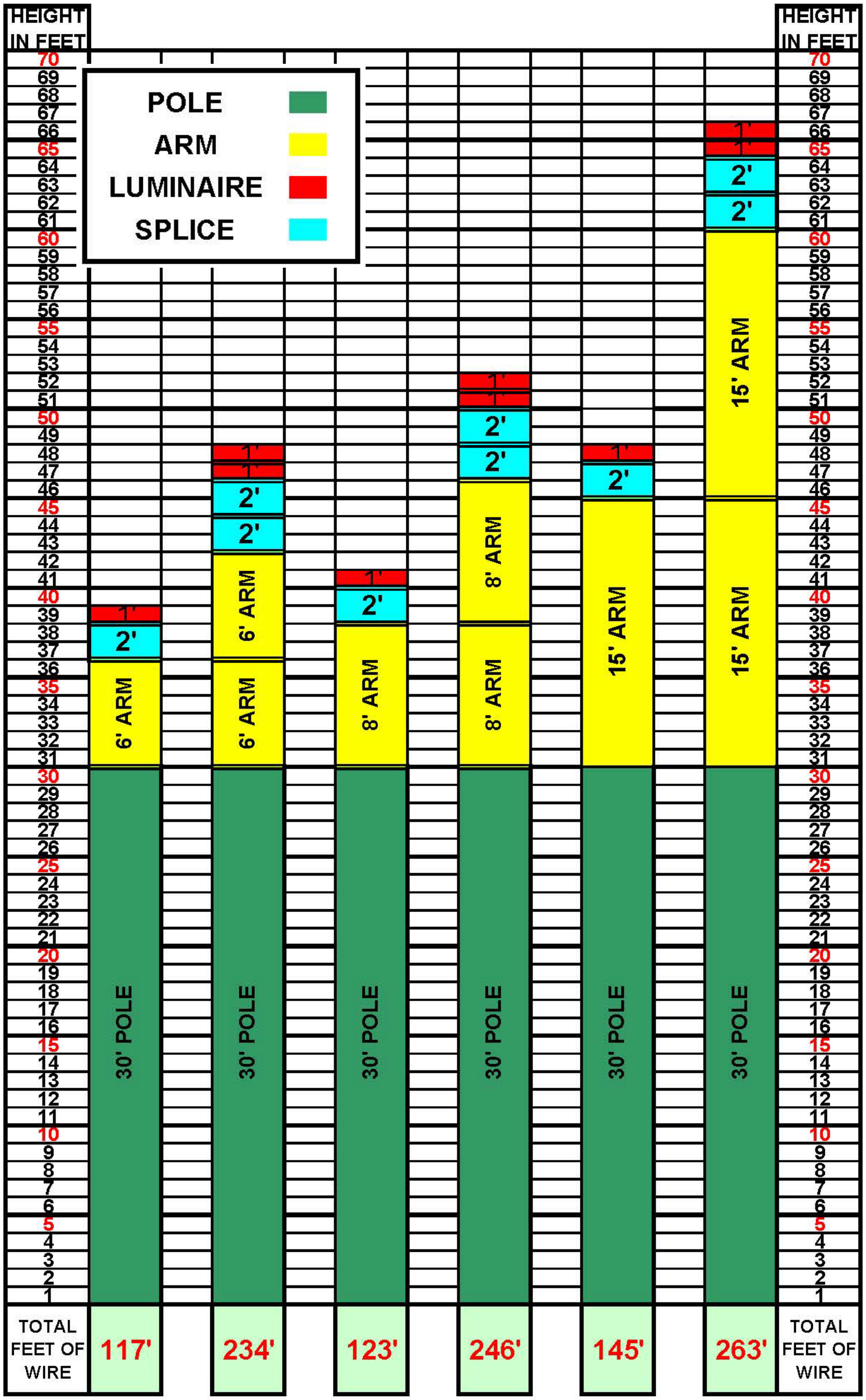
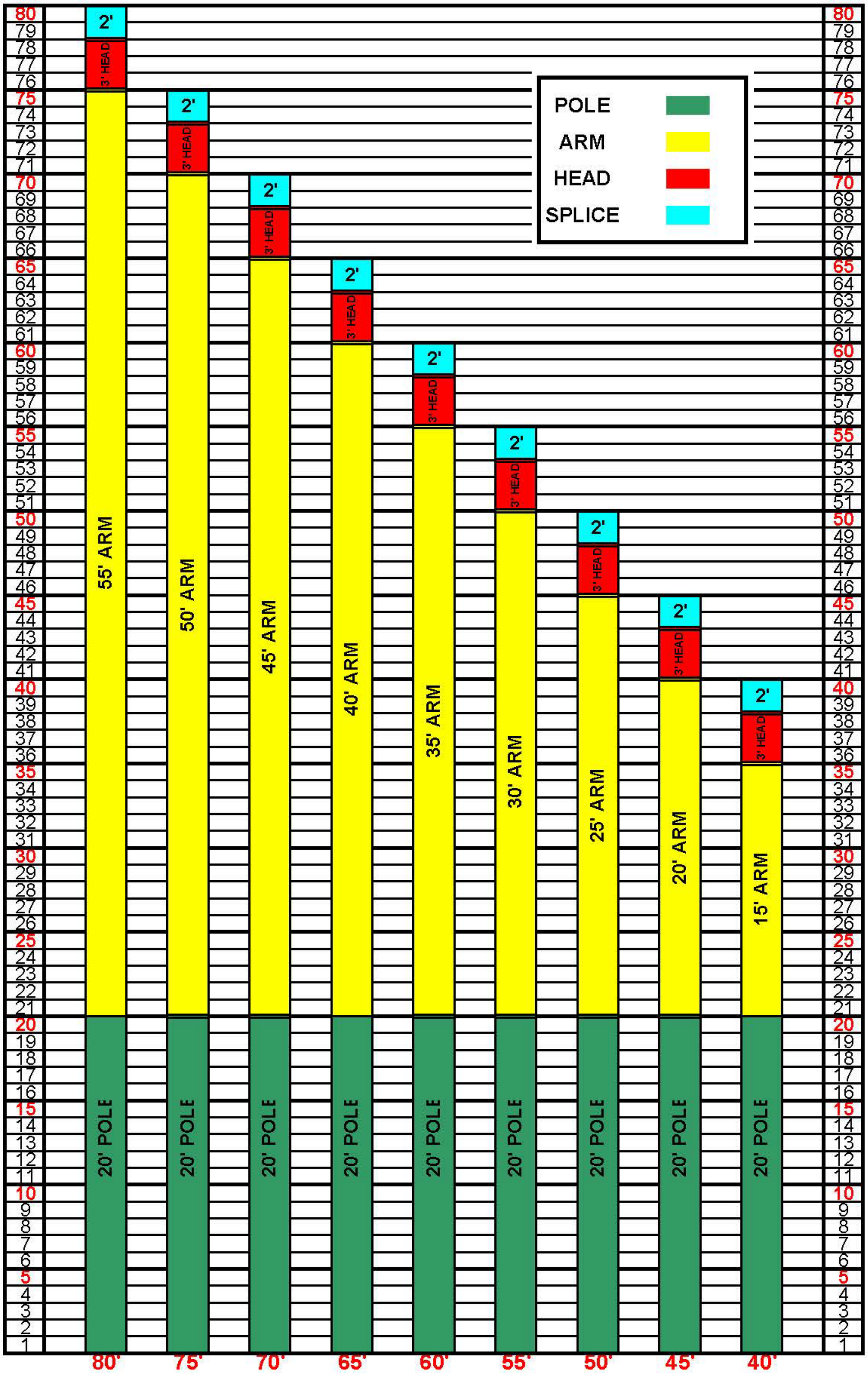


Table 1.3. Suggested cable measurements for monotubes



4-5-2 Signal Plan Revisions April 2025

Wherever an existing signal is modified, the change **shall** be reflected on the signal plan. Any change **shall** be documented in a revision block located in the bottom right of the signal plan sheet. Revisions **shall** be approved by Bureau of Traffic Operations Statewide Traffic Signal Engineer or a designated representative. Examples of these changes would include:

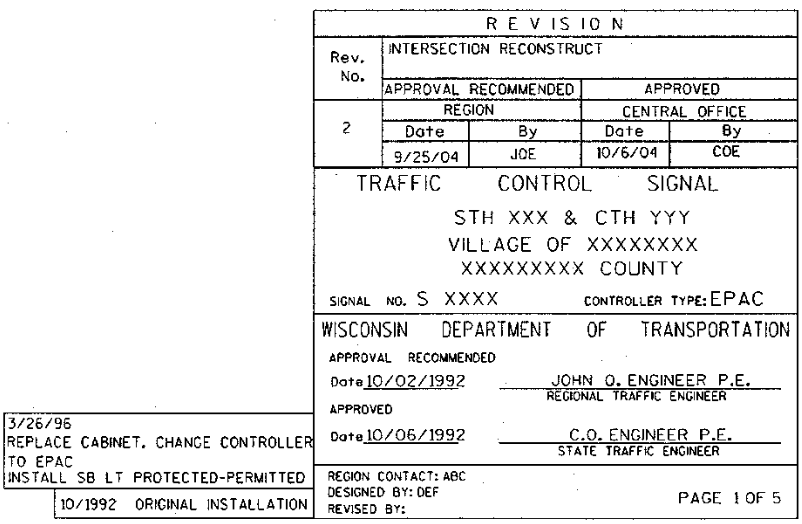
- adding pedestrian phasing and pushbuttons,
- modifying phasing, including reassigning to NEMA phasing,
- adding preemption,
- modifying detection design,
- modifying signal/lighting equipment,
- as-built plans, or
- other changes that would require a cabinet wire change.

An addition or deletion of a pull box, signal base, signal head, or detection to an existing installation does not require renumbering the existing PB, SB, etc. on the signal plan; the next consecutive number *should* be used.

Only one revision block will appear on the signal plan. Any previous revisions will be noted along with the date approved in history blocks, as shown in the example in Figure 2.1. The original signature block and signature *should* remain on the plan. With a CADD-prepared plan, the name of the original signers and dates *should* be inserted in place of the original signatures (see example).

Revised signal plans **shall** bear the initials of a Regional Traffic Signal Unit Professional Engineer. In addition, plans not developed by WisDOT staff **shall** include the stamp and signature of the Professional Engineer.

Figure 2.1. Sample History, Signature and Revision Blocks



4-5-3 Signal Plan Development Process April 2025

The PS&E review process is covered in FDM Chapter 3 and Chapter 19. Signal Plans that will require right-of-way acquisition, utility relocation, or railroad coordination *may* require greater coordination efforts. Approval of the traffic signal plan set at the Regional level is required to occur prior to the final submittal. The level of coordination between individuals developing the plan set and the regional traffic section is dependent on the project complexity.

Bureau of Project Development has set specific schedules for PS&E submittal. Chapter 19 of the FDM presents a detailed description of the review process, schedule/timing, and plan composition. The signal plan set within the PS&E *should* include the following sheets:

1. Plan Sheet(s)
2. Sequence of Operations Sheet
3. Cable routing sheet

And if applicable:

1. Temporary signal plan and timings

2. Temporary Sequence of Operations Sheet
3. Miscellaneous quantities for electrical items
4. Engineering estimate for electrical items
5. Special provisions pertaining to electrical items
6. Signal Removal plans
7. Details of non-standard items
8. List of SDDs, general construction notes, and construction details pertaining to electrical items

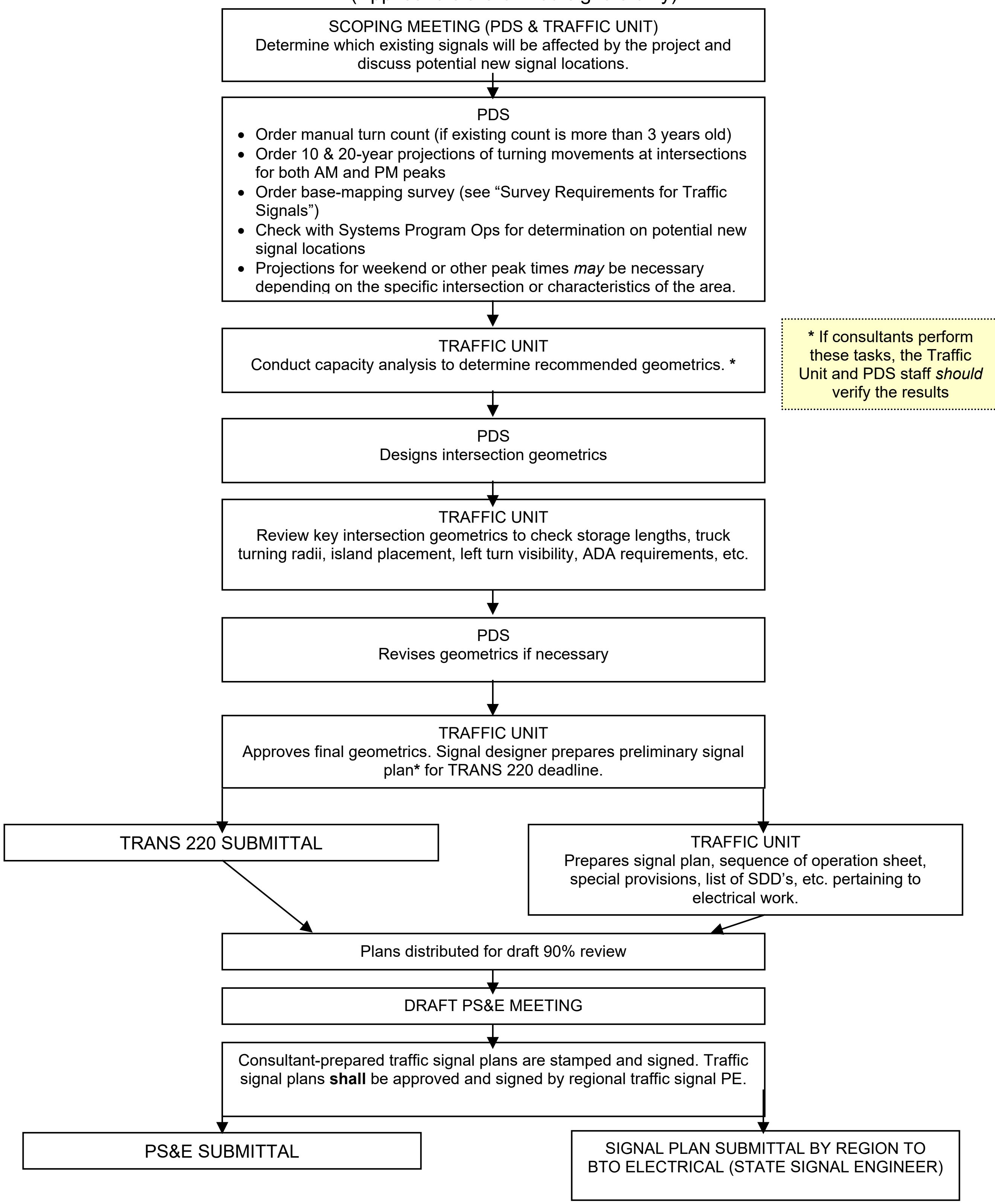
In cases where the maintaining authority is not the State (i.e. municipality, county, connecting highway), yet is installed through a state administered project on the local system, Regional Traffic Signal Engineers *may* provide a cursory plan review, however the ultimate maintaining authority will be responsible for the final design and approval.

Any questions regarding the approval process *should* be directed to the Bureau of Project Development.

Other necessary items that are part of the PS&E are the engineers' estimate plan letter and special provisions, and contract time for completion, etc., are the responsibility of the project manager.

SIGNAL PLAN DEVELOPMENT IN THE PS&E PROCESS

(Applies to state-owned signals only)



PERMIT PROJECTS

At times, signals or other roadway improvements are needed to mitigate adverse traffic impacts caused by land development. Signals that are designed and installed as a condition of an Access Permit (DT1646) or a Work on Highway Right-of-Way (DT1812) are referred to more generally as Permit Projects. Depending on the improvement program schedule, separate improvements that are required because of a development can be implemented through a let or non-let process, with cost-share provisions. Non-let projects can be performed by contract or State Forces. Signals that are warranted due to these situations are done so as part of a Traffic Impact Analysis (TIA).

Permit Project plan set will include:

1. Title Sheet
2. Signal Plan Set
3. Sequence of Operations Sheet
4. Miscellaneous Quantities
5. Special Provisions
6. Special Details
7. Standard Detail Drawings

Costs for State furnished materials and labor that are expended while overseeing Permit Projects *should* be assigned to the local municipality or developer responsible for the project.

SIGNAL PLAN DEVELOPMENT IN THE PERMIT PROCESS
(Applies to permit projects only)

Meeting between Traffic Section and Developer to discuss specifics / scope of project (typically cited by TIA).

↓

PDS / CONSULTANT
Designs intersection geometrics

↓

TRAFFIC UNIT
Review key intersection geometrics for operations (check storage lengths, truck turning radii, island placement, left turn visibility, ADA requirements, etc.)

↓

PDS / CONSULTANT
Revises geometrics if necessary

↓

TRAFFIC UNIT
Approves final geometrics. Signal designer prepares preliminary signal plan* for TRANS 220 deadline.

↓

TRAFFIC UNIT / CONSULTANT
Prepares signal plan, sequence of operation sheet, special provisions, list of SDD's, etc. pertaining to electrical work. *

↓

Plans distributed for draft 90% review

↓

90% DRAFT PLAN MEETING

↓

Consultant-prepared traffic signal plans are stamped. Traffic signal plans **shall** be approved and signed by regional traffic signal PE.

↓

FINAL PLAN SUBMITTAL

* If consultants perform these tasks, the Traffic Unit and PDS staff *should* review the results

4-5-4 Sample Plan Sheets April 2025

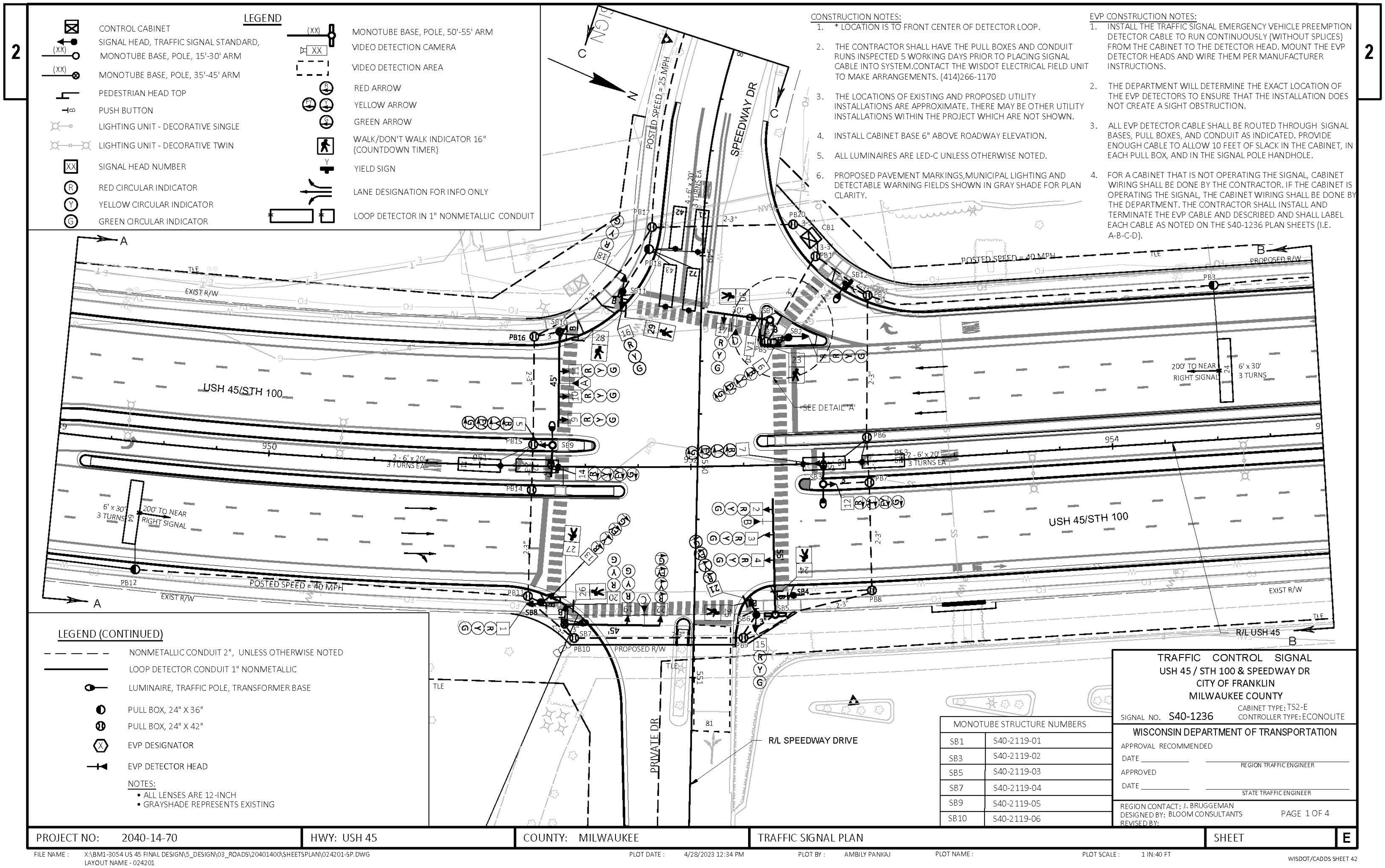
The following plan sets illustrate the possible stages a typical signalized intersection *may* go through when creating/revising traffic signal control plans of an example intersection. FDM 15-1-5 covers sample plans for all types of improvement projects.

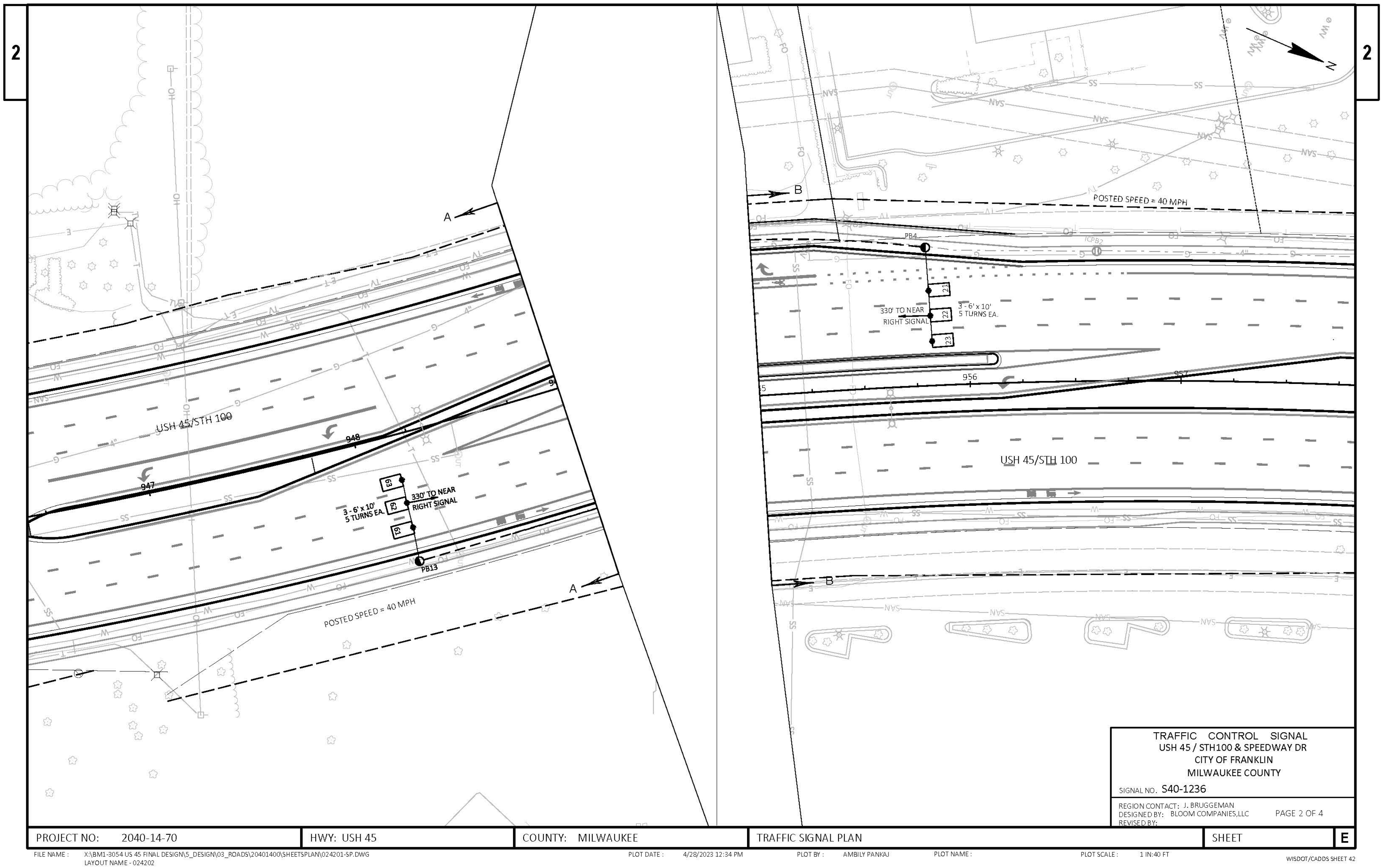
Example Plan Sets

1. Original plan with existing geometrics
2. Removal plan
3. Temporary plan
4. Revision plan (add monotubes)
5. Signalized intersection plan with railroad preemption
6. Single controller plan at an interchange (dual ring with overlaps)
7. TTI Phasing plan at an interchange

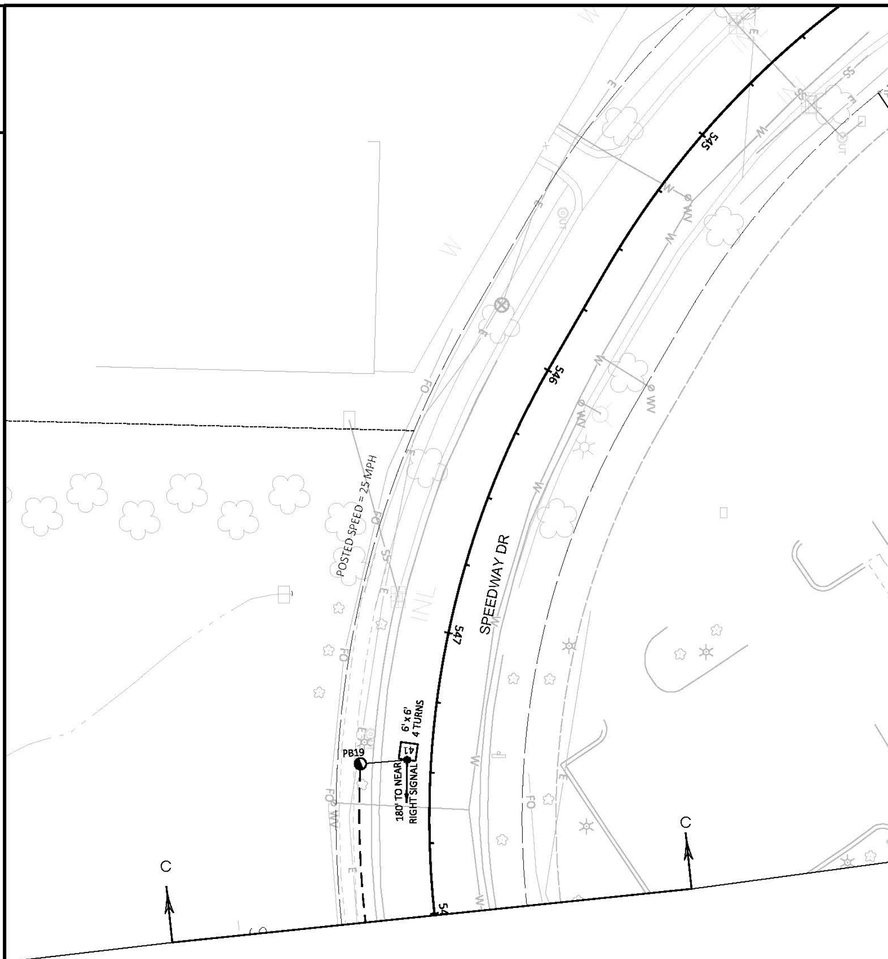
These sample traffic signal plans are strictly for reference. These plans attempt to demonstrate various signal operations and applications of special features (EVP, railroad, interchanges, overlaps). The Regional Traffic Signal Engineering staff *should* be involved during the development of traffic signal plans or special applications.

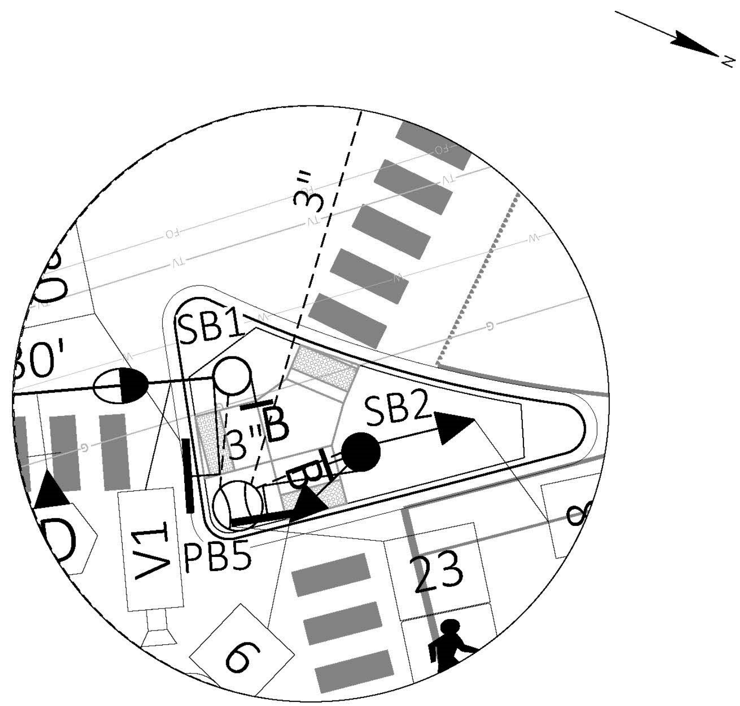
Example 1. Original plan with existing geometrics (4 sheets)




2
2
USH 45/STH 100
POSTED SPEED = 40 MPH
3 - 6' x 10'
5 TURNS EA.
330' TO NEAR
RIGHT SIGNAL
PB13
PB4
956
957
947
948
A
B
TRAFFIC CONTROL SIGNAL
USH 45 / STH100 & SPEEDWAY DR
CITY OF FRANKLIN
MILWAUKEE COUNTY
SIGNAL NO. S40-1236
REGION CONTACT: J. BRUGGEMAN
DESIGNED BY: BLOOM COMPANIES,LLC
PAGE 2 OF 4
REVISED BY:
PROJECT NO: 2040-14-70
HWY: USH 45
COUNTY: MILWAUKEE
TRAFFIC SIGNAL PLAN
SHEET
E
FILE NAME : X:\BM1-3054 US 45 FINAL DESIGN\5_DESIGN\03_ROADS\20401400\SHEETSPLAN\024201-SP.DWG
LAYOUT NAME - 024202
PLOT DATE : 4/28/2023 12:34 PM
PLOT BY : AMBILY PANKAJ
PLOT NAME :
PLOT SCALE : 1 IN:40 FT
WISDOT/CADDS SHEET 42

2





DETAIL 'A'

2

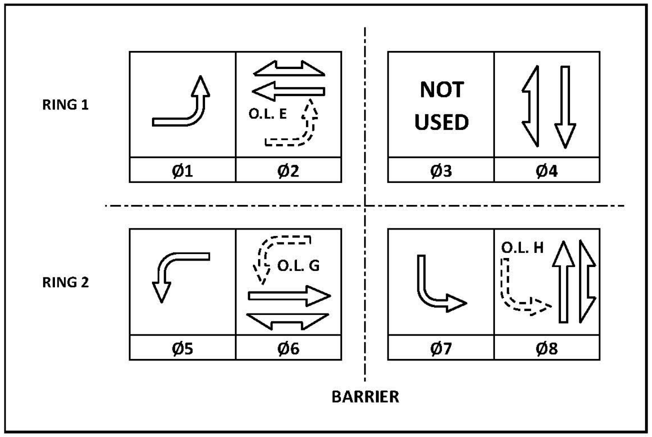
TRAFFIC CONTROL SIGNAL USH 45 / STH100 & SPEEDWAY DR CITY OF FRANKLIN MILWAUKEE COUNTY	
SIGNAL NO. S40-1236	
REGION CONTACT: J. BRUGGEMAN DESIGNED BY: BLOOM COMPANIES,LLC REVISED BY:	PAGE 3 OF 4

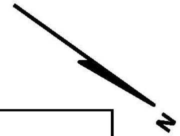
PROJECT NO: 2040-14-70	HWY: USH 45	COUNTY: MILWAUKEE	TRAFFIC SIGNAL PLAN	SHEET	E

FILE NAME : X:\BM1-3054 US 45 FINAL DESIGN\5_DESIGN\03_ROADS\20401400\SHEETSPLAN\024201-SP.DWG
LAYOUT NAME - 024203
PLOT DATE : 4/28/2023 12:34 PM PLOT BY : AMBILY PANKAJ PLOT NAME : PLOT SCALE : ##########
WISDOT/CADDS SHEET 42

2

	HEAD NUMBERS	FLASH
Ø1	5,6,7	R ←
Ø2	8,9,10,11	R
Ø3		
Ø4	18,19,20	R
Ø5	12,13,14	R ←
Ø6	1,2,3,4	R
Ø7	21,22	R ←
Ø8	15,16,17	R
Ø2P	29,30	
Ø4P	27,28	
Ø6P	25,26	
Ø8P	23,24	
OLE	5,6,7	-
OLF		
OLG	12,13,14	-
OLH	18,19	-





CONTROLLER LOGIC

PHASE NUMBER	PHASE LOCKING	DUAL ENTRY W / Ø	PHASE RECALL	PHASE ACTIVE
1		6		X
2	X	6	MIN	X
3				
4		8		X
5		2		X
6	X	2	MIN	X
7		4		X
8		4		X

EMERGENCY VEHICLE PREEMPTION SEQUENCE

EMERGENCY VEHICLE PREEMPTOR	A	B	C	D
MOVEMENT				
PHASE	2+5	1+6	4+7	8

AFTER PREEMPTION SEQUENCE 2+5 OR 1+6, CONTROLLER SHALL RETURN TO PHASES 2+6.
AFTER PREEMPTION SEQUENCE 4+7 OR 8, CONTROLLER SHALL RETURN TO PHASES 4+8.

TYPE OF INTERCONNECT/COMMUNICATION	
NONE	
CLOSED LOOP	
TWISTED PAIR	
FIBER OPTIC*	
FIBER OPTIC (ETHERNET)	X
RADIO	
CELL MODEM	

TYPE OF COORDINATION	
NONE	
TBC	X
TRAFFIC RESPONSIVE	
ADAPTIVE	
*LOCATION OF MASTER CONTROLLER NO: S-	
SIGNAL SYSTEM NO: SS-	

TYPE OF LIGHTING	
BY OTHER AGENCY	
IN TRAFFIC CABINET	X
IN SEPARATE DOT LIGHTING CABINET	

TYPE OF PRE-EMPT	
NONE	
RAILROAD	
EMERGENCY VEHICLE	X
GTT	
TOMAR	X
HARDWIRE	
OTHER	
CONFIRMATION LIGHTS	
LIFT BRIDGE	
QUEUE DETECTION	

DETECTOR LOGIC

DETECTOR INPUT	3	1	7	5	11	9	15	13
PLAN LOOP DETECTOR*(S)	11	21	23	41	43	51	61	63
CALLED PHASE	1	2	2	4	4	5	6	6
CALL OPTION	X	X	X		X	X	X	X
DELAY TIME					X			
EXTENTION OPTION	X	X	X	X	X	X	X	X
EXTEND TIME				X				
USE ADDED INITIAL		X	X				X	X
CROSS SWITCH PHASE	2					6		

DETECTOR INPUT	19	17	23	21	27	33	37	29
PLAN LOOP DETECTOR*(S)	71		81					
CALLED PHASE	7		8					
CALL OPTION	X		X					
DELAY TIME								
EXTENTION OPTION	X		X					
EXTEND TIME								
USE ADDED INITIAL								
CROSS SWITCH PHASE	8							

DETECTOR INPUT	4	2	8	6	12	10	16	14
PLAN LOOP DETECTOR*(S)	12	22	24	42		52	62	64
CALLED PHASE	1	2	2	4		5	6	6
CALL OPTION	X	X	X	X		X	X	X
DELAY TIME				X				
EXTENTION OPTION	X	X	X	X		X	X	X
EXTEND TIME								
USE ADDED INITIAL		X	X				X	X
CROSS SWITCH PHASE	2					6		

DETECTOR INPUT	20	18	24	22	28	34	38	30
PLAN LOOP DETECTOR*(S)	72							
CALLED PHASE	7							
CALL OPTION	X							
DELAY TIME								
EXTENTION OPTION	X							
EXTEND TIME								
USE ADDED INITIAL								
CROSS SWITCH PHASE	8							

GENERAL NOTES:

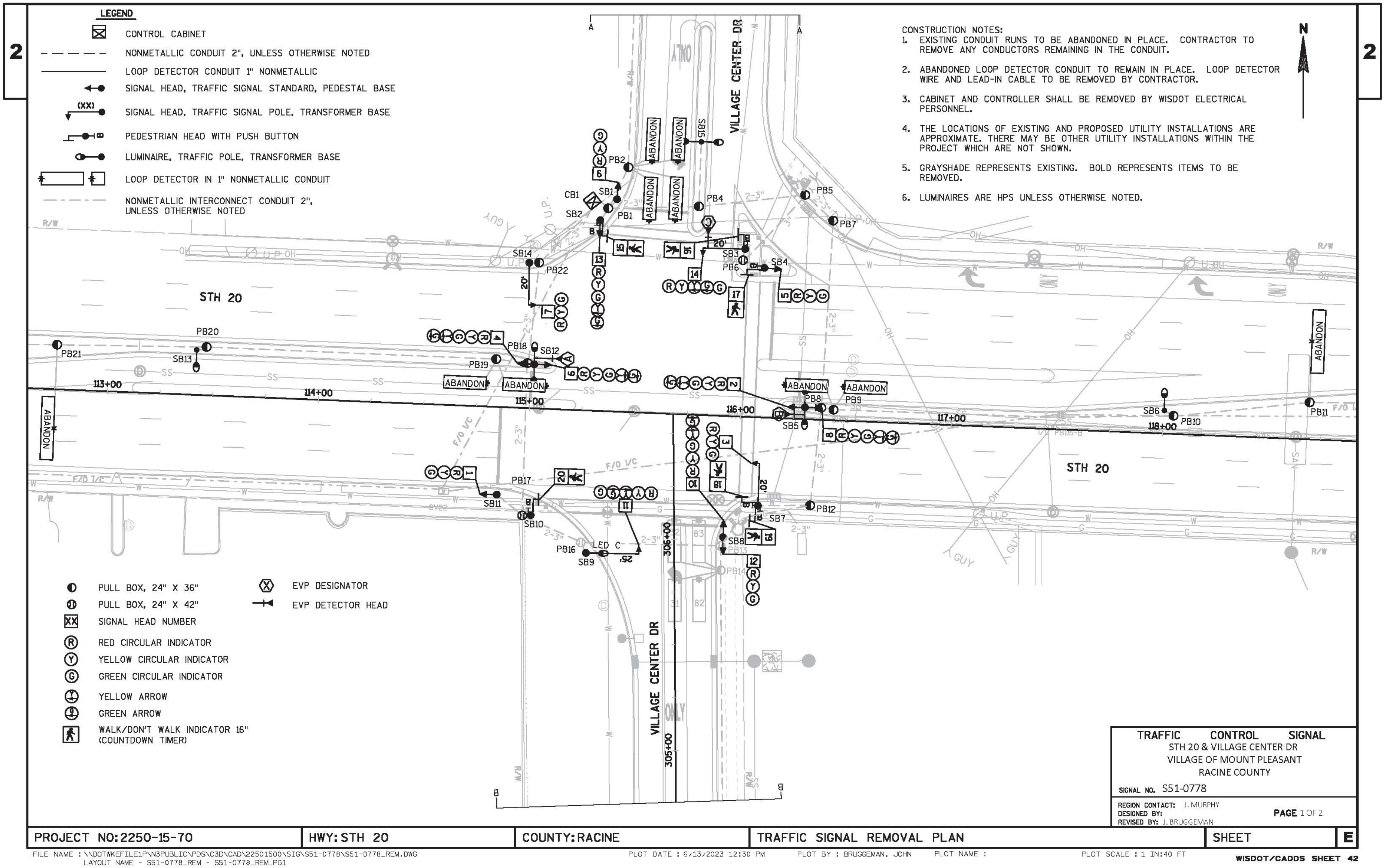
1.

USH 45 / STH 100 & SPEEDWAY DR
CITY OF FRANKLIN
MILWAUKEE COUNTY
SIGNAL NO: S40-1236 CABINET TYPE: TS2-E
CONTROLLER TYPE: ECONOLITE
DATE: 05/2023 PAGE NUMBER: 4 OF 4

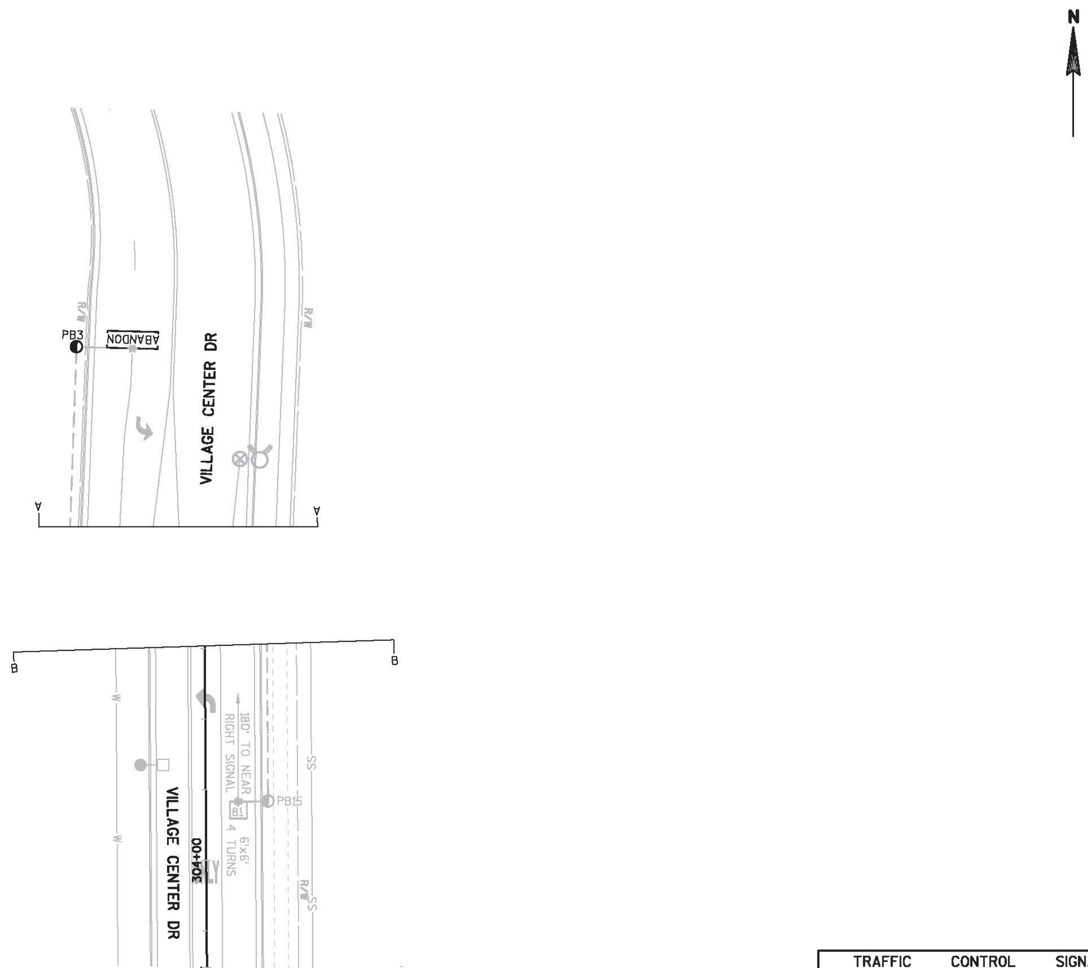
PROJECT NO: 2040-14-70 | HWY: USH 45 | COUNTY: MILWAUKEE | SEQUENCE OF OPERATIONS | SHEET NO: | E

FILE NAME: X:\BM1-3054 US 45 Final Design\5_Design\03_Roads\20401400\SheetsPlan\Speedway\TS2-S_E_FYA_EFGH_Econolite_SEQ.xlsx PLOT DATE: 4/28/2023 PLOT NAME: TS2-S_E_FYA_EFGH_Econolite_SEQ.xlsx PLOT BY: ______ PLOT SCALE: 1:1

Example 2. Removal Plan (2 sheets)



2



2

TRAFFIC CONTROL SIGNAL
STH 20 & VILLAGE CENTER DR
VILLAGE OF MOUNT PLEASANT
RACINE COUNTY

SIGNAL NO. S51-0778

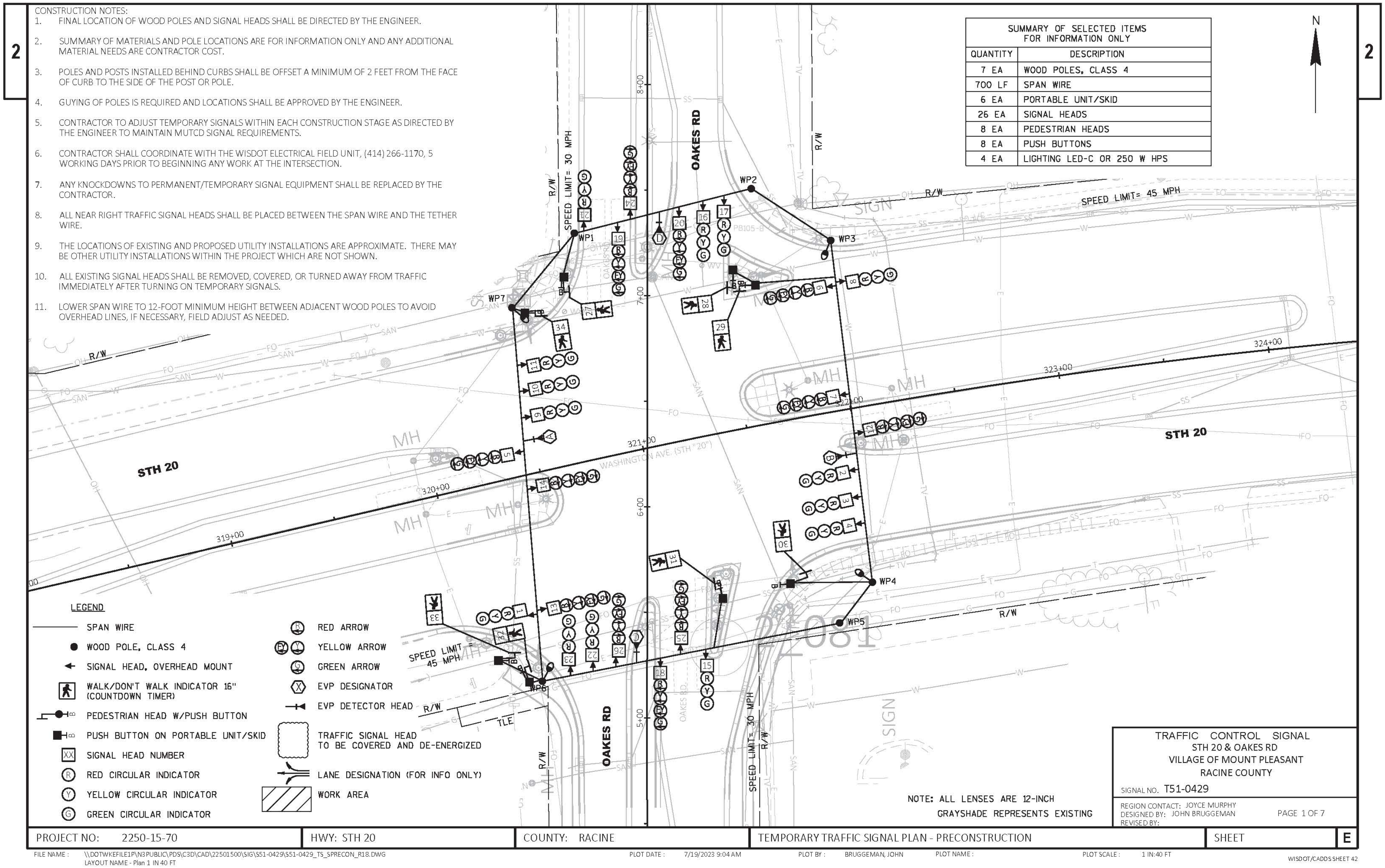
REGION CONTACT: J. MURPHY
DESIGNED BY:
REVISED BY: J. BRUGGEMAN

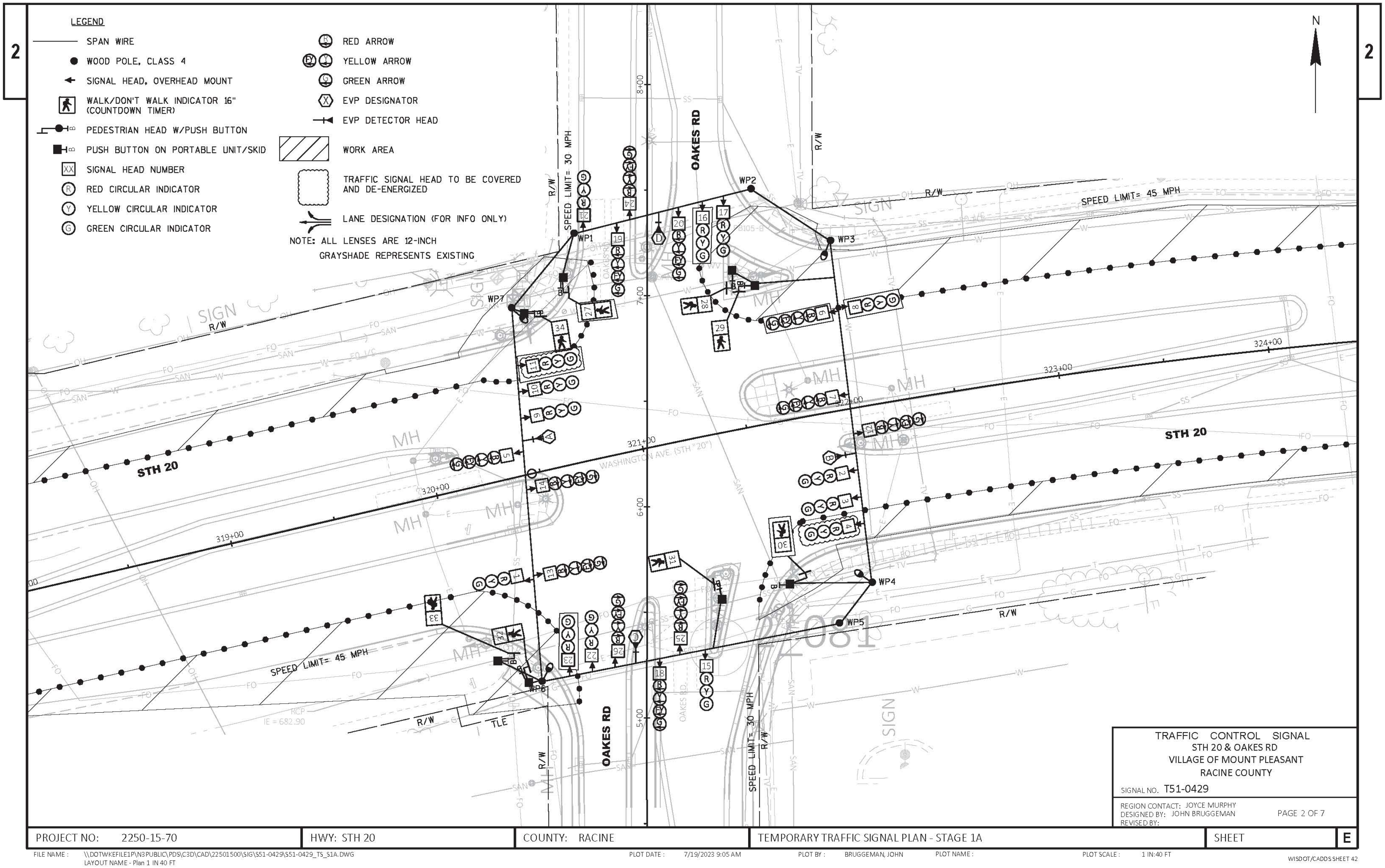
PAGE 2 OF 2

PROJECT NO:2250-15-70	HWY:STH 20	COUNTY:RACINE	TRAFFIC SIGNAL REMOVAL PLAN	SHEET	E

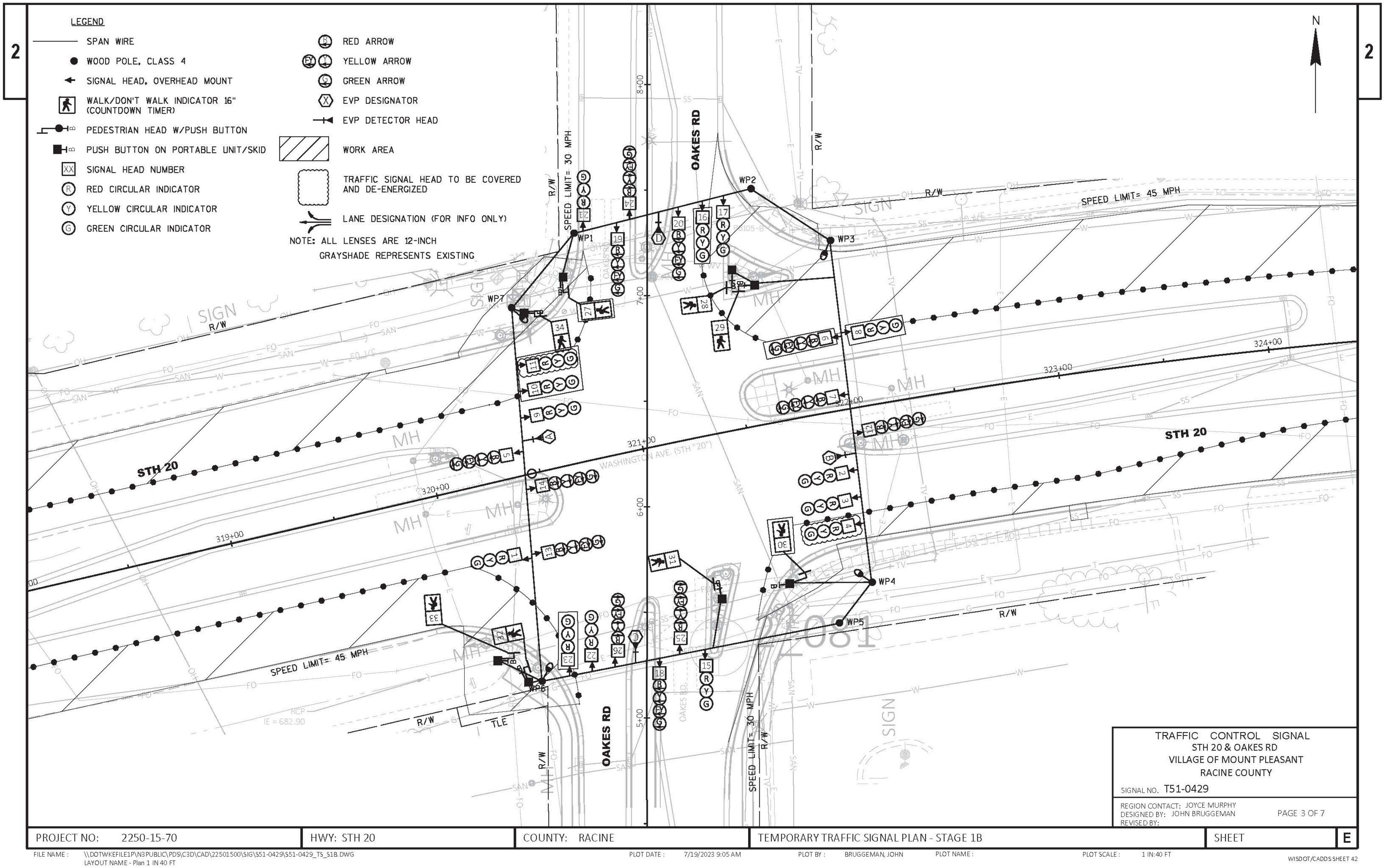
FILE NAME : \\DOTWKEFILE1P\N3PUBLIC\PDS\C3D\CAD\22501500\SIG\S51-0778\S51-0778_REM.DWG
LAYOUT NAME - S51-0778_REM - S51-0778_REM_PG2
PLOT DATE : 6/13/2023 12:30 PM PLOT BY : BRUGGEMAN, JOHN PLOT NAME : PLOT SCALE : 1 IN:40 FT
WISDOT/CADDS SHEET 42

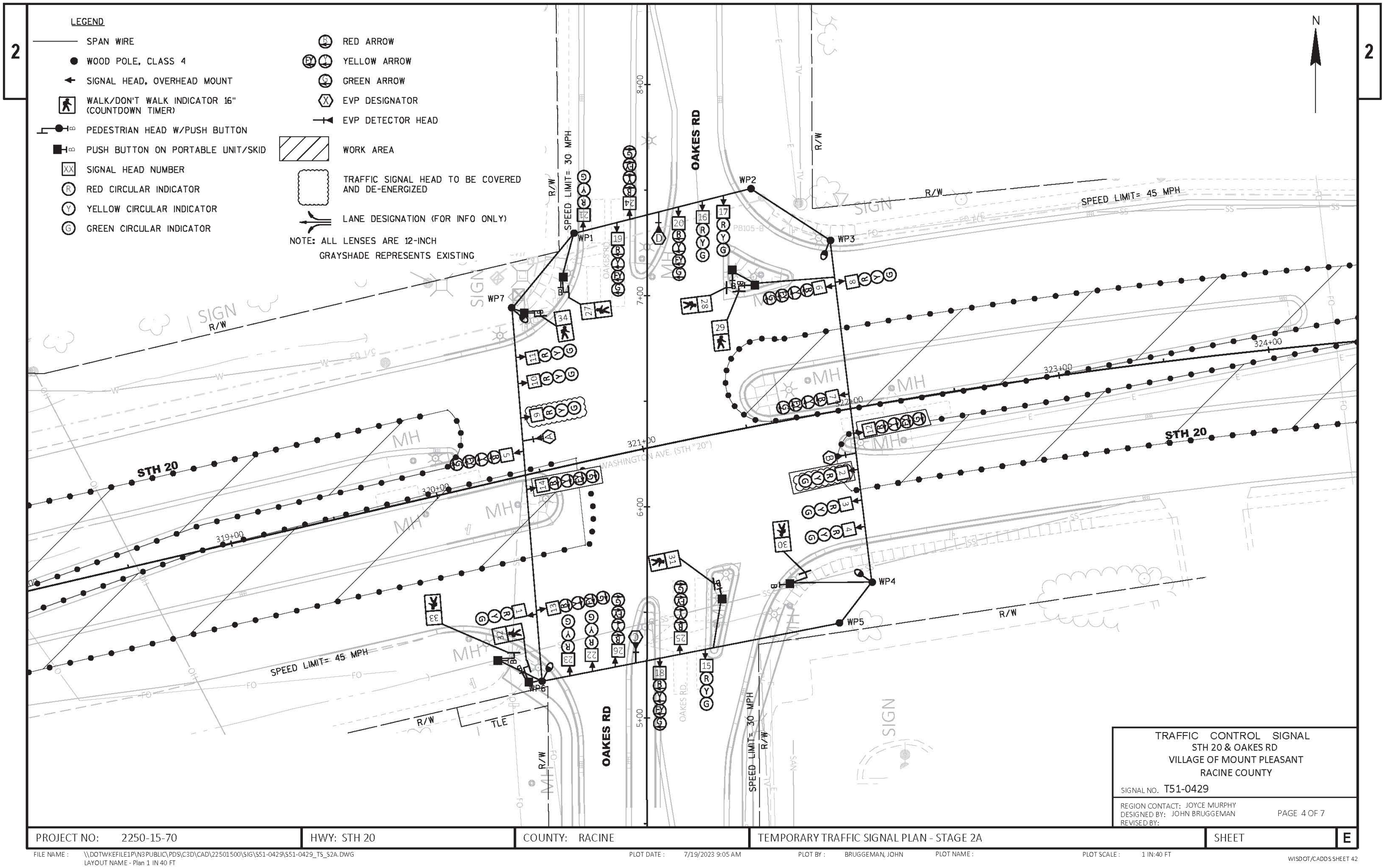
Example 3. Temporary Signal Plan (7 sheets)

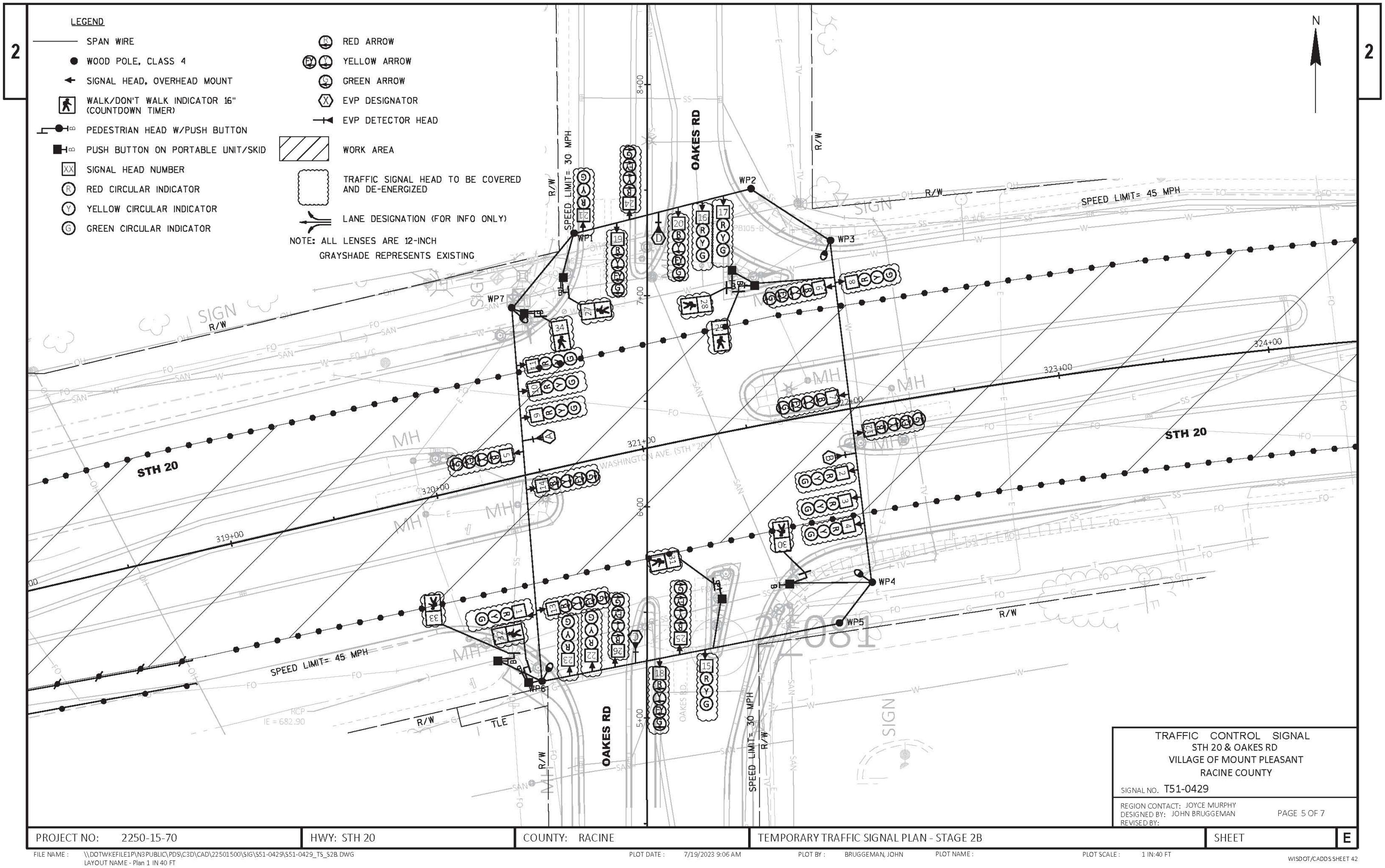


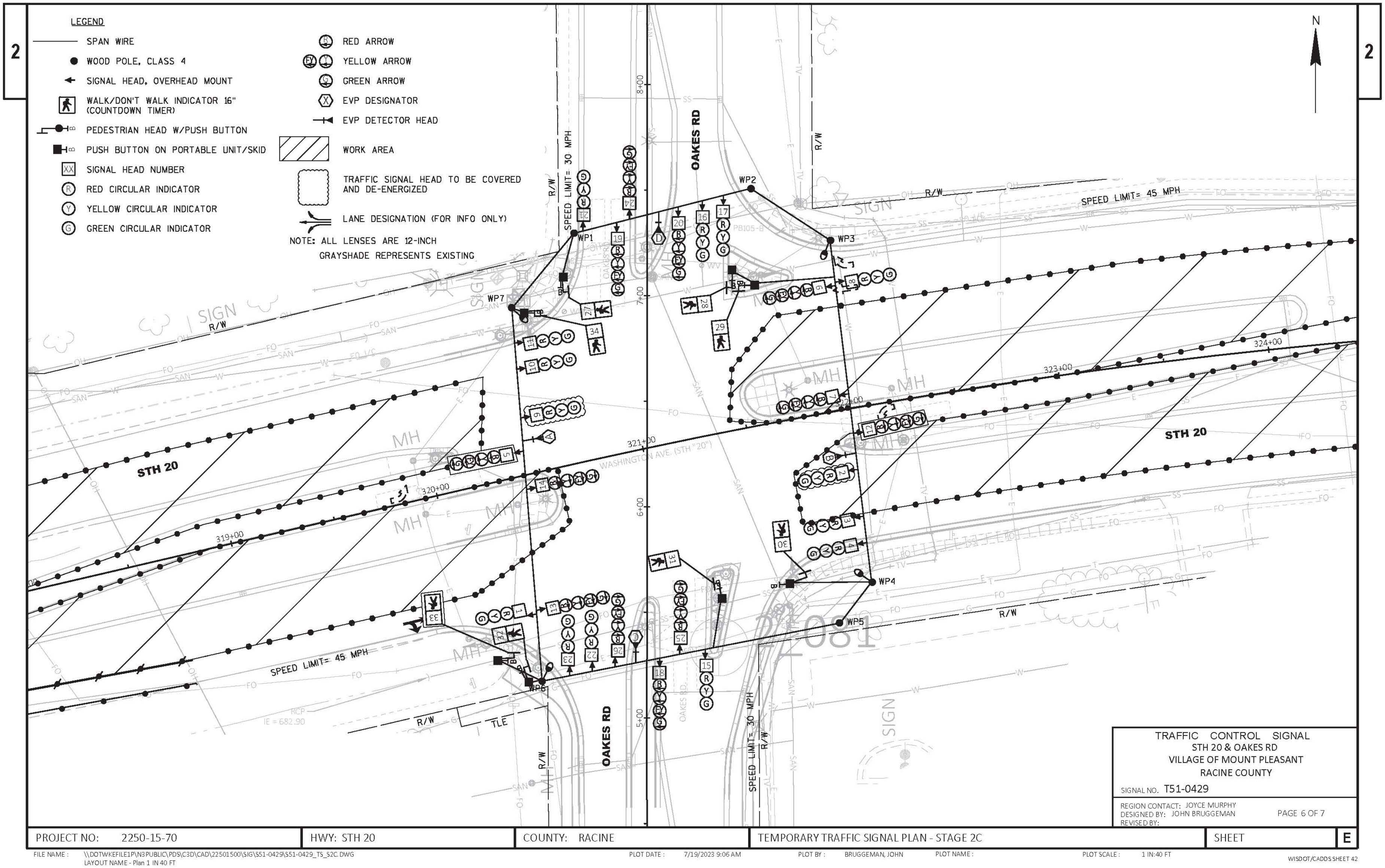


LEGEND
SPAN WIRE
WOOD POLE, CLASS 4
SIGNAL HEAD, OVERHEAD MOUNT
WALK/DON'T WALK INDICATOR 16" (COUNTDOWN TIMER)
PEDESTRIAN HEAD W/PUSH BUTTON
PUSH BUTTON ON PORTABLE UNIT/SKID
SIGNAL HEAD NUMBER
RED CIRCULAR INDICATOR
YELLOW CIRCULAR INDICATOR
GREEN CIRCULAR INDICATOR
RED ARROW
YELLOW ARROW
GREEN ARROW
EVP DESIGNATOR
EVP DETECTOR HEAD
WORK AREA
TRAFFIC SIGNAL HEAD TO BE COVERED AND DE-ENERGIZED
LANE DESIGNATION (FOR INFO ONLY)
NOTE: ALL LENSES ARE 12-INCH
GRAYSHADE REPRESENTS EXISTING
OAKES RD
STH 20
SPEED LIMIT= 30 MPH
SPEED LIMIT= 45 MPH
WP1
WP2
WP3
WP4
WP5
WP6
WP7
R/W
N
TRAFFIC CONTROL SIGNAL
STH 20 & OAKES RD
VILLAGE OF MOUNT PLEASANT
RACINE COUNTY
SIGNAL NO. T51-0429
REGION CONTACT: JOYCE MURPHY
DESIGNED BY: JOHN BRUGGEMAN
REVISED BY:
PAGE 2 OF 7
PROJECT NO: 2250-15-70
HWY: STH 20
COUNTY: RACINE
TEMPORARY TRAFFIC SIGNAL PLAN - STAGE 1A
SHEET
E
PLOT DATE: 7/19/2023 9:05 AM
PLOT BY: BRUGGEMAN, JOHN
PLOT SCALE: 1 IN:40 FT
WISDOT/CADDS SHEET 42


LEGEND
SPAN WIRE
WOOD POLE, CLASS 4
SIGNAL HEAD, OVERHEAD MOUNT
WALK/DON'T WALK INDICATOR 16" (COUNTDOWN TIMER)
PEDESTRIAN HEAD W/PUSH BUTTON
PUSH BUTTON ON PORTABLE UNIT/SKID
SIGNAL HEAD NUMBER
RED CIRCULAR INDICATOR
YELLOW CIRCULAR INDICATOR
GREEN CIRCULAR INDICATOR
RED ARROW
YELLOW ARROW
GREEN ARROW
EVP DESIGNATOR
EVP DETECTOR HEAD
WORK AREA
TRAFFIC SIGNAL HEAD TO BE COVERED AND DE-ENERGIZED
LANE DESIGNATION (FOR INFO ONLY)
NOTE: ALL LENSES ARE 12-INCH
GRAYSHADE REPRESENTS EXISTING
OAKES RD
STH 20
SPEED LIMIT= 30 MPH
SPEED LIMIT= 45 MPH
WP1
WP2
WP3
WP4
WP5
WP6
WP7
TRAFFIC CONTROL SIGNAL
STH 20 & OAKES RD
VILLAGE OF MOUNT PLEASANT
RACINE COUNTY
SIGNAL NO. T51-0429
REGION CONTACT: JOYCE MURPHY
DESIGNED BY: JOHN BRUGGEMAN
PAGE 3 OF 7
REVISED BY:
PROJECT NO: 2250-15-70
HWY: STH 20
COUNTY: RACINE
TEMPORARY TRAFFIC SIGNAL PLAN - STAGE 1B
SHEET
E
PLOT DATE: 7/19/2023 9:05 AM
PLOT BY: BRUGGEMAN, JOHN
PLOT SCALE: 1 IN:40 FT
WISDOT/CADDS SHEET 42

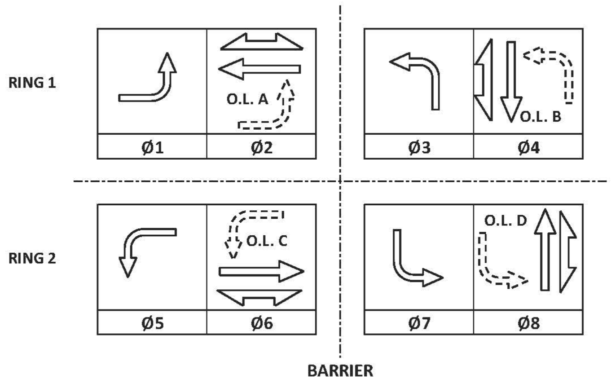

LEGEND
SPAN WIRE
WOOD POLE, CLASS 4
SIGNAL HEAD, OVERHEAD MOUNT
WALK/DON'T WALK INDICATOR 16" (COUNTDOWN TIMER)
PEDESTRIAN HEAD W/PUSH BUTTON
PUSH BUTTON ON PORTABLE UNIT/SKID
SIGNAL HEAD NUMBER
RED CIRCULAR INDICATOR
YELLOW CIRCULAR INDICATOR
GREEN CIRCULAR INDICATOR
RED ARROW
YELLOW ARROW
GREEN ARROW
EVP DESIGNATOR
EVP DETECTOR HEAD
WORK AREA
TRAFFIC SIGNAL HEAD TO BE COVERED AND DE-ENERGIZED
LANE DESIGNATION (FOR INFO ONLY)
NOTE: ALL LENSES ARE 12-INCH
GRAYSHADE REPRESENTS EXISTING
N
OAKES RD
STH 20
SPEED LIMIT= 30 MPH
SPEED LIMIT= 45 MPH
WASHINGTON AVE. (STH "20")
WP1
WP2
WP3
WP4
WP5
WP6
WP7
R/W
TLE
TRAFFIC CONTROL SIGNAL
STH 20 & OAKES RD
VILLAGE OF MOUNT PLEASANT
RACINE COUNTY
SIGNAL NO. T51-0429
REGION CONTACT: JOYCE MURPHY
DESIGNED BY: JOHN BRUGGEMAN
REVISED BY:
PAGE 4 OF 7
PROJECT NO: 2250-15-70
HWY: STH 20
COUNTY: RACINE
TEMPORARY TRAFFIC SIGNAL PLAN - STAGE 2A
SHEET
E
FILE NAME : \\DOTWKEFILE1P\N3PUBLIC\PDS\C3D\CAD\22501500\SIG\S51-0429\S51-0429_TS_S2A.DWG
LAYOUT NAME - Plan 1 IN 40 FT
PLOT DATE : 7/19/2023 9:05 AM
PLOT BY : BRUGGEMAN, JOHN
PLOT NAME :
PLOT SCALE : 1 IN:40 FT
WISDOT/CADDS SHEET 42


LEGEND
SPAN WIRE
WOOD POLE, CLASS 4
SIGNAL HEAD, OVERHEAD MOUNT
WALK/DON'T WALK INDICATOR 16" (COUNTDOWN TIMER)
PEDESTRIAN HEAD W/PUSH BUTTON
PUSH BUTTON ON PORTABLE UNIT/SKID
SIGNAL HEAD NUMBER
RED CIRCULAR INDICATOR
YELLOW CIRCULAR INDICATOR
GREEN CIRCULAR INDICATOR
RED ARROW
YELLOW ARROW
GREEN ARROW
EVP DESIGNATOR
EVP DETECTOR HEAD
WORK AREA
TRAFFIC SIGNAL HEAD TO BE COVERED AND DE-ENERGIZED
LANE DESIGNATION (FOR INFO ONLY)
NOTE: ALL LENSES ARE 12-INCH
GRAYSHADE REPRESENTS EXISTING
N
OAKES RD
STH 20
SPEED LIMIT= 30 MPH
SPEED LIMIT= 45 MPH
WP1
WP2
WP3
WP4
WP5
WP6
WP7
TRAFFIC CONTROL SIGNAL
STH 20 & OAKES RD
VILLAGE OF MOUNT PLEASANT
RACINE COUNTY
SIGNAL NO. T51-0429
REGION CONTACT: JOYCE MURPHY
DESIGNED BY: JOHN BRUGGEMAN
REVISED BY:
PAGE 5 OF 7
PROJECT NO: 2250-15-70
HWY: STH 20
COUNTY: RACINE
TEMPORARY TRAFFIC SIGNAL PLAN - STAGE 2B
SHEET
E
FILE NAME: \\DOTWKEFILE1P\N3PUBLIC\PDS\C3D\CAD\22501500\SIG\S51-0429\S51-0429_TS_S2B.DWG
LAYOUT NAME - Plan 1 IN 40 FT
PLOT DATE: 7/19/2023 9:06 AM
PLOT BY: BRUGGEMAN, JOHN
PLOT NAME:
PLOT SCALE: 1 IN:40 FT
WISDOT/CADDS SHEET 42


LEGEND
SPAN WIRE
WOOD POLE, CLASS 4
SIGNAL HEAD, OVERHEAD MOUNT
WALK/DON'T WALK INDICATOR 16" (COUNTDOWN TIMER)
PEDESTRIAN HEAD W/PUSH BUTTON
PUSH BUTTON ON PORTABLE UNIT/SKID
SIGNAL HEAD NUMBER
RED CIRCULAR INDICATOR
YELLOW CIRCULAR INDICATOR
GREEN CIRCULAR INDICATOR
RED ARROW
YELLOW ARROW
GREEN ARROW
EVP DESIGNATOR
EVP DETECTOR HEAD
WORK AREA
TRAFFIC SIGNAL HEAD TO BE COVERED AND DE-ENERGIZED
LANE DESIGNATION (FOR INFO ONLY)
NOTE: ALL LENSES ARE 12-INCH
GRAYSHADE REPRESENTS EXISTING
OAKES RD
STH 20
SPEED LIMIT= 30 MPH
SPEED LIMIT= 45 MPH
WP1
WP2
WP3
WP4
WP5
WP6
WP7
R/W
TLE
N
TRAFFIC CONTROL SIGNAL
STH 20 & OAKES RD
VILLAGE OF MOUNT PLEASANT
RACINE COUNTY
SIGNAL NO. T51-0429
REGION CONTACT: JOYCE MURPHY
DESIGNED BY: JOHN BRUGGEMAN
PAGE 6 OF 7
REVISED BY:
PROJECT NO: 2250-15-70
HWY: STH 20
COUNTY: RACINE
TEMPORARY TRAFFIC SIGNAL PLAN - STAGE 2C
SHEET
E
FILE NAME: \\DOTWKEFILE1P\N3PUBLIC\PDS\C3D\CAD\22501500\SIG\S51-0429\S51-0429_TS_S2C.DWG
LAYOUT NAME - Plan 1 IN:40 FT
PLOT DATE: 7/19/2023 9:06 AM
PLOT BY: BRUGGEMAN, JOHN
PLOT NAME:
PLOT SCALE: 1 IN:40 FT
WISDOT/CADDS SHEET 42

2

	HEAD NUMBERS	FLASH
Ø1	5,6,7	-
Ø2	8,9,10,11	R
Ø3	18,19,20	-
Ø4	21,22,23	R
Ø5	12,13,14	-
Ø6	1,2,3,4	R
Ø7	24,25,26	-
Ø8	15,16,17	R
Ø2P	27,28	
Ø4P	33,34	
Ø6P	31,32	
Ø8P	29,30	
OLA	5,6,7	R ←
OLB	18,19,20	R ←
OLC	12,13,14	R ←
OLD	24,25,26	R ←



2

CONTROLLER LOGIC

PHASE NUMBER	PHASE LOCKING	DUAL ENTRY W / Ø	PHASE RECALL	PHASE ACTIVE
1		6	MAX	X
2	X	6	MAX	X
3		8	MAX	X
4		8	MAX	X
5		2	MAX	X
6	X	2	MAX	X
7		4	MAX	X
8		4	MAX	X

TYPE OF INTERCONNECT/COMMUNICATION	
NONE	X
CLOSED LOOP	
TWISTED PAIR	
FIBER OPTIC*	
FIBER OPTIC (ETHERNET)	
RADIO	
CELL MODEM	

TYPE OF COORDINATION	
NONE	
TBC	X
TRAFFIC RESPONSIVE	
ADAPTIVE	
*LOCATION OF MASTER	
CONTROLLER NO:	S-
SIGNAL SYSTEM NO:	SS-

TYPE OF LIGHTING	
BY OTHER AGENCY	
IN TRAFFIC CABINET	X
IN SEPARATE DOT LIGHTING CABINET	

TYPE OF PRE-EMPT	
NONE	
RAILROAD	
EMERGENCY VEHICLE	X
GTT	X
TOMAR	
HARDWIRE	
OTHER	
CONFIRMATION LIGHTS	
LIFT BRIDGE	
QUEUE DETECTION	

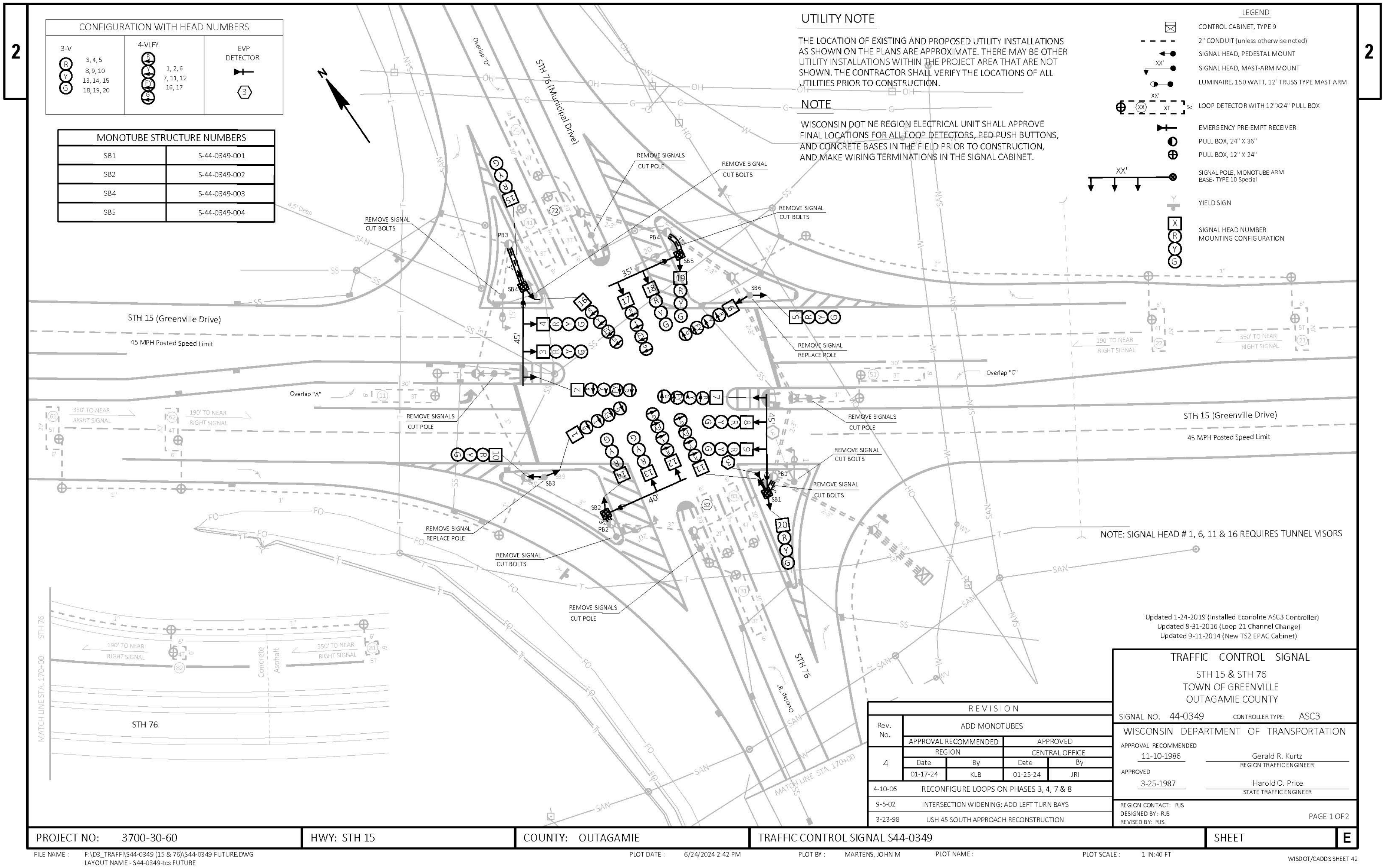
STH 20 & OAKES RD
VILLAGE OF MOUNT PLEASANT
RACINE COUNTY

SIGNAL NO:	T51-0429	CABINET TYPE:	TEMP
		CONTROLLER TYPE:	ECONOLITE
DATE:	AUGUST 2023	PAGE NUMBER:	7 OF 7

PROJECT NO: 2250-15-70	HWY: STH 20	COUNTY: RACINE	TEMPORARY SEQUENCE OF OPERATIONS	SHEET NO: E

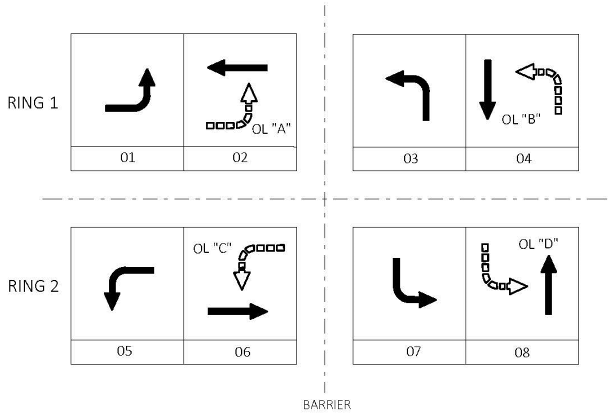
FILE NAME: \\WKERTOVFILPI01\n3public\SPO\Operations\Signals\Databases\Signal Intersection Files\S40-1144\PLANS\TS1.xlsx PLOT DATE: 3/2/2020 PLOT NAME: TS1.xlsx PLOT BY: __________ PLOT SCALE: 1:1

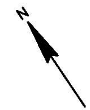
Example 4. Revision Plan to Add Monotubes (2 sheets)



2

	HEAD NUMBERS	FLASH
01	6, 7	-
02	3, 4, 5	R
03	16, 17	-
04	13, 14, 15	R
05	1, 2	-
06	8, 9, 10	R
07	11, 12	-
08	18, 19, 20	R
02P		
04P		
06P		
08P		
OLA	6, 7	R
OLB	16, 17	R
OLC	1, 2	R
OLD	11, 12	R





CONTROLLER LOGIC

PHASE NUMBER	PHASE LOCKING	DUAL ENTRY W/Ø	PHASE RECALL	PHASE ACTIVE
1				YES
2			MIN	YES
3				YES
4	YES	8		YES
5				YES
6			MIN	YES
7				YES
8		4		YES

TYPE OF INTERCONNECT/COMMUNICATION	
CELL MODEM	X
CLOSED LOOP	
TWISTED PAIR*	
FIBER OPTIC*	
FIBER OPTIC (ETHERNET)	
RADIO	

TYPE OF COORDINATION	
NONE	X
TBC	
TRAFFIC RESPONSIVE	
ADAPTIVE	
*LOCATION OF MASTER CONTROLLER NO:	S00-0000
SIGNAL SYSTEM #:	SS-0000

EMERGENCY VEHICLE PREEMPTION

EMERGENCY VEHICLE DETECTOR	3
MOVEMENT	
PHASE	4+7

TYPE OF LIGHTING	
BY OTHER AGENCY	
IN TRAFFIC SIGNAL CABINET	X
IN SEPARATE DOT LIGHTING CABINET	

TYPE OF PRE-EMPT	
NONE	
RAILROAD	
EMERGENCY VEHICLE	
GTT/3M	X
TOMAR	
HARDWIRE	
OTHER (GPS)	
LIFT BRIDGE	
QUEUE DETECTOR	

DETECTOR LOGIC

RACK # 1

DETECTOR CHANNEL	3	1	7	5	11	9	15	13
PLAN LOOP DETECTOR #(S)	11		31	41				
ASSIGNED PHASE	1		3	4				
OPERATION MODE	Veh	BAD	Veh	Veh				
SWITCH TO PHASE								
EXTEND								
DELAY								
DETECTOR CHANNEL	4	2	8	6	12	10	16	14
PLAN LOOP DETECTOR #(S)	21	22	32					
ASSIGNED PHASE	2	2	3					
OPERATION MODE	Veh	Veh	Veh					
SWITCH TO PHASE								
EXTEND	Yes							
DELAY								

RACK # 2

DETECTOR CHANNEL	19	17	23	21	27	25	31	29
PLAN LOOP DETECTOR #(S)	51	61	71	81	83			
ASSIGNED PHASE	5	6	7	8	8			
OPERATION MODE	Veh	Veh	Veh	Veh	Veh			
SWITCH TO PHASE								
EXTEND		Yes						
DELAY				Yes				
DETECTOR CHANNEL	20	18	24	22	28	26	32	30
PLAN LOOP DETECTOR #(S)		62	72	82				
ASSIGNED PHASE		6	7	8				
OPERATION MODE		Veh	Veh	Veh				
SWITCH TO PHASE								
EXTEND								
DELAY				Yes				

Revision 4 - Add Monotubes
Updated 1-24-2019 (Installed Econolite ASC3 Controller)
Updated 8-31-2016 (Loop 21 Channel Change)
Updated 9-11-2014 (New TS2 EPAC Cabinet)

GENERAL NOTES:

1. PROVIDE FOR HAND CONTROL
2. MMU SET UP FOR MODE B

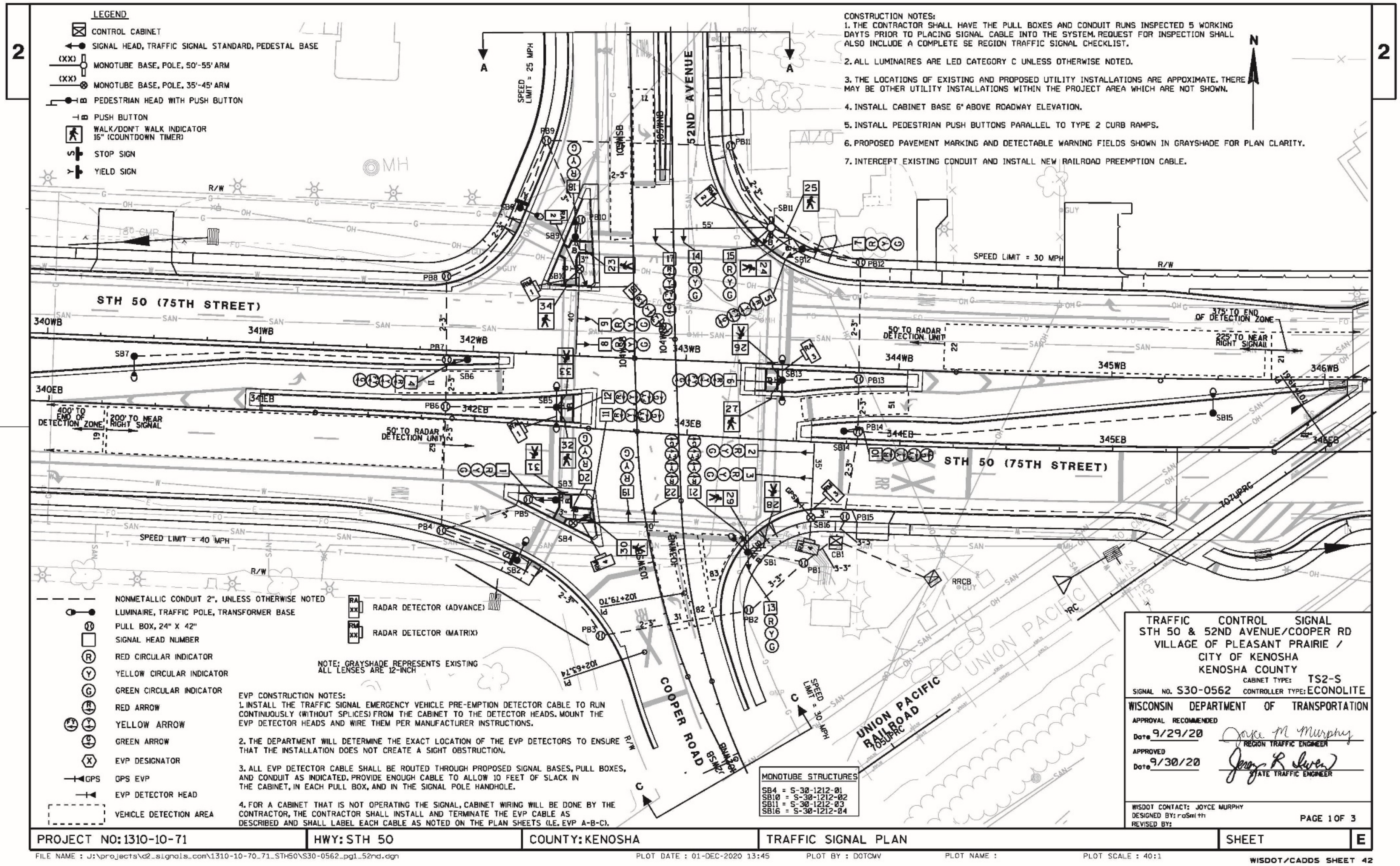
STH 15 & STH 76
TOWN OF GREENVILLE
OUTAGAMIE COUNTY

SIGNAL NO. 44-0349
CABINET: TS2 CONTROLLER: ASC3
DATE: 01-17-24 PAGE NO. 2 OF 2

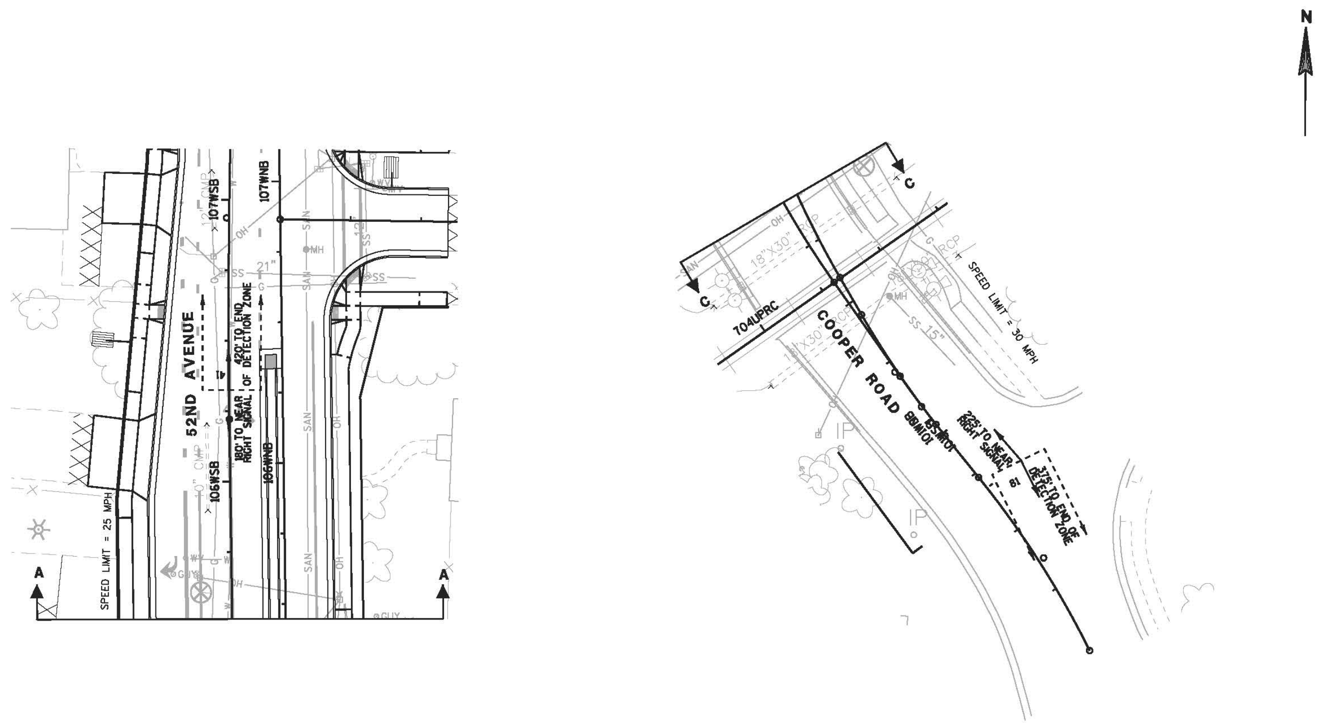
PROJECT NO: 3700-30-60	HWY: STH 15	COUNTY: OUTAGAMIE	SEQUENCE OF OPERATIONS - S44-0349	SHEET	E

FILE NAME : F:\D3_TRAFF\S44-0349 (15 & 76)\S44-0349 FUTURE.DWG
LAYOUT NAME - S44-0349-seq FUTURE
PLOT DATE : 6/24/2024 2:42 PM PLOT BY : MARTENS, JOHN M PLOT NAME : PLOT SCALE : 1 IN:40 FT WISDOT/CADDS SHEET 42

Example 5. Signalized Intersection Plan with Railroad Preemption (3 sheets)



2



2

TRAFFIC CONTROL SIGNAL
STH 50 & 52ND AVENUE/COOPER RD
VILLAGE OF PLEASANT PRAIRIE /
CITY OF KENOSHA
KENOSHA COUNTY

SIGNAL NO. S30-0562
WISDOT CONTACT: JOYCE MURPHY
DESIGNED BY: raSmith
REVISED BY:
PAGE 2 OF 3

PROJECT NO:1310-10-71	HWY:STH 50	COUNTY:KENOSHA	TRAFFIC SIGNAL PLAN	SHEET	E

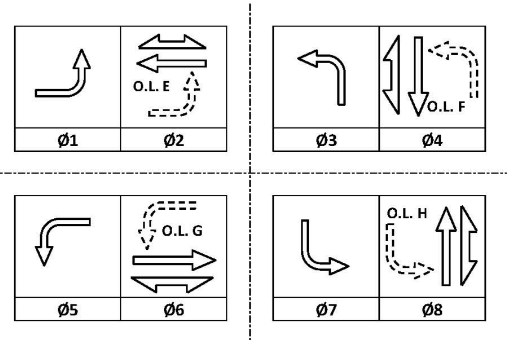
FILE NAME : J:\projects\d2_signals_com\1310-10-70_71_STH50\S30-0562_pg2_52nd.dgn PLOT DATE : 01-DEC-2020 13:46 PLOT BY : DOTCMV PLOT NAME : PLOT SCALE : 40:1 WISDOT/CADDS SHEET 42

2

	HEAD NUMBERS	FLASH
Ø1	4,5,6	R ←
Ø2	7,8,9	R
Ø3	16,17	R ←
Ø4	18,19,20	R
Ø5	10,11,12	R ←
Ø6	1,2,3	R
Ø7	21,22	R ←
Ø8	13,14,15	R
Ø2P	23,24	
Ø4P	31,32,33,34	
Ø6P	29,30	
Ø8P	25,26,27,28	
OLE	4,5,6	-
OLF	16,17	-
OLG	10,11,12	-
OLH	21,22	-

RING 1

RING 2



BARRIER

N

CONTROLLER LOGIC

PHASE NUMBER	PHASE LOCKING	DUAL ENTRY W / Ø	PHASE RECALL	PHASE ACTIVE
1		6		X
2	X	6	MIN	X
3		8		X
4		8		X
5		2		X
6	X	2	MIN	X
7		4		X
8		4		X

TYPE OF INTERCONNECT/COMMUNICATION	
NONE	
CLOSED LOOP	
TWISTED PAIR	
FIBER OPTIC*	
FIBER OPTIC (ETHERNET)	X
RADIO	
CELL MODEM	

TYPE OF COORDINATION	
NONE	
TBC	X
TRAFFIC RESPONSIVE	
ADAPTIVE	
*LOCATION OF MASTER CONTROLLER NO:	S-
SIGNAL SYSTEM NO:	SS-30-0116

TYPE OF LIGHTING	
BY OTHER AGENCY	
IN TRAFFIC CABINET	X
IN SEPARATE DOT LIGHTING CABINET	

TYPE OF PRE-EMPT	
NONE	
RAILROAD	X
EMERGENCY VEHICLE	X
GTT	X
TOMAR	
HARDWIRE	
OTHER - GPS	X
CONFIRMATION LIGHTS	
LIFT BRIDGE	
QUEUE DETECTION	

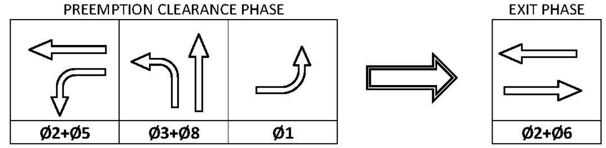
EMERGENCY VEHICLE PREEMPTION SEQUENCE

EMERGENCY VEHICLE PREEMPTOR	A	B	C	D
MOVEMENT				
PHASE	2+5	6+1	4+7	8+3

AFTER PREEMPTION SEQUENCE 2+5 OR 6+1, CONTROLLER SHALL RETURN TO PHASES 2+6.

AFTER PREEMPTION SEQUENCE 4+7 OR 8+3, CONTROLLER SHALL RETURN TO PHASES 4+8.

RAILROAD PREEMPTION PHASING



DETECTOR LOGIC

DETECTOR INPUT	3	1	7	5	11	9	15	13
PLAN LOOP DETECTOR*(S)	11	42	71	83				
CALLED PHASE	1	4	7	8				
CALL OPTION	X	X	X	X				
DELAY TIME				X				
EXTENTION OPTION	X	X	X	X				
EXTEND TIME								
USE ADDED INITIAL								
CROSS SWITCH PHASE								

DETECTOR INPUT	19	17	23	21	27	25	31	29
PLAN LOOP DETECTOR*(S)	21	41	62					
CALLED PHASE	2	4	6					
CALL OPTION	X		X					
DELAY TIME								
EXTENTION OPTION	X	X	X					
EXTEND TIME		X						
USE ADDED INITIAL								
CROSS SWITCH PHASE								

DETECTOR INPUT	4	2	8	6	12	10	16	14
PLAN LOOP DETECTOR*(S)	31	51	82					
CALLED PHASE	3	5	8					
CALL OPTION	X	X	X					
DELAY TIME								
EXTENTION OPTION	X	X	X					
EXTEND TIME								
USE ADDED INITIAL								
CROSS SWITCH PHASE								

DETECTOR INPUT	20	18	24	22	28	26	32	30
PLAN LOOP DETECTOR*(S)	22	61	81					
CALLED PHASE	2	6	8					
CALL OPTION	X	X						
DELAY TIME								
EXTENTION OPTION	X	X	X					
EXTEND TIME			X					
USE ADDED INITIAL								
CROSS SWITCH PHASE								

GENERAL NOTES:

1. TRAFFIC SIGNAL CABINET SHALL OPERATE WITH BATTERY BACKUP TO ACCOMMODATE RAILROAD PREEMPTION.
2. IN THE EVENT OF RAILROAD PRE-EMPTION, PHASES 2 + 5 SHALL RECEIVE A GREEN INDICATION FOLLOWED BY A CLEARANCE PERIOD TO CLEAR PHASES 3+8. THE INTERSECTION WILL DWELL IN PHASE 1 UNTIL THE CONCLUSION OF THE PRE-EMPTION EVENT. AT THE CONCLUSION OF PRE-EMPTION, THE INTERSECTION WILL RETURN TO PHASE 2 + 6 GREEN.

STH 50 & 52ND AVENUE/COOPER RD
VILLAGE OF PLEASANT PRAIRIE/CITY OF KENOSHA
KENOSHA COUNTY

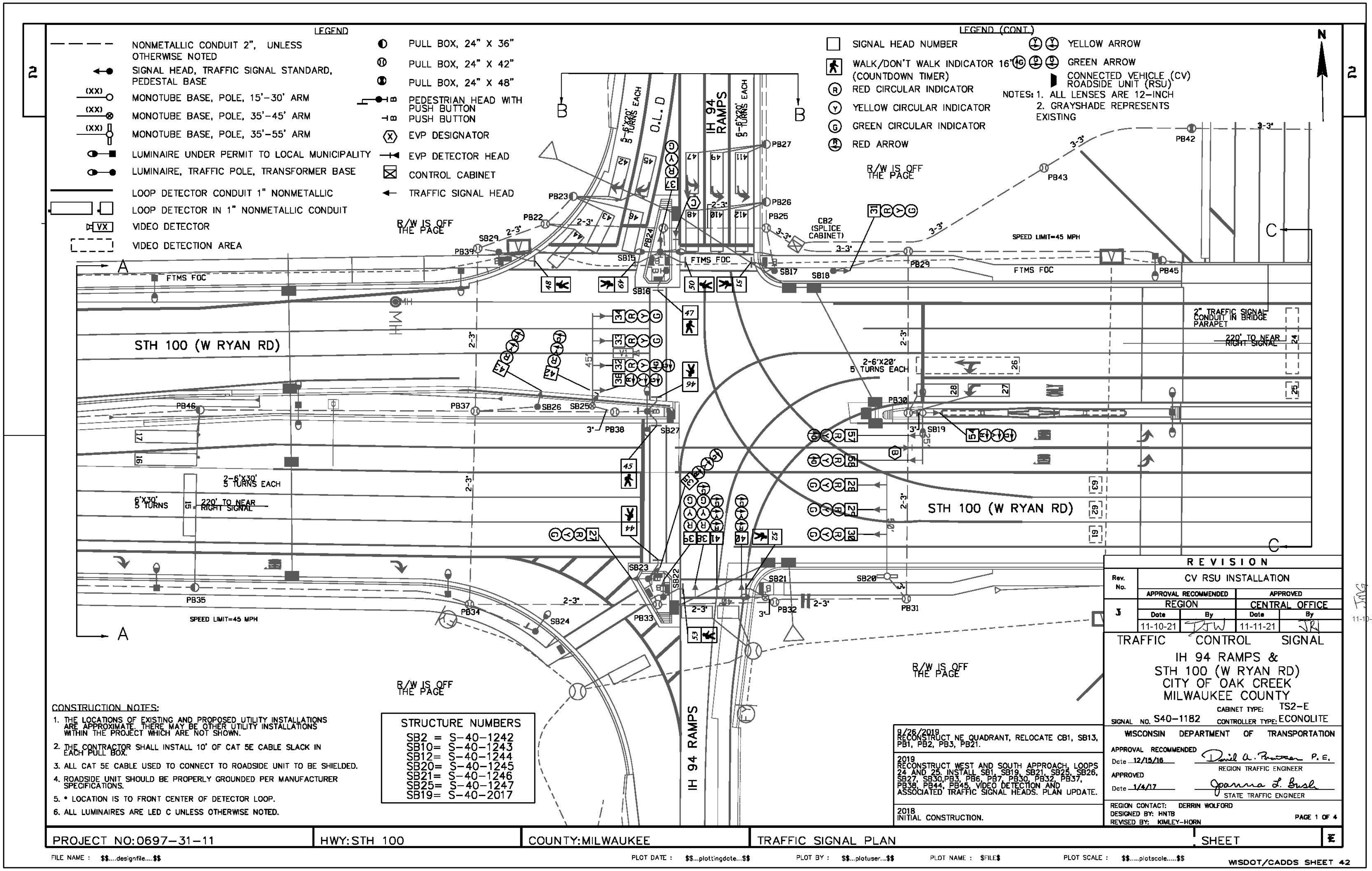
SIGNAL NO: S30-0562		CABINET TYPE: TS2-S
		CONTROLLER TYPE: ECONOLITE
DATE: 10/2020		PAGE NUMBER: 3 OF 3

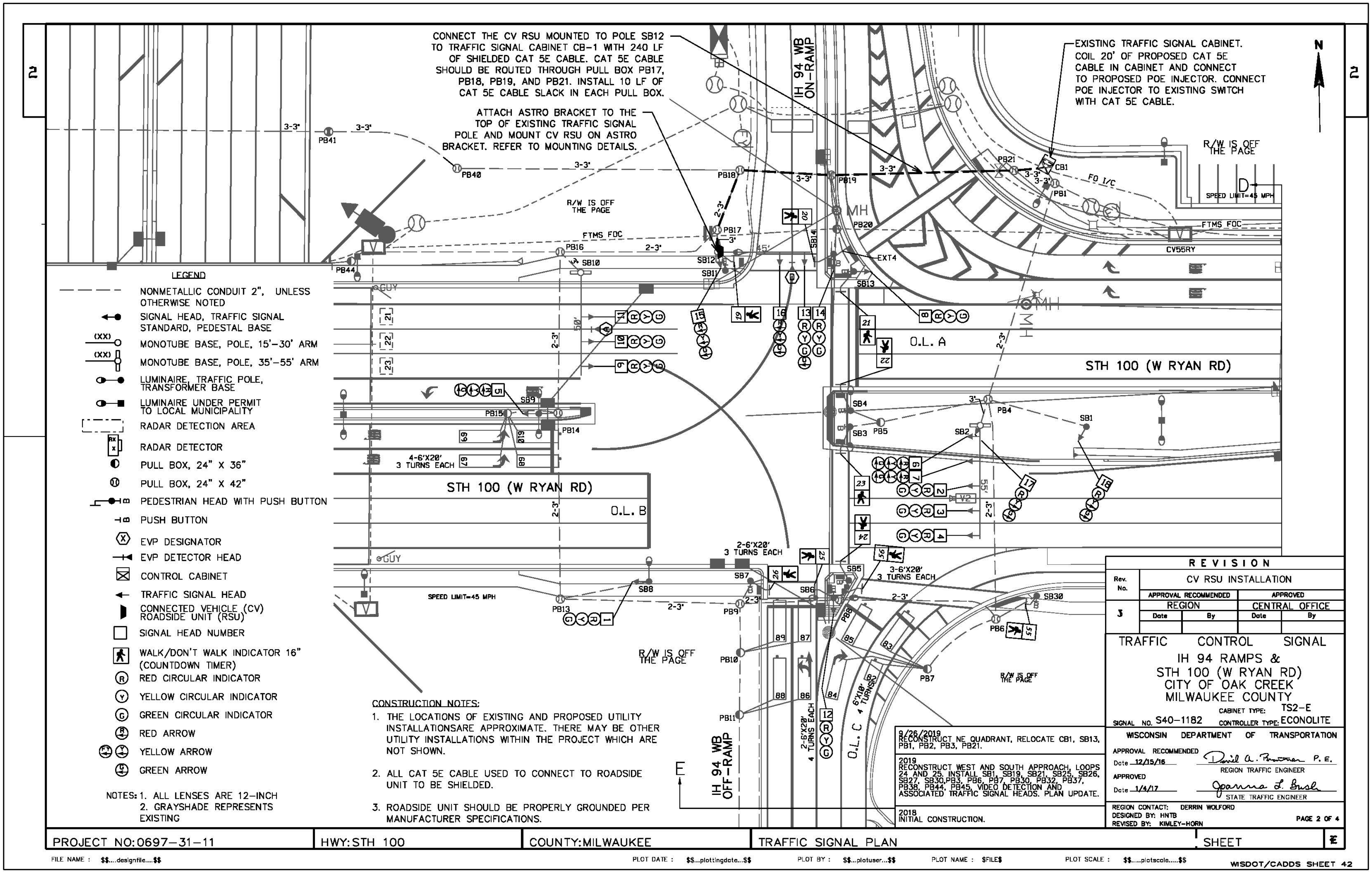
PROJECT NO: 1310-10-71	HWY: STH 50	COUNTY: KENOSHA	SEQUENCE OF OPERATIONS	SHEET NO:	E

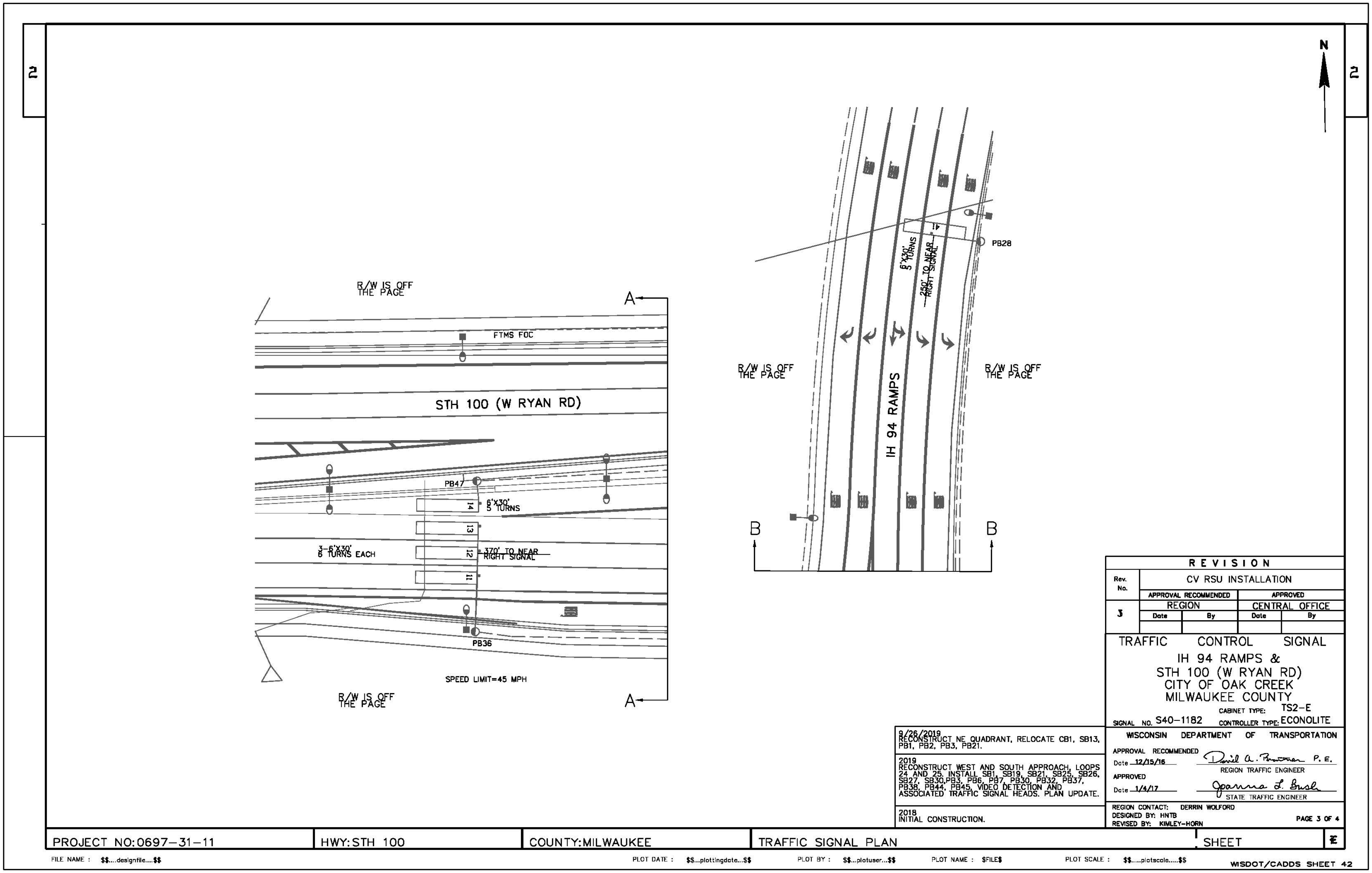
FILE NAME: \\rasmith.com\Brookfield\Transportation\1112711\Traffic\Signal Design\Sequence Sheets\WIS 50 & 52nd\TS2-S_E_FYA_EFGH_Econolite_SEQ.xlsx PLOT DATE: 9/29/2020 PLOT NAME: TS2-S_E_FYA_EFGH_Econc PLOT BY: ________ PLOT SCALE: 1:1

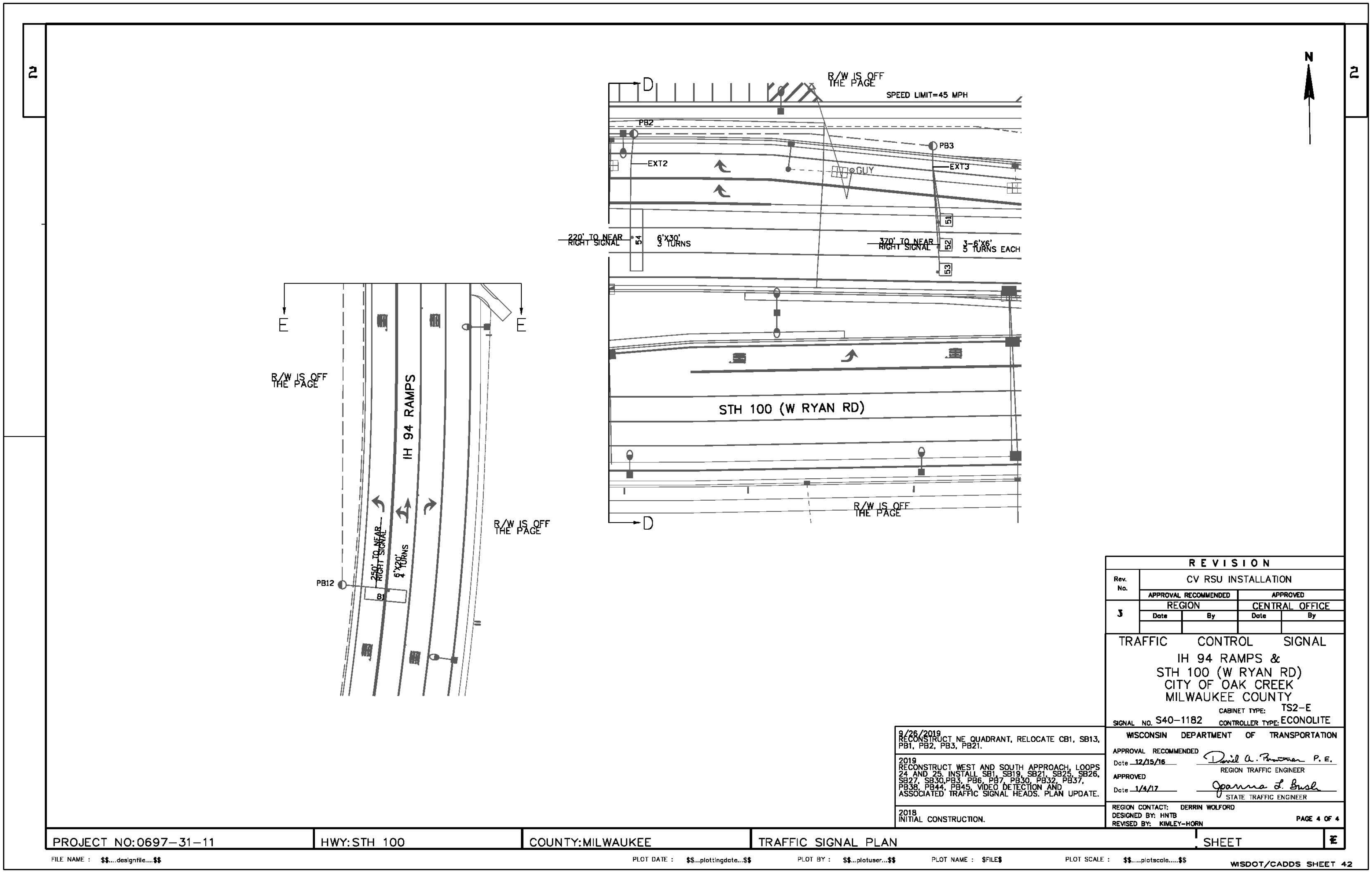
2

Example 6. Signal Controller Plan at an Interchange - Dual Ring with Overlaps (5 sheets)




CONNECT THE CV RSU MOUNTED TO POLE SB12 TO TRAFFIC SIGNAL CABINET CB-1 WITH 240 LF OF SHIELDED CAT 5E CABLE. CAT 5E CABLE SHOULD BE ROUTED THROUGH PULL BOX PB17, PB18, PB19, AND PB21. INSTALL 10 LF OF CAT 5E CABLE SLACK IN EACH PULL BOX.
ATTACH ASTRO BRACKET TO THE TOP OF EXISTING TRAFFIC SIGNAL POLE AND MOUNT CV RSU ON ASTRO BRACKET. REFER TO MOUNTING DETAILS.
EXISTING TRAFFIC SIGNAL CABINET. COIL 20' OF PROPOSED CAT 5E CABLE IN CABINET AND CONNECT TO PROPOSED POE INJECTOR. CONNECT POE INJECTOR TO EXISTING SWITCH WITH CAT 5E CABLE.
IH 94 WB ON-RAMP
IH 94 WB OFF-RAMP
STH 100 (W RYAN RD)
O.L. A
O.L. B
O.L. C
R/W IS OFF THE PAGE
SPEED LIMIT=45 MPH
FTMS FOC
FO I/C
LEGEND
NONMETALLIC CONDUIT 2", UNLESS OTHERWISE NOTED
SIGNAL HEAD, TRAFFIC SIGNAL STANDARD, PEDESTAL BASE
MONOTUBE BASE, POLE, 15'-30' ARM
MONOTUBE BASE, POLE, 35'-55' ARM
LUMINAIRE, TRAFFIC POLE, TRANSFORMER BASE
LUMINAIRE UNDER PERMIT TO LOCAL MUNICIPALITY
RADAR DETECTION AREA
RADAR DETECTOR
PULL BOX, 24" X 36"
PULL BOX, 24" X 42"
PEDESTRIAN HEAD WITH PUSH BUTTON
PUSH BUTTON
EVP DESIGNATOR
EVP DETECTOR HEAD
CONTROL CABINET
TRAFFIC SIGNAL HEAD
CONNECTED VEHICLE (CV) ROADSIDE UNIT (RSU)
SIGNAL HEAD NUMBER
WALK/DON'T WALK INDICATOR 16" (COUNTDOWN TIMER)
RED CIRCULAR INDICATOR
YELLOW CIRCULAR INDICATOR
GREEN CIRCULAR INDICATOR
RED ARROW
YELLOW ARROW
GREEN ARROW
NOTES: 1. ALL LENSES ARE 12-INCH
2. GRAYSHADE REPRESENTS EXISTING
CONSTRUCTION NOTES:
1. THE LOCATIONS OF EXISTING AND PROPOSED UTILITY INSTALLATIONSARE APPROXIMATE. THERE MAY BE OTHER UTILITY INSTALLATIONS WITHIN THE PROJECT WHICH ARE NOT SHOWN.
2. ALL CAT 5E CABLE USED TO CONNECT TO ROADSIDE UNIT TO BE SHIELDED.
3. ROADSIDE UNIT SHOULD BE PROPERLY GROUNDED PER MANUFACTURER SPECIFICATIONS.
9/26/2019 RECONSTRUCT NE QUADRANT, RELOCATE CB1, SB13, PB1, PB2, PB3, PB21.
2019 RECONSTRUCT WEST AND SOUTH APPROACH, LOOPS 24 AND 25. INSTALL SB1, SB19, SB21, SB25, SB26, SB27, SB30,PB3, PB6, PB7, PB30, PB32, PB37, PB38, PB44, PB45, VIDEO DETECTION AND ASSOCIATED TRAFFIC SIGNAL HEADS. PLAN UPDATE.
2018 INITIAL CONSTRUCTION.
REVISION
CV RSU INSTALLATION
TRAFFIC CONTROL SIGNAL
IH 94 RAMPS & STH 100 (W RYAN RD)
CITY OF OAK CREEK
MILWAUKEE COUNTY
CABINET TYPE: TS2-E
SIGNAL NO. S40-1182
CONTROLLER TYPE: ECONOLITE
WISCONSIN DEPARTMENT OF TRANSPORTATION
REGION TRAFFIC ENGINEER
STATE TRAFFIC ENGINEER
REGION CONTACT: DERRIN WOLFORD
DESIGNED BY: HNTB
REVISED BY: KIMLEY-HORN
PAGE 2 OF 4
PROJECT NO:0697-31-11
HWY:STH 100
COUNTY:MILWAUKEE
TRAFFIC SIGNAL PLAN
SHEET
WISDOT/CADDS SHEET 42


N
R/W IS OFF THE PAGE
FTMS FOC
STH 100 (W RYAN RD)
PB47
6'X30' 5 TURNS
3-6'X30' 6 TURNS EACH
370' TO NEAR RIGHT SIGNAL
PB36
SPEED LIMIT=45 MPH
A
PB28
6'X30' 5 TURNS
250' TO NEAR RIGHT SIGNAL
IH 94 RAMPS
B
REVISION
Rev. No.
CV RSU INSTALLATION
APPROVAL RECOMMENDED
APPROVED
REGION
CENTRAL OFFICE
Date
By
3
TRAFFIC CONTROL SIGNAL
IH 94 RAMPS &
STH 100 (W RYAN RD)
CITY OF OAK CREEK
MILWAUKEE COUNTY
CABINET TYPE: TS2-E
SIGNAL NO. S40-1182
CONTROLLER TYPE: ECONOLITE
9/26/2019
RECONSTRUCT NE QUADRANT, RELOCATE CB1, SB13, PB1, PB2, PB3, PB21.
2019
RECONSTRUCT WEST AND SOUTH APPROACH, LOOPS 24 AND 25. INSTALL SB1, SB19, SB21, SB25, SB26, SB27, SB30,PB3, PB6, PB7, PB30, PB32, PB37, PB38, PB44, PB45, VIDEO DETECTION AND ASSOCIATED TRAFFIC SIGNAL HEADS. PLAN UPDATE.
2018
INITIAL CONSTRUCTION.
WISCONSIN DEPARTMENT OF TRANSPORTATION
APPROVAL RECOMMENDED
Date 12/15/16
P. E.
REGION TRAFFIC ENGINEER
APPROVED
Date 1/4/17
STATE TRAFFIC ENGINEER
REGION CONTACT: DERRIN WOLFORD
DESIGNED BY: HNTB
REVISED BY: KIMLEY-HORN
PAGE 3 OF 4
PROJECT NO:0697-31-11
HWY:STH 100
COUNTY:MILWAUKEE
TRAFFIC SIGNAL PLAN
SHEET
E
FILE NAME : $$...designfile...$$
PLOT DATE : $$...plottingdate...$$
PLOT BY : $$...plotuser...$$
PLOT NAME : $FILE$
PLOT SCALE : $$.....plotscale.....$$
WISDOT/CADDS SHEET 42



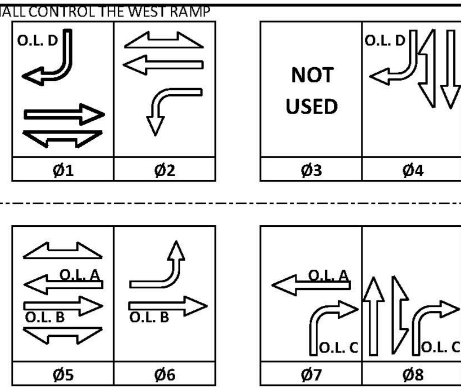
R/W IS OFF THE PAGE
SPEED LIMIT=45 MPH
PB2
PB3
EXT2
EXT3
GUY
220' TO NEAR RIGHT SIGNAL
6'X30' 3 TURNS
370' TO NEAR RIGHT SIGNAL
3-6'X6' 5 TURNS EACH
STH 100 (W RYAN RD)
IH 94 RAMPS
250' TO NEAR RIGHT SIGNAL
6'X20' 4 TURNS
PB12
N
REVISION
CV RSU INSTALLATION
APPROVAL RECOMMENDED
APPROVED
REGION
CENTRAL OFFICE
TRAFFIC CONTROL SIGNAL
IH 94 RAMPS &
STH 100 (W RYAN RD)
CITY OF OAK CREEK
MILWAUKEE COUNTY
CABINET TYPE: TS2-E
SIGNAL NO. S40-1182
CONTROLLER TYPE: ECONOLITE
9/26/2019 RECONSTRUCT NE QUADRANT, RELOCATE CB1, SB13, PB1, PB2, PB3, PB21.
2019 RECONSTRUCT WEST AND SOUTH APPROACH, LOOPS 24 AND 25. INSTALL SB1, SB19, SB21, SB25, SB26, SB27, SB30,PB3, PB6, PB7, PB30, PB32, PB37, PB38, PB44, PB45, VIDEO DETECTION AND ASSOCIATED TRAFFIC SIGNAL HEADS. PLAN UPDATE.
2018 INITIAL CONSTRUCTION.
WISCONSIN DEPARTMENT OF TRANSPORTATION
APPROVAL RECOMMENDED
Date 12/15/16
REGION TRAFFIC ENGINEER
APPROVED
Date 1/4/17
STATE TRAFFIC ENGINEER
REGION CONTACT: DERRIN WOLFORD
DESIGNED BY: HNTB
REVISED BY: KIMLEY-HORN
PAGE 4 OF 4
PROJECT NO:0697-31-11
HWY:STH 100
COUNTY:MILWAUKEE
TRAFFIC SIGNAL PLAN
SHEET
E
WISDOT/CADDS SHEET 42

2

** RING 1 SHALL CONTROL THE WEST RAMP

RING 1

RING 2



** RING 2 SHALL CONTROL THE EAST RAMP

2

	HEAD NUMBERS	FLASH
Ø1	27,28,29,30,57,58	R
Ø2	21,32,33,34,35,36,54	R,R ←
Ø3		
Ø4	37,38,39,40,41	R,R ←
Ø5		
Ø6	5,6,7	R ←
Ø7		
Ø8	12,13,14,15,16	R,R ←
Ø1P	52,53	
Ø2P	48,49,50,10	
Ø4P	44,45,46,47	
Ø5P	19,20,25,26,55,56	
Ø8P	21,22,23,24	
OLA	8,9,10,11	R
OLB	1,2,3,4	R
OLC	17,18	R
OLD	42,43	R

CONTROLLER LOGIC

PHASE NUMBER	PHASE LOCKING	DUAL ENTRY W / Ø	PHASE RECALL	PHASE ACTIVE
1	X		MIN	X
2	X		MIN	X
3				
4				X
5				X
6	X		MIN	X
7				X
8				X

EMERGENCY VEHICLE PREEMPTION SEQUENCE

EMERGENCY VEHICLE PREEMPTOR	A	B	C	D
MOVEMENT	O.L A, O.L B	O.L B	O.L D, O.L B	O.L C
PHASE	5+2	1+6	4+6	8+2

AFTER PREEMPTION SEQUENCE 5+2, CONTROLLER SHALL RETURN TO PHASES 5+2.
AFTER PREEMPTION SEQUENCE 1+6, CONTROLLER SHALL RETURN TO PHASES 1+6.
AFTER PREEMPTION SEQUENCE 4+6, CONTROLLER SHALL RETURN TO PHASES 4+6.
AFTER PREEMPTION SEQUENCE 8+2, CONTROLLER SHALL RETURN TO PHASES 8+2.

TYPE OF INTERCONNECT/COMMUNICATION	
NONE	
CLOSED LOOP	
TWISTED PAIR	
FIBER OPTIC*	
FIBER OPTIC (ETHERNET)	X
RADIO	
CELL MODEM	

TYPE OF COORDINATION	
NONE	
TBC	X
TRAFFIC RESPONSIVE	
ADAPTIVE	
*LOCATION OF MASTER CONTROLLER NO:	S-
SIGNAL SYSTEM NO:	SS- 40-0012

TYPE OF LIGHTING	
BY OTHER AGENCY	X
IN TRAFFIC CABINET	X
IN SEPARATE DOT LIGHTING CABINET	

TYPE OF PRE-EMPT	
NONE	
RAILROAD	
EMERGENCY VEHICLE	X
GTT	X
TOMAR	
HARDWIRE	
OTHER	
CONFIRMATION LIGHTS	
LIFT BRIDGE	
QUEUE DETECTION	

DETECTOR LOGIC

DETECTOR INPUT	3	1	7	5	11	9	15	13	19	17	23	21	27	25	31	29	DETECTOR INPUT
PLAN LOOP DETECTOR*(S)	11	13	15	17	28	42	44	46	48	410	412	52	54	68	610	82	PLAN LOOP DETECTOR*(S)
CALLED PHASE	1	1	1	1	2	4	4	4	4	4	4	5	5	6	6	8	CALLED PHASE
CALL OPTION	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	CALL OPTION
DELAY TIME						X	X	X								X	DELAY TIME
EXTENTION OPTION	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	EXTENTION OPTION
EXTEND TIME																	EXTEND TIME
USE ADDED INITIAL	X	X	X	X								X	X				USE ADDED INITIAL
CROSS SWITCH PHASE																	CROSS SWITCH PHASE

DETECTOR INPUT	4	2	8	6	12	10	16	14	20	18	24	22	28	26	32	30	DETECTOR INPUT
PLAN LOOP DETECTOR*(S)	12	14	16	27	41	43	45	47	49	411	51	53	67	69	81	83	PLAN LOOP DETECTOR*(S)
CALLED PHASE	1	1	1	2	4	4	4	4	4	4	5	5	6	6	8	8	CALLED PHASE
CALL OPTION	X	X	X	X		X	X	X	X	X	X	X	X	X		X	CALL OPTION
DELAY TIME						X	X									X	DELAY TIME
EXTENTION OPTION	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	EXTENTION OPTION
EXTEND TIME					X										X		EXTEND TIME
USE ADDED INITIAL	X	X	X								X	X					USE ADDED INITIAL
CROSS SWITCH PHASE																	CROSS SWITCH PHASE

DETECTOR INPUT	35	33	39	37	43	41	47	45	49	51	53	55	57	59	61	63	DETECTOR INPUT
PLAN LOOP DETECTOR*(S)	84	86	88						21	23	25	61	63	65			PLAN LOOP DETECTOR*(S)
CALLED PHASE	8	8	8						2	2	2	6	6	6			CALLED PHASE
CALL OPTION	X	X	X						X	X	X	X	X				CALL OPTION
DELAY TIME	X																DELAY TIME
EXTENTION OPTION	X	X	X						X	X	X	X	X	X			EXTENTION OPTION
EXTEND TIME									X	X	X			X			EXTEND TIME
USE ADDED INITIAL																	USE ADDED INITIAL
CROSS SWITCH PHASE												5	5				CROSS SWITCH PHASE

DETECTOR INPUT	36	34	40	38	44	42	48	46	50	52	54	56	58	60	62	64	DETECTOR INPUT
PLAN LOOP DETECTOR*(S)	85	87	89						22	24	26	62	64	66			PLAN LOOP DETECTOR*(S)
CALLED PHASE	8	8	8						2	2	2	6	6	6			CALLED PHASE
CALL OPTION	X	X	X						X	X	X	X	X				CALL OPTION
DELAY TIME	X																DELAY TIME
EXTENTION OPTION	X	X	X						X	X	X	X	X	X			EXTENTION OPTION
EXTEND TIME									X	X				X			EXTEND TIME
USE ADDED INITIAL																	USE ADDED INITIAL
CROSS SWITCH PHASE												5	5				CROSS SWITCH PHASE

GENERAL NOTES:

1. CABINET IS EQUIPPED WITH BATTERY BACK-UP.

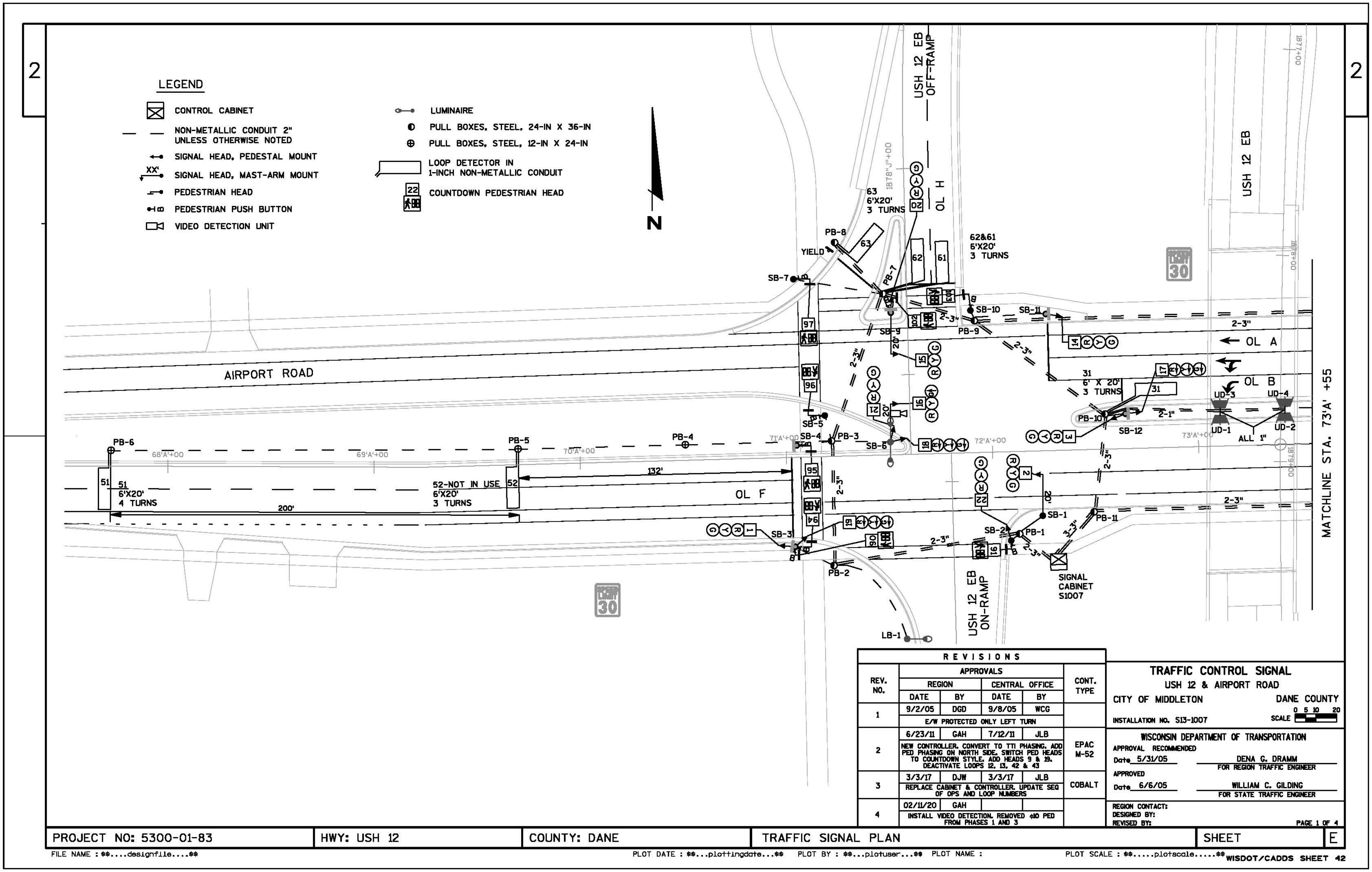
IH 94 RAMPS & STH 100 (W RYAN RD)
CITY OF OAK CREEK
MILWAUKEE COUNTY

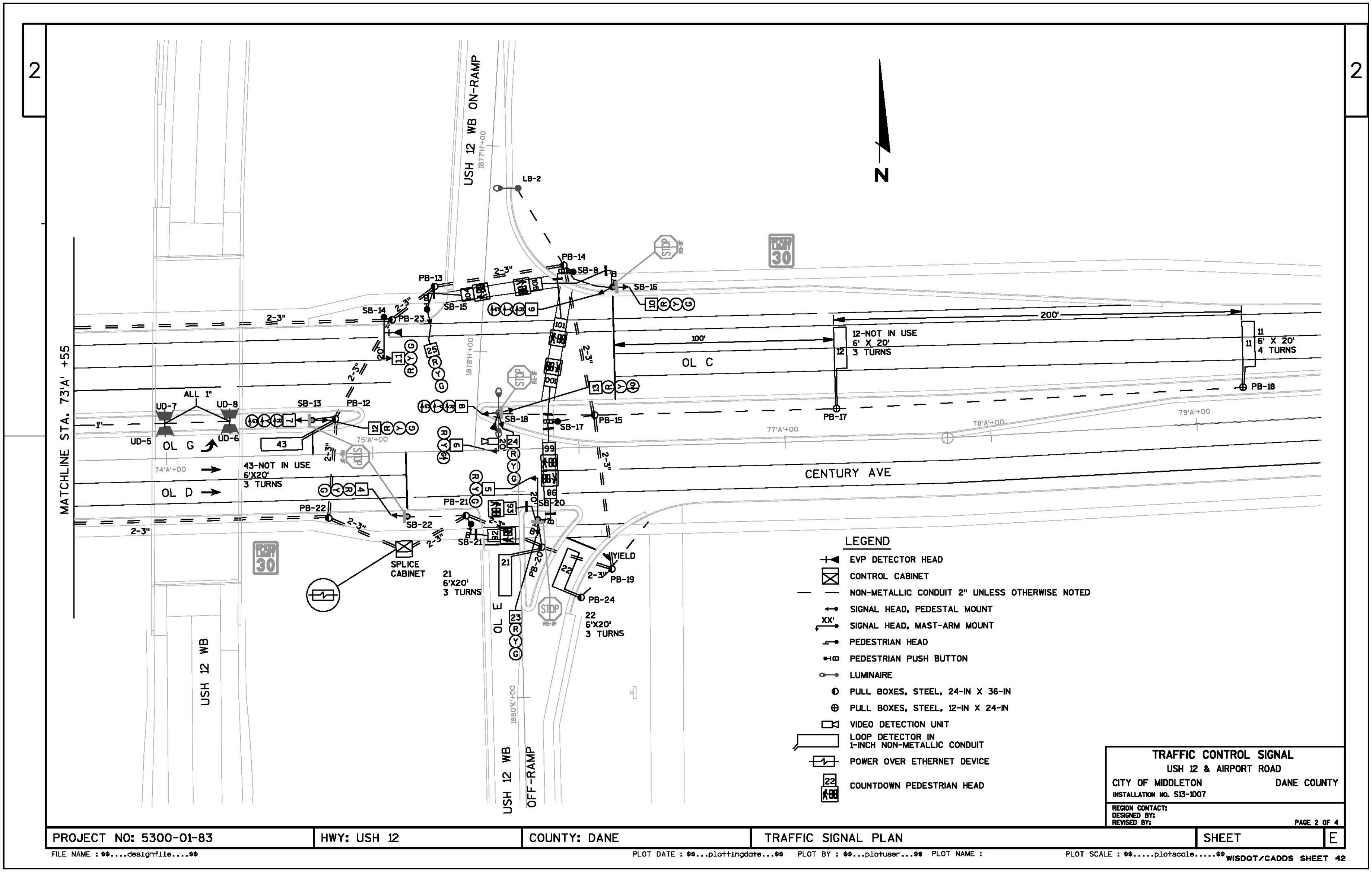
SIGNAL NO:	S40-1182	CABINET TYPE: TS2-E	
		CONTROLLER TYPE: ECONOLITE	
DATE:	7/21	PAGE NUMBER: 5 OF 5	

PROJECT NO: 0697-31-11	HWY: IH 94	COUNTY: MILWAUKEE	SEQUENCE OF OPERATIONS	SHEET NO:	E

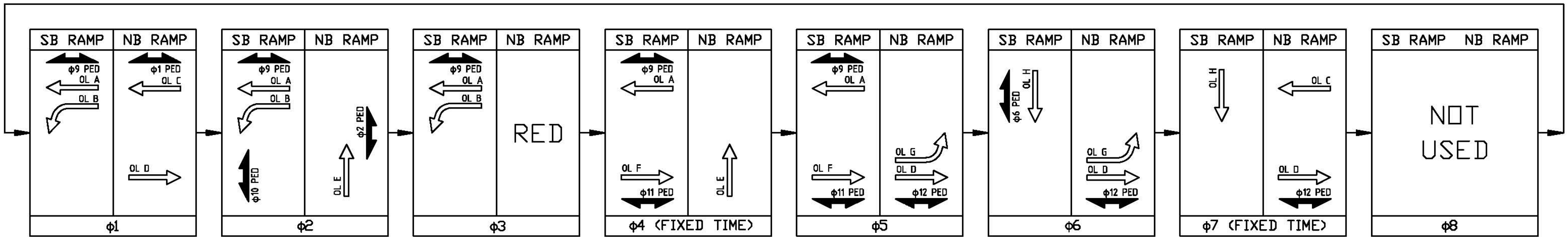
FILE NAME: \\WKERTOVFILPI01\n3public\SPO\Operations\Signals\Databases\Signal Intersection Files\S40-1182\PLANS\TS2-S_FYA_ABCD_Econolite_SEQ.xlsx PLOT DATE: 7/16/2021 PLOT NAME: TS2-S_FYA_ABCD_Econol PLOT BY: ________ PLOT SCALE: 1:1

Example 7. TTI Phasing Plan at an Interchange (4 sheets)




2
2
N
USH 12 WB ON-RAMP
USH 12 WB
USH 12 WB
OFF-RAMP
CENTURY AVE
MATCHLINE STA. 73'A' +55
LB-2
PB-13
PB-14
SB-8
SB-16
SB-14
PB-23
SB-15
PB-12
SB-13
SB-18
SB-17
PB-15
PB-17
PB-18
PB-22
SB-22
PB-21
SB-21
SB-20
PB-20
PB-19
PB-24
UD-5
UD-6
UD-7
UD-8
ALL 1"
OL G
OL D
OL C
OL E
43-NOT IN USE
6'X20'
3 TURNS
12-NOT IN USE
6' X 20'
3 TURNS
11
6' X 20'
4 TURNS
200'
100'
SPLICE
CABINET
21
6'X20'
3 TURNS
22
6'X20'
3 TURNS
YIELD
STOP
30
LEGEND
EVP DETECTOR HEAD
CONTROL CABINET
NON-METALLIC CONDUIT 2" UNLESS OTHERWISE NOTED
SIGNAL HEAD, PEDESTAL MOUNT
SIGNAL HEAD, MAST-ARM MOUNT
PEDESTRIAN HEAD
PEDESTRIAN PUSH BUTTON
LUMINAIRE
PULL BOXES, STEEL, 24-IN X 36-IN
PULL BOXES, STEEL, 12-IN X 24-IN
VIDEO DETECTION UNIT
LOOP DETECTOR IN 1-INCH NON-METALLIC CONDUIT
POWER OVER ETHERNET DEVICE
COUNTDOWN PEDESTRIAN HEAD
TRAFFIC CONTROL SIGNAL
USH 12 & AIRPORT ROAD
CITY OF MIDDLETON
DANE COUNTY
INSTALLATION NO. S13-1007
REGION CONTACT:
DESIGNED BY:
REVISED BY:
PAGE 2 OF 4
PROJECT NO: 5300-01-83
HWY: USH 12
COUNTY: DANE
TRAFFIC SIGNAL PLAN
SHEET
E
FILE NAME : ##....designfile....##
PLOT DATE : ##...plottingdate...##
PLOT BY : ##...plotuser...##
PLOT NAME :
PLOT SCALE : ##.....plotscale.....##
WISDOT/CADDS SHEET 42

2



2

PREEMPTION ASSIGNMENTS				
PREEMPTION DESIGNATION	PREEMPTION TYPE	EVP CHANNEL	PHASE(S) CALLED	PREEMPTED APPROACH
1	RESERVED			
2	RESERVED			
3	EVP	A	φ1	WB
4	NOT USED			
5	EVP	C	φ2	NB
6	NOT USED			
7	NOT USED			
8	NOT USED			
9	NOT USED			
10	NOT USED			

TYPE OF INTERCONNECT COMMUNICATION	
NONE	
TBC	
CLOSED LOOP TWISTED PAIR	
CLOSED LOOP FIBER OPTIC	
RADIO	
CELL MODEM	X
LOCATION OF MASTER	
CONTROLLER NO: S	
SIGNAL SYSTEM: SS	

TYPE OF LIGHTING	
BY OTHER AGENCY	
IN TRAFFIC SIGNAL CABINET	X
IN SEPERATE DOT LIGHTING CABINET	

N

TYPE OF COORDINATION	
NONE	
TBC	X
TRAFFIC RESPONSIVE	
ADAPTIVE	

TYPE OF PRE-EMPT	
NONE	
RAILROAD	
EMERGENCY VEHICLE	X
3M	X
TOMAR	
HARDWARE	
OTHER	
LIFT BRIDGE	
QUEUE DETECTOR	

	INTERSECTION	MOVEMENT	HEAD NUMBERS	FLASH	OL PARENT PHASES / PED PHASE COMPATIBILITY	CHANNEL	PED DETECTOR INPUT
OL A	W RAMP	WB THRU	14-16	R	φ1,φ2,φ3,φ4,φ5	1	
OL B	W RAMP	WB LEFT	17-19	R ←	φ1,φ2,φ3	2	
OL C	E RAMP	WB THRU	10-13	R	φ1,φ7	3	
OL D	E RAMP	EB THRU	4-6	R	φ1,φ5,φ6,φ7	4	
OL E	E RAMP	NB THRU	23-25	R	φ2,φ4	5	
OL F	W RAMP	EB THRU	1-3	R	φ4,φ5	6	
OL G	E RAMP	EB LEFT	7-9	R ←	φ5,φ6	7	
OL H	W RAMP	SB THRU	20-22	R	φ6,φ7	8	
OL I							
OL J							
φ1 PED	E RAMP	N PED	104,105		φ1	9	1
φ2 PED	E RAMP	E PED	98-101		φ2	10	3
φ6 PED	W RAMP	NW PED	96,97		φ6	11	2
φ9 PED	W RAMP	N PED	102,103		φ1,φ2,φ3,φ4,φ5	12	4
φ10 PED	W RAMP	SW PED	94,95		φ1,φ2,φ3	13	6
φ11 PED	W RAMP	S PED	90,91		φ4,φ5	14	8
φ12 PED	E RAMP	S PED	92,93		φ5,φ6,φ7	15	5

DETECTOR LOGIC

DETECTOR INPUT	3	1	7	5	11	9	15	13
DETECTOR(S)	11	21	31	43	51	63		
PHASE CALLED	1	2	3		5	6		
PHASE EXTENDED	1	2	3		5	6		
DISCONNECT PHASE								
CALLING DELAY						15		
EXTENSION STRETCH								
LOOP FUNCTION				NIU				

DETECTOR INPUT	19	17	23	21	27	25	31	29
DETECTOR(S)								
PHASE CALLED								
PHASE EXTENDED								
DISCONNECT PHASE								
CALLING DELAY								
EXTENSION STRETCH								
LOOP FUNCTION								

DETECTOR INPUT	4	2	8	6	12	10	16	14
DETECTOR(S)	12	22			52	61	62	
PHASE CALLED		2				6	6	
PHASE EXTENDED		2				6	6	
DISCONNECT PHASE								
CALLING DELAY		15						
EXTENSION STRETCH								
LOOP FUNCTION	NIU				NIU			

DETECTOR INPUT	20	18	24	22	28	26	32	30
DETECTOR(S)								
PHASE CALLED								
PHASE EXTENDED								
DISCONNECT PHASE								
CALLING DELAY								
EXTENSION STRETCH								
LOOP FUNCTION								

NIU = NOT IN USE

GENERAL NOTES

1. φ3 SHALL ONLY BE SERVED FOLLOWING THE TERMINATION OF φ2 AND AN ACTUATION ON DETECTOR 31.
2. φ4 SHALL ONLY BE CALLED FOLLOWING AN ACTUATION ON φ2 AND NO ACTUATION ON DETECTOR 31.
3. φ7 SHALL ONLY BE CALLED FOLLOWING AN ACTUATION ON φ6.
4. φ9 PED SHALL HAVE THE ABILITY TO BEGIN TIMING WITH φ1 AND FINISH TIMING WITH φ5.
5. φ10 PED SHALL HAVE THE ABILITY TO BEGIN TIMING WITH φ1 AND FINISH TIMING WITH φ3.
6. φ11 PED SHALL HAVE THE ABILITY TO BEGIN TIMING WITH φ4 AND FINISH TIMING WITH φ5.
7. φ12 PED SHALL HAVE THE ABILITY TO BEGIN TIMING WITH φ5 AND FINISH TIMING WITH φ7.
8. φ9 PED IS ASSIGNED IN RING 2 (NOT SHOWN).
9. φ10 AND φ11 PED ARE ASSIGNED IN RING 3 (NOT SHOWN).
10. φ12 PED IS ASSIGNED IN RING 4 (NOT SHOWN).

CONTROLLER LOGIC

PHASE NUMBER	PHASE LOCKING	DUAL ENTRY W / φ	PHASE RECALL	PHASE ACTIVE
1	X		MIN	X
2			MIN	X
3				X
4				X
5	X		MIN	X
6				X
7				X
8				

TRAFFIC CONTROL SIGNAL
USH 12 & AIRPORT ROAD
CITY OF MIDDLETON DANE COUNTY
SIGNAL NO. S13-1007
REGION CONTACT:
DESIGNED BY:
REVISED BY:
PAGE 3 OF 4

PROJECT NO: 5300-01-83	HWY: USH 12	COUNTY: DANE	TRAFFIC SIGNAL SEQUENCE OF OPERATIONS	SHEET	E

FILE NAME : **....designfile....** PLOT DATE : **...plottingdate...** PLOT BY : **...plotuser...** PLOT NAME : S-400,seq,rev2 PLOT SCALE : **.....plotscale.....** WISDOT/CADDS SHEET 42

2

USH 12 & AIRPORT ROAD (WEST INTERSECTION) TRAFFIC SIGNAL CABLING CHART NO. 14 CABLE

CABLE RUN	CABLE	HEAD NUMBER	MOVEMENT	LENS	CONDUCTOR COLOR	REMARKS
CABINET TO SB-1	5C	2	EB	R	R	OL F
				Y	O	
				G	G	
CABINET TO SB-2	12C	22	SB	R	R	OL H
				Y	O	
				G	G	
		91	S LEG	W	BLU	φ11 PED
				DW	BLK	
				PB	W	
CABINET TO SB-3	19C	1	EB	R	R	OL F
				Y	O	
				G	G	
		19	WB LT	←R	R/BLK	OL B
				←Y	O/BLK	
				←G	G/BLK	
		90	S LEG	W	BLU	φ11 PED
				DW	BLK	
				PB	W	
		94	W LEG	W	BLU/BLK	φ10 PED
				DW	BLK/W	
				PB	W/BLK	
CABINET TO SB-4	5C	95	W LEG	W	G	φ10 PED
				DW	R	
				PB	W	
CABINET TO SB-5	5C	96	W LEG	W	G	φ6 PED
				DW	R	
				PB	W	
CABINET TO SB-6	12C	21	SB	R	R	OL H
				Y	O	
				G	G	
		16	WB	R	R/BLK	OL A
				Y	O/BLK	
				G↑	G/BLK	
		18	WB LT	←R	BLK	OL B
				←Y	W/BLK	
				←G	BLU	

USH 12 & AIRPORT ROAD (WEST INTERSECTION) TRAFFIC SIGNAL CABLING CHART NO. 14 CABLE

CABLE RUN	CABLE	HEAD NUMBER	MOVEMENT	LENS	CONDUCTOR COLOR	REMARKS
CABINET TO SB-9	15C	20	SB	R	R	OL H
				Y	O	
				G	G	
		15	WB	R	R/BLK	OL A
				Y	O/BLK	
				G	G/BLK	
		97	W LEG	W	G/W	φ6 PED
				DW	R/W	
				PB	BLK/W	
		102	N LEG	W	BLU	φ9 PED
				DW	BLK	
				PB	W/BLK	
SB-9 TO SB-7	5C	97	W LEG	W	G	φ6 PED
				DW	R	
				PB	W	
CABINET TO SB-10	5C	103	N LEG	W	G	φ9 PED
				DW	R	
				PB	W	
CABINET TO SB-11	5C	14	WB	R	R	OL A
				Y	O	
				G	G	
CABINET TO SB-12	12C	17	WB LT	←R	R/BLK	OL B
				←Y	O/BLK	
				←G	G/BLK	
		3	EB	R	R	OL F
				Y	O	
				G	G	

USH 12 & AIRPORT ROAD TRAFFIC SIGNAL CHART

WIRE SIZE	LUMINAIRE WIRE RUN
2-12C	CABINET TO SPLICE CABINET

USH 12 & AIRPORT ROAD (EAST INTERSECTION) TRAFFIC SIGNAL CABLING CHART NO. 14 CABLE

CABLE RUN	CABLE	HEAD NUMBER	MOVEMENT	LENS	CONDUCTOR COLOR	REMARKS
SPLICE CABINET TO SB-13	12C	7	EB LT	←R	R	OL G
				←Y	O	
				←G	G	
		12	WB	R	R/BLK	OL C
				Y	O/BLK	
				G	G/BLK	
SPLICE CABINET TO SB-14	5C	11	WB	R	R	OL C
				Y	O	
				G	G	
SPLICE CABINET TO SB-15	12C	25	NB	R	R	OL E
				Y	O	
				G	G	
		104	N LEG	W	BLU	φ1 PED
				DW	BLK	
				PB	W/BLK	
SPLICE CABINET TO SB-8	5C	101	E LEG	W	G/BLK	φ2 PED
				DW	R/BLK	
				PB	W/BLK	
SPLICE CABINET TO SB-16	12C	10	WB	R	R	OL C
				Y	O	
				G	G	
		9	EB LT	←R	R/BLK	OL G
				←Y	O/BLK	
				←G	G/BLK	
		105	N LEG	W	BLU	φ1 PED
				DW	BLK	
				PB	W/BLK	
SPLICE CABINET TO SB-17	12C	99	E LEG	W	G	φ2 PED
				DW	R	
				PB	W	
		100	E LEG	W	G	φ2 PED
				DW	R	
SPLICE CABINET TO SB-18	15C	6	EB	R	R/BLK	OL D
				Y	O/BLK	
				G↑	G/BLK	
		8	EB LT	←R	BLK	OL G
				←Y	W/BLK	
				←G	BLU	
		24	NB	R	R	OL E
				Y	O	
				G	G	
		13	WB	R	R/W	OL C
				Y	BLK/W	
				G	G/W	

USH 12 & AIRPORT ROAD (EAST INTERSECTION) TRAFFIC SIGNAL CABLING CHART NO. 14 CABLE

CABLE RUN	CABLE	HEAD NUMBER	MOVEMENT	LENS	CONDUCTOR COLOR	REMARKS
SPLICE CABINET TO SB-20	12C	23	NB	R	R	OL E
				Y	O	
				G	G	
		5	EB	R	R/BLK	OL D
				Y	O/BLK	
				G	G/BLK	
		98	E LEG	W	BLU/BLK	φ2 PED
				DW	BLK/W	
				PB	W/BLK	
		93	S LEG	W	BLU	φ12 PED
				DW	BLK	
				PB	W	
SPLICE CABINET TO SB-21	5C	92	S LEG	W	G	φ12 PED
				DW	R	
				PB	W	
SPLICE CABINET TO SB-22	5C	4	EB	R	R	OL D
				Y	O	
				G	G	

USH 12 & AIRPORT ROAD LIGHTING CABLING CHART NO. 12 UF W/GROUND

CABLE	CABLE RUN	LUMINAIRE LOCATION
2C W/ GROUND	CABINET TO LB-1	W INT, SW QUAD
	CABINET TO SB-6	W INT, W MEDIAN
	CABINET TO SPLICE CABINET	
	SPLICE CABINET TO SB-17	E INT, E MEDIAN
	SB-17 TO LB-2	E INT, NE QUAD
	CABINET TO UD-1	BENEATH USH 12 EB
	UD-1 TO UD-2	BENEATH USH 12 EB
	UD-1 TO UD-3	BENEATH USH 12 EB
	UD-3 TO UD-4	BENEATH USH 12 EB
	CABINET TO UD-5	BENEATH USH 12 WB
	UD-5 TO UD-6	BENEATH USH 12 WB
	UD-5 TO UD-7	BENEATH USH 12 WB
	UD-7 TO UD-8	BENEATH USH 12 WB

CABLE ROUTING PLAN
USH 12 & AIRPORT ROAD

CITY OF MIDDLETON — DANE COUNTY
SIGNAL NO. S13-1007
REGION CONTACT:
DESIGNED BY:
REVISED BY:
PAGE 4 OF 4

PROJECT NO: 5300-01-83	HWY: USH 12	COUNTY: DANE	CABLE ROUTING PLAN	SHEET	E

FILE NAME : **....designfile....** PLOT DATE : **...plottingdate...** PLOT BY : **...plotuser...** PLOT NAME : S-400,seq,rev2 PLOT SCALE : **.....plotscale.....** WISDOT/CADDS SHEET 42

2

4-6-1 Signal Infrastructure Design Introduction April 2025

The design of new or updated traffic signal installations have many interrelated elements. Uniformity in the design of those elements promotes efficient traffic operations and reduces the potential for driver confusion and crashes. Traffic signals must be designed and installed to convey clear and positive guidance to drivers and pedestrians. This subject contains discussions, illustrations, and examples of the design elements that are necessary to achieve this.

In addition to the information contained in this subject there are several standard references that *may* prove valuable to the designer.

4-6-2 Signal Head Layout April 2025

The layout and display of traffic signal heads are two of the most important elements in the design of a traffic signal installation. Traffic signals must be clearly visible (have good target value) and convey the proper message to the driver and pedestrian. Certain basic principles **shall** be followed at all times when developing the traffic signal head layout. These principles, explained in detail in the WMUTCD, include the following:

1. There **shall** be at least two primary signal faces provided to control the major movement on each approach. The major movement is defined as either the through movement, or the signalized turning movement that is considered as the major movement if a through movement does not exist on an approach. The two primary signal faces **shall** be located on the far side of the intersection, including one on the far left and one on the far right in relation to the approach roadway. A near right signal face *may* also be provided, based on the region traffic signal engineer's discretion or as required per WMUTCD 4D.07. If included, the near right signal face *should* be located approximately at the stopping point.
    a. On multi-lane highways / expressways, newly installed traffic signals **shall** include a signal face for each through lane, or for each lane associated with the major movement, on their respective approaches. These signal faces **shall** be mounted vertically and located approximately over the center of the lane.
2. For non-highway approaches, at least one, preferably both of the far side primary signal faces **shall** be located within a 20-degree cone of vision starting from 10 feet behind the stop line in the center of the approach as defined and illustrated in Figure 4D-4 of the WMUTCD (New installations on multi-lane highway / expressway approaches **shall** have the primary signal faces lined up overhead and approximately centered over each through lane). On all roadway approaches, except where the width of the intersecting street or other conditions make it physically impractical, at least one and preferably both far side primary signals **shall** be located not less than 40 feet or more than 180 feet beyond the stop line (a 50-foot minimum is recommended for post-mounted signals and a 75-foot minimum for overhead mounted signals). A near signal face is required per WMUTCD 4D.07, if the primary signal faces on an approach are located more than 180 feet beyond the stop line. The WMUTCD also states, where the nearest signal face is located between 150 and 180 feet beyond the stop line, engineering judgment of the conditions, including the worst-case visibility conditions **shall** be used to determine if the provision of a supplemental near-side signal face would be beneficial.
3. When a separate left-turn phase is provided, at least two signal faces **shall** be provided to control that movement. Their positions *should* make them readily visible to roadway users making that movement. If two or more left-turn lanes are provided for a separately controlled left-turn phase, then place one signal face per lane.
    a. Supplemental left-turn signal faces *may* be added if engineering judgment dictates their use based on visibility and / or knockdown potential (Consult with the Regional Traffic Signal Engineer).
    b. When right-turn signalization is used for a channelized right-turn lane, at least two signal faces **shall** be provided to control that movement. Their positions *should* make them readily visible to roadway users making that movement. If two or more right-turn lanes are provided for a separately controlled right-turn phase, then place one signal face per lane.

   c. Supplemental right-turn signal faces *may* be added if engineering judgment dictates their use based on visibility and / or knockdown potential (Consult with the Regional Traffic Signal Engineer).

4. The primary signal faces located on the far side of the stem approach to a "T" intersection, *should* be post mounted and one of the signals **shall** be placed directly in line with the center of the approach lane or lanes.
5. State owned traffic signals **shall** utilize 12-inch indications.
6. For new installations or modernization projects, the design goal *should* be to install vertically mounted signal faces in all cases. For signal modification or rehabilitation projects, consult the Regional Traffic Signal Engineer for signal layout questions.
7. Retroreflective backplates **shall** be utilized on all vehicular signal faces for added visibility. Consult with the Regional Traffic Signal Engineer and/or Regional Safety Engineer to discuss the backplate material and if the side street backplates *should* be retroreflective.
8. Pedestrian Signal Faces with Countdown Displays **shall** be utilized for all state-owned traffic signals. Pedestrian signal faces **shall** be located as nearly in line with the crosswalk as possible. If the signal pole is located such that the pedestrian signal will be blocked by stopped vehicles or if it is more than 20 feet outside of the crosswalk line extended, then an alternative means of mounting *should* be designed. Pedestrian faces **shall** be mounted at a minimum of 7 feet (to the bottom of the head) above the walking surface on the side of the pole away from conflicting vehicular traffic. Pedestrian faces are typically mounted on the pole alongside the vehicular signal controlling the corresponding through movement.
   a. Pedestrian push buttons, when needed, **shall** be located for convenient use by pedestrians as outlined in WMUTCD 4I.05 and as required by the Americans with Disabilities Act (ADA). In some situations, it *may* be necessary to install a pedestrian push button standard to make the buttons accessible (Refer to SDD 9E7-6). Each push button **shall** be accompanied by a R10-3 series sign explaining its use.
   b. Pedestrian signals *should not* be installed in the medians of divided highways unless vision and timing conditions require it.
9. Permanent traffic signal faces **shall not** be installed on overhead cables or by any other means, which would permit significant movement under windy conditions. Temporary traffic signal faces *may* be installed on overhead cables if construction or maintenance operations would not make post or mast arm mounting feasible. Temporary signal installations **shall** only be used for road construction purposes and *should* be removed upon completion of the project. If a signal will be placed for a long-term duration, a permanent signal *should* be considered.

These guidelines are intended to establish minimum design criteria for traffic signal head layout. Consideration must be given by the signal designer to the unique conditions associated with a specific location and an appropriate design developed in response to these conditions. Specifically, consideration must be given to left-turn movements, right-turn overlaps, pedestrian activity, preemption, and channelization. All these aspects must be evaluated to achieve the best design.

In establishing the traffic signal head layout, attention must be given to signal head displays. Signal head displays will have a direct effect on the location and orientation of the signal heads. These signal head displays must be consistent with the intersection geometrics, vehicular demands, and desired operation. Signal head displays typically consist of three, four, and five section displays. No more than five indications are allowed in each display. Within a signal face, two Circular Red or Red Arrow signal indications **shall not** be displayed immediately adjacent to each other. Reference WMUTCD 4D.08 for Typical Signal Face Arrangements used for Through Movements. Reference WMUTCD 4F.02 through 4F.08 for Typical Signal Face Arrangements used for various types of Left-Turn Movements. Reference WMUTCD Sections 4F.09 through 4F.15 for Typical Signal Face Arrangements used for various types of Right-Turn Movements. Reference WMUTCD 4F.16 for Typical Signal Face Arrangements used for various types of Shared Left-Turn / Right-Turn Lanes and No Through Movement.

In addition to the general design criteria already discussed, further consideration *should* be given to the following items:

- Arrows *should not* be used on near or far indications for through movements. Arrow displays significantly limit the luminance level and conspicuity compared to circular displays.
- Traffic movements that conflict with pedestrian movements **shall** be controlled by circular green or a flashing yellow arrow.

- Consideration *should* be given to using visibility-limiting or optically programmed heads (lenses, louvers, or tunnel visors) under certain conditions. These conditions *may* include two closely spaced intersections where the intent is to limit a driver's ability to see the adjacent intersection display; for exclusive turn movements; or possibly where irregular street alignments necessitates the placement of conflicting signal faces at small angles. In addition, these types of heads *may* prove beneficial where direct sunlight causes drivers problems in determining which indication is illuminated.
- The use of all arrow indications for protected left turn only phasing *should* be used. This eliminates the need for most signing and for programmed heads and their associated maintenance problems and cost.
- The bottom housing of a signal assembly not mounted over a roadway **shall** be at least 8 feet but no more than 15 feet above the sidewalk or, if no sidewalk, above the pavement grade at the center of the highway.
- The lowest part of a signal assembly and all other signal components suspended over a roadway **shall not** be less than 17 feet (20 feet Minimum if located on a Designated Overheight Corridor) nor more than 25.6 feet above the pavement grade of the highest point on the roadway.
- Poles **shall** be located such that all portions of the poles and attached equipment have clearances from overhead utilities in accordance with the requirements of the local utility and the National Electrical Safety Code (NESC).

4-6-3 Signal Poles and Foundations April 2025

In determining the location of traffic signal poles/standards and related foundations, primary consideration must be given to the proper visibility of signal faces. After determining the signal head placement/location for the intersection, the designer **shall** use WMUTCD 4D.10 (Lateral Offset / Clearances) and engineering judgment to determine safe setback distances from the edge of the traveled way for poles and foundations. Poles and standards at the side of a street with curbs must have a horizontal setback clearance of 2 feet minimum, 4’ typical from the face of a vertical curb to the edge of the signal face or sign mounted on that pole (whichever extends closest to the curb). Where no curb exists, proper placement of supports is measured from the edge of the pavement. Traffic signal standards **shall not** have a horizontal setback greater than 12 feet from the face of a vertical curb (or edge of pavement if there is no curb). A signal support *should not* obstruct a crosswalk.

Poles **shall** be located such that all portions of the poles and attached equipment have clearances from overhead utilities in accordance with the requirements of the local utility and the National Electrical Safety Code (NESC).

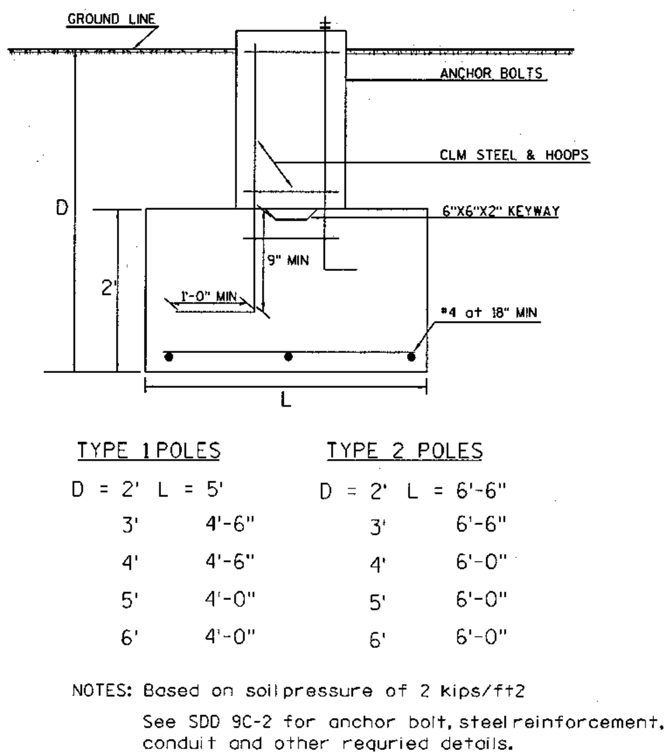
There are nine possible concrete bases available for use. (see FDM Chapter 16, Standard Detail Drawings).

Type 1	For use with Traffic Signal Standards, 15 feet or less.
Type 2	For use with Pole Types 2, 3, and 4
Type 5	For use with Pole Type 5 (Lighting Units 30 Ft)
Type 6	For use with Pole Type 6 (Lighting Units 35-Ft)
Type 7	For use with Pole Type 17 (Lighting Units 40-Ft)
Type 8	For use with Pole Type A (Lighting 46’6”) and Type E (Lighting 49’)
Type 10	For use with Type 9 and 10 Monotube Poles
Type 10 Special	For use with Type 9 Special and Type 10 Special Monotube Poles
Type 13	For use with Type 12 and 13 Monotube Poles

The current WisDOT signal standard (pedestal) bases and transformer bases (used with Type 1, 2 or 5 / 6 bases) are breakaway. Type 17, A, E, 9, 10, 9 Special, 10 Special, 12 & 13 Poles (used with Type 7, Type 8, Type 10, Type 10 Special and Type 13 bases) are not breakaway and while allowable within the clear zone, *should* be placed as far back from the back of curb as can be reasonable accomplished.

Some areas *may not* allow for the installation of concrete signal bases due to utility conflicts. In these cases, a spread-footing concrete base *may* be required (see Figure 3.1). The Regional Traffic Signal Engineer *should* be contacted to discuss the options when bedrock or utility conflicts obstruct the concrete base depth. Consult with the Bureau of Structures if a spread footing is needed.

Figure 3.1. Alternate Spread Footing Detail (Type 1, 2, 5, or 6 bases)



4-6-4 Conduit Size, Type and Layout — April 2025

CONDUIT SIZING

Conduit sizes of 1, 2 and 3-inch diameter *should* normally be used for traffic signal applications, or for interconnection. Below are the typical sizes of conduit used for various applications (Consult with the individual Regions regarding preferences):

Controller Cabinet to Pull Box:	Varies (see Standard Detail Drawings, and consult with Region Traffic Signal Engineer)
Main Ring Around Intersection (Pull Box to Pull Box):	Two 3” Typical
Pull Box to Signal or Light Base:	2" or 3”
Detector Lead-In:	2”
Loop Detector Conduit:	1”

The minimum conduit size is determined by the number and sizes of cables to be contained in the conduit. For large installations (interchange intersections, major intersections, etc.) the conduit sizing calculations used by WisDOT Regional electrical staff *should* be followed.

CONDUIT LAYOUT

All conduits **shall** be installed in accordance with the Standard Specifications, Wisconsin Administrative Code, and the Wisconsin State Electrical Code.

The conduit layout *should* be designed to minimize conflicts in construction. All conduit runs *should* be as straight as possible to minimize material costs, construction costs and to facilitate the pulling of electrical cable. An attempt **shall** be made to locate equipment such that conflicts between state-owned equipment and existing utilities are avoided.

A conduit **shall** be provided from each signal or light base to the nearest pull box, from pull box to pull box, from pull box to controller cabinet, and from detector to pull box.

Any conduit under a roadway **shall** have a pull box at each end. Spare conduit **shall** be installed as directed by the signal-maintaining authority. In general, conduit runs crossing existing streets, drives, and alleys *should* be directional bored rather than trenched. Conduit **shall** encircle the entire intersection due to the flexibility it will offer for future changes.

For new road construction, trenched conduit *may* be installed around the entire intersection. The conduit layout at the intersection *should* be designed so that the controller is in a quadrant and not on an island or median. This will allow for cabling in two separate directions, which minimizes voltage drop.

CONDUIT CROSSING STRUCTURES

At times, there *may* be a need to install conduit across structures. Typically, this will be the case at diamond interchanges when both ramp terminals are signalized.

When there needs to be a crossing of an existing structure, conduit *may* be installed on the structure itself or *may* be routed below the roadway that the structure crosses. To determine which method is appropriate, the Regional Traffic Signal Engineer and Regional Structures Engineer **shall** be consulted.

When installing conduit on the structure, the conduit *should* run either parallel to or at right angles to the structural girders. A variation of ± 15 degrees *may* be acceptable. A conduit expansion fitting **shall** be installed at each structure joint, hinge, or abutment where longitudinal movement greater than 1/2" *may* occur, or in accordance with manufacturer recommendations.

At locations where conduit runs through a structure, the conduit **shall** be terminated at a pull box. An adjustment *may* be needed to avoid guardrail posts. At the midpoint of the length of the wingwall, run all conduits out of the inside edge of the wingwall (into abutment fill) with a 45-degree bend and continue to a pull box (24” x 42”). The location of the pull box will be dependent on the presence of paved shoulder, sidewalk, terrace, curb, guardrail, drop inlet or surface drain. The intent is to avoid placing the conduit and pull box behind the guardrail. The preferred location will be in the sidewalk (or future sidewalk) or paved shoulder beyond a surface drain or inlet. The conduit *should* then continue from this first pull box to a second pull box located in the grass beyond the guardrail terminal end. Both pull boxes *should* be 24” x 42”.

For exposed locations, such as installations on structural girders, Schedule 80 PVC or RTRC (Reinforced Thermosetting Resin Conduit) **shall** be used. RTRC is generally preferable to PVC due to its durability. The regional traffic section *should* be involved in the selection of the exposed conduit materials.

A third alternative to provide conduit to the opposite side of a bridge, is to install an underground conduit system parallel to the structure and underneath the feature (i.e., roadway, railroad, etc.) being crossed.

USE OF SIGNAL CONDUIT FOR OTHER APPLICATIONS

Electrical wiring in state-owned signal conduit systems for other types of installations that are not associated with signal operation **shall** be avoided for several reasons:

- Reduces capacity of conduit that *may* be required for future signal modifications.
- Wiring used for multiple applications in the conduit *may* violate Electrical Code.
- WisDOT staff does not provide maintenance and locating services for the other electrical and municipal facilities (such as outsourced maintenance and locating of state-owned ITS facilities).
- Changes to wiring that could occupy the same space as signal wiring *may* affect signal operations.

4-6-5 Control Cabinet and Electrical Service — April 2025

SIZES

The standard traffic signal control cabinet in use is approximately 44" x 24” x 55" and is currently specified as a NEMA TS2 Type 1 cabinet. An oversized cabinet approximately 44” x 24” x 65” is available for intersections that require more components than usual (Consult with the Regional Traffic Signal Engineer).

LOCATION

The Regional Traffic Unit will work with the local utility company and signal designer to determine the most appropriate location for the traffic signal control cabinet and electrical service. Control cabinets **shall** be in accordance with, the following considerations:

1. The control cabinet *should not* be vulnerable to traffic. A distance of 20 feet back of curb or 30 feet off the edge of pavement is desirable for offsetting the control cabinet.
2. The control cabinet **shall not** be in a drainage ditch, in an area which could be under water, or where subjected to water from sprinklers. If the only option is to locate in a low area, it is necessary to fill the area in where cabinet is placed.

3. All traffic movements at the intersection *should* be visible from the control cabinet such that when an electrician is troubleshooting the intersection they *may* view the intersection and the interior of the control cabinet simultaneously. The door of the cabinet *should* open away from the curb or traveled way.
4. A maintenance vehicle *should* be able to park close to the cabinet and out of the traveled lanes.
5. The control cabinet **shall not** obstruct sidewalks, multi-use trails, curb ramps, or driveways.
6. The cabinet **shall not** obstruct pedestrian or driver visibility at the intersection.

ELECTRICAL SERVICE

For state-maintained signals, coordinate with the Regional Traffic Signal Engineer regarding how to prepare an application for the electrical service. Some regions *may* prepare the application / wiring affidavit and install the meter pedestal themselves. Other regions *may* set this all up as a contract item for the contractor's coordination / installation. Electrical installations maintained by other jurisdictions often submit their own application for their electrical service (Coordinate with the Local Municipality for clarification). The local utility company installs the electrical service lateral from the power source to the meter socket/pedestal.

The service connection point **shall** be located as close as possible to, or mounted on, the control cabinet. Electrical services *may* come from overhead or underground lines. Underground service feeds are preferred due to their protection from weather and aesthetics compared to overhead lines. The electrical service **shall** be in accordance with WisDOT *Standard Specifications and* local utility requirements.

COMMUNICATIONS

Similar to electrical service, provisions *should* be given for communications service for control cabinet placement options. When deciding if communications are required, consult with the Regional Traffic Signal Engineer. Future operations *should* also be considered when determining whether provisions for communications are applicable.

CONSTRUCTION INSPECTION

Refer to the Construction and Materials Manual, Section 6-55.1.3 Miscellaneous Construction, Electrical Construction for Checklists that pertain to the installation and inspection of these units:

- Figure 1 Conduit
- Figure 2 Lighting
- Figure 3 Traffic Signals
- Figure 4 Loop Detectors

CONTROL CABINET SERVICE PLACEMENT

Since a large part of a signal's design can relate to the location of the signal controller cabinet, this decision *should* be made early in the design. When selecting the location of the controller cabinet at an intersection, there are three primary considerations: available right-of-way, availability of electrical service, and drainage.

There must be an appropriate amount of right-of-way for control cabinet placement. The minimum amount of right-of-way needed to accommodate the signal controller only is approximately 10 x 10-ft. When dealing with very constrained locations, it is important to consider door swing, cabinet access & pull box placement.

Contact the Electrical Utility regarding availability of commercial power at the intersection quadrant being considered. In some cases, it is necessary to provide conduits under roadways, sidewalks, etc. within the design to allow to utility to feed the cabinet location.

Other location considerations include placing the cabinet where it is possible to observe vehicles within the intersection and where it's not likely to be struck by errant vehicles or snow removal operations. Signal controller cabinets *should* be located on higher ground and outside drainage features such as ditches or near spillways.

4-6-6 Battery Backup Systems — April 2025

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.

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. Diverging Diamond interchanges, or
4. Intersections with triple-left turn lanes

Signalized intersections with battery backup systems are not limited to these intersections. Use engineering judgement to determine other locations to equip signalized intersection with a battery backup system.

POLICY

Location Criteria

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 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 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 considering increased signal infrastructure and associated maintenance demands.

4-6-7 Pull Boxes April 2025

MATERIAL

The old standard pull boxes were constructed from corrugated steel pipe. Because of corrosion associated with certain soil conditions, new side-of-the-roadway installations are now generally constructed from Non-Conductive Materials according to the Standard Specifications. Any pull boxes installed in concrete pavements for loop detectors **shall** be constructed of corrugated steel pipe.

For new construction, side-of-the-roadway pull boxes manufactured with Non-Conductive Materials *should* typically be used. However, like materials (i.e. Steel) *should* still be considered for rehabilitation projects where newly installed or added pull boxes are being intermixed with existing corrugated steel pull boxes (Consult with the Region Traffic Signal Engineer regarding the regional preferences).

SIZES

There are generally nine sizes of steel pull boxes used for traffic signal installations. 12-Inch pull boxes are used in concrete roadways for certain types of loop detector installations. 18-Inch or 24-Inch pull boxes are generally used for Side-Of-The-Roadway installations (Consult with the Region Traffic Signal Engineer regarding Size Preferences for Various Uses)

Standard Size Corrugated Steel Pull Boxes:
12x24-Inch
12x30-Inch
12x36-Inch
18x24-Inch
18x30-Inch
18x36-Inch

24x36-Inch
24x42-Inch
24x48-Inch

Currently, there are two sizes used for Non-Conductive Pull Boxes:
24x36-Inch
24x42-Inch

The engineer *may* use depths up to 42-inches for Non-Conductive and 48-inches for steel. 42-Inch depths are generally considered the minimum depth if running conduit under curb-and-gutter, roadways, and driveways. Refer to the Standard Specifications and Standard Detail Drawings for specific requirements for pull boxes and depth exceptions, or consult with the Region Traffic Signal Engineer for guidance

SPECIAL REQUIREMENTS

Pull boxes **shall not** be installed in asphaltic pavement. 12-Inch corrugated steel pull boxes **shall** be used in concrete pavements for certain types of loop detector installations and **shall** include locking covers.

PLACEMENT

Pull boxes *should* be located at junctions of two or more conduit lines and as near as possible to roadway loop detectors. Pull boxes provide a point from which cables are to be pulled through the conduit or where extra lengths of cables are stored. Pull boxes *should* also be installed:

1. At 200-foot, or less, spacing in conduit runs. Longer runs *may* be used for fiber optic interconnects.
2. At locations where conduits branch.
3. Adjacent to the foundations for signal standards, lighting poles, and controller cabinets.
4. Where loop detector leads are spliced to lead-in cable.

Pull boxes *should not* be in the sidewalk if an alternate location is possible, as they can present a tripping hazard for pedestrians. One possible exception is in the case where conduit is to cross a structure.

4-6-8 Signing and Pavement Marking — April 2025

SIGNS

Supplemental signs recommended for traffic signal operation need not be shown on the signal plan sheet (except for specific signing controlling right turns, i.e. STOP or YIELD). Some of the more common signs include:

SIGNAL AHEAD	W3-3
Pedestrian push button supplemental signs	R10-3 series
LEFT ON GREEN ARROW ONLY	R10-5
LEFT TURN SIGNAL	R10-10
NO TURN ON RED	R10-11b
LEFT TURN YIELD ON FLASHING YELLOW ARROW	R10-50L
RIGHT TURN YIELD ON FLASHING YELLOW ARROW	R10-50R

Foldable stop signs *may* be installed on signal poles for use when state-owned signals are not operating. If folding stop signs are to be used on an approach that has an emergency red flash, they **shall** be placed on the near right and in the median, if a near left signal support exists. Stop signs **shall not** be installed on approaches with an emergency yellow flash.

State of Wisconsin law allows U turns at signalized intersections, unless signs restrict the movement. See TEOpS 2-2-19.1 for additional guidance for placement and use of NO U TURN signs at signalized intersections.

The purpose of left turn arrows on signal heads is to eliminate the need for the use of left turn signs (LEFT ON GREEN ARROW ONLY, LEFT TURN SIGNAL, etc.). The use of these signs *should* be determined on a case-by-case basis. For guidance on the use and placement of LEFT TURN YIELD ON FLASHING YELLOW ARROW signs, refer to TEOpS 2-2-53.

Other traffic control signs (e.g. one-way, no parking, etc.) *should* be installed as needed. These signs **shall** meet the requirements of the WMUTCD and TEOpS policies.

PAVEMENT MARKINGS

Prior to designing the traffic signals on the plan sheet, the pavement markings *should* be located to act as a guide in the location of signal heads, pedestrian heads, and detector loops. All pavement markings **shall** be in conformance with Standard Specifications, TEOpS, and WMUTCD. Any questions regarding pavement markings *should* be directed to the Regional Pavement Marking Engineer.

As stated in 4-5-1, the signal plan sheet **shall** show all crosswalks and stop lines due to their influence on signal and detector placement. The location of handicap ramps *should* also be shown if the crosswalk marking does not adequately show where they are located. The lane lines need to be shown because of their effect on detector and signal head placement and to convey to the review staff the lane designations. Arrows and "ONLY" markings do not need to be placed in all left-turn lanes. Such markings are typically placed at locations where major roads cross, or certain geometric conditions exist. The Regional Pavement Marking Engineer will determine the use of these markings.

4-6-9 Intersection Lighting — April 2025

All state-maintained traffic signals **shall** have lighting installed as part of the signal installation. Local municipality lighting under permit *may* be able to satisfy this requirement. Poles *should* be minimized as much as possible to provide clear sight lines to the signal heads. Therefore, the design *should* combine roadway luminaires with signal poles wherever feasible. When separate street light poles are required, they **shall** be placed to avoid obstructing signal indications.

Historically, it has been standard practice to install at least one luminaire per intersection approach, with additional lighting for high priority area (such as outbound vehicle paths, pedestrian crosswalks, large radius channelized right-turns, and slotted left-turn pockets). For more refined lighting design guidance, reference TEOpS 11-5-1, Signalized Intersection Lighting, and consult with the Regional Lighting Engineer regarding preferences.

Requests for decorative roadway lighting will be handled similar to requests for non-standard WisDOT equipment.

4-6-10 Pedestrian and Bicyclist Crossings — April 2025

Once the determination to install pedestrian signals is made, the next step is to determine where to install the pedestrian signal faces and detection (push buttons) if applicable. The designer **shall** consult the WMUTCD, Section 4E for Pedestrian Control Features and Chapter 9, Traffic Controls for Bicycle Facilities.

Pedestrian push buttons **shall** be shown on the signal plan, mounted approximately perpendicular and in advance of the crossing as required by the WMUTCD.

All pedestrian push buttons **shall** be accessible from the sidewalk to be able to be reached by walkers or people in a wheelchair. This *may* require the installation of a separate pedestrian pushbutton standard. Attempts to locate the pedestrian push buttons as shown in the WMUTCD and per ADA requirements **shall** be made.

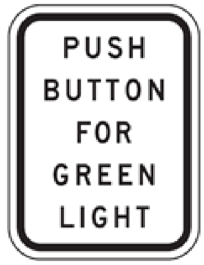
The R10-3E, 3H, 3I, and 3J series pedestrian signs **shall** be mounted on the same poles or standards as the pedestrian push buttons for pedestrian signals with countdown displays. The countdown display style of pedestrian signals **shall** be used on all state-owned traffic signals.

All pedestrian signal faces *should* be conspicuous and recognizable to pedestrians at all distances from the beginning of the controlled crosswalk to a point 10 feet from the end of the controlled crosswalk during both day and night. Sometimes this can be accomplished by attaching the pedestrian signal faces to traffic signal poles or standards. But, to meet the above requirement, a 10-foot pedestrian signal standard *may* need to be installed with just the pedestrian signal face and push button. If the pedestrian signal face can be installed on the traffic signal pole or standard, a 3.5-foot standard *may* still need to be used for a pedestrian push button to comply with the accessible requirements.

The pedestrian phasing *should* be shown adjacent the vehicular phasing on the sequence of operations sheet, shown by a double half arrow on the appropriate side of the vehicular phase arrow.

To accommodate bicyclists who want to cross a highway, a push button accessible to the bicyclist and sign stating, “Push Button for Green Light” (R10-3) as shown in Figure 10.1, *may* be installed. In this case, pedestrian signal faces are not installed; activation of the push button will call and time the pedestrian phase intervals or the bike minimum green interval.

Figure 10.1. R10-3 Sign for Bicyclist



ANIMATED EYES SYMBOL

Reference is made to the WMUTCD 4I.02.

The animated eyes symbol is a dynamic display that supplements standard pedestrian signal indications within the same section. This symbol consists of illuminated eyes that scan from side to side and is meant to prompt pedestrians to be aware of approaching vehicles.

POLICY

Pedestrian signal heads **shall** not incorporate the animated eyes symbol at state-owned signal installations.

SUPPORT

WisDOT supports the use of technologies that address a distinct need related to highway safety & traffic operations. Animated eyes are expected to have a limited effect on improving intersection safety but would require an increase in capital, operations, and maintenance costs. Benefits are not expected to outweigh additional resource expenditures.

IN-ROADWAY WARNING LIGHTS AT PEDESTRIAN CROSSINGS

Reference is made to the MUTCD Chapter 4U.

In-roadway warning lights (IRWLs) are special types of highway traffic control devices installed in the roadway pavement to warn road users that they are approaching a condition on or adjacent to the roadway that *may* not be clear and might require the road users to slow down and/or yield.

IRWLs are actuated devices with flashing indications that provide real-time warning of a specific condition. In-pavement lights that supplement pavement markings by operating in a steady burn state **shall** also require WisDOT approval but are not the focus of this policy.

On the STH system in Wisconsin, IRWLs are limited to situations warning of: marked school crosswalks, marked mid-block crosswalks, marked crosswalks on uncontrolled approaches, and other roadway situations involving pedestrian crossings that are not associated with other types of traffic control.

POLICY

IRWLs, as defined herein, *may* be used on the Wisconsin STH system provided the local jurisdiction:

1. Applies for a permit
2. Agrees to fund the installation, operation, and maintenance of the device
3. Agrees to be responsible for any corresponding damage to the roadway or damage to highway maintenance equipment, and
4. Properly cites appropriate locations based on the conditions of this policy.

The municipality *should* understand that the permit *may* be revoked, especially in the event of safety or operational issues. In such a situation, the original costs and costs to restore the pavement are the obligation of the permit holder.

When allowed by permit, IRWLs **shall** be installed perpendicular to the direction of travel on the roadway and used to supplement crosswalk markings. IRWLs placed along the centerline of a highway, parallel to the direction of travel, **shall not** be used. IRWLs **shall not** be allowed on freeways or expressways.

Prior to the use of IRWLs, adequate trail of standard remedial measures **shall** be used to warn motorists of pedestrian crossings. IRWLs will be used only to supplement typical warning devices such as signs, markings, and crossing guards. Other strategies, such as providing a median refuge roadway lighting in advance of the crossing, or enforcement campaigns, are more universally recognizable methods of warning motorists of these conditions and *should* also be implemented when practicable.

Location Criteria

It is recognized that the use of IRWLs *may* affect STH traffic operations by increasing delay and reducing mobility, especially if used near existing signalized or stop-controlled intersections. The following criteria **shall** be met:

1. Location is an uncontrolled pedestrian crossing.
2. Location is an established school route, accommodates a minimum pedestrian volume of 100 pedestrians/day, or location has experienced pedestrian crashes in the past 3 years.
3. Subject crossing is in municipal (non-rural) limits.
4. There exists a minimum of 300 feet between the subject crossing and the nearest uncontrolled pedestrian crossing, or intersection traffic control device on the STH.
5. There exists a minimum of 1200 feet between the subject crossing and the nearest uncontrolled pedestrian crossing supplemented with in-roadway warning lighting unless exceptional conditions exist.
6. Roadway has a maximum of four travel lanes with a maximum single-stage crossing distance of 50 feet.
7. Approach speed is posted at less than 50 mph.
8. Adequate stopping sight distance exists based on the following approach speeds:
    a. 15 or 25 mph = 200 ft
    b. 30 mph = 250 ft
    c. 35 mph = 300 ft
    d. 40 mph = 400 ft
    e. 45 mph = 500 ft

Design Requirements

In the interest of uniformity, reliability, and consideration for other highway users, the following minimum design requirements for IRWLs **shall** be met:

1. Number/positioning of lights:
    a. For two-lane undivided roadways: 5 IRWLs per direction
    b. For four-lane undivided roadways: 7 IRWLs per direction
    c. For four-lane divided roadways: 5 IRWLs per direction.
2. IRWLs **shall** be actuated and **shall not** flash continuously.
3. If pedestrian push buttons are used to actuate the IRWLs, a PUSH BUTTON TO TURN ON WARNING LIGHTS (R10-25) sign **shall** be mounted adjacent to or integral with each pedestrian push button.
4. For four-lane divided roadways with median widths equal to or exceeding 6 feet, pedestrian actuation in the median **shall** be provided to allow for a two-stage crossing of the roadway.
5. Lights **shall** be evenly spaced across the entire traveled way. Lights *should* be positioned outside of vehicle wheel paths and *should* also consider bicyclist routes adjacent the traveled way. Lights placed near the centerline of the roadway *should* be offset slightly to minimize interference with pavement marking operations.
6. Electrical wire **shall** be cast in a minimum of 8-inch concrete pavement. If IRWLs are being installed with an improvement project that requires a pavement section greater than 8 inches, then the pavement at the crossing *should* be made to match that of the adjacent roadway. Pavement reinforcement *may* not be required, but this decision will reside with the regional pavement design unit. Doweling to adjacent concrete pavement will also be required at the direction of the regional pavement engineer. A minimum 2 feet of clearance to the edge of the concrete **shall** be maintained. Pavement structure **shall** be installed according to WisDOT Standard Specifications. Installation in existing pavement by sawing or coring is not permissible. Minimal width of the concrete, measured longitudinally in the direction of traffic, **shall** be 12 feet.

7. Roadway profile **shall** be appropriately maintained by milling or wedging the approach to the crossing, as required.
8. IRWLs **shall** flash for the entire calculated pedestrian clearance time. Pedestrian clearance *should* be calculated based on a 3.5 ft/sec walking speed. Locations frequented by children and elderly users *may* have a pedestrian clearance based on a slower walking speed. A brief time extension of 3 to 7 seconds *may* be added to allow for vehicle/pedestrian response and separation.
9. Features meant to accommodate impaired pedestrians such as actuator buttons with locator tones, supplemental braille signing, etc., *should* be considered at individual locations on a case-by-case basis. If used, these devices **shall** be furnished and maintained by the municipality that requests the IRWLs.
10. Other design criteria **shall** conform to the manufacturer's recommendations.

SUPPORT

There are several general points of concern regarding the use of these devices:

1. IRWLs do not ensure that motorists will appropriately yield the right of way to pedestrians in the crossing.
2. A public awareness and education campaign *may* be required to educate the public prior to operating IRWLs.
3. IRWLs *may* cause rear-end collisions similar to a signal installation.
4. Placement of IRWLs between coordinated traffic control signals *may* cause progression problems.
5. Any improperly installed electrical equipment *may* pose a hazard to the public.
6. In Wisconsin, IRWLs *may* be susceptible to premature failure due to moisture buildup and/or snow removal operations.
7. The type of actuation used for IRWLs needs to be considered. Active detection (i.e. pushbutton) *may* create a false sense of security for pedestrians who are not familiar with the use of such devices or the rules of the road. Because of these factors, passive detection (i.e. infrared) is considered more appropriate for these types of applications, especially in crosswalks associated with school zones. In either case, an informational plaque *should* be used to briefly describe proper crossing behavior while using IRWLs. These are similar to informational plaques used at signalized pedestrian crossings (R10 series).
8. In IRWLs will be placed outside of existing connecting highway limits within a municipality, consideration *should* be given to extend those limits to include the installation location.

4-6-11 Emergency Vehicle Preemption (EVP) and Traffic Signal Priority (TSP) Detection — April 2025

Follow the manufacturer's specification for correct mounting height of emergency vehicle detectors. Line of sight criteria **shall** be considered when showing EVP and TSP detectors on signal plans for certain kinds of systems. The newer GPS based systems do not rely on line-of-site. Check with the vendor supplying the equipment and local municipality requesting the system regarding system requirements.

4-6-12 Monotube Signal Arms and Pole Structures — April 2025

The following is a set of guidelines related to the use and placement of monotube signal arm assemblies for traffic signals. It is to be used by Regional Traffic Signal Engineers and consultants for the design (or design review) of a signalized intersection.

1. Monotube arm assemblies **shall** be used on any approach with two or more through lanes for modernization projects (State owned signals only).
2. Monotube arm assemblies *should* be used on any approach with two or more through lanes for resurfacing, pavement replacement, and reconditioning projects (when feasible based on available right-of-way and other constraints) (State owned signals only).
3. Signal heads *should* be mounted in such a way that they are centered over their respective receiving lane. Two 3-section signal heads *may* be vertically mounted on a trombone arm if the far head placement does not exceed 22' from the pole. Engineering judgment *should* be used to determine the appropriate location

for each head when the roadway is skewed, or other unusual geometrics cause a shift between the approach lanes and receiving lanes.

4. Poles with monotube arm assemblies *may* be installed in “pork chop” divider safety islands and in median islands. A raised median is defined as having a minimum width of 6’ face-to-face (although 8’ is desirable).
5. Poles with monotube arm assemblies are not required to be shielded; however, engineering judgment *should* be used to determine a reasonable offset from any adjacent travel lanes since the bases are non-breakaway.
6. Reverse mounted monotube arm assemblies *may* be used.
7. Ideal pole placement *may not* facilitate proper ADA push button placement, therefore additional poles for pedestrian push buttons *may* be required.
8. Monotube arm assemblies with a signal head positioned for each lane *may* be utilized for single or multiple left turn lane designs however are not required.
9. A luminaire can be mounted above the monotube arm, 180-degrees from the monotube arm, or in both locations. Contact the Regional Signal Engineer for permission to add a clamp-on camera to the luminaire arm.
10. For typical design information, see Standard Detail Drawings 9E8.
11. The concrete base **shall** be further extended above ground when the ground elevation at the base is lower than the high point of roadway elevation. See Standard Detail Drawing 9C13 for construction information.
12. Each monotube arm assembly and pole structure **shall** be assigned a structure number by the Region. This number **shall** appear on the traffic signal plans and will be identified in the field on each pole. Regional electricians **shall** work directly with their Regional Signing Coordinator to place an order for each identification plaque. Installation of the plaques **shall** conform to the guidance in Standard Detail Drawing 12A4.
13. The Designer **shall** be responsible for calculating the overturning and twisting factors associated with each monotube arm assembly and pole structure layout to ensure that they have not exceeded the maximum loading. The table of maximum values for these factors (and an example calculation) can be found in Figure 12.1. The designer’s calculations *should* be made available to the Regional Traffic Signal Engineer or the Statewide Traffic Signal Engineer upon request. A few items to note when using these equations:
    - <u>No</u> additional calculations are required to account for the luminaire and luminaire arm on the Type 10 & Type 13 poles.
    - Signs and signals that are mounted perpendicular to the face of the monotube arm do <u>not</u> need to be included in the calculations.
    - Effects of push buttons are considered negligible and therefore do <u>not</u> need to be included in the calculation.
    - Square footage information for standard signal equipment is as follows:
        - 5 section signal head – 13.33 sq. ft.
        - 4 section signal head – 11.00 sq. ft.
        - 3 section signal head – 8.67 sq. ft.
        - 1 section pedestrian head – 2.0 sq. ft.

Figure 12.1. How to check loading on a monotube signal/sign structure

This example shows how to check the ability of a monotube traffic signal structure to carry a proposed loading. The number of traffic signal attachments, signs, and their dimensions are for illustrative purposes only. The calculations for any given installation will vary by the specific number of traffic signal attachments, signs, and their dimensions and positioning for that specific installation.

Given: Type 12 pole, 50' arm, loading with signals and signs, positioned and dimensioned as shown in illustration.

Determine: Adequacy of Type 12 pole with 50' arm to carry proposed attachments

Calculate overturning and twisting factors (mv) & (mh):

mv = sum (each attachment area X distance from arm attachment point to the bottom of the upright)

mh = sum (each attachment area X distance from the center of each attachment to the center line of the upright)

area of 5-head signal on arm = 2' X 6.67' = 13.33 sq.ft.

area of directional sign on arm = 2' X 2.50' = 5 sq.ft.

area of <u>each</u> 3-head signal on arm = 2' X 4.33' = 8.67 sq.ft. <u>each</u>

area of sign on pole = 3' X 4' = 12 sq.ft.

mv = [(13.33 sq.ft. + 5 sq.ft. + 8.67 sq.ft. + 8.67 sq.ft.) X (19 ft. nominal)] + [12 sq.ft. X 10 ft.] = 797.73 ft^3

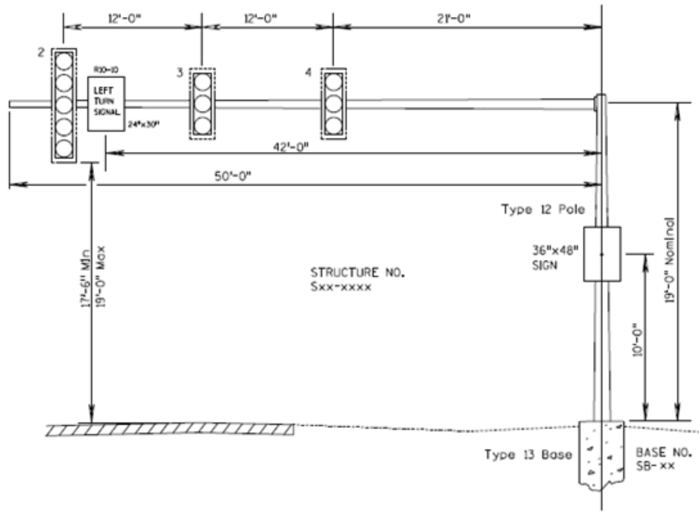
mh = (13.33 sq.ft. X 45 ft.) + (5 sq.ft. X 42 ft.) + (8.67 sq.ft. X 33 ft.) + (8.67 sq.ft. X 21 ft.) + (12 sq.ft. X 0 ft.) = 1278.0 ft^3

<u>Enter table for checking loading using the row for a 50 ft. arm length:</u>

Overturning factor = MV = 1733 ft^3 maximum

Twisting factor = MH = 2151 ft^3 maximum

The proposed loading of signal and sign attachments on the Type 12 pole with a 50 ft. arm is acceptable since mv = 798 ft^3 is less than MV = 1733 ft^3 and mh = 1278 ft^3 is less than MH = 2151 ft^3.



<u>Table for checking loading on a monotube traffic signal structure</u>

Arm length (ft)	MV (maximum) (ft^3)	MH (maximum) (ft^3)
15	834	295
20	1007	416
25	1007	594
30	1007	771
35	1560	1168
40	1560	1477
45	1733	1792
50	1733	2151
55	1733	2510

4-7-1 Sequence of Operations — April 2025

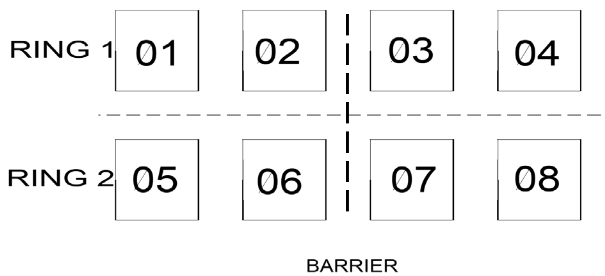
NEMA PHASING

The traffic signal maintaining authority **shall** be contacted for purposes of determining the type of NEMA phasing.

For all new state-owned signals, actuated controllers **shall** be used. Legacy equipment *may* remain for the remainder of the life of the equipment or until a construction project comes through; whichever comes first.

Traffic signal phasing **shall** be in accordance with NEMA standards for actuated signal controllers unless directed otherwise by a WisDOT Region Traffic Signal Engineer. Under NEMA phase designations, there can be a total of eight phases, which are grouped in two rings as illustrated in Figure 1.1.

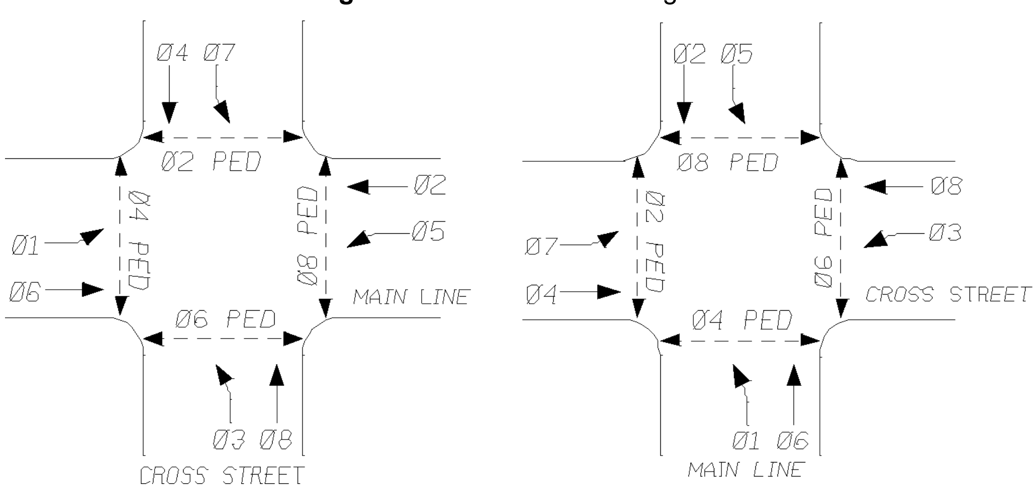
Figure 1.1. Ring Barrier Diagram



The phases are separated by what is referred to as a barrier, which prohibits the servicing of conflicting phases that are in separate rings simultaneously.

For standard traffic signal phasing the vehicular movements **shall** be referenced to the associated NEMA phase numbers as designated in Figure 1.2. The NEMA phase designation diagram represents an eight-phase signal operation with protected/permissive or protected-only left turns on all approaches. Pedestrian phasing, where applicable, *should* be designated by the complementary through movement phase associated with the specific pedestrian movement.

Figure 1.2. NEMA Phase Diagram



Phase 6 *should* normally be oriented in the mainline northbound or eastbound through direction for plan preparation purposes, with the remaining phases oriented according to the relationship illustrated in Figure 1.2.

For signals on a state trunk highway, NEMA phase designation **shall** be used. For example, mainline east-west through movements *should* be called out as Ø6 and Ø2, not just Ø2 (or just Ø6), and cross street through movements *should* be called out as Ø8 and Ø4, not just Ø8 or Ø4. In addition, left turn phasing *may* be added in the future. Due to this, eight-phase dual-ring controllers **shall** be used at state-owned signals.

STANDARD & SPECIAL OVERLAPS

Another factor related to phasing and head displays is the use of overlaps. There are two types of overlaps: standard overlaps and special overlaps. A Standard Overlap is defined as a right-of-way indication that allows traffic to turn when the right-of-way is assigned to two or more traffic phases. A Special Overlap is a non-standard overlap used to run a flashing yellow arrow which is tied to an opposing phase.

Standard Overlaps

Under this type of operation, for example, a right turn movement moves in conjunction with the complementary left turn movement from the crossing street. Typically, this type of operation is best utilized when there are exclusive lanes for each movement. This type of operation allows for efficient use of the green time for both streets by maximizing vehicle throughput. Standard Overlaps are also commonly used at interchanges, typically tying multiple complementary movements together across the interchange.

Right turn overlaps can be considered for use at locations where there is an exclusive right turn lane and a complementary left turn lane with a protected left turn phase on the crossing street. In areas where pedestrian demands are high, particularly in central business districts (CBDs), school crossings, or locations associated with special events, the use of right turn overlaps *should* be carefully evaluated with respect to pedestrian safety. In most cases, right-turn overlaps for these types of areas *should* be avoided.

Figure 1.3 illustrates the chart used for Standard Overlaps. This chart is located on the Sequence of Operations Sheet. The overlap *should* only be shown if it overlaps two (2) or more phases. The chart *should* indicate which phases the overlap times concurrently.

Figure 1.3. Standard Overlap Chart

O.L. “A” =
O.L. “B” =
O.L. “C” =
O.L. “D” =

Special Overlaps

Special Overlaps are non-standard overlaps used to control flashing yellow arrows for left or right turns tied to an opposing through phase.

The WMUTCD has instituted a requirement that green circular indications **shall not** be used in front of left turn lanes. Flashing yellow arrows (FYA) *should* be utilized by WisDOT for state owned signals to meet this requirement yet still provide either permissive only OR protected/permissive left turn and/or right turn movements. For right turn FYAs, the Region’s Traffic Signal Engineer **shall** be contacted on how to setup the right turn FYA.

The operation of the FYA signal heads is straight forward; however, it does require some additional wiring and programming in the cabinet. The following information details how to complete a Sequence of Operations Sheet for a traffic signal with a flashing yellow arrow.

Flashing yellow arrows are handled in the controller via the use of a SPECIAL overlap. To simplify and standardize the cabinet wiring, each overlap has been assigned to a specific phase as follows depending on what type of cabinet is used (TS1 or TS2):

Table 1.1 Overlap Assignments – TS2 Cabinet, Mode G

Overlap	Left Turn Phase	Opposing Thru Phase
“E”	1	2
“F”	3	4
“G”	5	6
“H”	7	8

For additional modes (e.g., Mode B) and TS1 cabinet overlaps, see signal controller & cabinet manufacturer documentation.

If your design only has one or two FYA operations, you do not simply assign Overlaps E & F, but rather the overlap that is associated with that left turn phase and/or opposing through phase as listed in Table 1.1.

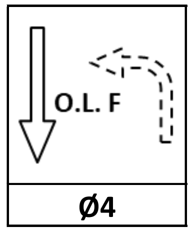
<u>Ring/Barrier Diagram:</u>

Permissive Only:

If your FYA is being operated in permissive mode only, your signal plan will show 3-section signal heads in the following configuration from top to bottom; red arrow, yellow arrow, flashing yellow arrow. The head numbers affiliated with these 3-section signal heads will be listed in the row for the associated overlap, only.

The overlap will graphically be shown in the same box as the arrow for the opposing through movement. It is recommended that this arrow either have a dotted/dashed pattern, or that it be hollow (with all other non-FYA arrows being filled in) to show that this is a flashing arrow, and not a green arrow (as shown in Figure 1.4).

Figure 1.4. Permissive Only FYA

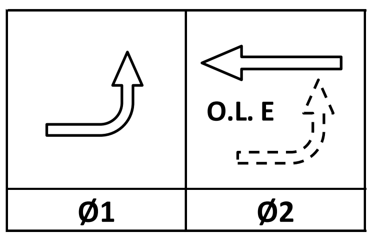


Protected / Permissive:

If your FYA is being operated in protected / permissive mode, your signal plan will show 4-section signal heads in the following configuration from top to bottom; red arrow, yellow arrow, flashing yellow arrow, green arrow. The head numbers affiliated with these 4-section signal heads will be listed in the row for the associated left turn movement **and** in the row for the associated overlap.

The overlap will graphically be shown in the same box as the arrow for the opposing through movement. It is recommended that this arrow either have a dotted/dashed pattern, or that it be hollow (with all other non-FYA arrows being filled in) to show that this is a flashing arrow, and not a green arrow (as shown in Figure 1.5).

Figure 1.5. Protected / Permissive FYA



OTHER TABLES

The Sequence of Operations Sheet contains several tables and charts. A complete description of the Detector Logic Chart and Controller Logic Chart is covered in TEOpS 4-8-2 and the Sequence of Operation Chart is discussed in TEOpS 4-7-1. Five tables have been created for special purposes; these are shown in Figure 1.6 below.

Figure 1.6. Sequence of Operations – Other Tables

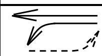
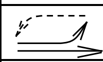
TYPE OF INTERCONNECT/COMMUNICATION	
NONE	
CLOSED LOOP	
TWISTED PAIR	
FIBER OPTIC*	
FIBER OPTIC (ETHERNET)	
RADIO	
CELL MODEM	

TYPE OF COORDINATION	
NONE	
TBC	
TRAFFIC RESPONSIVE	
ADAPTIVE	
*LOCATION OF MASTER CONTROLLER NO: S-	
SIGNAL SYSTEM NO: SS-	

TYPE OF PRE-EMPT	
NONE	
RAILROAD	
EMERGENCY VEHICLE	
GTT	
TOMAR	
HARDWIRE	
OTHER	
LIFT BRIDGE	
QUEUE DETECTION	

TYPE OF LIGHTING	
BY OTHER AGENCY	
IN TRAFFIC CABINET	
IN SEPARATE DOT LIGHTING CABINET	

EMERGENCY VEHICLE PREEMPTION SEQUENCE

EMERGENCY VEHICLE PREEMPTOR	A	B	C	D
MOVEMENT				
PHASE	2+5	6+1	4+8	8+3

The main purpose of these tables is to indicate what additional equipment *may* be installed at the intersection. These tables *should* always be filled in.

TYPE OF COORDINATION AND TYPE OF COMMUNICATION TABLES

Coordinating traffic signals requires several additional coordination settings to be made in the controller. The type of coordination *should* be indicated with an "X." If the type of coordination is other than TBC, then the master signal controller location **shall** be identified by the signal number.

Designate, with an “X”, the type of communication at the intersection in the Type of Communication Table.

TYPE OF PREEMPT AND EVP SEQUENCE TABLES

Use of a preempt device at some locations provides additional safety for both the motorist and preempt authority (i.e. railroad, emergency vehicle). The type of preempt *should* be indicated with an "X."

If railroad preemption is installed at the intersection, in addition to filling out the Type of Preempt Device Table, one *should* include a general note on the Sequence of Operations Sheet. The note *should* describe the preempt sequence beginning at the track clearance green through the preempt cycle. The note *should* describe the phases and sequence used at the intersection when the signal is preempted. A sample railroad preemption note is shown below:

> *IN THE EVENT OF A RAILROAD PREEMPTION CALL, PHASE 8 SHALL RECEIVE A GREEN INDICATION TO CLEAR THE SOUTH APPROACH. FOLLOWING THE TRACK CLEARANCE INTERVAL, THE CONTROLLER SHALL ADVANCE TO PHASES 2 & 6 GREEN AND HOLD FOR THE DURATION OF THE PREEMPTION. AT THE END OF THE PREEMPTION, THE CONTROLLER SHALL RETURN TO PHASES 4 & 8 GREEN.*

For Emergency Vehicle Preemption (EVP), emergency vehicle in the Type of Preempt Table and the brand of EVP equipment *should* be checked and the EVP Sequence Table *should* be filled in.

Additional discussion on the preemption of State signals; including eligibility, request procedure, review/approval, installation, and cost is covered in TEOpS 4-2-3.

TYPE OF LIGHTING TABLE

Designate with an "X" the type of lighting service installed at the intersection. It is important to indicate whether lighting is wired into the traffic signal cabinet or to a separate lighting cabinet. If state and local lighting exist at same intersection, multiple boxes **shall** be checked to reflect maintaining authority for all lighting.

FLASHING YELLOW ARROW

For information about flashing yellow arrows, see TEOpS 4-7-1 Standard & Special Overlaps, Special Overlaps topic.

4-7-2 Left Turn Phasing April 2025

Adding phases leads to an increase in cycle length and delay and decreases intersection efficiency, especially at pre-timed signals. In addition, adding non-warranted left turn phases *may* impact driver perception and lead to requests for left turn phases at other non-warranted locations. Left turn phasing *should* be determined early in the design process, prior to completing the capacity analysis and starting geometric design.

Left turn phases *should* be considered on approaches when:

- Visibility is limited. Queue spillback occurs into adjacent through lane
- Left turn queue does not consistently clear during permissive green.
- There exists a left turn delay of 2.0 vehicle hours or more in a peak hour on a critical approach.
- The left turn crash experience meets or exceeds: for one approach, four left turn crashes in one year or six in two years; or for opposing approaches, six left turn crashes in one year or ten in two years. Analysis **shall** include review of past 5 years of crash records. This will allow the engineer to determine if crash patterns exist, and what circumstances *may* be involved.
- The product of a left turning volume and its opposing through, and right-turn volume meet or exceed the minimum requirements given in the table below during the peak hour. All opposing through traffic including right turns *should* be considered unless the right turns are well removed from the intersection.

The number of phases at signalized intersections *should* be kept to a minimum.

Minimum Vehicular Volumes for Left Turn Analysis

Number of left turn lanes	Number of opposing through lanes	Product of peak hour left turning vehicles and opposing plus right-turn vehicles
1	1	50,000
1	2	100,000
1	3 or more	Engineering Judgement

In any case, left turn phasing **shall** be approved by the Regional Traffic Engineer.

Typically, separate opposing or positively offset left turn lanes *should* be provided on all approaches to allow for simultaneous leading left turn phases now and in the future. If the geometrics cannot be improved to allow simultaneous leading left turn phases, then alternative phasing could be considered (Such as “Split” or a “Lead-Lag Protected-Only Left”) to avoid the conflict. These phasing alternatives are not desired, therefore **shall** <u>only</u> be considered as last resort in extreme cases. These alternatives are inefficient, especially if there are pedestrian phases on both approaches of a street. Geometric improvements **shall** always be explored first.

In most cases, protected/permissive left turn phasing *should* be tried prior to installing protected only phasing. Installing protected/permissive phasing rather than protected only phasing typically results in increased intersection capacity and decreased intersection delay and driver frustration.

Protected only by time-of-day *may* also be an option when opposing through traffic is high at consistent, predicted times.

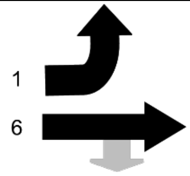
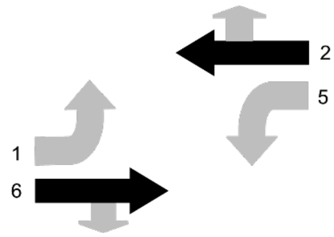
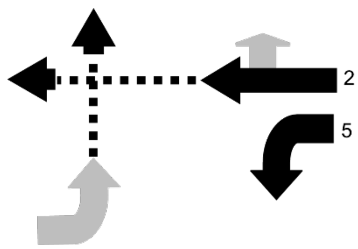
Protected only phasing *should* be used to control to control dual left turn lanes and **shall** be used to control triple left turn lanes. In addition, protected only phasing *should* be considered in cases where visibility of opposing thru traffic to left turning vehicles is not sufficient to allow for a safe movement and improving the geometrics is not feasible. This typically occurs with wide medians where left turn lanes are not opposing or positively offset. When protected only phasing is installed on one approach the opposing approach **shall** have protected only phasing **or** a flashing yellow arrow due to driver perception and safety.

Protected only left turn phasing *should* also be considered at locations with higher operating speeds (greater than 45 mph), when left-turn movements need to cross more than two opposing through lanes and when crash trends dictate.

Typically, left-turn phases are leading.

Lagging protected/permissive left turn phasing **shall not** be utilized as it creates a dangerous situation often referred to as a “left turn trap” or “yellow trap”. Figure 2.1 shows the phase intervals for this situation. Three exceptions are as follows; at T-intersections, at interchange ramp terminals where no opposing left turn movements exist, and when flashing yellow arrows are utilized for the protected/permissive left turn.

Figure 2.1. Left turn trap diagram

	**Interval 1**: Phase 1 eastbound shows protected left turn arrow while phase 6 eastbound through shows a green ball.
	**Interval 2**: Phase 1 eastbound and phase 5 westbound show permissive left turn (flashing yellow arrow or green ball) while phase 2 and phase 6 through shows green ball. At the end of interval 2, phase 1 displays a yellow indication. Since the eastbound left sees the yellow on all facing displays, they *may* incorrectly presume that westbound left and through is likewise receiving a yellow ball and about to stop.
	**Interval 3**: Phase 5 westbound shows protected left westbound turn arrow while phase 2 westbound through shows green ball. Eastbound left *may* have assumed the westbound through was stopping creating a crash situation.

Lead-lag left turn phasing *may* be utilized only when there is protected only phasing on both approaches of a street. This phasing sequence can be advantageous when used on a coordinated street as it has the potential to maximize two-way progression. An example of this sequence is: NB leading protected left phase and NB through phase followed by the NB and SB through phases, followed by the SB lagging left phase and SB through phase.

4-7-4 Flashing Operations — April 2025

Reference is made to the WMUTCD, Section 4G, and Wisconsin State Statute 346.37 and 346.39.

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 an 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.

4-7-5 Vehicle Clearance Intervals — April 2025

Reference is made to the WMUTCD 4F.17.

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 WMUTCD, 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:

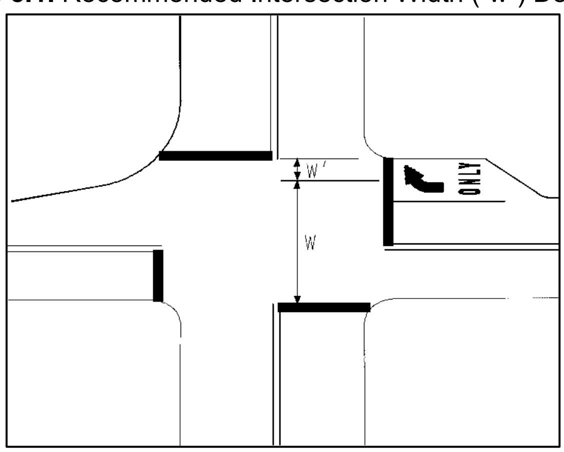
$$CT = prt + \frac{v}{2a+2Gg} + \frac{L+w}{v}$$

$$= \text{yellow portion} + \text{all-red portion}$$

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 5.1. 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 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 5.1. Yellow Clearance Intervals at Deceleration Rate of 10 fps^2

Approach Speed (mph)	Approach Grade								
	+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 5.2. Yellow Clearance Intervals at Deceleration Rate of 15 fps^2

Approach Speed (mph)	Approach Grade								
	+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 5.3. All-Red Clearance Intervals

Approach Speed (mph)	Intersection Width (ft)								
	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 near 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 near 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 using 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.

4-7-6 Traffic Signal Coordination and Communication — April 2025

"Signal systems…are proven to reduce stops, reduce delays and decrease accidents; increase average travel speeds; and decrease emissions." (ITE Traffic Control Devices Handbook, pg. 336, © 2001 Institute of Transportation Engineers). There are several parameters that affect coordinated signal system efficiency: spacing, vehicle travel time, cycle length, offset, splits, and phasing. The primary factors to consider for coordination of signals are spacing of signalized intersections, traffic characteristics, and signal operations.

When signalized intersections are spaced closer than a half-mile coordination **shall** be considered. This will usually include arterial segments and interchanges. Signalized intersections spaced less than a quarter mile can be coordinated but it *may* be difficult to maintain ideal two-way progression when closely spaced. Signals that are spaced greater than a half mile *should* also be considered for coordination if traffic progression can be maintained.

Traffic characteristics will also influence the decision to coordinate adjacent signals. Random arrival patterns and/or relatively light approach demand *may* indicate the need to coordinate signals only during certain times. Alternatively, heavy volumes with repetitive patterns such as commuter routes, *may* have variable timing plans throughout a day.

Regardless of existing volumes and turning movements, plans *should* include provisions for future coordination at closely spaced intersections. Such provisions will depend on the type of coordination but will commonly include a conduit run between controller cabinets to accommodate future interconnect cable.

There are multiple ways to provide coordinated systems; however, most state-owned systems will consist of Time-Based Coordination (TBC), traffic-responsive coordination, or adaptive coordination.

TBC uses the functionality of the internal controller clocks without a physical connection between control cabinets. Clocks need to be synchronized for TBC to be effective. This type of coordination utilizes minimal infrastructure yet *may* require a more significant effort from operations staff to maintain proper coordination.

Traffic-responsive and adaptive coordination requires communications between controllers. This can be achieved by radio, phone line (tone), twisted pair, fiber optic, or cellular modem. Fiber optic is the most common in urbanized areas where connection to the fiber backbone is possible. This type of connection requires a conduit run between each control cabinet with pull boxes and/or communication vaults spaced along the run. Cellular modem is most common in rural areas. Closed Loop systems have the added functionality of being remotely accessed for program changes and timing plan verification.

There are several methods for providing specialty equipment used for signal coordinated signal systems:

- Intersections where signals will be in the future. At such locations, underground facilities *should* be installed with an improvement project or permit project (TIA process). The underground facilities generally consist of conduit runs across the intersection approaches, some pull boxes, and *may* include some loop installations. These intersection locations will usually be cited based on an engineering study where warrants are close to being met, or at locations where adjacent properties are developing.

  At such locations, conduit *may* be installed between future controller cabinet locations (typically on the side of the highway segment). Common practice is to base the need for this equipment based on spacing between adjacent intersections that *may* become signalized. It is worth remembering that these electrical facilities will need to be included in the Regional database for purposes of marking them in the field during any construction activities.

- Intersections where signals are proposed. If an engineering study determines that a signal will benefit intersections operations, yet it will need to be interconnected with an adjacent signal installation, common practice is to fund and implement any interconnection provisions with that signal.

  If the installation cannot be provided for by an improvement project or is not the result of changes to the adjacent land use, The Regional operations budget *may* be used to fund candidate locations. Highway Safety Improvement Program (HSIP) or Signals and ITS Standalone Program (SISP) funds *may* also be applied for on a case-by-case basis.

- Intersection where signals exist. Funding opportunities are the same as bullet above.

4-7-7 Railroad Preemption — April 2025

According to the WMUTCD Part 8D.09, whenever a traffic control signal is located within 200-ft of a highway-rail grade crossing equipped with a flashing-light signal system, the traffic control signals *should* be interconnected to provide preemption. This distance criteria *may* need to be greater than 200-ft when conditions warrant (Factors to consider include: traffic volumes, highway vehicle mix, highway vehicle and train approach speeds, frequency of trains, and queue lengths). Potential queuing over the tracks *should* be checked using appropriate methods, and *should* be based on 95% probability levels, or field observations.

Any planned traffic signal near a highway-rail grade crossing will require close coordination with WisDOT Railroads & Harbors Section (RHS) in the Bureau of Transit, Local Roads, Railroads and Harbors (BTLRRH) and the appropriate railroad authority. Such coordination will likely affect the project budget and schedule. Early coordination will help minimize project delays, especially if work needs to be performed by the railroad (i.e., new or relocated control cabinet, interconnection, advance pre-emption circuits, gates, constant warning time circuitry, etc.)

A protected left turn signal indication **shall** be provided for the left turns from the intersection approach that crosses the tracks. The protected left turn indication (displayed as a green arrow) *may* or *may not* be displayed during normal signal operation depending on the normal signal phase sequence. Protected left turn indications at intersection approaches that cross the tracks **shall** display a green signal indication during the track clearance interval. The intent of the protected left turn indication is to minimize hesitation from drivers waiting to clear the crossing.

Timing calculations for appropriate advance warning will need to be provided to RHS for purposes of determining proper railroad systems design. Advance preemption calculations **shall** be determined for best-case and worst-case scenarios, based on planned phasing/timing schemes.

A railroad preemption timeline *should* be prepared and submitted to RHS with the advanced preemption calculations.

Highway Safety Improvement Program (HSIP) funding *may* be available for highway-rail grade signal interconnection projects. The WisDOT RHS *may* also be able to provide such funding.

If a traffic control signal will be pre-empted by railroad operations, then a signal cabinet battery back-up unit **shall** be used.

Figure 7.1a. Railroad Preemption Time Requirements

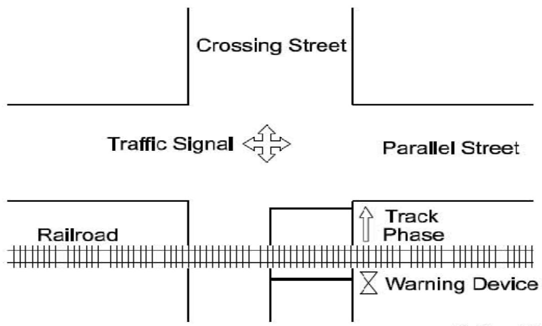
Version 2.0

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 ____

North Facing:(check one)
- ☐ Up
- ☐ Upper right
- ☐ Right
- ☐ Lower right
- ☐ Upper right
- ☐ Upper left
- ☐ Lower right
- ☐ Lower left
- ☐ Left



Parallel Street Name ____

Crossing Street Name ____

Railroad ____
Crossing DOT # ____
M.P. ____

Railroad Contact ____
Phone ____

SECTION 1: RIGHT-OF-WAY TRANSFER TIME CALCULATION

Preempt verification and response time — Remarks

1. Preempt delay time (seconds) ____
2. Controller response time preempt (seconds) ____ — Controller type ____

3. Preempt verification and response time (seconds) add lines 1 and 2 ____ seconds

Worst-case conflicting vehicle time — Remarks

4. Worst-case conflicting vehicle phase number ____
5. Minimum green time during right-of-way transfer (seconds) ____
6. Other green time during right-of-way transfer (seconds) ____
7. Yellow change time (seconds) ____
8. Red clearance time (seconds) ____

9. Worst-case controlling vehicle time (seconds) add lines 5 through 8 ____ seconds

Worst-case conflicting pedestrian time — Remarks

10. Worst-case conflicting pedestrian phase number ____
11. Minimum walk time during right-of-way transfer (seconds) ____
12. Pedestrian clearance time during right-of-way transfer (seconds) ____
13. Vehicle yellow change time, if not included on line 12 (seconds) ____
14. Vehicle red clearance time, if not included on line 12 (seconds) ____

15. Worst-case conflicting pedestrian time (seconds) add lines 11 through 14 ____ seconds

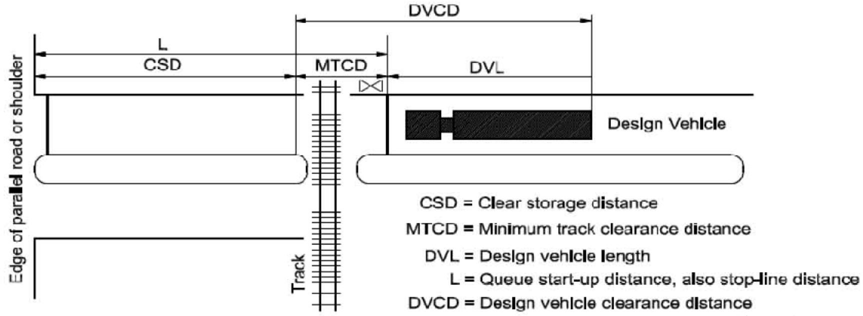
Worst-case conflicting vehicle or pedestrian time

16. Worst-case conflicting vehicle or pedestrian time (seconds) maximum of lines 9 and 15 ____ seconds

17. Right-of-way transfer time (seconds) add lines 3 and 16 ____ seconds

Figure 7.1b. Railroad Preemption Time Requirements

SECTION 2: QUEUE CLEARANCE TIME CALCULATION



Remarks

18. Clear storage distance (CSD, feet)
19. Minimum track clearance distance (MTCD, feet)
20. Design vehicle
    School Bus (use 45 feet)
    WB-62 (Semi Trailer) - (use 75 feet)

21. Queue start up distance, L (feet) add lines 18 and 19

Remarks

22. Time required for design vehicle to start moving (seconds): calculated as 2+(L/20)

23. Design vehicle clearance distance, DVDC (feet): add lines 19 and 20

24. Time for design vehicle to accelerate through the DVCD (seconds) See Figure 2

25. Queue clearance time (seconds): add lines 22 and 24

SECTION 3: MAXIMUM PREEMPTION TIME CALCULATION

Remarks

26. Right-of-way transfer time (seconds): line 17
27. Queue clearance time (seconds): line 25
28. Desired minimum separation time (seconds)

29. Maximum preemption time (seconds): add lines 26 through 28

SECTION 4: SUFFICIENT WARNING CHECK TIME

Remarks

30. Required minimum time, MT (seconds): per regulations
31. Clearance time, CT (seconds): get from railroad
32. Minimum warning time, MWT (seconds): add lines 30 and 31
33. Advance preemption time, APT, if provided (seconds): get from railroad

34. Warning time provided by the railroad (seconds): add lines 32 and 33

35. Additional warning time required from railroad (seconds): subtract lines 34 from line 29, round up to nearest full second, enter 0 if less than 0

If the additional warning time required (line 35) is greater than zero, additional warning time has to be requested from the railroad. Alternatively, the maximum preemption time (line 29) may be decreased after performing an engineering study to investigate the possibility of reducing the values on lines 1,5,6,7,8,11,12,13 and 14.

Remarks

Figure 7.1c. Railroad Preemption Time Requirements

SECTION 5: TRACK CLEARANCE GREEN TIME CALCULATION (OPTIONAL)

Preempt Trap Check

36. Advance preemption time (APT) provided (seconds): Line 33 only valid if line 35 is zero.
37. Multiplier for maximum APT due to train handling See instructions for details
38. Maximum APT (seconds): multiply line 36 and 37 Remarks
39. Minimum duration for the track clearance green interval (seconds) For 0 advance preemption time
40. Gates down after start of preemption (seconds): add lines 38 and 39
41. Preempt verification and response time (seconds): line 3 Remarks
42. Best-case conflicting vehicle or pedestrian time (seconds): usually 0
43. Minimum right-of-way transfer time (seconds): add lines 41 and 42
44. Minimum track clearance green time (seconds): subtract line 43 from line 40

Clearing of Clear Storage Distance

45. Time required for design vehicle to start moving (seconds). Line 22
46. Design vehicle clearance (DVCD, feet), line 23 Remarks
47. Portion of CSD to clear during track clearance phase (feet) CSD* in figure 3 in Instructions
48. Design vehicle relocation distance (DVRD, feet): add lines 46 and 47
49. Time required for design vehicle to accelerate through DVRD (seconds)
50. Time to clear portion of clear storage distance (seconds): add lines 45 and 49
51. **Track clearance green interval (seconds): maximum of lines 44 and 50, round up to nearest full second**

SECTION 6: VEHICLE-GATE INTERACTION CHECK (OPTIONAL)

52. Right-of-way transfer time (seconds): line 17
53. Time required for design vehicle to start moving (seconds), line 22
54. Time required for design vehicle to accelerate though DVL (seconds) DVL= 0 ft
55. Time required for design vehicle to clear descending gate (seconds): add lines 52 through 54
56. Duration of flashing lights before gate descent starts (seconds): get from railroad
57. Full gate descent time (seconds): get from railroad
58. Proportion of non-interaction gate descent time (percent - show as decimal) d=
59. Non-interaction gate descent time (seconds): multiply lines 57 and 58
60. Time available for design Vehicle to clear descending gate (seconds): add lines 56 and 59
61. Advance preemption time (APT) required to avoid design vehicle-gate interaction (seconds): subtract line 60 from 55, round up to nearest full second, enter 0 if less than 0

4-7-8 Preemption of Traffic Signals near Railroad Grade Crossings April 2025

Reference is made to the WMUTCD, 4F.18 and 8D.09.

Modern signal controllers can provide alternate phasing/timing plans based on train operations. Once it has been determined that a highway-rail grade crossing flashing light signal system will be interconnected with adjacent traffic signals, the traffic signal controller *should* be programmed to run an alternate sequence during railroad preemption.

Highway-rail grade crossings can be occupied by trains for extended periods of time depending on several operating conditions including reduced train speeds, train length, and/or switching movements. During the time a train is located within the approach circuit and the traffic signals remain under preempted control, any non-conflicting vehicular traffic *should* be served using specialized phasing (a.k.a. railroad preemption sequencing or railroad hold sequencing) to reduce vehicular delay.

POLICY

Even if trains are not expected to occupy crossings for long periods, signal controllers *should* be programmed to run two preemption sequences. The first preemption sequence **shall** initiate a phase to clear the tracks before the train reaches the crossing. This advanced preemption places a call in the traffic signal controller to transfer right-of-way from the current phase to the track clearance phase(s) or hold if already in those phases, prior to activating the railroad warning devices.

The second preemption sequence *should* begin once the controller receives the gate down call from the railroad bungalow, a set time after the gate down notification, or after the track clearance green interval plus the additional time to prevent turning the signal red prior to gate down. At the onset of the second preemption, or if the crossing enters failsafe mode, a constant call **shall** be placed in the signal controller, causing the signal to remain preempted. At that time, the signal controller *should* be programmed to operate a sub-routine to serve traffic that does not move toward the tracks. Either blank-out signs or a red signal indication *should* prohibit vehicles from moving toward the tracks.

According to WMUTCD 4F.18, 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. Minimum vehicular green times at actuated signals *should* be at least five seconds to allow drivers to react to the change in right-of-way and enter the intersection.

According to WMUTCD 4F.18, pedestrian WALK and/or pedestrian change intervals *may* be shortened or omitted in order to begin the track clearance interval earlier. This practice is not preferred since drivers might yield to crossing pedestrians, thereby preventing subsequent vehicles from clearing the tracks.

Shortened or omitted pedestrian clearance intervals are typically found in legacy systems where providing the full pedestrian change interval required a substantial increase in cost for the railroad track circuit.

For new signal designs, pedestrian clearance intervals *should not* be shortened or omitted unless all other methods to reduce the length of advance preemption time have been considered. Calculated pedestrian clearance time *may* include the yellow change interval and the red clearance interval to help satisfy the advance preemption requirements.

It is important to recognize the preemption capabilities of different signal controllers and firmware because they vary from one model or manufacturer to another. Some controllers allow minimum green times and pedestrian clearance times to be shortened during railroad preemption sequencing and others do not.

When a train no longer occupies the highway-rail grade crossing, the signal *should* serve the preempted approach immediately following preempted control before serving the mainline left-turn movements or mainline through movements if there are no left-turn phases. Additionally, the controller *should* be programmed to place calls on all initiated NEM phases upon exiting preemption.

According to WMUTCD 4F.18, during the transition out of preempted control, the preemption sequence **shall not** shorten or omit the yellow change interval and any red clearance interval that follows.

Eliminating the Left Turn Trap

When a protected/permitted phasing sequence is used for the track clearance phase, special consideration *should* be taken to eliminate the possibility of the left-turn trap at the onset of railroad preemption.

For example, if the preempted approach is already green when the preemption call is received (beset case scenario), the signal *should* finish servicing the minimum green time and yellow change interval before going into an all-red sequence. After the all-red sequence, the track clearance phase(s) *should* display a left-turn green arrow and a green ball indication. This will allow the track clearance phase to serve a protected left-turn movement and eliminate a left-turn trap condition.

Inspection of Signal Sequencing During Railroad Preemption

State-maintained 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 inspection **shall** be forwarded to the grade crossing safety engineer at the WisDOT Railroads & Harbors Section (RHS) in the Bureau of Transit & Local Roads (BTLR). The annual Highway-

Railroad Preemption Inspection Form is provided below.

<u>Second Train Re-Service Considerations</u>

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.

The point at which preemption is released from the railroad active warning devices to the traffic control signals is critical to the proper operation of preemption re-service. For the traffic signal controller to recognize the second train, the preempt call for first train must be released. The railroad active warning devices must release the preempt call just as the gates begin to raise, otherwise traffic *may* drive under the ascending gates and this traffic must be cleared in the event of a second train.

SUPPORT

According to WMUTCD 4F.18, "Traffic control signals operating under preemption control or under priority control *should* be operated in a manner designed to keep traffic moving."

Figure 8.1a. WisDOT Railroad Preemption Inspection Form (page 1)

WisDOT RAILROAD PREEMPTION INSPECTION FORM

1. REVIEW TEAM

TRAFFIC SIGNAL INSPECTION COMPLETED BY:	(include name & email)	INSPECTION DATE:	
RAILROAD INSPECTION COMPLETED BY:		DATE OF LAST INSPECTION:	

2. LOCATION DATA

HIGHWAY INTERSECTION:			
TRAFFIC SIGNAL OPERATING AGENCY:	WisDOT SIGNAL NO: (ex. S1056)	MUNICIPALITY:	COUNTY:
RAILROAD OPERATING COMPANY:	RR CROSSING ID: (ex. 391768X)	RR CONTACT:	RR CONTACT PHONE:

3. RAILROAD DATA

ACTIVE WARNING DEVICES: ☐4-Quadrant Gates ☐2-Quadrant Gates ☐Flashers	
TYPE OF TRAIN DETECTION:	GATE-DOWN LOGIC: ☐ Yes ☐ No ☐ Not to exceed timer
MAXIMUM TRAIN SPEED (MPH):	SPEED RANGE OVER XING (MPH):
NUMBER OF TRAINS PER DAY:	NUMBER OF TRACKS:
NUMBER OF BROKEN GATES SINCE PREVIOUS INSPECTION? (explain)	
DATE OF MOST CURRENT RAILROAD PLANS (in bungalow):	

4. TRAFFIC SIGNAL DATA

CABINET TYPE: ☐TS1 ☐TS2	CONTROLLER MAKE & MODEL:
TYPE OF SIGNAL PREEMPTION: ☐Advanced ☐Simultaneous	TYPE OF SIGNAL OPERATION: ☐Pretimed ☐ Actuated ☐Coordinated System
OTHER TYPES OF PREEMPTION: ☐Emergency Vehicle ☐Bus/Transit	DOES RR PREEMPT HAVE PRIORITY? ☐Yes ☐ No
GATE DOWN LOGIC INSTALLED? ☐Yes ☐No	
ROADWAY OR SIGNAL MODIFICATIONS SINCE PREVIOUS INSPECTION:	
BATTERY BACKUP PRESENT? ☐Yes ☐No	BATTERY AGE (in service reports):
TYPE OF COMMUNICATIONS DURING BATTERY BACKUP:	

5. RAILROAD PREEMPTION PHASING SEQUENCE

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

6. RAILROAD EQUIPMENT <u>PROGRAMMED</u> TIMINGS

			7. NOTES
Preempt Verification and Controller Response Time:	0	sec.	
Advance Preemption Time:	0	sec.	
Minimum Warning Time:	0	sec.	
Additional Clearance Time: (overspeed tolerance, wide/angled crossings)	0	sec.	
Buffer Time:	0	sec.	
Total Warning Time (Minimum Warning Time + Clearance Time + Buffer Time):	0	sec.	

8. FIELD TESTING AND INSPECTION

BLANKOUT SIGNS PRESENT AND WORKING PROPERLY?	☐YES ☐NO	IF INSTALLED, BATTERY BACKUP WORKING PROPERLY?	☐ YES ☐ NO
DOES PREEMPT RESERVICE ACTIVATE? (see instructions)	☐YES ☐NO	PROTECTED ARROW FOR TRACK CLEARANCE?	☐ YES ☐ NO

Test #	Example	1	2	3
Train's Direction of Travel	EB			
Signal Phase Active During Preempt Call	2 / 6			
	CUMULATIVE TIME (sec)			
Preempt call received (blank out signs turn on) at	0	0	0	0
Begin track clearance green at	0			
Railroad flashers activated at	35			
Gate descent started at	38			
Gate descent completed at	50			
End of track clearance green (start of track clearance yellow) at	50			
Train arrived at	56			
Railroad flashers deactivated at	240			
Measured Total Warning Time:	56 - 0 = **56**			
Preempt call released from signal controller at begin of gate ascent:	☑YES ☐NO	☐YES ☐NO	☐YES ☐NO	☐ YES ☐ NO
Railroad equipment and lamps functioned:	☑YES ☐NO	☐YES ☐NO	☐YES ☐NO	☐ YES ☐ NO
Track clearance and preempt dwell phases operated as expected:	☑YES ☐NO	☐YES ☐NO	☐YES ☐NO	☐ YES ☐ NO

Figure 8.1b. WisDOT Railroad Preemption Inspection Form (page 2)

9. OTHER INFORMATION / NOTES

4-7-9 Emergency Vehicle Preemption and Traffic Signal Priority April 2025

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

POLICY

Statutory Provisions

Traffic control signal preemption and priority devices. (2m) An authorized emergency vehicle *may* be equipped and operated with lamps designed and used, or with any other transmitter designed and used, to activate traffic control signal preemption devices. (2r) A snow removal vehicle equipped with oscillating, rotating, or flashing lights that is actively engaged in snow removal activities *may* be equipped and operated with lamps designed and used, or with any other transmitter designed and used, to activate traffic control signal priority devices (3m) The lamps authorized for use under this section *may* be any color and *may* be flashing, oscillating, rotating or pulsating. (4) No operator of an authorized emergency vehicle *may* use a transmitter, including lamps under sub (2m), 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 and snow removal services is eligible to request an EVP or TSP 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 / TSP 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 / TSP 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 / TSP 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 / TSP 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 / TSP 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. If 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 / TSP 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 to service the EVP / TSP system equipment located at 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 / TSP 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 / TSP system by performing a field test using an emergency vehicle equipped with an EVP emitter device and/or snow removal vehicle equipped with a TSP emitter device. The local unit is responsible for periodically checking the EVP / TSP equipment.
6. In the event of a construction project, EVP / TSP service **shall** be maintained at any intersection with permanent EVP / TSP agreements. In addition, EVP / TSP 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.

<u>Operation/Phase Timing</u>

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 / priority 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 and snow removal 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 or snow removal vehicle at the beginning of this policy
    b. The conditions when preemption or priority *may* be used
    c. The use of preemption / priority does not remove the responsibility of the vehicle operator from determining whether it is safe to enter the intersection
    d. The operator cannot assume that the preemption / priority 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 / TSP system has been local funds or federal urban funds. However, EVP / TSP 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 / TSP system at the traffic signal unless nonstandard EVP / TSP 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 / TSP system on temporary signals or on a temporary route during a construction project **shall** be borne by the project.

WISCONSIN DEPARTMENT OF TRANSPORTATION

Emergency Vehicle Pre-emption (EVP) and Traffic Signal Priority (TSP) 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) and/or Traffic Signal Priority (TSP) 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 / TSP equipment shall be provided by WisDOT/Local Agency.

The Department's Policy for *Use of Emergency Vehicle Pre-emption (EVP) and Traffic Signal Priority (TSP) 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 ______________________________

4-8-1 Vehicle Detection April 2025

DETECTOR/CONTROLLER FUNCTIONS

As it affects signal timing & operations, the signal designer *should* understand the modes of operation for both detectors and controllers. The scope of this manual does not cover guidelines for determining intersection signal timing; however, the following discussion provides a brief overview of various modes of operation, which are directly related to signal timing. The selection of the detector/controller mode of operation is dependent on the location and desired objective of the loop layout. It *should* be noted that certain loop layout strategies require specific detector/controller functions to be utilized.

DETECTOR BASED OPERATIONS

Pulse and Presence

There are two basic modes of vehicle detection, pulse and presence. In pulse detection, the detector amplifier sends a pulse call to the controller upon detection of a vehicle. This is a call of short duration, and it does not depend upon the speed of the detected vehicle, its length, its continued presence over the loop, or the length of the loop. In presence detection the detector amplifier issues a continuous call to the controller for as long as any portion of the vehicle remains over the loop. The length of the call is, therefore, dependent on the speed of the vehicle, the length of the vehicle, and the length of the loop. Default is to use presence-based detection.

Extension Stretch

Extension stretch is used when the passage interval feature is set at a low value. Extension stretch allows an increment of time to pass while a vehicle travels from one point of detection to some other position. The interval *may* be used to extend the green, allowing a vehicle to pass the dilemma zone, or allow a vehicle to enter or clear the intersection. The various detector placements have different passage and extension stretch intervals associated with them. The designer *should* select the passage intervals which fulfill the requirements of the loop detector layout selected.

Delayed Call

Using the delayed call mode, the output is deferred until the detection zone has been occupied for a preset time. This has two common uses. First: at near detection in shared through and right-turn lanes or right only lanes, vehicles turning right on red *may* occupy the near detection for a short period without unnecessarily calling the controller to the respective phase. Second, at near loops that *may* be driven over by cross street left turning vehicles, especially tractor-trailer combinations.

Detector Disconnect

The detector disconnect feature allows a chosen detector(s) to be disconnected when the indicated phase is active.

OTHER CONTROLLER MODES OF OPERATION

There are several other modes of operation related to detection, which can be programmed directly within the controller. Some more commonly used modes at signalized intersections include minimum green time, maximum green time, passage interval, non-locking detection memory, phase recall, etc. Phase recall is discussed below; other controller functions are included in the glossary.

Phase Recall Mode of Operation

Use of these features is common for major route intersections with heavy traffic or pedestrian volumes. The phase recall function allows a phase (vehicle or pedestrian) to be displayed during each cycle whether demand exists or not.

The MIN recall setting will force its respective PHASE NUMBER (column 1 of the Detector Logic Chart) to be serviced, each cycle, for the established minimum green time. The MAX recall setting will force its respective PHASE NUMBER to be serviced, each cycle, for its maximum green time. The SOFT recall setting will return to its respective PHASE NUMBER when the controller goes to green rest in all other phases. The PED recall setting will force its respective PHASE NUMBER pedestrian walk display to be serviced during each cycle.

At isolated intersections the mainline is generally put on MIN recall bringing the green back to dwell on the mainline phases.

Locking and Non-Locking Mode of Operation

All calling detectors can function as locking or non-locking. Locking detectors hold a call when a vehicle is at rest on the detector and after the vehicle passes over the detector when in the red interval. The non-locking detection mode requires the vehicle to occupy the detector for a call to be issued to the controller. The call would be dropped if the vehicle moves off the detector. All detectors for each phase must be set to locking or non-locking; controllers do not allow individual detector settings within a phase.

DETECTOR TYPES

Inherent to modern signal design and operations is vehicle detection. Proper consideration must be given to providing vehicle detection that will result in efficient and safe signal operations. The primary goal is to be able to detect vehicles and transmit this data back to the controller as input for controlling signal indications.

There are two general types of loop detector placements. The first type is referred to as "advance" or "far" detection and is used generally for mainline through traffic detection and side road extensions. It is located well in advance of the stop line. The second type is "near" or "stop line" detection. It is usually located near the stop line. Detectors are typically operated in presence mode, which means if a vehicle is within the zone of detection; it will continue to be detected, until it leaves the zone of detection.

It *should* be noted that efficient signal operations and timings are directly related to all detector placement strategies and methods. As with all traffic control devices, adjustments to loop placement and size *may* be necessary depending on actual field conditions and *should* be verified in the field by the maintaining authority prior to installation.

This section covers the various loop layout strategies, which can be used for left turn lanes, advance detection, and near detection. In addition, the loop types, inductance calculation, construction considerations, and detector/controller modes of operation are also discussed.

WisDOT generally recommends using standard inductive, loop detectors. These detectors are cost effective, reliable, require little maintenance and last indefinitely when installed properly. (See FDM Chapter 16, Standard Detail Drawings).

Any detection technology that is selected **shall** first be discussed with the Region Traffic Signal Engineer due to long term operations and maintenance considerations.

INDUCTIVE LOOP DETECTORS

The vast majority of State-owned signals are fully actuated and use inductive, in-pavement loop detection to adjust local timing at an intersection. This type of detection consists of a loop installed in the pavement, a separate lead-in cable, and a detector amplifier located in the controller cabinet. When energized, the loop configuration creates a magnetic flux field. When a vehicle passes over the loop it causes that flux to change, which the detector amplifier can sense. This disruption is interpreted as the presence of a vehicle and will generally place a call to the signal controller for a certain phase. Ultimately, programming in the controller dictates what actions *may* occur based on a vehicle call, but other functions *may* also include phase extensions, preemption, or other features.

Detector loops *may* be configured in many ways depending upon the application. This manual will discuss primarily rectangular loop configurations for all applications. The technology associated with today's modern loop detector amplifiers, particularly digital amplifiers, allows for a variety of motor vehicles to be detected successfully with typical rectangular configurations.

MICROLOOP

Microloops are small, cylindrical probes typically buried beneath the roadway surface. The installation time for Microloops is much shorter than for installation of standard loop detectors. Microloops *may* be wired or wireless, depending on the product used.

Microloops *may* be used on bridge decks where it is not practical to implement other loop types. Microloops for permanent installations are generally recommended only under special conditions such as poor pavement structure and bridge decks. Their use **shall** be discussed with the maintaining authority.

VIDEO DETECTION

Video detection makes use of a camera and video monitor to detect vehicles on the roadway. The camera is placed at a location above the intersection and directed toward the approach; typically, one camera is required for each approach. The image is transmitted onto a video monitor where the user graphically draws the detection zone(s). Different sizes of detectors can be selected, and detection zones can be placed anywhere within the camera's field of view. This detection method is very flexible in that the detector locations can be modified easily using the mouse and video monitor.

Video detection is expensive but *may* have benefits in temporary or construction applications. Their use *should* be discussed with the maintaining authority.

MICROWAVE/RADAR DETECTION

Radar detection is based on the Doppler principle. A transmitter directs microwave beams toward the roadway. Any vehicle passing through the beam reflects the microwaves back to an antenna at a different frequency. The detector senses the change in frequency.

Like video detection, microwave detectors are expensive but *may* have benefits in temporary or construction applications. Their use *should* be discussed with the maintaining authority.

CONSTRUCTION CONSIDERATIONS FOR IN-ROADWAY LOOPS

The construction staging of road projects *may* have a direct influence on the loop size used for detection. For example, construction of a three-lane approach *may* be staged for the placement of two lanes first and the third lane in a different pour. Advance detector placement *may* be one 6' x 20' loop covering the first construction stage and a single 6' x 6' for the second construction stage. Loop placement *should not* cross asphalt to concrete, or concrete-to-concrete joints, unless detectors are placed in the base below the pavement. Construction staging *may* also make it practical to install other types of detection. The use of these other types of detection *should* be discussed with the maintaining authority.

In-Roadway Loops (including lead--in) *should* be placed below the pavement into the base course to avoid pavement joints that can cause loops to fail, to be out of conflict with pavement milling operations.

Loops *may* be installed in two general methods. See the Standard Detail Drawings in the FDM for the specific information on each type.

<u>Loops in Conduit:</u>

Pavement Overlaid Loops – Used anyplace where the entire loop will be within an area of new, overlaid, milled and replaced, or seal-coated pavement. The excavation and patching required are easily covered by the pavement work. When properly installed, loop failure is very minimal.

Saw cut Loops – Used if the loop or any part of the loop would end up in an existing pavement that will not be modified by any of the methods above. When properly installed, loop failure is minimal.

Below Pavement Loops – Used at locations where entire pavement is new or rebuilt construction. Loops are generally placed in base course.

<u>Loops Not in Conduit:</u>

Saw cut Loops – Loops are installed directly into saw cut and then sealed with an approved loop sealer. Loop life for this type of loop is shorter compared to the conduit encased loops. Although not recommended by WisDOT for long-term installations, signals under local jurisdiction *may* use saw cut loops. Uses of saw cut loops include temporary signals, intersections scheduled for reconstruction, and permanent signals under <u>local jurisdiction.</u>

ADVANCE OR FAR DETECTION

The methods associated with advanced detection design must be compatible with signal timing objectives and intended operations. Detector placement strategies which require high values of allowable gap for safety can affect efficiency. For example, a long allowable gap *may* cause unnecessary delay to waiting vehicles or routinely extend the controller to maximum green even under moderate traffic. Conversely, strategies that allow for lower values of allowable gap *may* not provide adequate dilemma zone protection.

Depending on vehicle speeds and roadway geometrics, advance detection *may* be augmented by the placement of intermediate and/or stop line detection. Additional near detection is commonly used on low volume side street approaches and main street approaches that do not use phase recall.

There are a variety of strategies that can be employed for advance detection. However, primarily there are two which provide the most efficient and safe operation. These are single point detection and dilemma zone detection.

SINGLE POINT DETECTION (FOR LOW-SPEED APPLICATIONS)

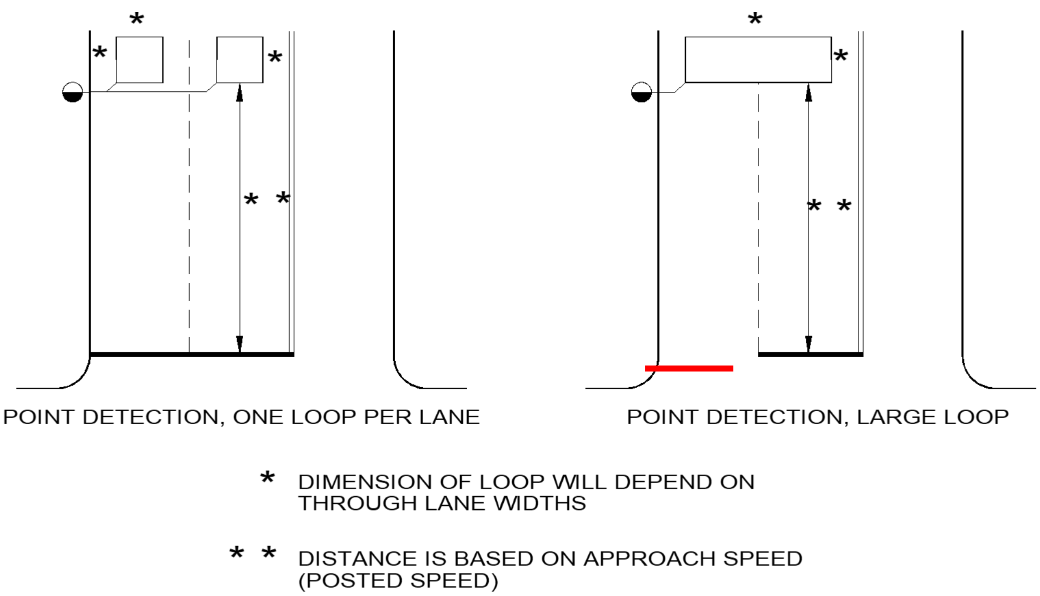
Single point detection consists of a single detection zone located two to five seconds of travel time in advance of the stop line. Single point detection is typically used where vehicle speeds are ≤35 mph or if the opposing volumes are such that it is inefficient to extend the green for sporadic arrivals.

Signal timing for this type of detector application is based on the distance from the stop line to the location of the advance detection. The minimum green time is commonly set for approximately 6 to 10 seconds. Variable initial time *may* be used to add green time beyond the minimum green value if the minimum green would not otherwise accommodate queue clearance back to the detector for additional extensions. While this type of detection can also be used for higher speeds, ≥35 mph, it is recommended that the second type, dilemma zone detection, be employed where speeds exceed 35 mph.

This loop layout *may* be used for extending the green time for a side street approach, and for left turn lanes. If extend only detection is installed without recall, it must be supplemented with near detection. This is required since extend only detection will not place a call from a passing vehicle when a red phase is being timed.

Figure 1.1 illustrates two commonly used layouts for Single Point Detection.

Figure 1.1. Advance Detection Loop Layout



DILEMMA ZONE DETECTION (FOR HIGH-SPEED APPLICATIONS)

The dilemma zone is defined as that portion of the roadway in advance of the intersection within which a driver is indecisive regarding stopping prior to the stop line or proceeding through the intersection at the termination of that approach's green interval. Detection designed to minimize driver decisions in this area is called dilemma zone detection.

The dilemma zone is generally identified in the area from 2- to 5-secs in advance of the intersection for a given speed. Empirical data suggest that at 2-secs from the intersection, it's 90% probable the vehicle will continue through. At 5-secs from the intersection, it's 90% probable the vehicle will stop. Based on kinematic principals, vehicles travelling at higher speeds will have a dilemma zone that physically begins further from the intersection than vehicles travelling more slowly.

For purposes of establishing the dilemma zone and advance loop placement, the 85^{th}-percentile speed *should* be used. This value can be measured in the field using standard spot-speed study techniques, or it can be estimated by using the posted speed, plus 5-mph. In higher speed environments (≥55-mph), or locations were either greater speed variability or a higher percentage of heavy vehicles exist, consideration for placing advance detection at 6-secs from the stop line *should* be considered.

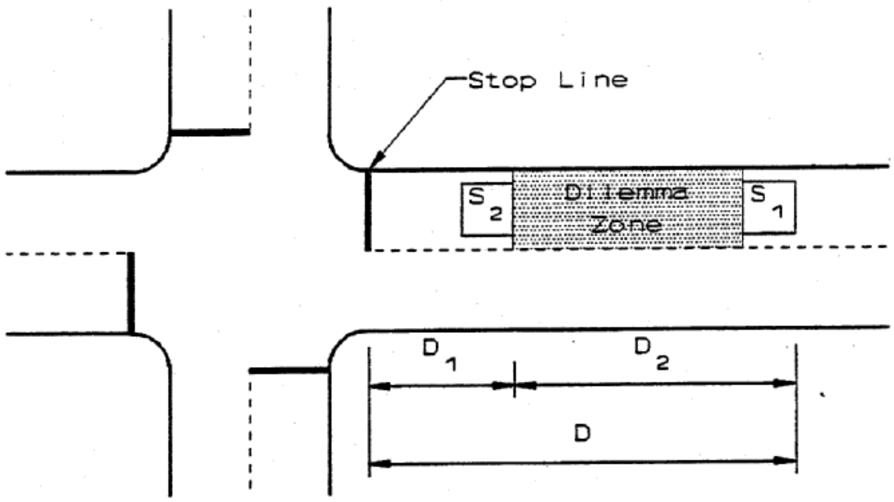
Any new or reconstructed WisDOT-owned, permanent signals located on ≥40 mph facilities **shall** incorporate considerations for dilemma zone protection. While there *may* be other ways of accommodating dilemma zone protection, the techniques discussed here are traditional methods.

The three primary dilemma zone detection methods described below are: 1) green extension system, 2) extended call detector system, and 3) single point. It *should* be noted that regardless of the method employed, vehicles *may* still be caught in the dilemma zone if traffic conditions, or timing parameters cause the respective phase to max out.

1) GREEN EXTENSION SYSTEM

The green extension system utilizes two loops per lane. The concept is to detect a vehicle as it enters the dilemma zone and then extend the green until the vehicle clears the dilemma zone. The advance loop (S_1) acts to extend the green time for a vehicle to reach the near loop (S_2). The near loop maintains the green time long enough to allow the vehicle to enter or clear the intersection. Figure 1.2 illustrates the Green Extension Detector system layout.

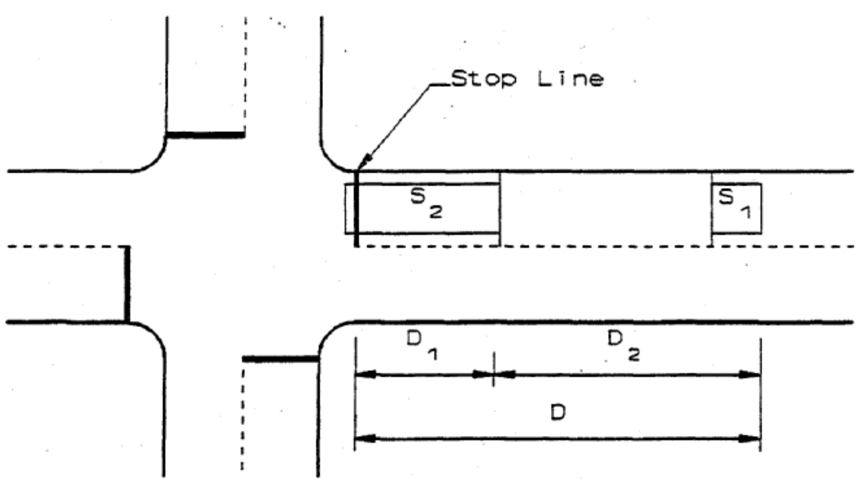
Figure 1.2. Green Extension System



2) EXTENDED CALL SYSTEM

The extended call detector system also utilizes two loops. However, under this method a long loop or series of long loops is placed at or near the stop line for presence detection, and a single extended call detector loop is placed upstream of the stop line. The advance loop (S_1), located at the beginning of the dilemma zone, extends the green time, allowing a vehicle to reach a point just prior to the stop line, but through the dilemma zone. The stop line loop (S_2, presence loop) ensures that vehicles queued at the intersection can enter the intersection without triggering a premature gap out in the case there are no subsequent calls from vehicles on the advance loops. Modern signal controllers allow for varied detector functions that can extend for the queued vehicles and shut off, such that the phase can be extended from approaching vehicles only, lending to more efficient gap reduction. Figure 1.3 illustrates the Extended Call Detector system layout.

Figure 1.3. Extended Call Detector System



3) SINGLE POINT DETECTION

One of the most straight forward conventional designs for “high-speed” approaches uses a controller with a volume-density mode. Based on a single advance point detector (S1) with the controller set on “Min Recall” and in “Locking Memory” this actuated operation can count waiting vehicles beyond the first because of the “Added Initial” feature. It also includes a timing adjustment to reduce the allowable gap based on the time vehicles have waited on the red on a conflicting phase. More efficient operation can be achieved with this controller mode than is possible with the normal full-actuated control because of these features and because detection is further back on the approaches (Up to and over 400-ft is possible when over 50 mph).

The basic concept for dilemma zone protection with this detection / controller strategy is to have the single advance detector (S1) detect a vehicle just prior to it entering the dilemma zone. Early in the cycle the detector would use the full passage time and would extend vehicles all the way to the stop line. Further into the cycle, after full “Gap Reduction”, the lowest extension setting would be timed to just clear the vehicle through the defined dilemma zone (Defined by the 90% GO Curve). If vehicles are separated by more than this Minimum Gap, then the phase will “Gap Out” at that point.

The Single Point Detection System layout is similar that shown in Figure 1.3 above but will have different spacing for the intersection.

REFERENCE CHARTS

There have been several tables published regarding the dilemma zone location for various design speeds. For the purpose of providing guidance, Chart 1.1 and Table 1.1 have been reprinted from a Northwestern University Traffic Institute course manual. Table 1.1 shows the dilemma zone response curves by vehicle speed and distance from intersection. The 90% Go and 90% Stop probability ranges have been marked for reference during design. Table 1 shows passage distances based on speed and time. The numbers shown in Table 1 are directly related to the curves shown in Chart 1.1. Chart 1.2 has been reprinted from the Federal Highway Administration Detector Manual. This chart shows various dilemma zone response curves by vehicle based on vehicle speed and percentage probability of stopping. The 90% and 10% probability ranges have been identified for reference during design. Chart 1.3 *may* be used to determine passage times for advance detection. Using the design speed and proposed passage distance, the passage time can be determined. It is the responsibility of the signal designer to determine the appropriate passage distance. The passage time *should* allow the vehicle to enter into the intersection; however, each case *should* be evaluated separately. Table 1.2 indicates loop placement options for the Green Extension System described above.

These tables and charts are provided only as a reference. In all cases the signal designer is responsible for selecting the appropriate design speed, passage time, and percentage probability of stopping.

Chart 1.1. Dilemma Zone Response Curves

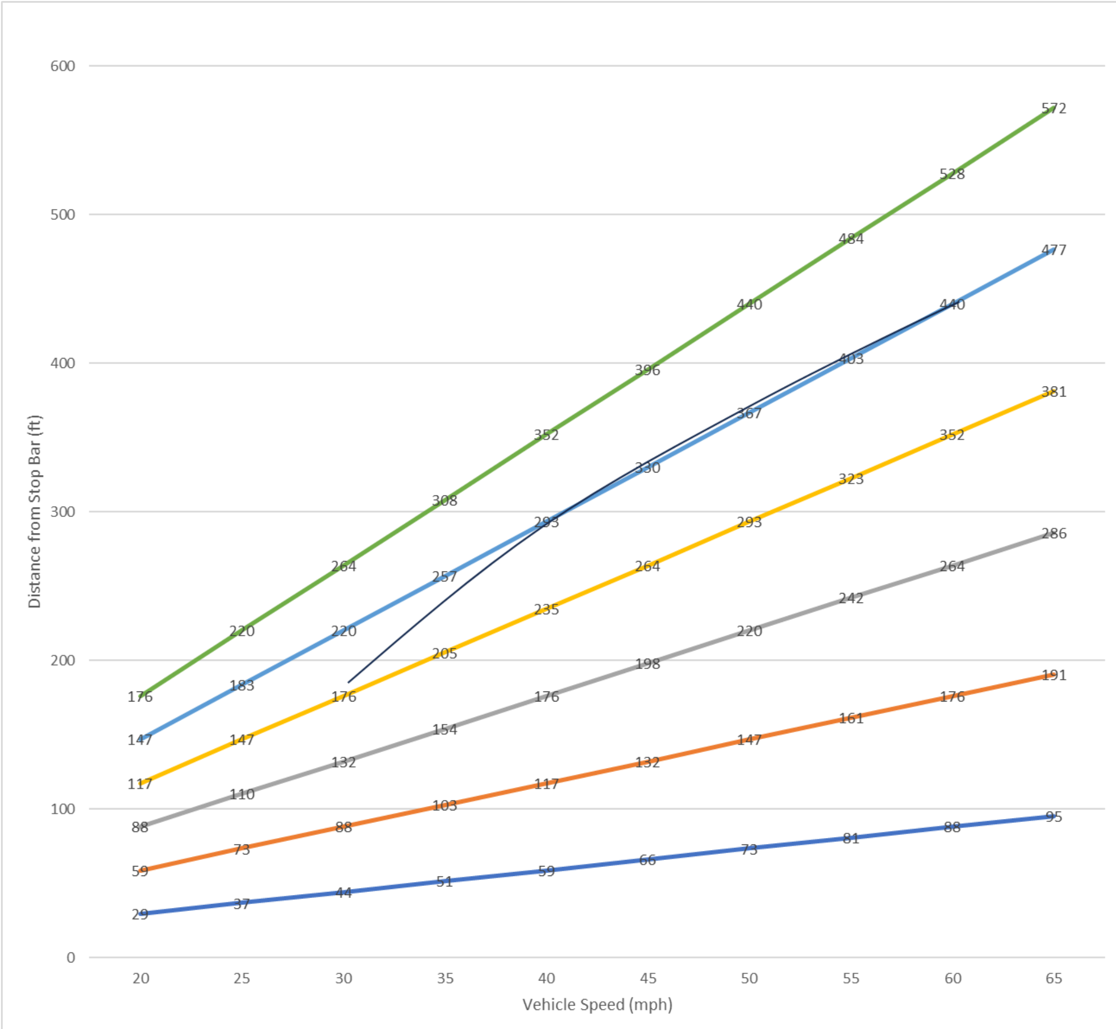


Table 1.1. Dilemma Zone Values

Passage/Travel Time from Detector to Stop Bar (Seconds)

Approach Speed (Miles per Hour)	1	2	3	4	5	6	7	8	9	10	11	12
20	29	59	88	117	147	176	205	235	264	293	323	352
25	37	73	110	147	183	220	257	293	330	367	403	440
30	44	88	132	176	220	264	308	352	396	440	484	528
35	51	103	154	205	257	308	359	411	462	513	565	616
40	59	117	176	235	293	352	411	469	528	587	645	704
45	66	132	198	264	330	396	462	528	594	660	726	792
50	73	147	220	293	367	440	513	587	660	733	807	880
55	81	161	242	323	403	484	565	645	726	807	887	968
60	88	176	264	352	440	528	616	704	792	880	968	1056
65	95	191	286	381	477	572	667	763	858	953	1049	1144

Density values (for reference) (columns 6–12)

Legend: [boxed] Variable Initial only; Dilemma Zone

Chart 1.2. Dilemma Zone Response Curves

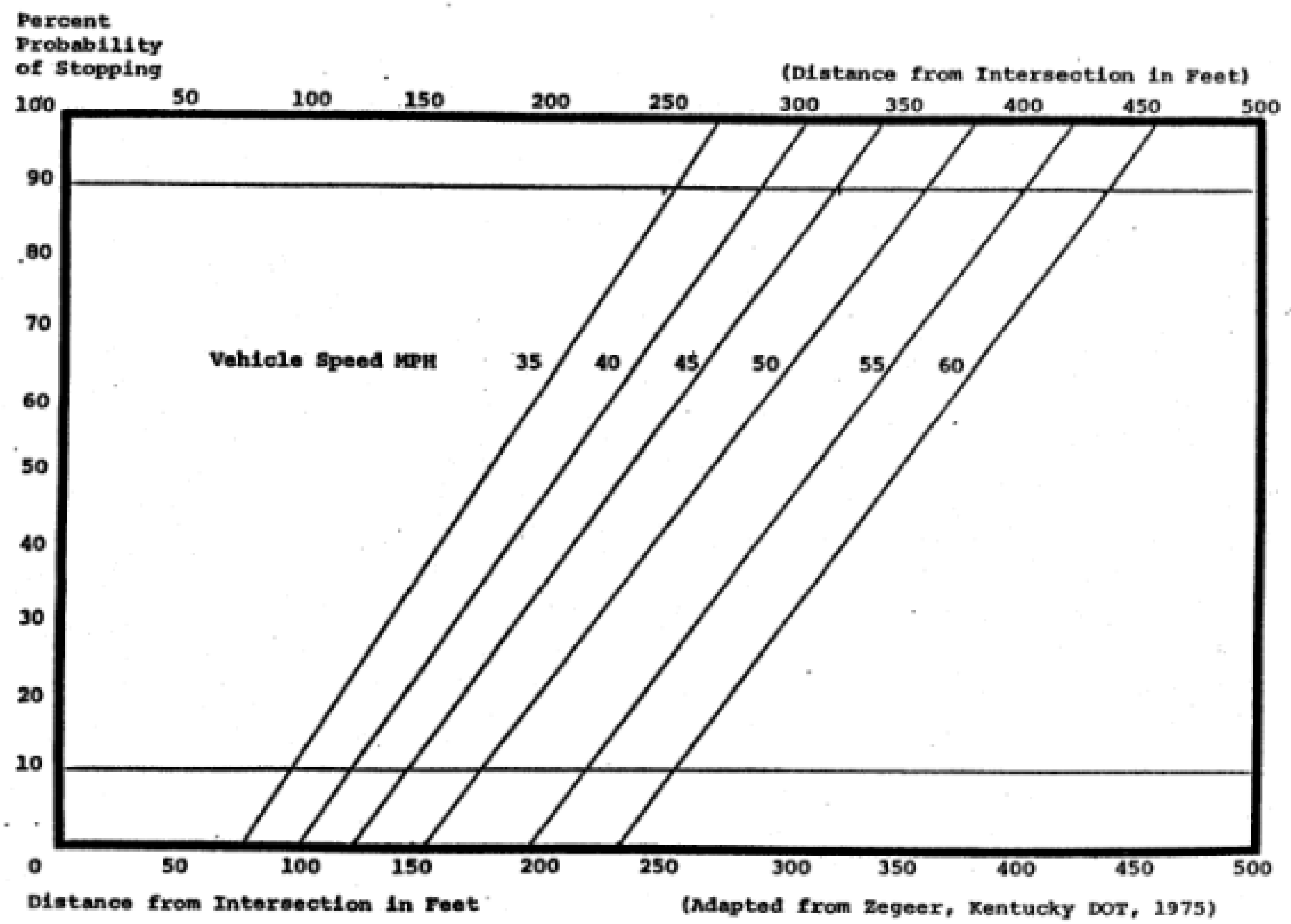
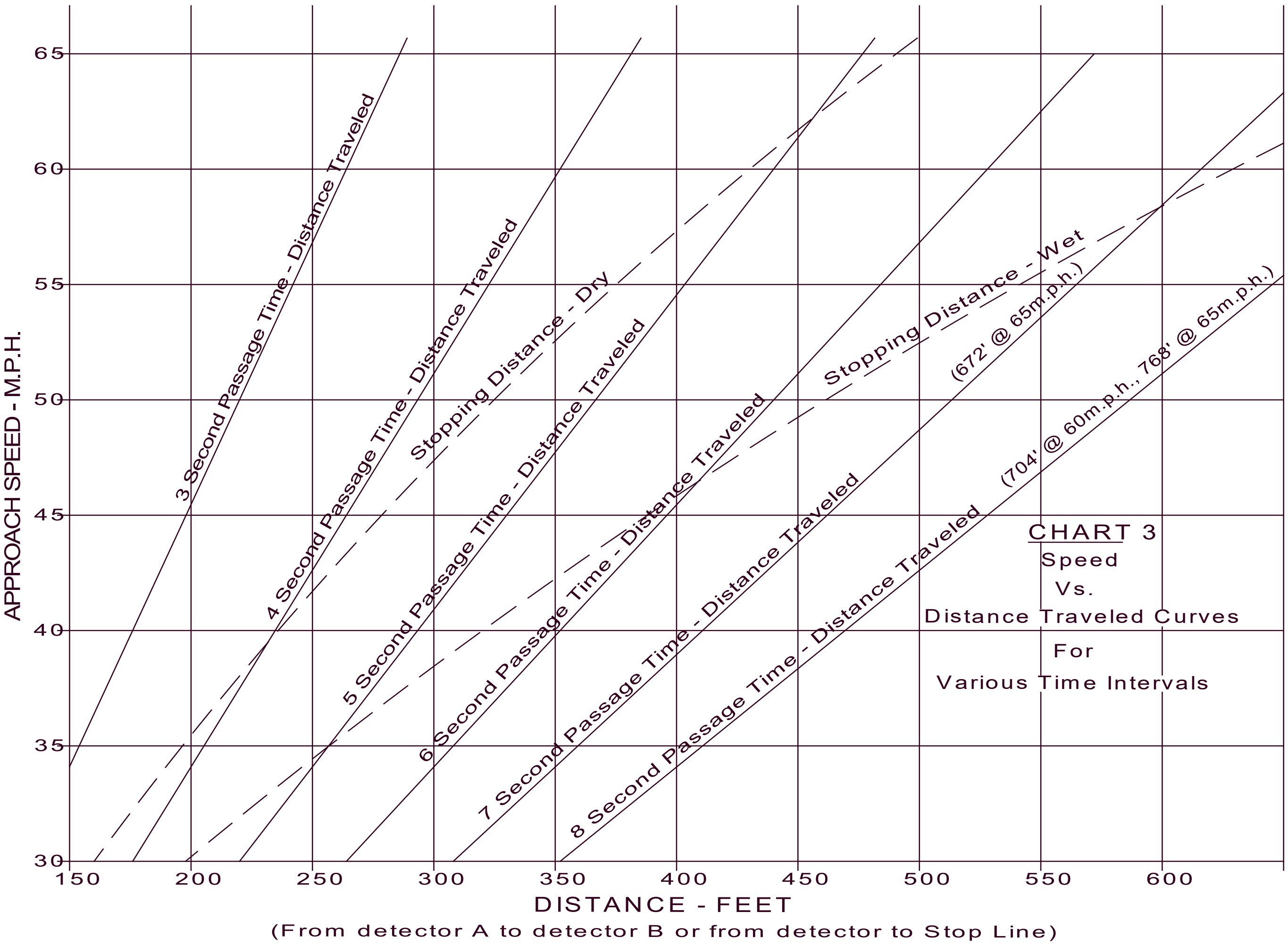


Table 1.2. Green Extension System Loop Placement Options

Advanced Detector Placement based on 90% Stop Probability (Measured from front of detector to near right signal)			
Vehicle Speed		Advance	Near
25-mph	37-fps	185-ft	---
30-mph	44-fps	220-ft	---
35-mph	51-fps	255-ft	---
40-mph	59-fps	295-ft	120-ft
45-mph	66-fps	330-ft	130-ft
50-mph	74-fps	370-ft	150-ft
55-mph	81-fps	405-ft	160-ft
60-mph	88-fps	440-ft	175-ft

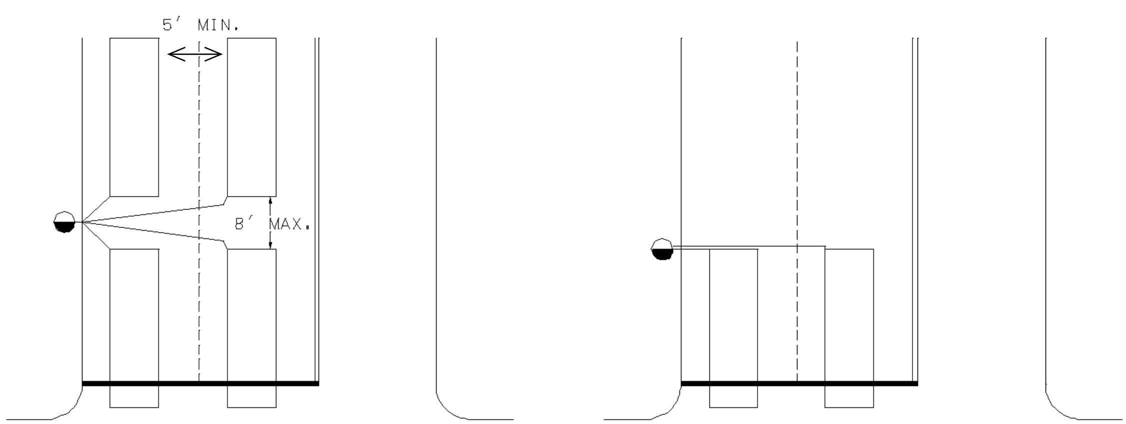
Chart 1.3. Passage Time Design Curves



NEAR DETECTION

Unless physical or operational characteristics are atypical, near detection for through movements *should* be placed at the stop line. The detector amplifier mode *should* be set to presence detection. However, detectors in the right lane and detectors that *may* be driven over by left turning vehicles *should* be set to a delay mode to allow those movements to occur without registering false calls. Figure 1.4 below illustrates common near detection layouts.

Figure 1.4. Near Detection



In many cases a set of loops is installed to provide a larger detection area and for redundancy in case of detector failure. This is especially important for detection on a single lane approach where loop failure (if only one loop is installed, and the phase is not set for recall) *may* cause failure of the corresponding phase.

Historically, motorcycles, bicycles, and/or small vehicles *may* have had problems with not being properly detected by large (≥ 6' x 20') loops at certain locations. While modern loop amplifiers have remedied issues related to missed calls, if concerns or issues at specific locations persist, other loop configurations *may* be considered. For example, smaller 6' x 6' loops turned 45-deg can result in increased sensitivity in locations where smaller vehicles need to be detected. Careful consideration *should* be given to using smaller detection zones due to their restricted ability to detect high bed trucks. WisDOT does not typically use quadrupole loops.

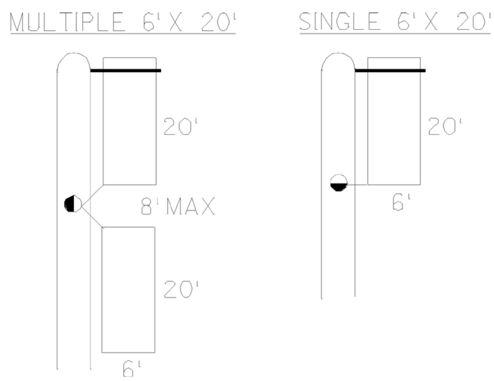
LEFT-TURN DETECTION

Several variations of detection *may* be used for left turn lane detection. The specific type of configuration that *should* be used is dependent upon many factors, including signal phasing, geometrics, vehicle classification, and turning volumes. All these factors must be considered when designing the detection scheme.

Alternative No. 1: Protected only or protected/permissive operation.

Detector loops are placed beginning at the stop line to call and extend the phase. This *may* be used for protected only or protected/permissive left turn operations. The detector amplifier is set to presence mode and controller logic to nonlocking memory. This allows for more efficient operation in that once a vehicle leaves the zone of detection the call is dropped, and the controller can begin to service other calls. This type of operation is often used for left turns where the opposing through volume is relatively high, and the left turn demand is constant. Figure 1.5 below illustrates two commonly used layouts.

Figure 1.5. Protected-Only or Protected/Permissive Left Turn Loop Layout



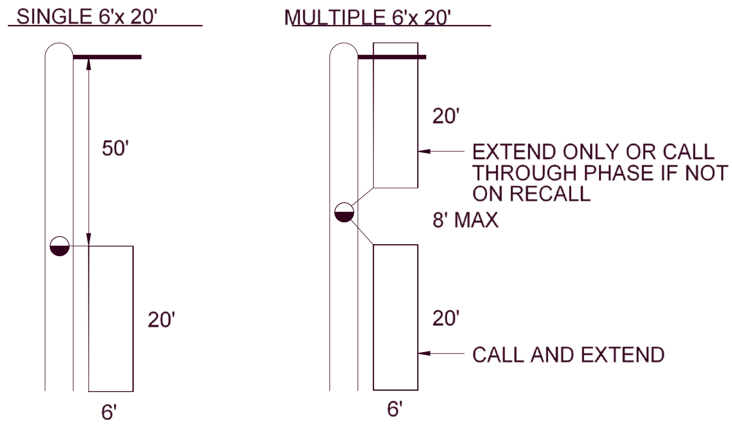
Alternative No. 2: Third vehicle detection. Protected/permitted operation only.

The detector is placed in advance (upstream) of the stop line such that the first one or two vehicles in the left turn lane will not place a call in the protective phase. This *should* not be used for protected only left turn operation. Figure 1.5 illustrates two commonly used layouts.

Sufficient gaps, particularly during non-peak hours, are usually available to permit vehicles to turn on a green ball. This alternative *may* be used only for approaches with minimum recall or approaches with stop line detection. The detector amplifier is set to presence mode and controller logic to non-locking memory. This type of operation allows for more efficient use of the green time for mainline traffic.

Detector layouts illustrated in Alternative 1 *may* be used for third-vehicle detection by programming the front loop for extend only. This layout allows for the flexibility of changing operations from third car to protected detection.

Figure 1.6. Third-Vehicle Detection Loop Layout



Alternative No. 3: Left-turn extension detection.

Long left turn lanes or high left turn volumes *may* require the use of advance detection for extending the green. Generally, an advance loop installed in the left turn lane *may* extend the left turn phase, the through movement, or both. Loop layout for left turn lane extension *should* follow the guidelines outlined in this subject.

Figure 1.7. Left Turn Extension Detection

INDUCTANCE CALCULATIONS

The ability to detect vehicles is primarily a function of the loop's inductance and sensitivity, not its shape. The advent of digital detector amplifiers and electronics has eliminated many problems associated with older loop detector amplifiers. These problems included splash over, crosstalk, and difficulty in detecting smaller vehicles with standard detector configurations.

The total inductance of loop detector systems is related to loop size, the number of turns in the loop and the length of lead-in cable. These elements will influence inductance associated with them. As a rule, the actual loop *should* have approximately twice the inductance as the lead-in cable to ensure good detection efficiency. Lead-in cable has approximately 23 microHenries of inductance per 100 feet. For the detector loop to have a 2:1 ratio of inductance compared to the lead-in cable, the loop must have a certain number of turns. The longer the lead-in the greater the number of turns. A commonly used formula for determining the loop inductance is shown below.

$$\text{Inductance} = (N^2 \times 5 \times P) / (10 + N)$$

Where: N = Number of turns in loop

P = Perimeter of loop

If two or more loops are wired in series, their inductances are additive (total inductance: $L = L_1 + L_2 + ... + L_n$). When several loops are installed, maximum inductance is obtained by wiring the loops in series. The total inductance for a single detector amplifier *should* not exceed 800 to 1000 mH.

If two or more loops are wired in parallel, the combined inductance is reduced (total inductance: $1/L = 1/L_1 + 1/L_2 + ... + 1/L_n$). When using parallel connections, the designer *should* calculate the total loop inductance to be sure it is approximately two (2) times that of the lead-in cable inductance. Often a combination of parallel and series connections is used to keep the total inductance below 800 to 1000 mH and to aid in installation.

An effort *should* be made to avoid installing loops of equal size, side by side with the same number of turns. Such installations are potential sources of trouble (cross-talk, false calls). If, for example, one loop (closest to the cabinet) has 3 turns, then the farther one *should* have 4 turns.

Table I can be used as a quick reference for single loop inductance for various loop sizes. Inductance for this table is determined by the formula stated above.

It is the responsibility of the signal designer to determine the proper loop size and number of turns. The designer is not restricted to the loop sizes shown in the following table.

However, loops with greater than 5 turns are generally not easily constructed or maintained in 1” conduit. If loops need 5 or more turns in accommodate 2:1 inductance relative to lead-in cable, 1-1/2” conduit *should* be considered.

Table 1.3. Single-Loop Inductance Calculations

Loop Size	INDUCTION					
	1 turn	2 turns	3 turns	4 turns	5 turns	6 turns
2’ x 6’	7.3	26.7	55.4	91.4	133.3	180.0
2’ x 8’	9.1	33.3	69.2	114.3	166.7	225.0
2’ x 10’	10.9	40.0	83.1	137.1	200.0	270.0
2’ x 12’	12.7	46.7	96.9	160.0	233.3	315.0
2’ x 14’	14.5	53.3	110.8	182.9	266.7	360.0
2’ x 16’	16.4	60.0	124.6	205.7	300.0	405.0
2’ x 18’	18.2	66.7	138.5	228.6	333.3	450.0
2’ x 20’	20.0	73.3	152.3	251.4	366.7	495.0
3’ x 6’	8.2	30.0	62.3	102.9	150.0	202.5
3’ x 8’	10.0	36.7	76.2	125.7	183.3	247.5
3’ x 10’	11.8	43.3	90.0	148.6	216.7	292.5
3’ x 12’	13.6	50.0	103.8	171.4	250.0	337.5
3’ x 14’	15.5	56.7	117.7	194.3	283.3	382.5
3’ x 16’	17.3	63.3	131.5	217.1	316.7	427.5
3’ x 18’	19.1	70.0	145.4	240.0	350.0	472.5
3’ x 20’	20.9	76.7	159.2	262.9	383.3	517.5
4’ x 4’	7.3	26.7	55.4	91.4	133.3	180.0
4’ x 6’	9.1	33.3	69.2	114.3	166.7	225.0
4’ x 8’	10.9	40.0	83.1	137.1	200.0	270.0
4’ x 10’	12.7	46.7	96.9	160.0	233.3	315.0
4’ x 12’	14.5	53.3	110.8	182.9	266.7	360.0
4’ x 14’	16.4	60.0	124.6	205.7	300.0	405.0
4’ x 16’	18.2	66.7	138.5	228.6	333.3	450.0
4’ x 18’	20.0	73.3	152.3	251.4	366.7	495.0
4’ x 20’	21.8	80.0	166.2	274.3	400.0	540.0
4’ x 30’	30.8	113.5	235.7	388.8		
5’ x 6’	10.0	36.7	76.2	125.7	183.3	247.5
5’ x 8’	11.8	43.3	90.0	148.6	216.7	292.5
5’ x 10’	13.6	50.0	103.8	171.4	250.0	337.5
5’ x 12’	15.5	56.7	117.7	194.3	283.3	382.5
5’ x 14’	17.3	63.3	131.5	217.1	316.7	427.5
5’ x 16’	19.1	70.0	145.4	240.0	350.0	472.5
5’ x 17’	20.0	73.3	152.3	251.4	366.7	495.0
5’ x 18’	20.9	76.7	159.2	262.9	383.3	517.5
5’ x 20’	22.7	83.3	173.1	285.7	416.7	562.5
5’ x 30’	31.8	116.7	242.3	400.0	583.3	787.5

Table 1. Single-Loop Inductance Calculations (continued)

Loop Size	INDUCTION					
	1 turn	2 turns	3 turns	4 turns	5 turns	6 turns
6’ x 6’	10.9	40.0	83.1	137.1	200.0	270.0
6’ x 7’	11.8	43.3	90.0	148.6	216.7	292.5
6’ x 8’	12.7	46.7	96.9	160.0	233.3	315.0
6’ x 10’	14.5	53.3	110.8	182.9	266.7	360.0
6’ x 12’	16.4	60.0	124.6	205.7	300.0	405.0
6’ x 14’	18.2	66.7	138.5	228.6	333.3	450.0
6’ x 15’	19.1	70.0	145.4	240.0	350.0	472.5
6’ x 16’	20.0	73.3	152.3	251.4	366.7	495.0
6’ x 17’	20.9	76.7	159.2	262.9	383.3	517.5
6’ x 18’	21.8	80.0	166.2	274.3	400.0	540.0
6’ x 20’	23.6	86.7	180.0	297.1	433.3	585.0
6’ x 22’	25.5	93.3	193.8	320.0	466.7	630.0
6’ x 24’	27.3	100.0	207.7	342.9	500.0	675.0
6’ x 25’	28.2	103.3	214.6	354.3	516.7	697.5
6’ x 26’	29.1	106.7	221.5	365.7	533.3	720.0
6’ x 28’	30.9	113.3	235.4	388.6	566.7	765.0
6’ x 30’	32.7	120.0	249.2	411.4	600.0	-
6’ x 32’	34.5	126.7	263.1	434.3	633.3	-
6’ x 34’	36.4	133.3	276.9	457.1	666.7	-
6’ x 36’	38.2	140.0	290.8	480.0	700.0	-
6’ x 38’	40.0	146.7	304.6	502.9	733.3	-
6’ x 40’	41.8	153.3	318.5	525.7	766.7	-
6’ x 42’	43.6	160.0	332.3	548.6	800.0	-
6’ x 44’	45.5	166.7	346.2	571.4	-	-
6’ x 46’	47.3	173.3	360.0	594.3	-	-
6’ x 48’	49.1	180.0	373.8	617.1	-	-
6’ x 50’	50.9	186.7	387.7	640.0	-	-
6’ x 60’	60.0	220.0	456.9	754.3	-	-
6’ x 70’	69.1	253.3	526.2	-	-	-
6’ x 80’	78.2	286.7	595.4	-	-	-
7’ x 16’	20.9	76.7	159.2	262.9	383.3	517.5
7’ x 18’	22.7	83.3	173.1	285.7	416.7	562.5
7’ x 20’	24.5	90.0	186.9	308.6	450.0	607.5
8’ x 8’	14.5	53.3	110.8	182.9	266.7	360.0
8’ x 10’	16.4	60.0	124.6	205.7	300.0	405.0
8’ x 12’	18.2	66.7	138.5	228.6	333.3	450.0
8’ x 14’	20.0	73.3	152.3	251.4	366.7	495.0
8’ x 16’	21.8	80.0	166.2	274.3	400.0	540.0
8’ x 18’	23.6	86.7	180.0	297.1	433.3	585.0
8’ x 20’	25.5	93.3	193.8	320.	466.7	630.0

ASCT & TR DETECTION CONSIDERATIONS

Some traffic signal designs *may* need to include considerations for Adaptive Signal Control Technologies (ASCT) and/or Traffic Responsive (TR). ASCT allows for near real-time changes to coordinated signal offset and splits settings. TR allows for changes between timing plans (i.e,. cycle length and sequencing adjustments). Both forms of control require communication back to a central system, as well as an increased amount of detection.

Detection for ASCT systems will need to include by-lane stop line detection on each intersection approach for split adjustments. While mainline advance detection *should* likely be accounted for within the design at some level, both advance and exit *may* be required for offset adjustments. Ideally, advance and exit detection for ASCT are also by-lane.

Detection needs for TR systems are not far beyond those required to operate an isolated intersection. The primary additional needs are likely limited to mainline exit detection for measuring system volumes associated with timing plan changes vs. running a similar set of plans via time-of-day schedule.

4-8-2 Detector/Controller Logic Chart — April 2025

The Detector Logic Chart is located on the Sequence of Operations Sheet. There are several columns, which supply information regarding the detector location, mode of operation, and several other optional settings.

TS1 DETECTOR LOGIC CHART

A blank Detector Logic Chart for a TS1 signal cabinet with shelf-mounted loop amplifiers is shown below.

Figure 2.1. Detector Logic Chart

DETECTOR LOGIC

DETECTOR NUMBER	AMPLIFIER CHANNEL NUMBER	DETECTOR OPERATION			PHASE CALLED	PHASE EXTENDED	DETECTOR DISCONNECT PHASE	CALLING DELAY	EXTENSION STRETCH	LOOP SIZE	NUMBER OF TURNS
		CALLS & EXTENDS	CALLS ONLY	EXTENDS ONLY							
Column 1	2	3	4	5	6	7	8	9	10	11	12

Column 1: DETECTOR NUMBER - Indicate the detector number for all detectors at the signalized intersection. Detectors are numbered according to the phase they are associated with (first digit) and the order in which they would be encountered (second digit). Detectors adjacent to one another are numbered from the centerline to the outside.

Column 2: AMPLIFIER CHANNEL NUMBER - The second column indicates the amplifier channel corresponding to each detector or detector group. Every effort *should* be made to group detectors performing like functions. Do not wire more than two loops per amplifier channel.

Column 3-5: DETECTION OPERATION - Place an "X" in the cell to indicate a specific operation. Only one of the three columns *should* have an "X".

Column 6: PHASE CALLED - Indicate which phase is called when a vehicle arrives at a CALLS & EXTENDS or CALLS ONLY detector. This column must be filled out if the detector operation is set for CALLS & EXTENDS or CALLS ONLY: otherwise, it *should* be left blank.

Column 7: PHASE EXTENDED - Indicate which phase will be extended. This cell must be filled out if the detector operation is set to CALLS & EXTENDS or EXTENDS ONLY; otherwise, it *should* be left blank.

Column 8: DETECTOR DISCONNECT PHASE - Indicate which detectors use the detector disconnect feature by placing an "*" in the column. A note is also needed to explain when the detector(s) are disconnected.

Column 9: CALLING DELAY - Indicate which detectors use the calling delay feature by placing an "X" in the column.

Column 10: EXTENSION STRETCH - Indicate which detectors use the extension stretch function by placing an "X" in the column.

Column 11: SIZE - Enter the dimensions of the detector (e.g. 6'x 6').

Column 12: NUMBER OF TURNS - Indicate the number of turns required for the detector.

TS2 DETECTOR LOGIC CHART

A blank Detector Logic Chart for a single TS2 signal cabinet detector rack with rack-mounted loop amplifiers is shown below.

DETECTOR INPUT	3	1	7	5	11	9	15	13	Row 1
DETECTOR No.									2
PHASE CALLED									3
PHASE EXTENDED									4
CALLING DELAY									5
EXTENSION STRETCH									6
LOOP FUNCTION									7

DETECTOR INPUT	4	2	8	6	12	10	16	14
DETECTOR No.								
PHASE CALLED								
PHASE EXTENDED								
CALLING DELAY								
EXTENSION STRETCH								
LOOP FUNCTION								

Row 1: DETECTOR INPUT – NEMA defined assignment that corresponds to controller-based detector settings.

Row 2: DETECTOR NUMBER - Indicate the detector number for all detectors at the signalized intersection. Detectors are numbered according to the phase they are associated with (first digit) and the order in which they would be encountered (second digit). Detectors adjacent to one another are numbered from the centerline to the outside.

Row 3: PHASE CALLED - Indicate which phase is called when a vehicle arrives at a detector. This column must be filled out if the detector operation is set for CALLS & EXTENDS or CALLS ONLY: otherwise, it *should* be left blank.

Row 4: PHASE EXTENDED - Indicate which phase will be extended. This cell must be filled out if the detector operation is set to CALLS & EXTENDS or EXTENDS ONLY; otherwise, it *should* be left blank.

Row 5: CALLING DELAY - Indicate which detectors use the calling delay feature by placing an "X" in the column.

Row 6: EXTENSION STRETCH - Indicate which detectors use the extension stretch function by placing an "X" in the column.

Row 7: LOOP FUNCTION – Only intended to indicate the special or unique use of a detector. Data in this field *may* vary depending on the type controller. For example, some controller types allow detectors channels to be used to collect system data (such as volume and occupancy). Check with the Regional Traffic Signal Engineer for questions regarding specific locations.

CONTROLLER LOGIC CHART

The Controller Logic Chart is also located on the Sequence of Operations Sheet. The columns on this chart supply information regarding various controller operations. The designer **shall** show all phases in the controller logic box, and where appropriate, leave spaces for the unused phases (i.e. if phase 1 is not used, leave the first-row blank). A blank Controller Logic Chart is shown in Figure 2.2.

Figure 2.2. Controller Logic Chart

CONTROLLER LOGIC

PHASE NUMBER	PHASE LOCKING	DUAL ENTRY w / Ø	PHASE RECALL	PHASE ACTIVE
1				
2				
3				
4				
5				
6				
7				
8				
Column 1	2	3	4	5

Column 1: PHASE NUMBER - Enter the used phases associated with the controller logic settings.

Column 2: PHASE LOCKING - Indicate with an "X" which phases **shall** have locking memory.

Column 3: DUAL ENTRY - Enter which phase number will be permitted to be serviced concurrently with the phase number designated in column 1. This mode of operation requires two phases to be serviced concurrently even in the absence of vehicle demand. Single-entry operation will be programmed if no entry is made.

Column 4: PHASE RECALL - Indicate use of the phase recall function by listing MIN, MAX, or PED; otherwise, leave blank.

Column 5: PHASE ACTIVE - Indicate use of the phase active function. Dummy phases *may* be required in the case of EVP use with LC-8000 controllers and at T-intersection locations. The Regional Traffic Engineer **shall** be contacted regarding the use of the phase active function.

4-9-1 Cable Type/Information/Connections — April 2025

GENERAL

This section presents information, some of which has been previously printed from in such documents as the Standard Specifications for Road and Bridge Construction, Standard Detail Drawings, and the *Wisconsin Electrical Code*.

Refer to the Construction Materials Manual, Section 6-55 Electrical Construction for checklists that pertain to the inspection of installation of these units.

CABLE TYPE/INFORMATION

All wiring, cable, and connections **shall** be installed according to the Standard Specifications and the Wisconsin Electrical Code.

Detector Lead-in Cable

The loop detector lead-in cable **shall** be continuous from the loop detector splice to the loop detector input terminal strip in the controller cabinet.

Each loop **shall** have a separate lead-in cable from the cabinet to the loop detector splice.

Signal Cable

All traffic signal cable **shall** be installed in accordance with the Standard Specifications.

An as-built intersection wiring diagram **shall** be developed in accordance with the wiring as it was installed in the field and placed inside the controller cabinet upon completion of electrical work at the signalized intersection.

Due to the differences in cable size and wiring schemes, signal designers *should* contact the respective maintaining authorities to determine the proper wiring guidelines.

Spare Conductors

Where future pedestrian movements or left turn signal heads are anticipated, electrical cable with spare conductors *may* be routed from the controller cabinet to the quadrant or pole on which they would be installed. Due to the relatively low cost, spare conductors *should* be provided for possible future equipment. Spare conductors, if desired, *should* be shown on the plans and identified as such. *Should* questions arise, contact the maintaining authority for proper direction.

CABLE CONNECTIONS (SPLICES)

All cable splicing **shall** be installed in accordance with the Standard Specifications.

Underground splicing is not acceptable, except for the loop detector wire to its loop detector lead-in cable, which is spliced in an acceptable pull box or junction box.

4-10-1 Temporary Signal Plan **April 2025**

TEMPORARY SIGNAL PLAN

Once the decision to install temporary signals on the state trunk highway system has been made, a temporary signal plan **shall** be developed. The temporary signal plan set **shall** include construction staging plan, temporary pavement marking and signing plan, temporary timing plan, placement of lane control devices (barrel or wands), a temporary signal plan, and an abbreviated sequence of operation sheet for the temporary signal.

Temporary signals, as part of a construction project, are installed and maintained by the contractor for the length of the project. The Regional Traffic Unit or consultant *may* provide signal timing. Contact the Regional Traffic Unit to determine the responsible party for providing the temporary signal timing plans. The temporary signal timing plan *may* be included in the plan set and *may* be included in the PS&E submittal.

Decisions regarding the design and operation of temporary signals on the local system, including connecting highways, are at the discretion of the local municipality.

General Plan Development

1. Temporary signal plans for construction do not contain signature blocks indicating approvals or revision history. To show changes made to temporary signals caused by construction staging, individual plan sheets *should* be developed. Complex staging projects, which are likely to be field modified, can develop a single plan sheet which details pole placement and standard head quantities and locations. A note on the plan sheet **shall** define proper head placement based on the requirements. The signal plan for each stage **shall** indicate:
   - North arrow
   - Route designations
   - Symbol legend
   - Cabinet location (if known)
   - Signing & marking
   - Supports
   - Signal indications
   - Lighting
   - Detection (if used)
   - Signal timing
   - Temporary roadway geometrics
   - Roadway geometrics
   - Right-of-way lines
   - Reference lines
   - Access points (temporary & permanent)
   - Utilities
   - Lane assignments
   - Work zone areas
   - Work zone traffic control devices
   - EVP Detection (if used)
   - Pedestrian Crossings
   - Pedestrian Detection (if used)
2. The STH *should* be designated as the mainline.
3. NEMA phasing convention **shall** be used. Typically, NEMA phase 6 is in the Cardinal direction (Northbound/Eastbound).
4. Show right-turn control. STOP or YIELD if separated by an island and not controlled by the signal.
5. Configuration of each individual head **shall** be shown (3-v, 5-v, etc., **shall not** be used). The State signal cell library **shall** be used for signal design. Each signal head **shall** have a number.
6. It is the policy of the Department to provide intersection lighting with temporary signals per TEOpS 11-05-01.
7. If used, each detector **shall** be assigned a two-digit number, the first digit of the number being the phase number with which it is associated.
8. Signal plans **shall** be printed at 1”=40’ scale on an 11”x17” (D-size) number 2 tab plan sheet. For signal plans to be included in a PS&E submittal, refer to FDM Chapter 15, Plan Preparation.
9. The Department has a cell library specifically to aid in the creation of signal and lighting plans. All temporary signal plans **shall** use the latest signal cell library.

Cabinet Numbering

If a temporary cabinet is shown on the plan, it **shall** be labeled “TCB#”.

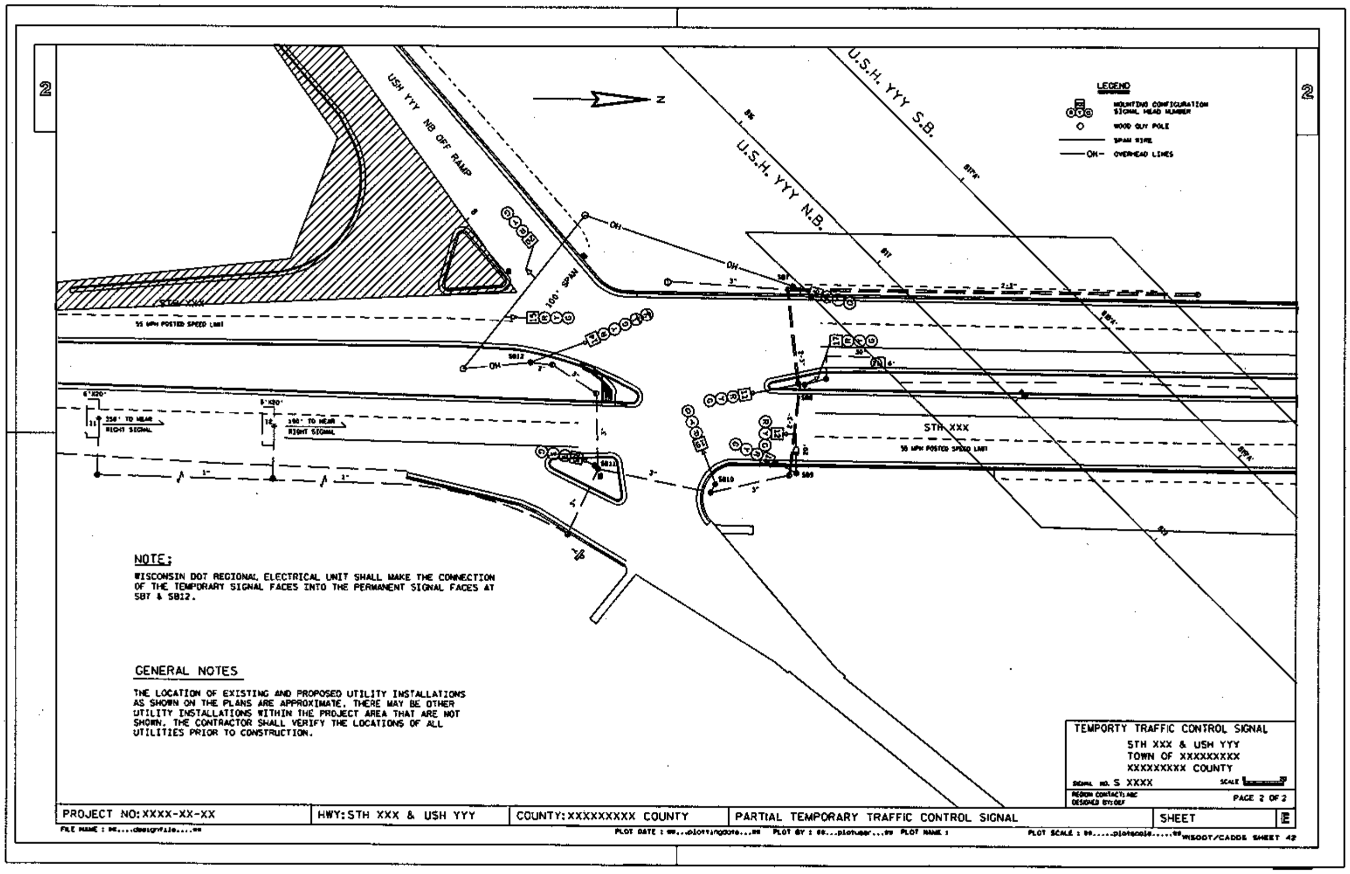
PARTIAL TEMPORARY SIGNAL PLAN

Partial-temporary signals are generally used at an existing signal when only one approach is to be reconstructed. The signal is a hybrid of existing permanent signal equipment (standard bases, poles, mast arms, etc.) and temporary supports (wood poles, span wire, etc.). The use of these types of installations are generally dependent on the type of improvement project or construction staging that will be performed.

Since the partial-temporary signal will be wired into an existing, permanent signal, the Regional Traffic Signal Engineer **shall** be contacted prior to plan development. When partial-temporary signal indications will be connected to the state-owned signal, the final wiring connections **shall** be performed by state-forces.

The partial-temporary signal plan **shall** indicate the entire signalized intersection. Existing signal equipment **shall** be gray-shaded. Temporary equipment **shall** be shown in standard line weights. The required plan elements **shall** be used. Refer to Figure 1.1 for an example of a partial-temporary signal plan.

Figure 1.1. Partial-Temporary Signal Plan Example



TEMPORARY BRIDGE SIGNAL PLAN

According to the WMUTCD 4D.11 Temporary and Portable Traffic Control Signals:

> *Option:*
>
> *Temporary or portable traffic signals associated with one lane, two-way facilities in temporary traffic control zones, may use a minimum of 2 signal faces per direction.*
>
> *Standard:*
>
> *For temporary or portable traffic signals associated with one lane, two-way facilities in temporary traffic control zones, one of the two heads **shall** be located at least 50 feet, but not more than 100 feet beyond the stopping point. If both heads are located more than 50 feet beyond the stopping point, at least one of the indications **shall** extend out over the roadway.*

Standard detail drawings (SDD 9G1 sheet a through g, 9G2 sheet a through c, and 15D33) for temporary or portable traffic signals are available in the FDM. There is only need to develop a signal plan for these applications if the design will be substantially different from that indicated by the SDD.

4-10-2 Signal Infrastructure Design - Temporary Signals — April 2025

The design of temporary traffic signal installations have many interrelated elements. Uniformity in the design of those elements promotes efficient traffic operations and reduces the potential for driver confusion and crashes. Temporary traffic signals must be designed and installed to convey clear and positive guidance to drivers and pedestrians. This subject contains discussions, illustrations, and examples of the design elements that are necessary to achieve this.

In addition to the information contained in this subject there are several standard references that *may* prove valuable to the designer.

4-10-3 Temporary Signal Head Design/Layout April 2025

SIGNAL HEAD DESIGN/LAYOUT

If the reconstruction of an existing signalized intersection does not require major shifting of the traffic due to lane reconstruction, such as replacement of underground conduits and rewiring, then the temporary signal heads **shall** be positioned to mirror the placement of those same heads on the permanent signal plan.

If the reconstruction project requires all the traffic to be on one side of the median while the other lanes are being reconstructed, then the span wire mounted temporary signal heads *should* be positioned over the driving lanes that they control. This type of installation provides better visibility and direction for the motorists during the reconstruction project.

Before developing a temporary signal plan, consult with the Regional Traffic Unit concerning placement of the temporary signal heads.

4-10-4 Temporary Signal Detection April 2025

Due to product improvements, the practice of using vehicle detection at temporary signal installations has become more common. Reasons that detection at temporary signals *may not* be considered feasible include: relatively short duration, construction staging, and cost of non-intrusive detection technologies. Detection for specific movements that experience high variability *may* be considered (i.e. a left-turn movement that exhibits excessive queuing by time-of-day). Verify the type of operation for temporary signals with the Region Traffic Signal Engineer.

Requests for pedestrian detection and emergency vehicle preemption are allowable. However, because of conditions associated with construction zones, these types users *should* ideally consider other routes. For example, due to lane reductions, delay through a work zone for an emergency vehicle *may* be greater than using an alternate route.

Factors that *may* influence the type and amount of detection for a temporary signal include:

- Type and location of supports used to mount non-intrusive detection (that *may* be prone to movement depending on construction activities),
- Variability in traffic volumes (this *may* be accounted for by time-of-day plans),
- Duration of the construction project,
- Type of construction being performed,
- Construction staging plans,
- Route significance to pedestrians and emergency vehicles,
- Availability of alternate routes.

4-11-1 Pedestrian and Bicyclist Crossings April 2025

Once the determination to install pedestrian signals is made, the next step is to determine where to install the pedestrian signal faces and detection (push buttons) if applicable. The designer **shall** consult the WMUTCD, Section 4E for Pedestrian Control Features and Chapter 9, Traffic Controls for Bicycle Facilities.

Pedestrian push buttons **shall** be shown on the signal plan, mounted approximately perpendicular and in advance of the crossing as required by the WMUTCD.

All pedestrian push buttons **shall** be accessible from the sidewalk to be able to be reached by walkers or people in a wheelchair. This *may* require the installation of a separate pedestrian pushbutton standard. Attempts to locate the pedestrian push buttons as shown in the WMUTCD and per ADA requirements **shall** be made.

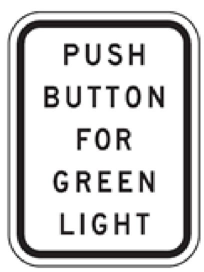
The R10-3E, 3H, 3I, and 3J series pedestrian signs **shall** be mounted on the same poles or standards as the pedestrian push buttons for pedestrian signals with countdown displays. The countdown display style of pedestrian signals **shall** be used on all state-owned traffic signals.

All pedestrian signal faces *should* be conspicuous and recognizable to pedestrians at all distances from the beginning of the controlled crosswalk to a point 10 feet from the end of the controlled crosswalk during both day and night. Sometimes this can be accomplished by attaching the pedestrian signal faces to traffic signal poles or standards. But, to meet the above requirement, a 10-foot pedestrian signal standard *may* need to be installed with just the pedestrian signal face and push button. If the pedestrian signal face can be installed on the traffic signal pole or standard, a 3.5-foot standard *may* still need to be used for a pedestrian push button to comply with the accessible requirements.

The pedestrian phasing *should* be shown adjacent the vehicular phasing on the sequence of operations sheet, shown by a double half arrow on the appropriate side of the vehicular phase arrow.

To accommodate bicyclists who want to cross a highway, a push button accessible to the bicyclist and sign stating, “Push Button for Green Light” (R10-3) as shown in Figure 1.1, *may* be installed. In this case, pedestrian signal faces are not installed; activation of the push button will call and time the pedestrian phase intervals or the bike minimum green interval.

Figure 1.1. R10-3 Sign for Bicyclist



ANIMATED EYES SYMBOL

Reference is made to the WMUTCD 4I.02.

The animated eyes symbol is a dynamic display that supplements standard pedestrian signal indications within the same section. This symbol consists of illuminated eyes that scan from side to side and is meant to prompt pedestrians to be aware of approaching vehicles.

POLICY

Pedestrian signal heads **shall** not incorporate the animated eyes symbol at state-owned signal installations.

SUPPORT

WisDOT supports the use of technologies that address a distinct need related to highway safety & traffic operations. Animated eyes are expected to have a limited effect on improving intersection safety but would require an increase in capital, operations, and maintenance costs. Benefits are not expected to outweigh additional resource expenditures.

IN-ROADWAY WARNING LIGHTS AT PEDESTRIAN CROSSINGS

Reference is made to the WMUTCD Chapter 4U.

In-roadway warning lights (IRWLs) are special types of highway traffic control devices installed in the roadway pavement to warn road users that they are approaching a condition on or adjacent to the roadway that *may* not be clear and might require the road users to slow down and/or yield.

IRWLs are actuated devices with flashing indications that provide real-time warning of a specific condition. In-pavement lights that supplement pavement markings by operating in a steady burn state **shall** also require WisDOT approval but are not the focus of this policy.

On the STH system in Wisconsin, IRWLs are limited to situations warning of: marked school crosswalks, marked mid-block crosswalks, marked crosswalks on uncontrolled approaches, and other roadway situations involving pedestrian crossings that are not associated with other types of traffic control.

POLICY

IRWLs, as defined herein, *may* be used on the Wisconsin STH system provided the local jurisdiction:

1. Applies for a permit
2. Agrees to fund the installation, operation, and maintenance of the device
3. Agrees to be responsible for any corresponding damage to the roadway or damage to highway maintenance equipment, and
4. Properly cites appropriate locations based on the conditions of this policy.

The municipality *should* understand that the permit *may* be revoked, especially in the event of safety or operational issues. In such a situation, the original costs and costs to restore the pavement are the obligation of the permit holder.

When allowed by permit, IRWLs **shall** be installed perpendicular to the direction of travel on the roadway and used to supplement crosswalk markings. IRWLs placed along the centerline of a highway, parallel to the direction of travel, **shall not** be used. IRWLs **shall not** be allowed on freeways or expressways.

Prior to the use of IRWLs, adequate trail of standard remedial measures **shall** be used to warn motorists of pedestrian crossings. IRWLs will be used only to supplement typical warning devices such as signs, markings, and crossing guards. Other strategies, such as providing a median refuge roadway lighting in advance of the crossing, or enforcement campaigns, are more universally recognizable methods of warning motorists of these conditions and *should* also be implemented when practicable.

<u>Location Criteria</u>

It is recognized that the use of IRWLs *may* affect STH traffic operations by increasing delay and reducing mobility, especially if used near existing signalized or stop-controlled intersections. The following criteria **shall** be met:

1. Location is an uncontrolled pedestrian crossing.
2. Location is an established school route, accommodates a minimum pedestrian volume of 100 pedestrians/day, or location has experienced pedestrian crashes in the past 3 years.
3. Subject crossing is in municipal (non-rural) limits.
4. There exists a minimum of 300 feet between the subject crossing and the nearest uncontrolled pedestrian crossing, or intersection traffic control device on the STH.
5. There exists a minimum of 1200 feet between the subject crossing and the nearest uncontrolled pedestrian crossing supplemented with in-roadway warning lighting unless exceptional conditions exist.
6. Roadway has a maximum of four travel lanes with a maximum single-stage crossing distance of 50 feet.
7. Approach speed is posted at less than 50 mph.
8. Adequate stopping sight distance exists based on the following approach speeds:
    a. 15 or 25 mph = 200 ft
    b. 30 mph = 250 ft
    c. 35 mph = 300 ft

   d. 40 mph = 400 ft
   e. 45 mph = 500 ft

Design Requirements

In the interest of uniformity, reliability, and consideration for other highway users, the following minimum design requirements for IRWLs **shall** be met:

1. Number/positioning of lights:
   a. For two-lane undivided roadways: 5 IRWLs per direction
   b. For four-lane undivided roadways: 7 IRWLs per direction
   c. For four-lane divided roadways: 5 IRWLs per direction.
2. IRWLs **shall** be actuated and **shall not** flash continuously.
3. If pedestrian push buttons are used to actuate the IRWLs, a PUSH BUTTON TO TURN ON WARNING LIGHTS (R10-25) sign **shall** be mounted adjacent to or integral with each pedestrian push button.
4. For four-lane divided roadways with median widths equal to or exceeding 6 feet, pedestrian actuation in the median **shall** be provided to allow for a two-stage crossing of the roadway.
5. Lights **shall** be evenly spaced across the entire traveled way. Lights *should* be positioned outside of vehicle wheel paths and *should* also consider bicyclist routes adjacent the traveled way. Lights placed near the centerline of the roadway *should* be offset slightly to minimize interference with pavement marking operations.
6. Electrical wire **shall** be cast in a minimum of 8-inch concrete pavement. If IRWLs are being installed with an improvement project that requires a pavement section greater than 8 inches, then the pavement at the crossing *should* be made to match that of the adjacent roadway. Pavement reinforcement *may* not be required, but this decision will reside with the regional pavement design unit. Doweling to adjacent concrete pavement will also be required at the direction of the regional pavement engineer. A minimum 2 feet of clearance to the edge of the concrete **shall** be maintained. Pavement structure **shall** be installed according to WisDOT Standard Specifications. Installation in existing pavement by sawing or coring is not permissible. Minimal width of the concrete, measured longitudinally in the direction of traffic, **shall** be 12 feet.
7. Roadway profile **shall** be appropriately maintained by milling or wedging the approach to the crossing, as required.
8. IRWLs **shall** flash for the entire calculated pedestrian clearance time. Pedestrian clearance *should* be calculated based on a 3.5 ft/sec walking speed. Locations frequented by children and elderly users *may* have a pedestrian clearance based on a slower walking speed. A brief time extension of 3 to 7 seconds *may* be added to allow for vehicle/pedestrian response and separation.
9. Features meant to accommodate impaired pedestrians such as actuator buttons with locator tones, supplemental braille signing, etc., *should* be considered at individual locations on a case-by-case basis. If used, these devices **shall** be furnished and maintained by the municipality that requests the IRWLs.
10. Other design criteria **shall** conform to the manufacturer’s recommendations.

SUPPORT

There are several general points of concern regarding the use of these devices:

1. IRWLs do not ensure that motorists will appropriately yield the right of way to pedestrians in the crossing.
2. A public awareness and education campaign *may* be required to educate the public prior to operating IRWLs.
3. IRWLs *may* cause rear-end collisions similar to a signal installation.
4. Placement of IRWLs between coordinated traffic control signals *may* cause progression problems.
5. Any improperly installed electrical equipment *may* pose a hazard to the public.
6. In Wisconsin, IRWLs *may* be susceptible to premature failure due to moisture buildup and/or snow removal operations.

7. The type of actuation used for IRWLs needs to be considered. Active detection (i.e. pushbutton) *may* create a false sense of security for pedestrians who are not familiar with the use of such devices or the rules of the road. Because of these factors, passive detection (i.e. infrared) is considered more appropriate for these types of applications, especially in crosswalks associated with school zones. In either case, an informational plaque *should* be used to briefly describe proper crossing behavior while using IRWLs. These are similar to informational plaques used at signalized pedestrian crossings (R10 series).
8. In IRWLs will be placed outside of existing connecting highway limits within a municipality, consideration *should* be given to extend those limits to include the installation location.

4-11-2 Pedestrian Phasing April 2025

Due to the impacts on the geometric design, ADA requirements, signal placement, and potential impacts on capacity analysis, system analysis and signal timing, accommodating pedestrians *should* be explored early in the scoping process. The geometrics of signalized intersections **shall** be designed to accommodate pedestrian traffic now and in the future; however, discretion *should* be exercised when determining where to install pedestrian phases. The surrounding area *should* be surveyed for schools, elderly and disabled housing, multipurpose trails, parks, and developments which *may* generate pedestrian traffic to help identify the need for pedestrian signals.

If it is determined that pedestrian phasing will be installed, early consideration *should* be given to the manner in which the pedestrian movement will be called. In most instances, a pedestrian push button *should* be installed to allow for on-demand call of a pedestrian phase. This is typically applicable to pedestrian movements across the mainline street and *may* also be applicable to pedestrian movements across the side street, especially at an isolated intersection. Calling pedestrian phase by push button increases the efficiency and decreases the delay and driver frustration by minimizing the number of times that the pedestrian phase is activated.

It is also possible to call the pedestrian phase each cycle by putting the phase on pedestrian recall. Typically, pedestrian recall is the preferred application in downtown areas or where there is high transit usage where the pedestrian volumes are high and consistent. It is usually a function of pedestrian demand and the ability or need to implement the necessary timing parameters to accommodate pedestrians on a constant call basis.

Pedestrian clearance time, FLASHING DON'T WALK (FDW) time, *should* always be sufficient for pedestrians to cross the entire approach especially at fully actuated isolated signals with push buttons. When pedestrian phase(s) are being added to an existing signal that operates in coordination or a new signal that will operate in coordination, it is important to assess the impact of the FDW interval on the cycle length. If a signal is pre-timed or operates in coordination, there *may* be some constraints against providing the entire pedestrian clearance every cycle. Ideally, the cycle length *should* be long enough to accommodate all ped phases every cycle. However, at large intersections this *may* lead to extremely long cycle lengths, excessive delays, long queues and a decrease in LOS.

Depending on the coordination settings used, the timing can be set up to allow the controller to go out of coordination when a pedestrian phase is actuated. This allows for the full pedestrian clearance to be provided and a feasible cycle length. However, this *may* not be desired since it can take several cycles to get back into coordination. Routine pedestrian actuations at a signal in a coordinated system *may* not allow for proper coordination.

An exclusive pedestrian phase (Barnes Dance) is <u>not</u> typically used. If an exclusive pedestrian phase is being considered for use, it **shall** be approved by the Regional Traffic Signal Engineer.

<u>Channelized Right-turns</u>

If a pork chop island exists, the recommended practice is to cross pedestrians from the radius to the pork chop island, then cross the mainline or side street.

For single lane channelized right turns that are not signalized (STOP, YIELD or free-flow conditions), pedestrian signals **shall not** be used. Pedestrian signals *should* be considered at crossings of single lane channelized right turns movements that are signalized. In that case, attention *should* be given to the placement of vehicular signal indications and whether those signals are readily viewable for the benefit of the pedestrian. Pedestrian signals **shall** be used at crossings of dual lane channelized right turn movements that are signalized.

<u>Two-stage Crossings</u>

Per WMUTCD 4I.06, where the pedestrian clearance time is sufficient only for crossing from the curb or shoulder to a median of sufficient width for pedestrians to wait, median-mounted pedestrian signals (with pedestrian detectors if actuated operations is used) **shall** be provided and signing such as the R10-3e sign **shall** be provided to notify pedestrians to cross only to the median to await the next WALKING PERSON (symbolizing WALK) signal indication. A median of sufficient width to accommodate two-stage crossings are generally considered a minimum of 6-ft in total width for pedestrians and a minimum of 8-ft in total width for bicyclists if the crossing is associated with a path.

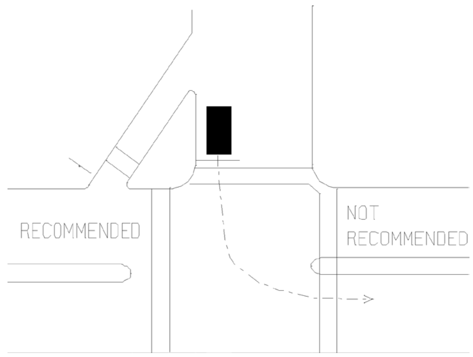
ADA requirements **shall** be considered when designing two-stage pedestrian crossings.

At any intersection with medians where a pedestrian could become stranded pedestrian push buttons *should* be placed in the median.

T-Intersections

It is recommended to place pedestrian crossings on the right side of a T-intersection to reduce the likelihood of left turning vehicles conflicting with pedestrians occupying the crosswalk on the receiving approach, as shown in Figure 2.1.

Figure 2.1. Pedestrian crossings at T-intersection



Visually Impaired Pedestrians

An engineering study *should* be conducted upon request for special accommodations for visually impaired pedestrians. Wide streets, right turn on reds, and complex signal operations are some of the factors that make it hard for visually impaired pedestrians to cross signalized intersections. Refer to WMUTCD 4K for guidance on when to install Accessible Pedestrian Signals (APS) for visually impaired. In general, APS devices are reserved for use at crossings that are part of a route, along which the pedestrian with visual disabilities who is requesting the device, typically travels.

Bicycle Phasing

Bicycles *should* be treated as pedestrians or vehicular traffic depending on the type of user. If bicyclists that use pedestrian facilities request detection, then other pedestrian devices such as pedestrian signal heads, *should* be installed.

4-11-3 Beacons — April 2025

Reference is made to the WMUTCD Chapter 4S.

Flashing beacons (a.k.a. flashers, warning flashers, beacons) are a special type of signal indication used to supplement standard regulatory and warning signs. According to the WMUTCD, flashing beacons have the following applications:

1. Intersection control beacon
2. Stop beacon
3. Speed limit sign beacon
4. Warning beacon (includes Rectangular Rapid Flashing Beacons)

Warning beacon includes Rectangular Rapid Flashing Beacons (RRFB). Flashing beacons are part of a sign, as it pertains to the provisions for allowing the installation of the beacons on highway right-of-way. Statutes 84.02 (4)(c) and 86.19 (3) convey exclusive authority for signs and warning devices on the state trunk system to the department.

This policy contains provisions for proper application, design, and permitting of flashing beacons on the STH system.

POLICY

General

The following general criteria apply to all flashing beacon installations on the STH system:

1. There are two types of flashing beacons:
   a. Red—only to be used with STOP signs
   b. Yellow—to be used with any yellow warning (W-series) signs, speed limit, speed limit reduction, pedestrian warning and school speed limit signs

   Flashing beacons **shall** only be associated with the sign installations referred to above.
2. Flashing beacons are supplementary to signs. When used, they **shall** be mounted on the same support as the sign which the beacon supplements in accordance with WMUTCD 4S.01.
3. Activated flashing beacons **shall not** be approved on the STH system for use in conjunction with train crossings.
4. Emergency vehicle entrances *may* have activated flashing beacons, which will cancel after a pre-timed period of flash.
5. State-owned and permitted installations
   a. The department *may* determine that flashing beacons are needed and *may* install and maintain them at specific sites. In this case, the regional traffic engineer **shall** make a final determination regarding the use of these devices on behalf of the department.
   b. At locations where, local authorities determine that the use of flashing beacons is desirable, a permit *may* be issued for the installation and maintenance of flashing beacons. Permitted installations are subject to the approval of the department and the conditions of this policy. Additionally, permits are revocable at the discretion of the department.

Application of Flashing Beacons

The following sections highlight policy items for flashing beacons that *may* be different from those represented in WMUTCD Chapter 4S.

Intersection Control Beacon: Used at intersections where traffic or physical conditions do not justify conventional traffic control signals, but crash rates indicate the possibility of a special need, generally located over the center of an intersection. Refer to WMUTCD 4S.02.

Stop Beacon: Refer to WMUTCD.

Speed Limit Sign Beacon: Refer to WMUTCD 4S.04. The department rarely, if ever, would install and maintain flashing beacons with speed limit signs or school speed limit signs. Local authorities **shall** follow the permit requirements stated below.

Warning Beacon: Refer to WMUTCD 4S.03.

Flashing Beacon Design & Installation

The following provisions pertain to the installation, operation, and maintenance of flashing beacons other than rectangular rapid flashing beacons (RRFBs) on the state trunk highway system.

1. Location
   a. Ground mount: Flashing beacons *may* be ground mounted, where they will be approximately one foot above the sign they supplement. The sign *should* be in the lateral and vertical location as specified in the WMUTCD Chapter 2. Illustrations of typical ground-mount installations are in Figure 3.1 below.
   b. Overhead mount: A flashing beacon *may* be mounted on one or both sides of an overhead sign. It *may* be mounted above the sign if the entire assembly including the sign has a minimum clearance of 17 feet.
2. For state-maintained installations, the standard size of flashing beacons is 12 inches in diameter. At the discretion of the regional traffic engineer, permitted (not state-maintained) installations that are in areas with a posted speed less than 30mph *may* use 8-inch diameter beacons.

3. Ground-mounted supports **shall** be the same as are normally used to support the sign, and of the same cross-section as normally used. These **shall** be 4 x 4 or cross-drilled 4 x 6 posts, or in urban areas signal posts on concrete footings, or light poles or wood poles where speeds are low. Usage of any kind of pole **shall** be in conformance with the offsets specified in highway lighting permit policy, FDM 11-15-1.
4. The installation of two posts, one for the sign and the other for the flashing beacon, is not permissible within the clear zone because of the unpredictable behavior of the combination of two posts when struck.
5. Service poles must be offset to the right-of-way line or in conformance with offsets in FDM 11-15-1.
6. Service *may* drop to the top of the support, which would be extended to maintain an 18-foot minimum wire-to-ground clearance as per Wisconsin electrical code. Service *should* preferably be installed underground. In the latter case, the conduit **shall** be run up and attached to the post or pole. The control box *may* be mounted on the post or pole.
7. At the discretion of the regional traffic engineer, solar-powered flashing beacon installations *may* be allowed on the STH system provided the installation meets applicable electrical and crash standards.
8. According to TEOpS 2-1-8, flashing beacons and STOP or STOP AHEAD signs that incorporate flashing displays (e.g. blinker signs) **shall not** be used at the same intersection approach.

Warning Beacon (i.e., RRFBs) Design & Installation

Yellow flashers are to be used with any yellow warning (W-series) signs and school speed limit signs. Actuated blinker signs are supplementary to warning signs. When used, they **shall** be mounted on the same support as the sign which the beacon supplements in accordance with WMUTCD 4S.03.

At locations where it is determined that the use of warning sign enhancements signs is desirable, a permit *may* be issued for the installation and maintenance of these blinker-type signs. Permitted installations are subject to the approval of the Department and the conditions of this policy. Additionally, permits are revocable at the discretion of the Department.

It is recognized that the use of warning sign enhancements *may* affect STH traffic operations by increasing delay and reducing mobility, especially if used near existing signalized or stop controlled intersections. The following location criteria *should* be met prior to approval:

1. The location is an uncontrolled pedestrian crossing.
2. A minimum volume of 20 or more pedestrians during a single hour (any four consecutive 15-minute periods) of an average day *should* be met. Young (<12), elderly (>85) and disable pedestrians count 2 times toward volume thresholds. Additionally, seasonal day volumes can be used in place of average day volumes if the crossing is in a known tourist area.
3. A minimum vehicular volume of 1,500 vehicles per day.
4. Maximum of four lanes crossed, unless there is a raised median, in which case it can be six lanes.
5. There exists a minimum of 300 feet between the subject crossing and the nearest controlled pedestrian crossing or intersection traffic control device on the state trunk highway system. Consideration *should* be given to extending this distance beyond 300 feet if the proposed crosswalk location falls within an auxiliary turn lane for the nearby intersection or if the standing queue from the intersection extends over the proposed crosswalk location.
6. Adequate stopping sight distance exists based on FDM 11-10-5 or greater than 8 times the posted speed limit.
7. RRFBs **shall** use a much faster flash rate and **shall** provide 75 flashing sequences per minute (except for existing RRFBs that follow FHWA IA-11). According to IA-21, the left and right RRFB indications **shall** operate using the following sequence:

RRFB Flash Pattern												
Beacon	0.05 sec	0.05 sec	0.05 sec	0.05 sec	0.05 sec	0.05 sec	0.05 sec	0.05 sec	0.05 sec	0.05 sec	0.05 sec	0.25 sec
Left	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
Right	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF

The use of warning sign enhancements *may not* be appropriate at locations where there is a combination of both high traffic volumes and high pedestrian volumes. In these situations, there *may* be an increase in crashes and/or delay that make the use of the actuated blinker signs inappropriate. Instead, a traffic signal or Pedestrian Hybrid Beacon (PHB) *should* be considered, if feasible.

Consideration *should* also be given to spacing between pedestrian crossings – both uncontrolled as well as those supplemented with warning sign enhancements. These blinker-type signs are highly visible and therefore can be confusing or distracting to drivers if there are too many within their field of vision at one time. Historically, 1,200 feet has been a rule of thumb for minimum spacing.

Warning beacon types

There are four options that *may* be used to enhance pedestrian and school warning signs:

1. Blinker Sign. Refer to TEOpS 2-1-8 for application criteria.
2. Standard Blinker Beacon. Refer to TEOpS 4-2-3 for application criteria.
3. Rapid Flashing Beacon (Wig-Wag).
4. Rectangular Rapid Flashing Beacon (RRFB). RRFBs can only be pedestrian actuated.

These devices can be pedestrian actuated and/or time-of-day programmed.

Figure 3.1. Warning Sign Enhancement Options

Blinker Sign | Standard Blinker Beacon | Rapid Flashing Beacon (Wig-Wag) | Rectangular Rapid Flashing Beacon

As of March 20, 2018, FHWA has granted interim approval (IA-21) for the optional use of the RRFB as a pedestrian-actuated conspicuity enhancement to supplement standard pedestrian crossing or school crossing signs at uncontrolled marked crosswalks to any jurisdiction that submits a written request to FHWA. WisDOT received statewide approval from FHWA to allow all jurisdictions to install an RRFB. The jurisdiction must agree to furnish a list of locations where RRFBs are installed, acknowledge that FHWA has the right to rescind the interim approval at any time and acknowledge that the interim approval does not guarantee that the provisions will be adopted into the WMUTCD.

PERMITTING OF FLASHING BEACONS

Any improperly installed electrical equipment *may* pose a hazard to the public. As such, the department spells out general and specific conditions, which are part of the permit agreement. These conditions are incorporated into the permit form, DT1877, a copy of which is appended to this policy. The WMUTCD Chapter 4S and specific conditions stated above **shall** also be followed for flashing beacons installed on all state trunk highways. Flashing beacons installed on connecting highways **shall not** require a WisDOT permit.

The following information provides conditions and processes related to the issuance of permits:

1. Permit applications **shall** be received, and permits issued, by the appropriate regional office.
2. Permits for flashing beacons *may* only be issued to municipalities, not to private individuals at agencies, or to power companies. This *should* result in working with the most responsible and objective agency associated with the safety problem being addressed.
3. The region *may* rightfully deny the issuance of the permit. Reasons for denial *may* include: lack of need, conflict with other traffic control devices, vulnerable location, lack of confidence in the maintaining ability of the subject agency, or knowledge that the request is due to reaction rather than long term need of commitment.
4. The region *may* revoke the permit for any of the reasons above, especially regarding lack of maintenance, as well as for reasons cited on the permit itself.
5. For permitted flashing beacons installed on signal standards, Standard Detail Drawings 9C2, 9C3, and

9E7 *should* be made part of the permit. SDDs 9C5 and 9D3 for control cabinet installations *may* also apply.

6. In the event of the reconstruction of the highway, reasonable notice *should* be given to the municipality to allow their removal of the equipment and arranging for disconnecting the electrical service.

Figure 3.2. Standard Flashing Beacon Installations for Rural & Urban Districts