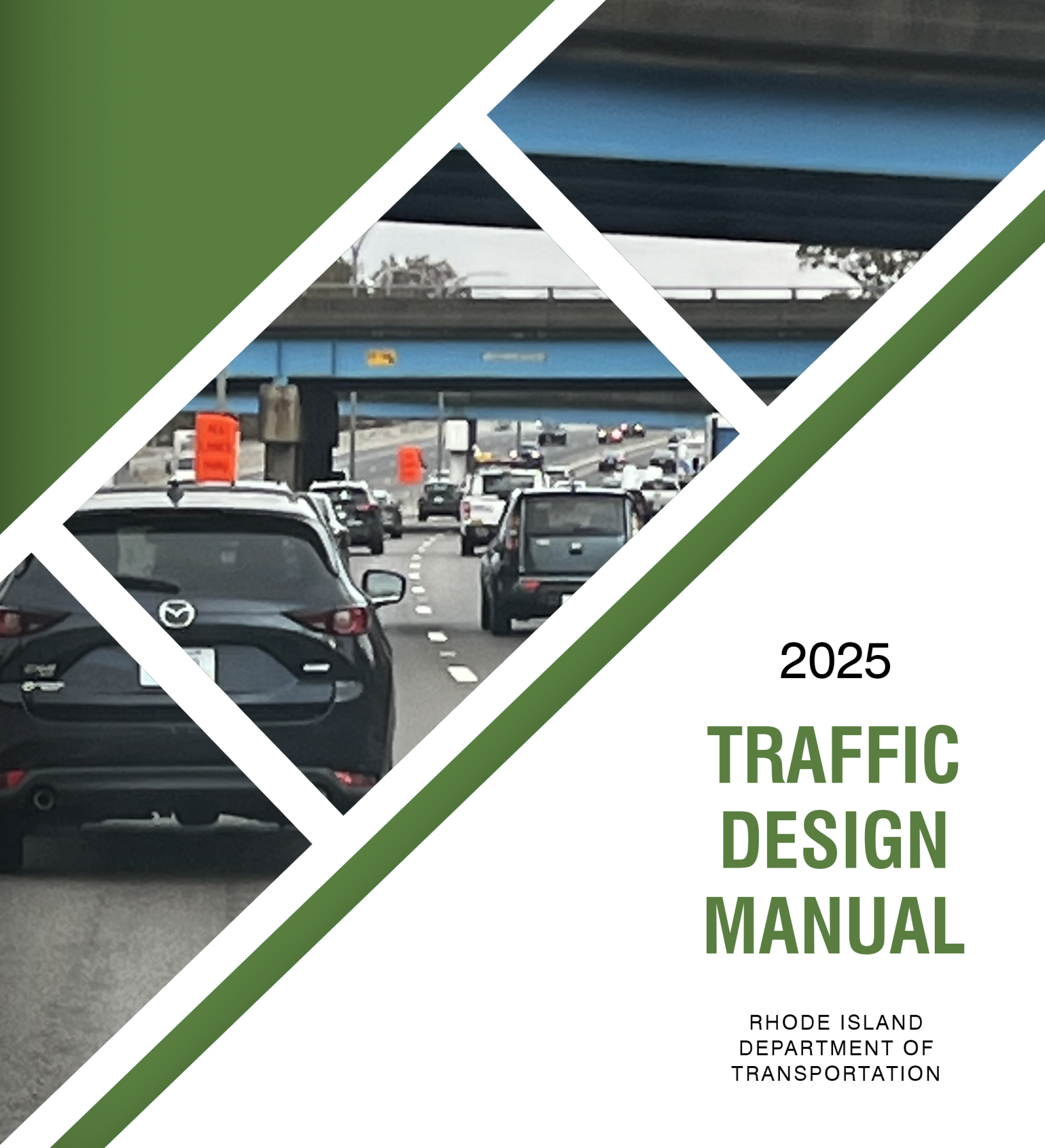

2025

TRAFFIC DESIGN MANUAL

RHODE ISLAND
DEPARTMENT OF
TRANSPORTATION

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CHAPTER 1
INTRODUCTION

1.1 Background and Scope

This Manual was developed by the Rhode Island Department of Transportation (RIDOT) to present in a consolidated resource its policies, practices, and preferences related to traffic engineering not covered in other RIDOT publications. This Manual shall be used in conjunction with other official RIDOT publications such as the Highway and Bridge Design Manuals, the *Rhode Island Standard Specifications for Road and Bridge Construction*, the *Rhode Island Standard Details*, and Design Policy Memoranda (DPMs). References to specific DPMs, and other industry publications are made throughout this Manual.

This Manual is intended to be utilized as an aid and reference to the Designer and is not meant to be a substitute for engineering judgment. Designers shall consider all appropriate factors during design to develop solutions that address the specific safety, operational, environmental, and regulatory requirements of the site or Project.

As RIDOT policies, practices, and preferences evolve and change over time, this Manual will be periodically updated. Questions, requests for clarification, or suggestions for modifications to the content of this Manual shall be submitted in writing to the RIDOT Office of Safety at DOT.Design@dot.ri.gov.

1.2 Manual Applicability

The stipulations of this Manual are effective as of the date the Manual is issued. If a Project's scope is already finalized and conformance to one or more requirements or recommendations of this Manual is believed to result in an undue hardship or is otherwise deemed to not be feasible, the Designer shall contact the RIDOT Project Manager and/or Traffic Engineer. The Project Manager/Traffic Engineer may proceed to obtain an exception from the Department if warranted.

Unless specifically noted otherwise, the stipulations included in this Manual shall apply to all work where RIDOT is the Project owner and/or manager, RIDOT funded Projects, and anywhere else RIDOT has jurisdiction at the site of the work. This includes all activities and Projects affecting state-owned facilities (e.g., highways, pedestrian/bicycle facilities, etc.), including applications for Physical Alteration Permits, Utility Permits, Temporary Traffic Control Permits and Traffic Management Plans (TMPs).

In cases where a stipulation of this Manual conflicts with the content of previously issued RIDOT Policy or other written direction and/or guidance, the stipulation of this Manual shall govern.

1.3 Definitions

When the following terms and acronyms are used in this Manual, they shall be defined as described below:

- AADT: Annual Average Daily Traffic
- AASHTO: American Association of State Highway and Transportation Officials
- ADA: Americans with Disabilities Act
- ADT: Average Daily Traffic
- APD: Accessible Pedestrian Detector
- APS: Accessible Pedestrian Signals
- ATR: Automatic Traffic Recorder
- AWG: American Wire Gauge
- B/C: Benefit to Cost
- BBI: Ball Bank Indicator
- C&M: Construction and Maintenance
- Chief Engineer: A senior-level role in a state transportation department that manages the department's infrastructure program and oversees engineering Projects. They are responsible for planning, coordinating, and implementing the department's infrastructure program.
- CMF: Crash Modification Factor
- CMS: Changeable Message Sign
- Contractor: The individual, partnership, firm, corporation, joint venture or legal entity contracting with the State for performance of the Work
- Designer: The consultant or other design professional responsible for the preparation of Project deliverables (e.g., reports, plans, traffic signal timings, etc.). For Projects that are designed “in-house” by RIDOT, this is the Traffic Engineer.
- DPM: Design Policy Memorandum: A memorandum issued by RIDOT which details specific RIDOT processes.
- FHWA: The Federal Highway Administration
- HAWK: High-Intensity Activated Crosswalk; also referred to as a Pedestrian Hybrid Beacon.
- HCM: Highway Capacity Manual
- HCS: Highway Capacity Software

- HDPE: High Density Polyethylene
- HSIP: Highway Safety Improvement Plan
- IEEE: Institute of Electrical and Electronics Engineers
- IMSA: International Municipal Signal Association
- ISP: Internet Service Provider
- ITE: Institute of Transportation Engineers
- ITS: Intelligent Transportation Systems
- Lane Closure: A reduction in the number of travel lanes available for use by motorists and/or bicyclists or in the number of travel paths available for use by pedestrians due to construction work operation or setup.
- LOS: Level of Service
- LPI: Leading Pedestrian Interval
- MASH: Manual for Assessing Safety Hardware
- MPH: Miles per hour
- MUTCD: The latest Edition and Revision(s), including Official Rulings, Interpretations, and Interim Approvals, of the *Manual on Uniform Traffic Control Devices* approved by the FHWA, unless a specific Edition and/or Revision is noted otherwise.
- NFPA: National Fire Protection Association
- OM: Object Marker
- NCHRP: National Cooperative Highway Research Program
- NEC: National Electric Code
- NEMA: National Electric Manufacturers Association
- NESC: National Electric Safety Code
- OSHA: Occupational Safety and Health Administration
- PAP: Physical Alteration Permit
- PAR: Pedestrian Access Route
- PEDSAFE: Pedestrian Safety Guide and Counter Measure Selection System, developed by the FHWA
- PHB: Pedestrian Hybrid Beacon, also referred to as a HAWK

- Preliminary Design: Defining the general project location and design concepts. It includes, but is not limited to, preliminary engineering and other activities and analyses, such as environmental assessments, topographic surveys, metes and bounds surveys, geotechnical investigations, hydrologic analysis, hydraulic analysis, utility engineering, traffic studies, financial plans, revenue estimates, hazardous materials assessments, general estimates of the types and quantities of materials, and other work needed to establish parameters for the final design. Prior to completion of the NEPA review process, any such preliminary engineering and other activities and analyses must not materially affect the objective consideration of alternatives in the NEPA review process.
- Project: (Pertaining to traffic related Projects), a RIDOT-managed and/or -owned design and/or construction Project or service; a Physical Alteration, Utility, or Temporary Traffic Control Permit including application for such; and any other planning, investigative, design, construction, maintenance, or field work completed by or on behalf of RIDOT.
- Project Manager**:** The RIDOT point of contact responsible for managing a Project through the entire planning, design, and construction process.
- PROWAG: Public Right-of-Way Accessibility Guidelines
- PS&E: Plans, Specifications, and Estimates
- PVC: Polyvinyl Chloride
- RIDOT: Rhode Island Department of Transportation
- RIDOT TMC: RIDOT Transportation Management Center
- RIE: Rhode Island Energy
- ROW: Right-of-Way
- RRB: Rolling Roadblock
- RRFB: Rectangular Rapid Flashing Beacon
- RSA: Road Safety Assessment
- RSC: Rigid Steel Conduit
- SLM: Shared Lane Markings
- STC: The Rhode Island State Traffic Commission
- STIP: Rhode Island State Transportation Improvement Program
- TAC Letter: To All Consultants Letter issued by RIDOT
- TCDH: Traffic Control Design Handbook
- TIS: Traffic Impact Study

- TMC: Turning Movement Count
- TMP: Transportation Management Plan, which lays out a set of coordinated transportation management strategies and describes how they will be used to manage the Work Zone impacts of a Project.
- TPAR: Temporary Pedestrian Access Route
- Traffic Data: Traffic volume, speed, classification, delay, gap, travel time, and/or queue length data, and/or other type of traffic-related data.
- Traffic Engineer: The point of contact from the RIDOT Office of Safety, who provides direction and/or recommendations on all traffic design and engineering related matters for the Project.
- TRB: Transportation Research Board
- TTC: Temporary Traffic Control
- TTCP: Temporary Traffic Control Plan
- TTC Permit: Temporary Traffic Control Permit – A permit granted by the RIDOT Chief Engineer for non-RIDOT Projects to set up temporary traffic control devices within the RIDOT right-of-way. These permits are not tied to any RIDOT Projects or other permits (utility permits, PAPs, etc.) and are typically issued for parades, road races, etc.
- TWLTL: Two Way Left Turn Lane
- US DOJ: United States Department of Justice
- Utility Permit: A permit granted by the Division of Highway and Bridge Maintenance for the installation or maintenance of utility facilities within the State Highway ROW.
- Vulnerable Road User (VRU): Any non-motorist utilizing the roadway, including pedestrians, bicyclists, roadside workers, and individuals using micromobility devices such as wheelchairs, scooters, and skateboards.

1.4 References

In addition to this document, the designer shall refer to the standards, policies, and standard specifications that are listed in 23 CFR 625[1] and the latest edition of the following documents and publications, unless otherwise directed by RIDOT. This Manual includes references to specific editions of the documents and publications listed below:

AASHTO. *A Policy on Geometric Design of Highways and Streets, 2018*

AASHTO. *Guide for the Development of Bicycle Facilities, 2012*

AASHTO. *Manual for Assessing Safety Hardware, 2016*

AASHTO. *Roadside Design Guide, 2011*

AASHTO. *LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*

FHWA. *FHWA-HRT-06-108 and FHWA-HRT-06-139. Traffic Detector Handbook, 3rd Edition*

FHWA. *FHWA-SA-21-041. Dedicated Left- and Right-Turn Lanes at Intersections*

FHWA. *FHWA-SA-21-034. Appropriate Speed Limits for All Roadway Users Proven Safety Countermeasure*

FHWA. *FHWA-SA-17-072. Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations*

FHWA. *FHWA-SA-14-028. Road Diet Informational Guide*

FHWA. *FHWA-SA-13-027. Signalized Intersections: An Informational Guide*

FHWA. *FHWA-HRT-04-100. Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations*

FHWA. *Manual on Uniform Traffic Control Devices for Highways and Streets*

FHWA. *NCHRP Report 731. Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections*

FHWA. *NCHRP Report 780. Design Guidance for Intersection Auxiliary Lanes*

FHWA. *NCHRP Report 812. Signal Timing Manual, 2nd Edition*

FHWA. *NCHRP Synthesis 515: Practices for Preventing Roadway Departures*

FHWA. *Pedestrian Safety Guide and Countermeasure Selection System* (PEDSAFE)

[1] https://www.ecfr.gov/current/title-23/chapter-I/subchapter-G/part-625?toc=1

FHWA. *Standard Highway Signs and Markings*

FHWA. *Traffic Monitoring Guide*

ITE. *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*

ITE. *Trip Generation Manual*

Rhode Island Division of Statewide Planning. *Existing Highway Functional Classification*

Rhode Island Division of Statewide Planning. *Rhode Island Statewide Bicycle Mobility Plan*

RIPTA. *Rhode Island Bus Stop Design Guide*

RIDOT. *Bridge Design Manual*

RIDOT. *CAD Standards Manual*

RIDOT. *Design Policy and Procedures Manual*

RIDOT. *Guidelines for Unsignalized Pedestrian Crossing Treatments*

RIDOT. *Highway Design Manual*

RIDOT. *Rules and Regulations Concerning Permission for Use of State Highway Rights-of-Way (PAPA Manual)*

RIDOT. *Specific Service Logo Sign Program*

RIDOT. *Standard Details*

RIDOT. *Standard Specifications for Road and Bridge Construction*

TRB. *Highway Capacity Manual*

TRB. *NCHRP Report 475. A Procedure for Assessing and Planning Nighttime Highway Construction and Maintenance.*

United States Department of Justice (US DOJ) Civil Rights Division. *2010 ADA Standards for Accessible Design*

Architectural and Transportation Barriers Compliance Board (United States Access Board). *Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG)*

1.4.1 Additional References

Additional valuable references and resources for Designers are listed below:

AASHTO. *A Policy on Design Standards – Interstate System, May 2016*

FHWA. *FHWA-HRT-23-035. Compendium of Wrong-Way-Driving Treatments and Countermeasures*

FHWA. *FHWA-SA-12-004. Methods and Practices for Setting Speed Limits: An Informational Report*

FHWA. *FHWA-SA-21-130. Improving Safety for Pedestrians and Bicyclists Accessing Transit*

FHWA. *FHWA-SA-22-017. Improving Intersections for Pedestrians and Bicyclists*

FHWA. *FHWA-SA-23-002. Safe System Approach for Speed Management*

FHWA. *FHWA-SA-24-063. Speed Limit Setting Handbook*

FHWA. *Low-Cost Treatments for Horizontal Curve Safety 2016*

FHWA. *NCHRP Report 834. Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities*

FHWA. NCHRP *Report 966. Posted Speed Limit Setting Procedure and Tool: User Guide*

FHWA. NCHRP *Report 1043. Guide for Roundabouts (2023)*

FHWA. *Pedestrian and Bicycle Safety*

FHWA. *Traffic Calming ePrimer*

ITE. Traffic Calming Measures

NACTO. *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*

NACTO. *Transit Street Design Guide*

NACTO. *Urban Bikeway Design Guide*

NACTO. *Urban Street Design Guide*

NEMA. *NEMA Standards Publication TS 2*

1.5 State Traffic Commission Requirements

Per Rhode Island (RI) General Law §31-13-1, the State Traffic Commission (STC) has authority over the installation of traffic control devices on state highways.

The Designer shall provide assistance to the RIDOT Office of Safety where required in order to ensure that the Project is completed in accordance with the latest STC records and approvals. Exceptions to the above include the following types of Projects:

- PAPs, Utility Permits, Temporary Traffic Control Permits, and TMPs that do not require or propose any regulatory or permanent traffic control device modifications within work limits.
- Projects and work that only involve the adjustment or fine-tuning of traffic signal timings and controller settings, without any changes to signal phasing.
- Any other planning, investigative, or maintenance work completed by or on behalf of RIDOT that does not include or involve changes to permanent traffic control devices.

The Designer should coordinate with the RIDOT Office of Safety early in the design process to determine if STC approval is required.

Traffic control devices (existing, proposed, or proposed to be altered) within the Project work limits are subject to STC approval per Table 1-1 on the next page.

Table 1-1. Traffic Control Device Types Subject to STC Approval

Specific Types and Conditions[1]
Regulatory Signs – All Types[2]
Changes to Speed Limits (permanent and during construction)
Passing/No Passing Zone Pavement Markings
On-Street Parking Restrictions (including times)
Marked Crosswalks across Uncontrolled Approaches[3]
Traffic Signals (All Types, including Rectangular Rapid Flashing Beacon (RRFB)/High-Intensity Activated Crosswalk (HAWK) Beacon/Pedestrian Hybrid Beacon (PHB))

Notes:

1. Traffic control devices that are not located on (or do not control access to or egress from) state roadways and/or state pedestrian/bicycle facilities do not fall under the jurisdiction of the STC.
2. Exceptions can be made for signs that assert an existing Rhode Island (RI) General Law (e.g., "DO NOT DRIVE ON SHOULDER"), but only when permitted by the RIDOT Office of Safety. Existing Regulatory signs replaced in kind do not require STC approval.
3. All marked crosswalks that are (or are proposed to be) installed across an uncontrolled roadway approach on (or anywhere at an intersection with) a State-owned and/or maintained roadway must be approved by the STC.

The Designer and/or RIDOT Project Manager may need to attend an STC meeting(s) to speak or present on behalf of proposed Project traffic control device changes. Changes to regulatory traffic control devices require coordination between the STC and local community officials, which often takes several months to complete.

1.6 *MUTCD* Applicability and Official Rulings, Interpretations, and Approvals

Historically, the *MUTCD* in its entirety has been adopted by/through the State Traffic Commission (STC) as the legal standard for traffic control devices on State owned roadways. RIDOT has not issued, and does not plan to issue, any official supplement to the national *MUTCD.*

After each new *MUTCD* Edition is issued by the FHWA, numerous Rulings, Interpretations, and Interim Approvals are officially issued by FHWA in response to industry and agency requests for clarifications, changes, and experiments. Prior to submitting each deliverable that involves a traffic control device(s) to the RIDOT Office of Safety, the Designer shall check the latest listing of official FHWA Rulings, Interpretations, and Interim Approvals to ensure that their design does not conflict with any such official determination and has considered the latest traffic control device treatments that the FHWA has acknowledged as being potentially helpful. The FHWA *MUTCD* website[2] provides links that enable the Designer to fulfill this expectation.

The Designer shall not include a traffic control device that is under interim approval without approval from the RIDOT Office of Safety. The RIDOT Office of Safety is required to request approval from the FHWA in order to use traffic control devices under interim approval and must keep a list of locations utilizing these devices.

[2] https://mutcd.fhwa.dot.gov/kno_11th_Edition.htm

CHAPTER 2
TRAFFIC STUDIES, EVALUATIONS, AND DATA

2.1 Traffic Studies and Evaluations

2.1.1 General Requirements and Guidelines

MUTCD Section 1D.03

Designers shall complete and prepare a documented engineering study for traffic control devices wherever stipulated in the latest *Manual on Uniform Traffic Control Devices* (*MUTCD)*. This will provide the RIDOT Office of Safety a record of the information and assumptions used in making engineering decisions about such devices.

When a traffic study or evaluation is conducted as part of a RIDOT-managed and/or -owned Project and includes the collection of new traffic data, the Designer shall submit an electronic copy of all traffic data in the approved file formats to dot.trafficdata@dot.ri.gov (and to the RIDOT Project Manager) for the enablement of future reference purposes. Submissions shall be made as soon as feasible, but no later than 45 days after the data has been collected. Final versions of all traffic analyses completed as part of a RIDOT-managed and/or -owned Project shall be provided to the RIDOT Office of Safety for record keeping purposes. Files shall include both PDFs of capacity analysis reports/outputs and the raw software tool file(s). See **Section 2.2.2** for additional guidance regarding the collection and submission of traffic volume, classification, and speed data.

2.1.2 Traffic Capacity and Delay Studies

When traffic capacity must be studied and/or traffic delays must be estimated, the methods included in the latest Transportation Research Board (TRB) *Highway Capacity Manual* (HCM) are generally acceptable since they are based on a wealth of research and empirical data.

A traffic capacity and/or delay analysis shall be completed by the Designer for Projects that are proposing any of the following at an intersection or interchange:

- a lane configuration modification(s)
- a change in existing geometry (e.g., adding/removing intersection legs, one-way versus two-way travel, etc.)
- installation of a traffic signal
- a traffic signal phasing modification(s)
- a change to multimodal accommodation(s) (pedestrians, bicyclists)

- a traffic signal timing modification(s), except where the scope of the Project is for the Designer to adjust (fine-tune) signal timings in response to a reported issue and/or field observations only.

For existing condition traffic capacity/delay analysis purposes, bicyclists and micromobility devices traveling in the street shall be treated as vehicles, and bicyclists and micromobility devices traveling along pedestrian facilities (including shared use paths) shall be treated as pedestrians. For future/proposed condition traffic capacity/delay analysis purposes, the Designer shall consider that some bicyclists and micromobility devices previously field-observed/counted as traveling along pedestrian facilities may use the roadway in the future build condition.

Various software tools for completing traffic capacity and delay analyses exist. Acceptable traffic analysis software tools for intersection analyses include *Highway Capacity Software* (HCS), *Synchro/SimTraffic*™, *SIDRA INTERSECTION*, and *Vissim*, but other tools may be used if approved in advance by the RIDOT Office of Safety. The software tool used shall provide the most appropriate and reasonably accurate analysis based on the proposed location and impacts to traffic, unless a more elaborate tool is needed to provide the required or desired level of detail. If a microscopic simulation model, such as Vissim is used, it shall be properly calibrated and validated. Vissim may be required when Projects involve limited access highways and on/off ramps.

2.1.3 Traffic Impact Studies

A Traffic Impact Study (TIS) is completed to show and document how forecasted traffic demands associated with a proposed site development or change in land use are expected to impact traffic safety and mobility on the surrounding and nearby roadway network. A TIS is not typically required during the design stage of a RIDOT Project. Coordinate with the Project Manager to confirm.

For non-RIDOT Projects, a TIS shall be prepared for any of the following:

- A proposed site development or change in land use that will generate 100 or more additional (new) vehicle trips during the adjacent roadway's peak hour or the development's peak hour
- A proposed site development or change in land use that will generate an increase in pedestrian activity such that improvements/enhancements to existing pedestrian accommodations are necessary
- A new traffic signal is proposed as part of the proposed site development or change in land use

- When changes to the existing roadway lane configurations or modifications to an existing signalized intersection are proposed on the State Highway, or
- As required by the RIDOT Office of Safety.

At the discretion of the RIDOT Office of Safety, a TIS may also be required if the Project may have an impact on safety and traffic operations. If there is a specific question as to whether a TIS is required for a non-RIDOT Project, the Designer shall contact the RIDOT Office of Safety for final determination on whether a TIS is required.

Crash analyses are required for any TIS and shall be performed as outlined in **Section 7.1.1.**

Access management-related treatments shall be considered and evaluated via the TIS wherever applicable per **Section 2.1.8**.

2.1.4 Traffic Signal Studies and Warrants

MUTCD Section 1D.03

An engineering study shall be completed to determine whether any type of traffic signal (e.g., a traffic control signal, a flashing beacon, a hybrid beacon, etc.) is warranted for installation or removal. Such studies shall follow the recommendations included in the *MUTCD*. Traffic signal warrants shall be performed using current traffic volumes in lieu of future volumes.

MUTCD Sections 4C.01 – 4C.10

A proposed new traffic control signal will only be approved if at least one of the warrants included in the *MUTCD* is met, but the satisfaction of one or more such warrants shall not in itself justify the installation of a traffic control signal. If Designers find that a traffic signal is warranted, consideration should be given to installation of a roundabout in lieu of a traffic signal.

Right-turning volumes at intersections can potentially overstate the need for a traffic signal, as these movements typically operate with lower delays than left-turning movements and would reduce the need for a traffic signal. The *MUTCD* signal warrant methodology considers the total approach volumes and does not account for the relative percentage of individual turning movements. As such, the *MUTCD* permits the reduction of right-turn volumes to identify if left-turn and/or through volumes exceed the warrant for the installation of a traffic signal. Engineering judgment should be used when addressing the need for installing a traffic signal under the below scenarios:

- If there is an existing exclusive right-turn lane for a minor street approach, up to 100% of right turns can be omitted from the warrant analysis if the movement enters the major street with minimal delay based on engineering judgment.

- If the minor street approach consists of an existing shared left-turn/through/right-turn lane or through/right-turn lane, a sensitivity analysis omitting right turns from the warrant analysis shall be conducted.

Engineering judgment should be used to determine what, if any, portion of the right-turn traffic is subtracted from the minor-street traffic count when evaluating the count against the signal warrants. The right-turn traffic reduction shall be justified and documented by the Designer in the corresponding engineering study.

When completing a traffic signal warrant analysis, if some or all bicyclists and/or micromobility devices that were field-counted as traveling in the sidewalk are expected to instead travel in the street once the potential traffic signal and other roadway improvements are completed, such users shall be considered as vehicles traveling in the street (If/where permitted by latest laws and regulations).

2.1.5 Stop Control Studies and Warrants

MUTCD Sections 2B.12 – 2B.17

An engineering study shall be completed to determine if stop control is warranted for installation. Such studies shall follow the recommendations included in the *MUTCD*. Stop control warrants shall be performed using current traffic volumes in lieu of future volumes.

2.1.6 Turn Lane Warrants and Evaluations

Installation of left-turn lanes and/or right-turn lanes shall be based on the American Association of State Highway and Transportation Officials (AASHTO) *A Policy on the Geometric Design of Streets and Highways*, the *HCM*, and Federal Highway Administration (FHWA) publication *Dedicated Left- and Right-Turn Lanes at Intersections*.

Exclusive left-turn lanes shall be considered at signalized intersections to remove vehicles from the through lanes where they may present undesired conflicts or additional vehicular delays. The criteria for consideration of the installation of left-turn lanes are based on the turning volume, outlined in the *Highway Capacity Manual (HCM).*

AASHTO Chapters 9.7.3- 9.9.4

The criteria for consideration of installation of left-turn lanes are based on a combination of left-turning vehicular volumes plus opposing through vehicular volumes at unsignalized locations. The Designer shall follow the guidelines outlined in the *HCM* and AASHTO's *A Policy on Geometric Design of Highways and Streets* for the installation of a left-turn lane. The criteria include consideration for the major road approaches at both three- and four- leg intersections with stop control on the minor road, where significant turning volumes exist, or where there is a history of turn-related crashes.

NCHRP 780

Criteria for the installation of right-turn auxiliary lanes are more subjective than the volume guidelines for left-turn lanes. As there is a higher potential for vehicular conflicts with bicycles riding in the street and pedestrians crossing, consideration shall be given to the impacts to bicyclist/pedestrian safety. The Designer shall follow the guidelines outlined in the *National Cooperative Highway Report Program (NCHRP) Report 780 Design Guidance for Intersection Auxiliary Lanes* for the installation of a right-turn lane.

See **Section 7.7** for additional guidance regarding turn lanes at intersections.

2.1.7 Pedestrian- and Bicyclist-Specific Traffic Evaluations

Based on *Complete Streets Design Consideration* (Rhode Island (RI) General Law §24-16-2) and the latest version of ITE's *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*[3] the Designer shall consider the ways in which the Project can and/or should improve the safety and mobility of all road users, including motorized vehicles, pedestrians, and bicyclists on RIDOT-managed and/or -owned Projects. Any such enhancements that are believed to be feasible for implementation as part of the Project shall be proposed to the RIDOT Office of Safety during the pre-scoping process.

ITE Chapter 6

For each Project roadway segment and intersection that is planned or proposed for reconstruction, resurfacing, and/or other improvements that could involve sidewalk installation or upgrades, the Designer shall propose infrastructure enhancements that will improve the safety and/or connectivity of pedestrian travel ways. The Designer shall ensure that such enhancements do not conflict with the recommended design parameters and dimensions included in the latest version of ITE's *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach.* The same design considerations and proposals described above shall also be made for other Projects where there is documented pedestrian activity or where otherwise deemed warranted by the Designer or the RIDOT Office of Safety.

RIDOT HDM Chapter 9

HCM Volume 1: Chapters 5 & 8 Volume 3: Chapters 16-21 & 23

FHWA's online *Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE)*[4] may be used by the Designer to help identify which specific types of pedestrian-related infrastructure enhancements are most appropriate to consider, evaluate, and/or propose on each specific Project. In addition, Designers shall consider utilizing RIDOT's *Guidelines for Unsignalized Pedestrian Crossing*

[3] https://www.naturewithin.info/Roadside/ITE%20Walkable%20Urban%20Streets.pdf
[4] http://www.pedbikesafe.org/PEDSAFE/index.cfm

Treatments to determine appropriate crossing measures for unsignalized midblock crosswalks. These guidelines are available via the RIDOT Office of Safety website.

2.1.7.1. Bicyclist Level of Stress/Level of Service

An evaluation of either the Level of Traffic Stress[5] (LTS) or HCM Level of Service (LOS) for bicyclists shall be completed for each Project roadway segment and/or intersection that:

- Is planned or proposed for reconstruction, resurfacing, and/or other improvements that could involve roadway widening, lane configuration changes, and/or sidewalk installation or upgrades (freeway/expressway locations excluded) and/or
- Lies within a critical or top priority corridor as identified in the latest Rhode Island *Statewide Bicycle Mobility Plan*[6]. For roadways identified within the *Bicycle Mobility Plan*, Designers shall contact the RIDOT Office of Safety to determine if an LTS has already been completed.

The evaluation would be completed for the existing conditions and at least one alternative for the proposed Project design that shall consider infrastructure treatments/features that will improve the bicycle LTS or LOS.

The same combination of bicyclist LTS or LOS evaluation and improvement proposal described above shall also be completed for other Projects where there is documented bicyclist activity or where otherwise deemed warranted by the RIDOT Office of Safety.

A LTS evaluation shall be considered for completion on all Projects that are studying the feasibility of implementing designated conventional bike lanes or other bicycle travel ways (e.g., curb-separated bike lanes) along a roadway(s), especially during the planning-level stage of a Project.

[5] See https://peterfurth.sites.northeastern.edu/level-of-traffic-stress/ for details.
[6] https://planning.ri.gov/sites/g/files/xkgbur826/files/documents/LRTP/Bicycle-Mobility-Plan.pdf

The latest FHWA pedestrian and bicycle safety website[7] includes links to additional information that can assist the Designer with the consideration, evaluation, and ultimate selection of infrastructure enhancements on Projects.

2.1.8 Access Management Considerations

In order to improve traffic safety and/or mobility, the below list of treatments shall be considered on all proposed site developments requiring a Physical Alteration Permit (PAP) and changes in land use that affect the State roadway system. These treatments shall also be pursued on RIDOT-managed and/or -owned Projects where commensurate with the scope of work. At a minimum, these treatments shall be evaluated for feasibility and proposed unless implementation is clearly impractical or unreasonable given the scope of the Project.

- Right-in-only and right-out-only driveways
- Dedicated turn lanes to separate through and turning vehicles
- Closed or relocated driveways and/or median openings
- On-site shared access driveways between abutting properties
- Installation of sidewalk and/or sidewalk replacement
- Non-traversable medians
- Increased intersection spacing
- Pedestrian and bicycle accommodations

[7] https://safety.fhwa.dot.gov/ped_bike/

2.2 Traffic Data

2.2.1 General Guidelines

Appropriate types of Traffic Data shall be considered on all Projects (including Transportation Management Plan (TMP) restrictions) in order to ensure that the design accommodates such traffic and to confirm that impacts to the traveling public are expected to be acceptable.

If traffic volume, classification, and/or speed data are needed, the Designer shall submit an e-mail request for such data to dot.trafficdata@dot.ri.gov. Requests should be as specific and granular as needed for the Project and should include aerial image(s) or other plan view illustration(s) showing the location(s) of the requested data. The RIDOT Traffic Research Office will reply to indicate whether the requested data is available and, in cases when they are, will either attach such data or invite a discussion with the requestor regarding next steps and potential data collection timeframe.

If traffic data is requested for a PAP or other non-RIDOT Project, the request for traffic data should be completed via a RIDOT Public Records Request, accessed through the RIDOT website[8].

Note, traffic counts obtained prior to Spring 2022 should generally not be used unless approved by the RIDOT Office of Safety, as traffic volumes in Rhode Island were below average due to the ongoing COVID-19 pandemic.

2.2.2 Traffic Volume (Count), Classification, and Speed Data Collection and Submission

If the steps described in **Section 2.2.1** have been followed and traffic volume, classification, and/or speed data is not available or is not appropriate to use with the Project (e.g., data is prior to Spring 2022, not comprehensive enough, traffic volumes or patterns have changed significantly, etc.), the following guidelines for the collection of new data apply unless unique circumstances exist and support otherwise:

- Data shall be collected on a typical day(s) and under typical conditions (e.g., on a Tuesday, Wednesday, and/or Thursday during a non-holiday week when schools are in session, and during non-stormy weather conditions).

[8] https://www.dot.ri.gov/business/publicrecordsrequest.php

- Weekend and seasonal variations in traffic shall be considered where appropriate. Data collected during weekend and/or seasonal timeframes may be required for the development of traffic signal timing plans that vary by time-of-day/week/year (see **Section 2.2.1**) or for proposed developments and land use changes based on the type of traffic generator(s) being proposed. Designers can contact the RIDOT Office of Safety at dot.trafficdata@dot.ri.gov for the most recent seasonal adjustment factors.
- Hourly volumes shall be collected for use when preparing TMP restrictions.
- The following guidelines apply only to Turning Movement Count (TMC) collection:
    - RIDOT prefers a minimum of twelve (12) hours of counts be collected to ensure that all peak periods (both of roadside traffic generators and of the roadways themselves) are covered (e.g., morning, midday, and afternoon/evening). Additional traffic counts may be required outside of these hours based on the scope and nature of the Project and/or traffic generators that are nearby. Upon approval from the RIDOT Office of Safety, TMCs may be collected during typical weekday peak hours (7:00 AM to 9:00 AM and 4:00 to 6:00 PM) and Saturday midday peak hours (11:00 AM to 2:00 PM) if the Designer demonstrates specific situations warrant typical peak hour data collection only.
    - In addition to the traditional "3-class" system of traffic count differentiation (e.g., cars, light duty trucks and motorcycles [FHWA class 1-3 and 5], heavy vehicles [e.g., FHWA class 4 and 6-13], and pedestrians), the number of bicyclists shall always be collected and documented such that this mode is differentiated from the others.
    - The Designer shall consider whether additional or special effort is warranted to properly differentiate and document the number and movement of special types or classes of vehicles (e.g., buses, micro-transit vehicles such as micromobility devices, a complete breakdown consistent with the latest FHWA vehicle classification system[9]) and/or specific types or classes of pedestrians (e.g., young, elderly, etc.) as presented in FHWA's *Traffic Monitoring Guide*.

FHWA Appendix A

- The following guidelines apply only to traffic Automatic Traffic Recorder (ATR) data collection:

[9] https://www.fhwa.dot.gov/policyinformation/tmguide/2022_TMG_Final_Report.pdf

- Traffic count data shall consist of a minimum of forty-eight (48) hours.
- The ATR data shall include volumes, vehicle classification and speed information.

Digital platforms (such as *Replica, StreetLight Data,* etc.) may be used to supplement and/or estimate traffic volumes and determine overall trends using origin-destination data at a larger scale but shall not replace actual count data.

When new traffic data is collected for or as part of a RIDOT-managed and/or -owned Project, the raw electronic format version of such data shall be submitted to dot.trafficdata@dot.ri.gov as soon as feasible, but within 45 days of collection. Preferred electronic filetypes of the raw data include RIDOT Microsoft Excel Template, PETRA or PETRAPro text file, or Miovision "Intersection Full" CSV file. Please contact the RIDOT Office of Safety at dot.trafficdata@dot.ri.gov for the current template to be used.

2.2.3 Use of Traffic Speed Data

Actual traffic speeds collected from the field, rather than prima facie or posted speed limits, should be used for traffic design and study purposes.

Where a reference publication (e.g., the *MUTCD*) allows for the posted speed limit, design speed, anticipated operating speed, and/or 85th percentile speed to be used in a calculation for a traffic control device or treatment, the highest of such speeds shall be used for safety purposes.

2.2.4 Future Traffic Conditions

Traffic growth is generally a function of changes in motor vehicle use and expected land development within the area. To establish the rate at which traffic on the study area roadways can be expected to grow during the forecast period, both planned area developments and historic/background traffic growth shall be reviewed.

To determine future traffic demands on the study area roadways and intersections, existing traffic volumes shall be projected to the future-year as follows:

- Private developments – five (5) years
- Traffic Signal (excluding RRFBs/PHBs) – 10 years
- Bridge Project – 25 to 30 years

Traffic volumes on the study area roadways in future years are considered to include existing traffic, as well as new traffic resulting from general growth in the study area and from other planned development projects, independent of the proposed project. The potential background traffic growth, unrelated to the proposed project, shall be considered in the development of the future No Build (without the proposed project) peak hour traffic volumes. The estimated traffic increases associated with the proposed project shall then be added to the future No Build volumes to reflect the future Build (with the proposed project) traffic conditions. A more detailed description of the development of future No Build and Build traffic volume networks is presented below.

2.2.4.1 Predicted Traffic Data and Trip Generation

Vehicular demands (trips) for a proposed development or change in land use that does not include a new traffic signal shall be estimated using the methods and data included in the latest ITE *Trip Generation Manual* if no other local data is available and applicable.

Predicted vehicular trips for a proposed development or change in land use that includes a new traffic control signal shall be determined based on appropriate land use codes for vehicular trip projections from the ITE *Trip Generation Manual*, if available. Rates shall be developed from the "fitted curve" equations when available and appropriate.

If the above requirements are not or cannot be met (e.g., a similar type of ITE land use does not exist), alternative trip generation rates may be considered, upon approval by the RIDOT Office of Safety. Alternative trip generation rates include but are not limited to actual traffic volumes observed at a fully occupied and similar type of development/land use that is preferably in the same region as that being proposed. A sample size of at least three similar sites is desirable when utilizing alternative data.

For traffic studies where the installation of a traffic signal is being reviewed for a future scenario, ITE trip generation may be utilized as a basis for signal warrant volumes. However, site-specific data (if available), may be utilized for the signal warrant analysis upon approval from the RIDOT Office of Safety.

2.2.4.2 Planned Roadway Improvements

Planned roadway improvement projects can affect area travel patterns and future traffic operations. To develop a clearer understanding of future area roadway operations, Designers should consult the municipality to identify any projects which are anticipated to impact future design year traffic volumes.

Designers should also review the Rhode Island State Transportation Improvement Program (STIP) online map to develop an understanding of future area roadway improvement projects. The STIP map is accessible to the public and shows the locations of upcoming roadway improvement projects throughout the state.

2.2.4.3 Background Traffic Growth

Background traffic growth accounts for changes in traffic volumes associated with general changes in population and other developments that are not known at the time the study is prepared. An annual background traffic growth rate, compounded annually, shall be established for the study area. This growth rate should be based on information provided as part of the Rhode Island Statewide Planning Program, or obtained from the municipality, to grow the existing traffic volumes to a future year. To be conservative, negative growth rates should not be utilized.

CHAPTER 3
PAVEMENT MARKINGS

3.1 Marking Types and Installation Conditions

3.1.1 General Practice

RIDOT Standard Spec. Section T20

The following guidelines are to assist the Designer in developing estimated quantities for permanent and temporary pavement markings to be used on a Project. All pavement markings shall be called for in accordance with the *Manual on Uniform Traffic Control Devices* (*MUTCD)* and the Rhode Island Department of Transportation (RIDOT) *Standard Specifications for Road and Bridge Construction.*

The Designer shall determine the appropriate pavement marking material based on the categories outlined in Table 3-1:

Table 3-1. Pavement Marking Installation

Category	Pavement Marking Material	
	Waterborne[1]	Epoxy Resin[3]
Milled Surface Prior to Overlay	✓	-
Immediate Pavement Layers for Phased Construction[2]	✓	✓
Final/Permanent Pavement	-	✓

Notes:

1. When used, it should be assumed that one application of the markings can last up to one calendar year (including one winter season).
2. The Designer shall consider factors such as durability (excessive wearing by traffic on heavily traveled roadways), type of roadway, anticipated duration of application, etc., when determining pavement marking material and the number of applications required.
3. Shall be utilized on all RIDOT construction Projects for final/permanent pavement.

Pavement marking symbols (e.g., sharrows, bicycle lane markings, etc.) are to be installed in accordance with Table 3-2, as the type of material and extent of replication of pavement marking symbols depend on the nature of the roadway.

Table 3-2. Conditions for Temporary Pavement Marking Installation

Temporary Marking Type	Special Conditions for Temporary Installation
Bi-Directional Control Markings/Devices[2]	• On newly milled or -installed pavement surfaces that will be opened to traffic and are not the final surface course, only the white pavement marking arrow portion of the Device shall be installed. • On final surface course of pavement, the complete Device (including raised reflective markers and white arrow markings) shall be installed.
Stop Line Markings	Shall be installed if • an associated "STOP" sign is installed and/or • an associated traffic control signal is installed and is operational
Crosswalk Markings	Shall be installed only when • each end of the crosswalk is accessible in accordance with US DOJ *2010 ADA Standards for Accessible Design* • all existing/proposed marked crosswalks that are installed across an uncontrolled roadway approach on (or anywhere at an intersection with) a State-owned and/or maintained roadway must be approved by the STC
Yield Line Markings	Shall be installed only • if an associated "YIELD" sign is installed and • where required to show the alignment and position of permanent epoxy markings[1,2]
Parking Space Markings	Shall be installed only where required to show the alignment and position of permanent epoxy markings[1,2]
Lane-Use Arrow Pavement Markings at Roundabouts	Shall be installed at various construction phases for multi-lane roundabouts
Other Types of Pavement Markings Not Listed Above	Shall be installed only where required to show the alignment and position of permanent epoxy markings or where determined to be appropriate by the Designer based on engineering judgment.[1,2,3]

MUTCD Sections 6J.01-6P.41

MUTCD Section 2B.19

Notes:

1. Temporary markings of the type indicated are not required outside of the reconstruction or resurfacing limits.
2. If the Designer judges that the Project work warrants the use of this type of marking on a temporary, non-permanent basis only (e.g., a temporary freeway ramp is to be opened to

traffic for a year, prior to being removed once construction of a new ramp is complete), such temporary markings must be called for as appropriate.

3. When Elongated Route Shield symbol markings made of pre-formed thermoplastic material are required by the RIDOT Office of Safety, such markings must be proposed as permanent installations. Overlaying permanent epoxy resin markings over route shield symbols is not allowed.

3.1.2 Temporary Marking Considerations

The dimensions of all temporary pavement markings used in work zones (e.g., the width of an edge line) shall be equal to the dimensions of permanent pavement markings that will be installed on the facility.

To ensure that road users will be provided with a clear intended travel path through each Project work zone, Project contract documents shall require that existing and/or temporary (interim) pavement markings that conflict with proposed new pavement marking layouts during the Project work be removed by grinding. For temporary (interim) epoxy resin markings on intermediate pavement layers, the existing markings shall be ground off before paving to reduce the likelihood of future delamination.

Under certain circumstances for temporary uses, the covering of existing pavement markings with black thermoplastic pavement markings or black-out tape may be used upon approval from the RIDOT Office of Safety.

3.2 Marking Dimensions and Spacing

Dimensions and spacing of proposed pavement markings shall be in accordance with Table 3-3.

Table 3-3. Pavement Marking Dimensions and Spacing

MUTCD Sections 3A and 3B.01-3C.08

Pavement Marking Types (see *MUTCD* for descriptions)	Freeways, Expressways, and Ramps		All Other Roadways[1,7]	
	Width (in.)	Spacing Details	Width (in.)	Spacing Details
Left Edge Lines (Yellow)	6	N/A[4]	4	N/A[2]
Right Edge Lines (White)	6	N/A[4]	6	N/A[2]
Lane Lines (White)	6[3]	N/A[4]	6[3]	N/A[2]
Double Center Lines (Yellow)	6	6-inch gap btw. lines[2]	4	4-inch gap btw. lines[2]
Chevron Lines	12	20-foot gap btw. lines[5]	12	10-foot gap btw. lines[5]
Diagonal Crosshatch Lines	24	40-foot gap btw. lines[5]	12	10-foot gap btw. lines[5]

MUTCD Sections 3B.20 -3B.25

	All Roadways[1,7]	
	Width (in.)	Spacing Details
Channelizing Lines	12	N/A
Crosswalk Lines (White)	12	Per RIDOT *Standard Details*
Stop Lines (White)	12	Per RIDOT *Standard Details*
Yield Lines (White)	Per RIDOT *Standard Details*[6]	
Bus Stop Markings	Per latest *Rhode Island Bus Stop Design Guide*[11]	
Other Words and Symbols	Per RIDOT *Standard Details* and *MUTCD*	

MUTCD Sections 3D.01-3D.07

Pavement Marking Types (see *MUTCD* for descriptions)	Single and Multi-Lane Roundabouts	
	Width (in.)	Spacing Details
Left Edge Lines (Yellow)	6[8,9]	N/A
Right Edge Lines (White)		
In front of splitter islands	6	N/A
Across entry lanes	12	Note[9]
Across Exits	Shall Not Be Marked	
Lane Lines	6[10]	
Lane-Use Arrows[10]	Refer to Section 3.5.1	
Dotted Extension Lines (White)[10]	12	Note[9]

Notes:

1. On roadways where RIDOT does not have jurisdiction, the dimensions and spacing shown are preferred by the Department but the proposed design shall be in accordance with local policy if applicable.
2. Extensions of these lines may be used within an intersection or taper area and shall consist of 2-foot line segments and 4-foot gaps.
3. Shall be 12 inches in width where the *MUTCD* requires that a wide lane line be used.
4. Where the line shall or should be broken per the *MUTCD*, the broken line shall consist of 10-foot line segments and 30-foot gaps. Where the line shall or should be dotted per the *MUTCD*, the dotted line shall consist of 3-foot line segments and 9-foot gaps.
5. Other spacing may be used based on engineering judgment where necessary for improved visual appearance or for consistency with other chevron or diagonal crosshatch markings in the area.
6. For yield lines installed on shared use/bike paths, each triangle shall be 12-inches wide x 18-inches high, with a 3-inch gap between adjacent triangles.
7. If extra emphasis is deemed to be warranted based on engineering judgment, wider line widths can be called for if approved by the RIDOT Office of Safety. The width of a wide line shall be twice the width of a normal line as described in this manual.
8. Width can be reduced to 4 inches if a mountable truck apron area itself will be marked or colored yellow, or there are pavement width constraints.
9. Extensions of these lines within a roundabout shall consist of 2-foot line segments and 2-foot gaps.
10. Lane lines, approach lane-use arrows, and dotted white extension lines are not applicable to single lane roundabouts.
11. See Figure 5.1 of the 2017 Bus Stop Design Guide, available online at: https://www.ripta.com/wp-content/uploads/2024/06/RIPTA-Bus-Stop-Design-Guide_FINAL_240528.pdf

3.3 Marking Layout on Plans

Existing pavement markings shall be shown in grayscale on Signing & Striping Plans wherever doing so will help the installer lay out proposed markings.

On freeways, expressways, and associated ramps, the layout of longitudinal pavement markings on Signing & Striping Plans shall be referenced beginning at the left-side (high-speed) edge of pavement or inside edge of berm. Dimensioning longitudinal markings in this manner helps ensure that the left-side shoulder adjacent to the high-speed lane (the offset shown in Figure 3-1) will be installed at a constant width.

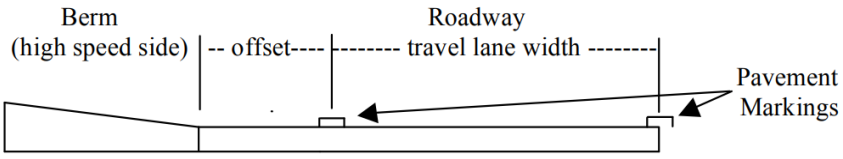


Figure 3-1. Section Showing Left-Side Shoulder Offset

Existing markings shall be confirmed by field observations prior to the advertising submission. Changes may have been made since the latest plan or aerial image or both.

3.4 Crosswalk Markings

3.4.1 Installation Requirements and Guidelines

Although crosswalks generally should be marked along preferred pedestrian routes where there is routine pedestrian demand, crosswalks shall not be marked across minor side streets with low vehicular volume, unless directed by the RIDOT Office of Safety.

A marked crosswalk shall not be called out for installation across an uncontrolled roadway approach (e.g., an approach not controlled by a traffic signal, "STOP" sign, or "YIELD" sign) unless an engineering study shows that it is warranted.

The engineering study must include (but not limited to) review of the following documents:

- *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations* (Federal Highway Administration (FHWA))
- The *MUTCD* (FHWA)
- *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* (FHWA)
- *Guidelines for Unsignalized Pedestrian Crossing Treatments* (RIDOT) available on the RIDOT Office of Safety website.

These documents use a number of roadway characteristics including Average Daily Traffic (ADT), pedestrian volumes, number of travel lanes, proximity to marked crosswalks, surrounding land uses, and 85th percentile operating speeds to determine appropriate recommendations for installing marked crosswalks at unsignalized and/or mid-block locations.

All marked crosswalks that are proposed to be installed across any uncontrolled roadway approach on or at an intersection with a State-owned or -maintained roadway shall be approved by the State Traffic Commission (STC) prior to installation.

3.4.2 Marked Crosswalk Design and Layout

All marked crosswalks installed across or at an intersection approach to a State-owned/maintained highway shall conform to RIDOT *Standard Details*. Marked crosswalks should be at least eight feet wide but can be wider if deemed appropriate given expected pedestrian demand and site conditions.

3.5 Markings for Roundabouts

Pavement markings on approaches to and within roundabouts are critical for guiding road users safely and efficiently through the intersection, especially at multi-lane roundabouts. Studies have shown that pavement markings indicating the proper (intended) lane use and travel path alignments at multi-lane roundabouts are a key to minimizing erratic maneuvers by motorists and suggest that drivers pay more attention to markings than they do to signs[10]. Designers shall propose roundabout marking designs that make the intended travel paths clear to all road users, including those who are not familiar with roundabouts.

In the early stages of roundabout design, the Designer shall also coordinate with the RIDOT Office of Safety to discuss conceptual thoughts and/or plans for the roundabout traffic controls to obtain preliminary comments and/or approval of such concept. The Designer shall be familiar with the guidelines presented below and in **Section 4.9** of this manual, as well as the design/layout of markings and signs used. The RIDOT roundabout website[11] includes an interactive tour that can help identify such locations.

3.5.1 Markings Within Roundabouts

Refer to Table 3-3 for pavement marking types and widths for single and/or multi lane roundabouts.

Within the circulatory roadway of all roundabouts, lane-use arrows shall be called for in accordance with RIDOT *Standard Details* to guide motorists safely through the intersection. For smaller single-lane roundabouts (e.g., those with an inscribed circle diameter of 100 feet or less) such arrows may be omitted if approved by the RIDOT Office of Safety.

MUTCD Sections 3D.01-3D.06

In addition to the *MUTCD* which provides examples of where to locate/position lane-use arrows inside roundabouts, at multi-lane roundabouts Designers shall consider whether supplemental arrows, “ONLY” markings, and/or elongated route shield markings are warranted to help positively guide road users as they traverse the roundabout. At multi-lane roundabouts, an “ONLY” word marking shall be called for upstream of the straight through lane arrow that is positioned inside the circulatory roadway in each lane that must “exit” the roundabout at the next leg (refer to the multi-lane roundabouts installed in the Apponaug Village of Warwick, RI shown in Figure 3.2 for examples).

[10] For example, see: https://safety.fhwa.dot.gov/intersection/innovative/roundabouts/docs/fhwasa15075.pdf
[11] https://www.dot.ri.gov/Safety/roundabout_safety.php

Figure 3-2. Apponaug Village Multi-Lane Roundabout

3.5.2 Markings on Roundabout Legs

Yield line markings shall be called for at the point behind which vehicles are required to yield at the entrance to a roundabout, and each such yield line shall be supplemented with the pavement marking word "YIELD" in advance of the yield line. Both markings shall be installed perpendicular to the approach.

The following stipulations apply only to multi-lane approaches to roundabouts:

MUTCD Figure 3B-21

- "Curved-Stem" lane-use arrows (with a center dot symbol for only the left-most lane) shall be called for on multi-lane approaches to roundabouts.
- A minimum of two (2) lane-use arrows shall be called for installation in each approach lane to the roundabout.
- Designers shall consider whether supplemental lane-use arrows, words, and/or elongated route shield markings are warranted to help align approaching road users within the appropriate travel lane, especially where such markings will be consistent with upstream signs.

MUTCD Figure 3D-6

- Designers should consider using a wider (12-inch) solid white lane line to separate adjacent travel lanes entering the roundabout.

- Flush gore areas between adjacent travel lanes on the approach can be helpful to properly align traffic entering the roundabout as well as to provide space for large vehicles to off-track. Such flush gore areas shall be called for wherever feasible. When called for, the width of a flush gore area should be five (5) feet (RIDOT preferred). If (5) feet width cannot be obtained, the minimum width shall be (4) feet. When called for, flush gore areas shall be marked with 12-inch-wide chevron markings bounded by 6-inch-wide white channelizing lines.
- The use of an extended solid lane line(s) between adjacent lanes on the approach (200 or more feet in length without discouraging necessary and/or reasonable traffic movements) shall be considered to help properly align road users and discourage “late” lane changes.

3.6 Line Extensions

MUTCD Sections 3B.01 - 3B.12

A dotted "skip line" extension of the downstream lane line shall be called for across the tapered entrances to all turn lanes and at freeway exit ramps. Dotted "skip line" and channelizing line applications for exit ramps shall be in accordance with Figure 3B-9 of the *MUTCD*.

Dotted lane, center, and edge line extensions through intersections ("cat tracks") should be called for where engineering judgment indicates that the extensions will be beneficial to help guide motorists through an intersection (e.g., between double left-turn lanes).

The widths of dotted line extensions shall be the same as the widths of the lines they extend, except where otherwise required by the *MUTCD* (e.g., where a double center line is extended through an intersection, a single line of equal width to one of the double lines shall be called for), as shown in Table 3-3.

3.7 Chevron and Diagonal Crosshatch Lines

All chevron and diagonal crosshatch lines shall be striped at a 45-degree angle from the longitudinal channelizing or edge line bounding the neutral area.

MUTCD Section 3B.25

On freeway and expressway facilities, chevron markings shall be called out for installation within exit ramp neutral gore areas to assist motorists and autonomous vehicles. On other facilities, chevron markings shall be called out for installation within gores at diverge areas, although exceptions can be made where the appearance of such chevron markings is not expected to provide clear guidance to road users (e.g., at a small gore area that is not big enough to stripe at least two chevron markings). Use of chevron and diagonal crosshatch line markings in other areas is subject to engineering judgment.

3.8 Stop and Yield Lines

Stop lines shall be installed in accordance with RIDOT *Standard Details*.

At skewed intersections, stop lines should generally be called out for installation perpendicular to abutting lane/edge lines. For this reason, staggered stop lines shall be called for where necessary at multi-lane approaches to a stop line.

MUTCD Section 3B.19

Yield line markings ("shark teeth") shall be called out for installation at all locations where a YIELD sign will be installed and shall be in accordance with RIDOT *Standard Details*. The Designer should consider installing yield line markings in advance of multi-lane crosswalks, in accordance with the MUTCD.

3.9 ONLY Word Markings

MUTCD Sections 3B.20-3B.21

The pavement marking word “ONLY” shall be used in exclusive turn lanes and where a through movement terminates and requires lane users to turn left or right at an intersection, where space allows. In instances where a turn lane is not long enough to in include both the arrow and “ONLY” marking, the “ONLY” marking shall be omitted.

3.10 Do Not Block Intersection Markings

MUTCD Figure 3B-24

The use of Do Not Block Intersection markings may be considered if an intersection is routinely blocked by vehicles resulting in excessive delay to road users.

MUTCD Section 3B.26

Where Do Not Block Intersection markings are called for, Option C of the *MUTCD* is the preferred layout. STC approval is required prior to installation.

3.11 Bicycle-Specific Markings

MUTCD Sections 9E.01 - 9E.17

Refer to the *MUTCD* and the American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* for requirements and guidelines related to pavement markings for bicyclists.

AASHTO Chapters 4.6-4.7

ITE Chapter 14

When shared lane markings (SLMs) are being considered, the Designer should review the above sources as well as the Institute of Transportation Engineers (ITE) *Traffic Control Devices Handbook* (*TCDH*), which provides examples and guidelines regarding SLM installation. The *TCDH* recommendation for installing SLMs in the center of travel lanes that are fourteen (14) feet wide or less shall be followed in areas away from intersections unless an engineering study recommends otherwise.

MUTCD Section 9E.15

MUTCD Figure 9E-16

If signal detection exists or will be installed to help detect bicyclists and other small vehicles on an approach to a traffic signal (see **Section 6.6.2**), a Bicycle Detector Pavement Marking (*MUTCD*) shall be called for installation to indicate the best location for cyclists to position themselves in order to actuate the signal. To help ensure proper placement of the Bicycle Detector Pavement Marking, notes must be included on the appropriate Plans (e.g., both Signing & Striping Plans and traffic signal plans) to stipulate that such markings shall not be installed until the detection is operational.

MUTCD Section 9E.01

MUTCD Figure 9E-1A

Where bicycle lanes exist or are proposed, bicycle lane markings shall consist of a bicycle symbol and arrow consistent with Figure 9E-1A of the MUTCD.

3.12 Colored Pavement Treatments

MUTCD Sections 3H.01 - 3H.08

Aesthetic treatments such as textured and/or colored pavement may be considered (e.g. crosswalks, bus lanes, bicycle lanes, etc.) in accordance with the *MUTCD* if requested by a municipality or other entity and upon approval from the RIDOT Office of Safety. The use of colored pavements shall be prohibited on freeways/expressways. Prior to installation of these types of treatments, a Construction and Maintenance (C&M) agreement will be required indicating maintenance will be the responsibility of the municipality or other entity.

3.13 Interstate/Route Markings

MUTCD Section 3B.22

Interstate Shield/Route Number markings shall consist of pre-formed thermoplastic material and be used in accordance with the *MUTCD*.

3.14 Speed Reduction Markings

MUTCD Section 3B.28

Designers should consider installing speed reduction pavement markings along unexpected curves to encourage drivers to slow down. These markings shall not be used on long tangent sections of roadway and shall not be used in lanes that do not have a longitudinal line (center line, edge line, or lane line) on both sides of the lane.

FHWA Table 3

The horizontal spacing between the sets of transverse stripes shall gradually decrease as they get closer to the curve. The transverse stripes should have an initial spacing of 24 feet, and gradually decrease so that the last spacing is 12 feet in length. Spacing may be adjusted based on engineering judgement.

Speed reduction markings shall be installed in accordance with the *MUTCD and* FHWAs *Low-Cost Treatments for Horizontal Curve Safety 2016*.

CHAPTER 4
SIGNS

4.1 General Design Considerations

MUTCD Section 2

When the Project scope includes any of the following, the Designer shall evaluate the condition and applicability of all existing traffic control signs within the Project limits for conformance to the *Manual on Uniform Traffic Control Devices* (*MUTCD)* and retroreflectivity requirements, and shall call for their removal and/or replacement as part of the Project where appropriate:

- sign installation, repair, and/or removal
- sidewalk improvements
- roadside earthwork and/or re-grading
- installation or removal of traffic control signals
- changes to pavement markings

When traffic control sign work is included in the Project, the Designer shall show on the appropriate Project plan(s) (e.g., the Signing & Striping Plans, or if none, then the General Plans), a graphic showing the legend of both existing (in gray scale) and proposed (in dark line) traffic control signs. Such graphics shall only show what the road user sees and shall not show details regarding type, spacing, and/or sizes of font, borders, etc. The graphics may be shown:

- adjacent to the actual sign locations,
- using standard Rhode Island Department of Transportation (RIDOT) callouts for sign work, or
- as a summary table that shows all sign legends.

Traffic control signs that are damaged or do not appear to meet retroreflectivity requirements shall be replaced.

Any non-standard signs developed by the Designer to address specific Project conditions shall be depicted graphically on the Project plans in the same manner as standard signs. A Sign Detail for the sign(s) shall be included in the Project plans. The Detail shall contain sufficient information to allow the Contractor to fabricate the sign correctly.

Extruded aluminum panels used as a substrate for large signs are available in height increments of six inches. For this reason, the overall height dimension of proposed signs that are expected to be constructed using such aluminum panels shall be rounded to the next 6-inch increment accordingly.

4.2 Sign Placement and Mounting

MUTCD Sections 2A.01- 2N.09

Proposed traffic control sign placement and mountings shall be in accordance with the *MUTCD*. Although two feet is generally the minimum lateral offset allowed between the edge of a sign and the face of curb, the *MUTCD* does allow for a one-foot lateral offset in urban areas where sidewalk width is limited or where existing poles are close to curbs. *Public Right-of-Way Accessibility Guidelines (PROWAG)*-compliant horizontal and vertical clearances around and beneath proposed sign edges and posts shall be provided in all pedestrian areas. Refer to **Section 6.9.1.3** for requirements and guidelines regarding pedestrian access routes, which the Designer shall consider and comply with when calling for signs.

MUTCD Sections 2A.13- 2A.16

Ground-mounted traffic control sign installations that require only a single post for structural rigidity but that include a street name sign panel that is up to 12 square feet shall be called out to be mounted on a square-tube post. All other ground-mounted traffic control signs (including parking signs) that do not require post foundations shall be called out to be mounted on u-channel post mountings unless otherwise directed by the RIDOT Office of Safety. More than one u-channel post shall be called for wherever street name sign panels are larger than 12 square feet and wherever else required for conformance to RIDOT *Standard Details*. Refer to RIDOT *Standard Details* for the various sign mountings.

Reflective strips may be installed on existing and new sign posts to increase sign visibility in accordance with Table 4-1. These strips shall not interfere with the breakaway features of the sign support.

Table 4-1. Guidance for Installing Reflective Strips on Sign Posts

Sign Designation	Reflective Color
R1-1 (STOP)	Red
R1-2 (Yield)	Red
R5-1 Series (Do Not Enter, Wrong Way)	Red
School Zone Signs (S1, S3 and S4)	Fluorescent Yellow-Green
W11-2 (Pedestrian)	Yellow/Fluorescent Yellow-Green

AASHTO Sections 2 & 10

Refer to the RIDOT *Bridge Design Manual* (BDM) and American Association of State Highway and Transportation Officials (AASHTO) *LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals* for structural design requirements and guidelines regarding the mounting of traffic signs on posts with foundations and within frames on vehicular bridges.

4.3 Pedestrian Signs

MUTCD Sections 2B.19 - 2B.20

If the *MUTCD* R1-5-, R1-6- or R1-9-series signs are in place or proposed for an unsignalized pedestrian crosswalk, the Designer shall ensure such sign legends are consistent with actual state laws (Rhode Island (RI) General Law §31-18-3 requires drivers to yield to, and not necessarily stop for, pedestrians).

4.4 Signs in School Areas

MUTCD Sections 7B.01 - 7B.07

All warning signs and plaques proposed for school facilities and within designated school zones (e.g., within the area marked by signs establishing a school zone, or if no such signs exist within 300 feet of a school's grounds) shall have a fluorescent yellow-green background with black legend and border for conformance to the *MUTCD*. Use of the fluorescent yellow-green background color outside of school zones shall not be called for unless otherwise required by the *MUTCD* (e.g., for school bus stop ahead signs).

The State Traffic Commission (STC) must approve all school speed limit signs and may approve of sign assemblies with flashing beacons. The operations and maintenance of such assemblies will be assigned to the local school and/or municipality. The Designer shall ensure local officials are aware of and open to this before proposing them on Plans. The design shall not include a flashing beacon assembly without a Construction and Maintenance (C&M) agreement.

When a school speed limit sign assembly is proposed without flashing beacons and without a "WHEN FLASHING" plaque, the assembly shall stipulate both the times and days when the school speed limit is in effect (e.g., call for the *MUTCD* Sign Designation S4-1P and S4-6P plaques beneath the S4-3P plaque and R2-1 sign), unless officials from the associated school and/or municipality request otherwise.

ITE TCDH Chapter 12

For additional guidance regarding the design of school speed limits in school zones, refer to the Institute of Traffic Engineers (ITE) *Traffic Control Devices Handbook*, 2nd Edition.

4.5 Street Name Signs

MUTCD Table 2D-3

MUTCD Sections 2D.45 - 2D.46

All proposed street name signs shall call for a combination of lower-case letters with initial upper-case letters for conformance to the *MUTCD*. The words Street, Boulevard, Avenue, etc., may be abbreviated to conserve sign panel length. Refer to the *MUTCD* for acceptable abbreviations.

Mast arm mounted street name signs shall be called for at all signalized intersections and shown on Signing and Striping Plans as well as Signal Plans. The overhead street name sign shall be mounted on the far-side mast arms oriented at 90 degrees to the approach between the signal heads and the mast arm pole. This configuration provides for the most visible organization and layout of signal heads and for overhead street signs. Designers proposing alternate structure layouts must consider the placement of overhead street signs in their design decisions.

MUTCD Table 2D-6

Lettering heights for overhead-mounted street name signs should conform to the *MUTCD*, although exceptions for smaller heights may be allowed if the Designer shows RIDOT that space constraints are an issue and/or smaller heights would be consistent with other mast arm mounted street name signs in the area.

Lettering heights for ground-mounted street name signs along roadways with more than one lane of traffic moving in the same direction should conform to the *MUTCD*. However, smaller lettering heights may be allowed where such lettering heights would cause the sign panel size to result in an infeasible mounting.

When a cross street has a different name on each side of the intersection, both names shall be shown on the overhead street name sign. Two signs shall be used with one on the left and one on the right side of the intersection.

Sign panels shall be printed on both sides where feasible to provide a sign display on both the right and left side of each intersection approach.

All street name signs shall call for a green background with white lettering and border unless a deviation is requested by the local municipality. Although the final decision regarding street name sign design will be made by RIDOT, design-stage coordination with the local municipality will be needed if any deviation from the above design criteria is desired (e.g., when a municipality desires to use pictographs and/or different colors).

4.6 Speed Limit-Related Signs

MUTCD Section 2B.21

Speed limit signs (*MUTCD* Sign Designation R2-1) showing the appropriate speed shall be called for at each of the following locations:

- After all major roadway junctions
- Where the legal speed limit changes
- at entrances to a state and, where appropriate, at jurisdictional boundaries in urban areas
- Where required by the *MUTCD*
- at periodic intervals to remind road users of the speed limit
- At other locations where engineering judgment indicates that the sign is or will be warranted

Where the limit itself is not changing, speed limit signs should be placed beyond the area of influence of an intersection/interchange - rule of thumb is 300 ft downstream of an intersection or end of entrance ramp.

Typical spacing requirements for repeating speed limit signs along a roadway are as follows:

Rural Roadways:

- High speed (≥ 55 mph) - approximately every 10 miles
- Intermediate speed (45-50 mph) - approximately every 2 miles
- Low speed (≤ 40 mph) - approximately every 1 mile

Urban Arterials:

- High speed (≥ 50 mph) - maximum spacing approximately 1 mile
- Intermediate speed (40-45 mph) - maximum spacing approximately 1/2 mile
- Low speed (≤ 35 mph) - maximum spacing approximately 1/4 mile

"REDUCED SPEED LIMIT AHEAD" signs (*MUTCD* Sign Designation W3-5) showing the appropriate speed shall be installed in accordance with the *MUTCD*.

4.7 Do Not Block Intersection Signs

A “DO NOT BLOCK INTERSECTION” sign (*MUTCD* Sign Designation R10-7) shall be called for when Do Not Block Intersection markings are used.

4.8 Signs for Traffic Signals

MUTCD Section 2B.59

A "LEFT TURN YIELD ON GREEN" (symbolic circular green) sign (*MUTCD* Sign Designation R10-12) or "LEFT TURN YIELD ON FLASHING YELLOW ARROW" (*MUTCD* Sign Designation R10-12a) shall be called for adjacent to the left-most traffic control signal head where there is an opposing vehicular movement and either:

- The signal operates with a protected/permissive mode left-turn movement, or
- The signal operates with a permissive only mode left-turn movement and a dedicated (separate) lane is provided for the left-turn movement.

MUTCD Section 2B.58

A *MUTCD*-compliant educational sign shall be called for installation at all pedestrian pushbutton locations to clearly show the direction of the crossing associated with the button as well as the meaning of the pedestrian signal displays. The R10-3b – R10-3i signs shown in the *MUTCD* are preferred by RIDOT at locations where countdown pedestrian signals are provided.

MUTCD Section 2B.59

At Pedestrian Hybrid Beacons (PHBs), in an effort to help clarify the intended meaning of such signals to road users, "STOP ON STEADY RED – YIELD ON FLASHING RED AFTER STOP" (*MUTCD* Sign Designation R10-23a) signs shall be called for. Where such R10-23a signs will be installed, a "STOP HERE ON RED" sign(s) (*MUTCD* Sign Designation R10-6) shall be considered for installation at approach stop lines if improper motorist stopping is observed or expected to be an issue.

MUTCD Section 2B.60

"NO TURN ON RED" restriction signs (*MUTCD* R10-11 Series) shall be installed (mounted overhead when possible) when at least one of the following conditions exist:

- In locations that meet the criteria listed in the *MUTCD*
- Locations with exclusive pedestrian phases, including Leading Pedestrian Intervals (LPIs)
- At intersections near significant pedestrian generating facilities (e.g., schools, parks, recreational areas, hospitals)

All "NO TURN ON RED" restrictions need written approval from the STC.

4.9 Signs for Roundabouts

Along with the geometric and pavement marking design at roundabouts, signs are important for guiding road users safely and efficiently through the intersection, especially at multi-lane roundabouts. The stipulations of this section exceed the minimum recommendations of the *MUTCD*. Designers need to meet these stipulations within the various constraints of each Project. See **Section 3.5** – Markings for Roundabouts for details regarding early-stage outreach to the RIDOT Office of Safety that the Designer is encouraged to complete for each roundabout design. With consideration of feedback received, the Designer shall finalize a design of signs on each multi-lane roundabout approach that is expected to both minimize erratic or "last-minute" swerving or lane changes (both within the roundabout and on the approach) and limit "information overload" caused by extraneous sign information. Space limitations in urban and other areas can make it challenging to achieve both of these ideals, so the Designer should carefully consider all feasible options before finalizing their design. The guidance below is intended to assist the Designer in this effort.

MUTCD Section 2B.51

4.9.1 Regulatory Signs for Roundabouts

MUTCD Sections 2B.05 & 2B.18

A "YIELD" (*MUTCD* Sign Designation R1-2) sign shall be called for installation on both sides of each approach to every roundabout. The "YIELD" sign on the left side may be omitted where there is no curbed area within which to install it.

If additional emphasis is deemed appropriate to clarify operations or to improve performance at a roundabout, the Designer should consider the following sign treatments where feasible:

- Increased size of "YIELD" signs
- Installation of a *MUTCD*-compliant retroreflective strip on "YIELD" sign post(s)
- Installation of a "TO All LANES" plaque (MUTCD Sign Designation R1-2c) beneath the "YIELD" sign, if entering traffic must yield to traffic in two circulatory lanes

MUTCD Section 2B.51

- Installation of ROUNDABOUT CIRCULATION (*MUTCD* Sign Designation R6-5p) plaques placed below the "YIELD" signs on each approach.

MUTCD Section 2B.49

- Installation of "ONE WAY" (*MUTCD* Sign Designation R6-1) signs. If used, signs shall have 4 feet of vertical clearance above the ground unless other center island features exist that would require a higher vertical sign clearance (e.g. plantings/vegetation obstructions).

MUTCD Section 2B.28

Unless otherwise approved or directed by RIDOT, one or more intersection lane control signs that use "fish-hook" arrows (including a center dot symbol for the left-most lane) shall be called for installation on each multi-lane approach to a roundabout. Larger sized lane control signs than required by the *MUTCD* shall be used unless justification is provided to use standard sign dimensions.

Where a separate destination guide sign(s) is or will be in place (see **Section 4.9.3** below), only one such intersection lane control sign or sign assembly per approach may be sufficient given the pavement markings to be called for per **Section 3.5** – Markings for Roundabouts. However multiple intersection lane control signs may be warranted where a diagrammatic guide sign(s) is not feasible. RIDOT's Apponaug roundabout Project used special oversized advance intersection lane control signs, augmented with left, center, right, and/or bypass lane text along the bottom of the signs, to help motorists understand which lane they should use.

Figure 4-1. Advanced Roundabout Lane Control Signs (Apponaug)

4.9.2 Warning Signs for Roundabouts

MUTCD Section 2C.55

MUTCD Section 2C.54

MUTCD Section 2C.63

On single-lane approaches to roundabouts, a PEDESTRIAN graphic (*MUTCD* Sign Designation W11-2) or combined BICYCLE/PEDESTRIAN graphic (*MUTCD* Sign Designation W11-15), if appropriate) warning sign with downward diagonal arrow (*MUTCD* Sign Designation W16-7p plaque) shall be considered only on the right side of the approach at each crosswalk that is marked, but exceptions can be made (e.g., smaller roundabouts may not warrant any such warning signs at all, but a duplicate sign assembly installed on the left side as well as the right may be appropriate if a sufficient-width curbed island exists).

On multi-lane approaches to roundabouts, a *MUTCD* Sign Designation W11-2 or W11-15 warning sign with W16-7P plaque shall be called for on each side of the approach at each marked crosswalk. Unless crash performance or engineering judgment suggest advanced W11-2 and/or W11-15 warning signs are needed, they shall not be called for.

Uncontrolled marked crosswalks across roundabout departure lanes warrant at least one W11-2 or W11-15 warning sign with W16-7P plaque, on the right side of the lane. Unless otherwise approved by RIDOT, roundabout exits with multiple departure lanes intersecting a marked crosswalk shall call for a W11-2 or W11-15 warning sign assembly on both the left and right sides.

MUTCD Section 2C.41

MUTCD Section 2C.59

A CIRCULAR INTERSECTION warning sign (*MUTCD* Sign Designation W2-6) with an ADVISORY SPEED PLAQUE (*MUTCD* Sign Designation W13-1P) beneath (indicating the advisory speed for the roundabout) shall be installed as the first roundabout-related sign on each approach to the intersection, to ensure conformance with the *MUTCD*. However, such W2-6 signs and plaques shall not be called for if:

- a diagrammatic destination guide sign is or will be installed on the approach,
- the actual or anticipated operating or 85th percentile speed on the approach is 40 MPH or less, and/or
- another roundabout already exists along the corridor, unless limited sight distance or other safety issues that would warrant the placement of the warning sign are determined to exist at the site based on engineering judgment.

4.9.3 Guide Signs for Roundabouts

MUTCD Sections 2D.39-2D.43

Wherever a numbered route intersects a roundabout, the use of numbered route signs (shields) and associated auxiliary signs shall receive primary consideration for prominent display on appropriate guide signs (whether diagrammatic or not); destinations and/or street names shall also be considered per the *MUTCD* but should never take precedence over numbered route signs unless a special case exists.

4.9.3.1 Guide Signs on Roundabout Approaches

MUTCD Figure 2D-12

On single-lane approaches to single-lane roundabouts, see Table 2D-1 of the *MUTCD* for examples of acceptable guide sign designs, noting that Figure 2D-12 of the *MUTCD* is preferred, and the "fish-hook" arrow options shall be called for. Where numbered routes are not involved in such cases, street names may be displayed on the D1-2d sign instead of the town destinations as shown in Figure 2D-12.

On multi-lane approaches to multi-lane roundabouts, wherever space permits, one or more diagrammatic destination guide signs shall be called for, as these can be the best signs to help road users intuitively understand how they will need to move through the roundabout to get to their desired destination. Because such guide signs can be very large if designed for best conformance to the *MUTCD*, RIDOT will consider exceptions to *MUTCD*-stipulated minimum spacing and/or legend sizes if the Designer shows that there is a need for such exceptions to fit a given space and that the sign legend will still be clear. Diagrammatic destination guide signs shall be installed on both sides of the roadway approach to the roundabout (if feasible).

Figure 4-2. Destination Roundabout Guide Sign (Apponaug)

Wherever diagrammatic guide sign(s) are not feasible or warranted, one or more CIRCULAR INTERSECTION DESTINATION signs (MUTCD Sign Designation D1-2d and/or D1-3d, with curved stem arrows where appropriate) shall be called for on the approach.

Careful consideration shall be given in designing and locating directional guide signs on multi-lane approaches to multi-lane roundabouts to ensure that such signs will appropriately complement the regulatory signing (e.g., R3-8-series signs) and pavement markings that will be installed, as motorists unfamiliar with the area will need both types of information to know which lane they should be in.

4.9.3.2 Guide Signs for Roundabout Exits

MUTCD Section 2D.32

With possible exception of roundabouts that are very small (e.g., inscribed circle diameter of 80 feet or less) and have very low vehicular demands, the RIDOT Office of Safety prefers to call for either a directional assembly (where a numbered route is involved – refer to the *MUTCD*) or an exit destination sign (e.g., *MUTCD* Sign Designation D1-1d or D1-1e) inside the splitter island at each exiting leg of the roundabout. Exit destination signs are usually warranted and feasible at most roundabouts, but the Designer should not overlook the wayfinding and target value that a simple (and oversized, wherever feasible and warranted) directional assembly can provide to motorists. In all cases, and for consistency with the first paragraph of **Section 4.9.3**, wherever a numbered route intersects with the roundabout, a guide sign in a splitter island for exiting road users shall prominently display at least the appropriate cardinal direction(s), route shield(s), and upward canted arrow.

4.9.4 Order of Signs on Approaches to Roundabouts

MUTCD Sections 2D.39-2D.43

The spacing and positioning of all signs on the approach to roundabouts shall be in conformance with the *MUTCD.* The Designer shall design multi-lane approaches to roundabouts such that ample space is provided for road users to safely change lanes if necessary once they see the first intersection lane control sign(s) and/or pavement markings. On most arterial roadway approaches, the first R3-8 sign may need to be installed 300 feet or more upstream of the intersection, as long as space permits.

4.10 Signs for Overhead Bridges

4.10.1 Low Clearance Signs

The Designer shall reference the RIDOT *Bridge Design Manual* for the type, location, and placement of minimum vertical clearance signs.

4.10.2 Bridge Identification Signs

RIDOT BDM Chapter 2

Refer to the RIDOT *Bridge Design Manual* for additional information regarding unique Bridge Identification guide signs (as shown in Figure 4-3) that shall be mounted on all bridges that pass over a roadway or shared-use path. White and black identification signs will no longer be accepted by RIDOT.

Figure 4-3. Bridge Identification Guide Sign

4.11 Bicycle-Specific Signs

MUTCD Section 9B.20

Wherever pavement markings are or will be installed to help cyclists position themselves on an approach to a traffic signal with bicycle detection (see **Section 3.11**), a "BICYCLE DETECTOR" (*MUTCD* Sign Designation R10-22) sign shall be called for installation to supplement the markings. When used, the "BICYCLE DETECTOR" sign shall be installed on the right side of the approach near the bicycle detection pavement marking. The "BICYCLE DETECTOR" sign may be installed on the left side of the approach only if there are no vehicular lanes to the left of the bicycle lane.

4.12 Specific Service Signs and Logos

Requirements, guidelines, and other information about RIDOT's Specific Service Logo Sign program[12] is available on the RIDOT website.

[12] http://www.dot.ri.gov/documents/doingbusiness/permits/RIDOT_Logo_Brochure.pdf

4.13 Traffic-Related Signs Specific to Rhode Island

Below are design guidance and details for select signs that are used throughout the State but are not included in the Federal Highway Administration (FHWA) *Standard Highway Signs and Markings* publication.

Designers shall refer to the RIDOT *Standard Details* for specific dimensions and other design details for the signs described below.

4.13.1 State Route Signs

MUTCD Sections 2D.09 - 2D.11

The official "State Route" sign design for Rhode Island is *MUTCD* Sign Designation M1-5 (RI). Signs shall be called for wherever necessary for best conformance to the *MUTCD*.

4.13.2 Signs for Shared-Use Paths

MUTCD Section 9B.13

For consistency with RI General Laws, a "WALK ON LEFT FACING BICYCLISTS" (Sign Designation R9-7a (RI)) sign shall be used in place of the "SHARED-USE PATH RESTRICTION" (*MUTCD* Sign Designation R9-7 sign). These R9-7a (RI) signs shall be placed within 100 feet of each shared-use path entrance, and at a reasonable recurring interval along the path to remind users of the law.

A special educational and symbolic version of the R9-7a (RI) sign, shown in Figure 4-4, has been used at some locations in the State. Such signs do not conform to the *MUTCD* but do include a symbolic illustration showing the intended traffic alignments on the shared-use path. The use of such signs on Projects may be considered if the path owner requests their use and approval is obtained from the RIDOT Office of Safety. Refer to the RIDOT *Standard Details.*

Figure 4-4. Special Educational Version of Walk on Left Facing Bicyclists Sign

4.13.3 Selective Exclusion Signs

A R5-10 (RI) "NO PEDESTRIANS BICYCLES NON-MOTORIZED TRAFFIC" sign shall be called for at all entrances to limited access facilities for conformance with Rhode Island (RI) General Law §31-15-15 and wherever else the STC may require.

MUTCD Section 2B.45

Where heavy vehicles are excluded from certain lanes on a limited access facility by the STC, a "NO TRUCKS/LEFT LANE" (*RI* sign designation R4-5a (RI) sign shall be called for in conformance with RI General Law §31-27-6. The Designer should consider utilizing a "NO TRUCKS/LEFT TWO LANES" (*RI* sign designation R4-5b (RI) where appropriate.

These signs are included in the RIDOT *Standard Details*.

4.13.4 Bus Stop Signs

Refer to the latest *Rhode Island Bus Stop Design Guide*[13] for guidance and details.

The Designer shall coordinate with the Rhode Island Public Transit Authority (RIPTA) regarding existing and/or proposed signs related to bus stops.

[13] https://www.ripta.com/wp-content/uploads/2024/06/RIPTA-Bus-Stop-Design-Guide_FINAL_240528.pdf

4.14 Mile Marker Reference Location Signs

MUTCD Section 2H.11

Mile marker reference location signs shall be installed on expressway/freeways and/or State numbered routes shall include even numbered integer distances (*MUTCD* Sign Designation D10-2a)

MUTCD Section 2H.12

For whole mile marker locations, the sign shall include the route emblem in accordance with the *MUTCD*.

4.15 Delineators for Guardrail

Red delineators shall be installed at the start of guardrail and green shall be used at the end of guardrail. These delineators shall be installed in accordance with the RIDOT Standard Details.

CHAPTER 5
TEMPORARY TRAFFIC CONTROL

The design of all Projects shall be completed in conjunction with a systematic consideration of the safety and mobility impacts of Work Zones on Rhode Island's highways. To the greatest extent practicable, Projects shall be designed with a goal of minimizing the amount and severity of both traffic crashes occurring within and traffic congestion resulting from the Project's Work Zones.

5.1 General Design Considerations

MUTCD Sections 6A.01 - 6P.01

All Temporary Traffic Control (TTC) measures shall be planned and designed in accordance with the *Manual on Uniform Traffic Control Devices* (*MUTCD)* and latest accessibility requirements (e.g. *Public Right-of-Way Accessibility Guidelines (PROWAG*)). The needs and control of all motorists and vulnerable road users (VRU) (e.g., bicyclists, pedestrians-including persons with disabilities, and transit users) through work zones shall be considered during the planning and design of all Projects. Refer to Part 6 of the *MUTCD* as well as **Section 5.6.6** of this Manual for requirements and guidelines regarding Temporary Pedestrian Access Routes (TPARs) in work zones.

Both permanent (e.g., roadway geometric) and temporary (e.g., material and equipment staging) physical site conditions that may affect the visibility of road users as they approach and pass through or around work zones should be considered during the design process (e.g., how sight distance may affect motorist reaction to or compliance with TTC setups).

RIDOT DPM 450.05

RIDOT's *Design Policy Memorandum (DPM) – Work Zone Safety and Mobility* describes work zone safety- and mobility-related requirements and guidelines to be considered during each stage of the design process for all Rhode Island Department of Transportation (RIDOT) - owned and/or -managed construction Projects, including stipulations for TMP preparation and submission.

5.1.1 Work Duration

Duration of work is defined as the length of time that temporary traffic control setups for the Project will typically be in place.

MUTCD Section 6N.01

The categories and descriptions of "Work Durations" presented in the *MUTCD* are accepted by RIDOT for use when designing Temporary Traffic Control Plans (TTCPs) and devices, with the below clarifications:

- The word “intermittently” in the MUTCD description for the “Mobile” category of work shall be assumed to mean “with the workspace being relocated at least once every fifteen (15) minutes”.
- Short Term = less than or equal to one day
- Intermediate Term = greater than one day but no greater than one week
- Long Term = greater than or equal to one week but no greater than one year
- Very Long Term = greater than or equal to one year

5.2 Travel Lane, Shoulder, and Sidewalk Closure Restrictions

When feasible, the existing number of travel lanes, shoulders, sidewalks, and other traffic paths should be maintained through a work zone.

Lane shifts should be considered in work areas where a travel lane(s) must temporarily be closed and paved surfaces suitable for carrying the shifted traffic are available.

Restricting when and where travel lanes, shoulders, and other traffic paths may be closed to traffic can help to mitigate the adverse impacts of Projects on traveler safety and mobility.

5.2.1 Transportation Management Plans

When work is to be performed within the state highway right-of-way, preparation of a Transportation Management Plan (TMP) will be required to manage the work zone impacts of the Project during the work, regardless of the level of impact anticipated to be caused by the Project's Work Zones. All TMPs include general Project information, a listing of the TTCPs to be used to facilitate traffic flow and safety through the Project's Work Zones, any traffic-related work restrictions, and any other Transportation Management Strategies to be used to maintain or improve road user/worker safety and/or minimize road user congestion and delays during the work.

TMPs (including detour routes) may also be required for TTC Permits[14] for non-RIDOT Projects (parades, road races, etc.).

It is the responsibility of the Designer to obtain the appropriate TMP Template from the Department and to develop and complete the TMP as the Project design progresses. Guidance for completing TMPs is presented below and is provided in comment form on the TMP Templates. TTCPs must either be attached to the TMP or, when included in the Project construction plan set, incorporated by reference.

The minimum number of travel lanes, shoulders, sidewalks, and other traffic pathways that shall remain open to traffic on specific days/times shall be clearly identified in the TMP for all RIDOT construction Projects, Physical Alteration Permits (PAPs) (where applicable), Utility Permits and TTC Permits. The presentation and arrangement of such information shall be consistent with the tabular formats shown in the example *Traffic-Related Work Restrictions - General*

[14] Parade/Event Permit:
https://www.dot.ri.gov/documents/travel/Parade_Race_permit_application.pdf

Restrictions and *Holiday Restrictions* tables on the RIDOT website unless the RIDOT Project Manager or Traffic Engineer requests or requires otherwise. Such *Restrictions* tables (including all backup necessary to support lane closures, detours, etc.) shall be included as an attachment to the TMP. Editable Microsoft® Excel® versions of the *General Restrictions* tables are available for download on the RIDOT website[15]

Work zone lane restrictions shown in Tables 5-1 and 5-2 shall be followed. Where traffic volume data is available, different site-specific travel lane and shoulder closures will be allowed if one or more of the following conditions are met:

- Freeways/Expressways ONLY: The traffic demand during the restriction falls below the appropriate threshold capacity shown in Table 5-3.
- A traffic analysis demonstrates that unacceptable congestion and delays will not occur (less than 15-minute delays).

Table 5-1. Default General Travel Lane and Shoulder Closure Restrictions

FACILITY TYPE	DEFAULT RESTRICTIONS
Freeways/Expressways	No lane closures allowed between 6:00 AM and 9:00 PM on any day of the week
	No shoulder closures allowed between 6:00 AM and 9:00 AM and/or between 3:00 PM and 6:00 PM, Monday through Friday
	No lane and/or shoulder closures allowed on Friday and/or Saturday nights, between 6:00 PM and 6:00 AM the next morning
Non-Freeways/Expressways with Average Daily Traffic (ADT) ≥5,000	No lane closures allowed between 6:00 AM and 9:00 AM on any day of the week and/or between 3:00 PM and 6:00 PM, Monday through Friday
	No lane and/or shoulder closures allowed on Friday and/or Saturday nights, between 6:00 PM and 6:00 AM the next morning
All Other Roadways and Facilities	Restrictions to be determined on a case-by-case basis

[15] Available online at: https://www.dot.ri.gov/business/contractorsandconsultants.php

Table 5-2. Default Holiday Travel Lane and Shoulder Closure Restrictions

HOLIDAY	DEFAULT RESTRICTIONS
General	No lane and/or shoulder closures allowed after 1:00 PM on the Friday preceding a holiday weekend
Easter Sunday	No lane and/or shoulder closures allowed on Saturday and/or Sunday
New Year's Day, Juneteenth National Freedom Day, Independence Day, Veterans Day, and Christmas Day	No lane and/or shoulder closures allowed after 1:00 PM on the day before the holiday
	No lane and/or shoulder closures allowed on the holiday
Dr. Martin Luther King Day, Presidents Day, Memorial Day, Victory Day, Labor Day, and Columbus Day	No lane and/or shoulder closures allowed on Saturday, Sunday, and/or Monday
Thanksgiving Day	No lane and/or shoulder closures allowed after 1:00 PM on the Wednesday preceding Thanksgiving Day
	No lane and/or shoulder closures allowed on Thanksgiving Day and/or on Friday, Saturday, and/or Sunday following the holiday

Table 5-3. Freeway and Expressway Work Zone Capacities

NCHRP 475
Table 3-1

Number of Travel Lanes in One Direction		Threshold Capacity, subject to Note below (vehicles/hour/lane)
Open Prior to Work	Open During Work	
5	2	1,370
4	3	1,520
	2	1,480
3	2	1,490
	1	1,170
2	1	1,340

Note: If empirical data collected (or a traffic study completed) locally shows a different capacity is applicable for the lane closure condition being considered, such different capacity value may be used as the threshold if approved in advance by the RIDOT Office of Safety.

5.2.2 Bus Stop Accommodations

In areas where RIPTA has a bus stop that will be unavailable during construction, the bus stop should be identified on the TMP. Accommodations for a temporary stop that can be safely accessed may be required and coordinated with RIPTA.

Where road restrictions may impact bus service by requiring temporary detours, this will be noted. Road closures will be communicated to RIPTA in advance to allow for detour planning and communications.

5.2.3 Pedestrian/Bicyclist Accommodations

On existing facilities that are open to pedestrian travel, at least one TPAR shall remain open to pedestrians at all times during the work unless otherwise permitted by the RIDOT Office of Safety.

If existing bicycle accommodations are provided on the roadway, the Designer should strive to maintain this accommodation through the work zone. When it is not possible to maintain bicycle accommodations, the following should be considered:

MUTCD Sections 2C.54 and 2C.67

- In work areas where motor vehicle speeds are in the range of 25 to 30 Miles per Hour (MPH), bicycles can use the same route as the motor vehicles. Bicycle Warning signs *(MUTCD* sign designation W11-1) and “IN ROAD” or “IN STREET” *(MUTCD* sign designations W16-1P or W16-1aP) plaques should be used to alert motorists to the presence of bicycles.
- On higher speed facilities, the designer should attempt to reduce motor vehicle speeds so that they are compatible with shared-lane operations. Reducing the vehicle speeds also improves the safety for pedestrians and crews within the work zone.

5.3 Use of Channelizing Devices

Channelizing devices (e.g., traffic cones, drums, barricades, pedestrian route devices, etc.) are used to define the intended travel path and guide road users through the work zone. Drums shall be called for whenever channelizing devices are needed to supplement Type III barricades used for road closures. Because of their improved visibility to road users, the use of drums instead of cones should also be considered at other work locations where enhanced positive guidance is deemed to be warranted, although the increased exposure of workers to traffic hazards due to drum placement and pick-up should be considered.

Use of RIDOT standard cones should be called for when a TTC set-up is utilized only during working hours and is subsequently broken down at the end of the work shift or day.

MUTCD Sections 6K.01 - 6K.02

Pedestrian channelization devices/protective barriers shall be installed in accordance with the *MUTCD*. These devices should be continuous and constructed of rigid materials in order to be discerned by pedestrians with vision impairments. The use of "caution" tape or other measures is not acceptable for defining a pedestrian route since these materials are easily broken and do not adequately direct pedestrians into the temporary pathway. Scaffolding and other construction fencing should not have objects that protrude into the clear head space for pedestrians.

Temporary work on sidewalks also needs to be barricaded. At fixed work sites of long term or very-long term durations, especially in urban areas with high pedestrian volumes, fences may be needed to prevent pedestrian access into the construction site. Where used, fences should be 8 (eight) feet high. If chain link fencing is used around an existing sidewalk, signs indicating "Sidewalk Closed/Detour" should be placed at eye height to increase visibility of the fence. Covered walkways and other barriers must be designed to provide sufficient sight distance at intersections and crosswalks for pedestrians, bicyclists, and motorists.

It may be necessary to use a longitudinal traffic barrier to separate pedestrians from vehicular traffic. The barrier must be of sufficient strength to avoid intrusion by an impacting vehicle and should meet the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware (MASH)* test level requirements as described in **Section 5.5**. For work adjacent to high-speed traffic, continuous temporary, pre-cast concrete or steel barriers are recommended. Wooden railings, chain link fences, and other similar systems are not suitable for use in this situation.

5.4 Use of Law Enforcement Officers and Flagpersons

RIDOT Standard Spec. Sections 913 and 914

Requirements and recommendations regarding the use of Law Enforcement Officers (with or without marked cruisers) and Flagpersons on RIDOT construction Projects shall be considered in accordance with the RIDOT *Standard Specifications for Road and Bridge Construction*.

The primary function of Law Enforcement Officers (with or without marked cruisers) and Flagpersons is to provide direction and control to road users through and/or around work areas while protecting on-site workers and equipment.

5.5 Use of Positive Protection Devices

AASHTO Section 2.2

Positive protection devices (portable precast concrete, temporary concrete or steel barrier, crash attenuators, etc.) can be used to contain and/or redirect errant vehicles in work zones, including in work zone situations that place workers at increased risk from motorized traffic, and where positive protection devices offer the highest potential for increased safety for workers and road users. Example situations include:

- Work zones that provide workers no means of escape from traffic (e.g., bridges)
- Long duration Projects (e.g., greater than one week) resulting in substantial worker exposure to motorized traffic
- Projects with high anticipated operating speeds (e.g., 45 miles per hour or greater), especially when combined with high traffic volumes
- Work operations that place workers close to travel lanes that are open to traffic
- Roadside hazards (e.g., drop-offs) that will remain in place overnight or longer

All positive protection devices shall be deemed crashworthy by Federal Highway Administration (FHWA) and shall meet the AASHTO *MASH* testing requirements. A list of positive protection devices and systems that have been tested for crashworthiness and deemed eligible by the FHWA is available at the FHWA Safety website[16]. Table 5-4 below summarizes the minimum MASH test level requirements for all temporary barrier and crash cushions.

Table 5-4. Minimum *MASH* Test Level Requirements

Roadway	Temporary Barrier Minimum Test Level	Crash Cushion Minimum Test Level
I-95, 195 and 295	TL-4	TL -3
US Route 1* and 6**	TL-4	
RI Route 4, 10, 24, 37, 78, 99, 138***, 146 and 403	TL-4	
Airport Connector	TL-4	
All other roadways	TL-3	

* Route 1 between Route 78 and Route 4
** Route 6 between I-295 and Route 10
*** Route 138 between Route 1 and Admiral Kalbfus Road

[16] http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/index.cfm

MUTCD Section 6M.02

The Designer shall determine whether the use of positive protection devices is warranted, based on a consideration of the standards and guidance contained in this manual, the AASHTO *Roadside Design Guide* and the *MUTCD*, as well as the specific Project characteristics and conditions.

AASHTO 9.2.1

When designing facilities that may involve large concentrations of pedestrians, the Designer shall strongly consider positive protection and/or vehicle deterrents.

A truck mounted attenuator may be used in a work zone without completing an engineering study. A truck mounted attenuator should be considered upstream of work operations requiring a shoulder and/or lane closure if any of the following conditions exist:

- Workers must be positioned in the closed shoulder and/or lane(s)
- The posted or 85th percentile speed of traffic is 40 MPH or greater
- Temporary barrier is not or will not be in place to provide workers with positive protection

MUTCD Section 6M.05

Refer to the *MUTCD* for additional guidance regarding truck- mounted attenuators.

RIDOT Standard Spec. Section T.18

Where temporary barrier is provided adjacent to an open travel lane with no shoulder/offset at locations with a posted or 85th percentile speed of traffic of 40 MPH or greater, the Designer should consider supplemental reflective delineators in addition to those already required by the RIDOT *Standard Specifications for Road and Bridge Construction*. A job specific specification may be needed.

5.6 Temporary Traffic Control Plan Considerations

5.6.1 General Considerations and RIDOT Plans

In a work zone, the width of all travel lanes should be eleven (11) feet or greater. The width of travel lanes in a work zone shall not be less than ten (10) feet.

All full closures, splits or shifts shall not remain in place over winter shutdown unless approved by the RIDOT Office of Safety. Work zones that remain in place over winter shutdown shall maintain a minimum width of 16 feet (including shoulder) to allow for plowing operations.

Notes describing the set-up, sequence, and/or staging of TTC should be included on TTCPs where such operations are complex and critical to the safety and/or mobility of the work zone (e.g., Projects with temporary roadways and traffic control signals). Temporary traffic regulations such as reduced speed limits, parking restrictions and other considerations such as temporary staging or emergency access should also be supplemented with notes if these strategies are called for on the Project plans.

Temporary traffic regulations shall be approved by the State Traffic Commission (STC) in accordance with **Section 1.5** of this Manual.

A set of RIDOT Typical TTCPs are available from the RIDOT Project Management Portal[17] (DPM 450.05). Designers should use one or more of these RIDOT Typical TTCPs wherever they are applicable to Project work and will be cost-effective for RIDOT.

A set of TTCPs for short- and intermediate-term work at RIDOT bridges that have previously been approved by RIDOT for use with its statewide bridge inspection program is also available. For proposed short- and/or intermediate-term work at existing bridges, the Designer should request a copy of the latest such approved TTCPs from the RIDOT Project Manager and, if applicable to the proposed work, consider using them on the Project if it will be cost-effective for RIDOT. Prior to using such TTCPs on a Project, the Designer is responsible for checking and confirming conformance with the *MUTCD*.

MUTCD Section 6B.01

[17] RIDOT Project Management Portal

For instances where conditions exist in close proximity that would introduce conflicts (including but not limited to on/off ramps, intersections, lane add/drops, etc.), site specific TTCPs shall be required.

5.6.2 Road Worker Considerations

In developing TTCPs, the Designer shall consider safety in worksite access and egress for road workers and equipment. Constructability reviews offer an opportunity for Designers to discuss safer worksite access, egress, and construction vehicle operations with personnel having construction operations experience.

To the extent practicable, the Designer shall propose TTCPs that avoid or minimize both worker exposure to motorized traffic and road user exposure to work activities/hazards. The setup and breakdown times of TTC devices should be considered, as should the possibility for using measures such as full road/ramp closures with detours, median crossovers, and/or techniques to accelerate construction.

5.6.3 Roadside Considerations

Pre-existing roadside safety elements (e.g., guardrail, crash attenuators, etc.) within the limits of work zones shall be maintained throughout the duration of the work. Callouts and details for existing roadside safety elements should be included on TTCPs wherever applicable. The Designer should also consider visibility and other environmental factors that may affect traffic safety and operations in and around the work zones (e.g., how geometry, sight distance, and/or sign clutter may degrade motorist reaction to or compliance with TTC setups).

5.6.4 Changeable Message Signs

When a temporary Changeable Message Sign (CMS) is called for, the details of each display message and sequence shall be shown on the TTCPs. Portable CMSs used by contractors often allow for up to 8 characters per line and 3 lines per display. Generally, displays should be limited to 2 panels in order for road users to understand the message displayed. Messages may be changed/updated over the duration of a Project as work progresses.

For Projects with more regional impacts, consideration should also be given to using existing RIDOT Intelligent Transportation System (ITS) devices to inform road users of changes in traffic patterns. Messages from these devices are controlled and monitored through the RIDOT Transportation Management Center (RIDOT TMC). Designers should coordinate use of such devices with the RIDOT Project Manager and the RIDOT TMC.

Refer to **Section 5.8.2** for additional recommendations for CMS at locations that propose changes to regulatory traffic controls.

5.6.5 Law Enforcement Officers and Flagpersons

Where appropriate, symbols for Law Enforcement Officers (with or without marked cruisers) and Flagpersons should be included on TTCPs to show their preferred locations.

5.6.6 Accessibility Considerations in Work Zones

MUTCD Sections 6C.02 - 6C.03

If pedestrian access needs to be modified to implement a work zone, the Designer shall ensure that the proposed TTCPs conform with the latest accessibility regulations and guidelines published by the US Access Board and adopted by the FHWA, United States Department of Justice (US DOJ), and/or RIDOT. Chapter R3 of the US Access Board's *Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way*[18] provides "best practice" clearances and conditions for TPARs in work zones, with a minimum four (4) foot wide accessible and detectable path generally being required. The *MUTCD* also requires that wherever a work zone affects an accessible and detectable pedestrian facility, such accessibility and detectability shall be maintained along the TPAR during the work.

Designers should strive to stay abreast of the latest adopted accessibility requirements in work zones and ensure that their proposed TTCPs are in compliance. In some cases, special provisions (Job Specific Specifications and/or details) may be needed to ensure that the Project TTCPs and work zones will be in such compliance. RIDOT *Standard Details* should be used wherever applicable. If Standard Details are not appropriate for a specific situation, the Designer shall develop site specific details and/or specifications. TTCPs may also need to call for alternate pedestrian circulation paths (detours) in order to provide an accessible TPAR during the proposed work.

If bicycle facilities need to be closed/detoured, the Designer shall develop an alternate route for bicyclists during the proposed work.

[18] https://www.federalregister.gov/documents/2023/08/08/2023-16149/accessibility-guidelines-for-pedestrian-facilities-in-the-public-right-of-way

5.7 Rolling Roadblocks

A Rolling Roadblock (RRB) may be used as a method of temporary traffic control to slow or stop traffic as a means of temporarily removing traffic from a roadway.

The RRB closes all lanes of traffic by using pacing vehicles to create a gap so that construction activities can be performed. RRBs should only be used for short term work where long-term road closures using TTC devices are not needed. Activities that may warrant the use of a rolling roadblock include, but are not limited to:

- Removing or setting bridge beams
- Placing overhead sign structures or
- Pulling wires or cables across the roadway.

At a minimum, RRBs involve the use of a number of traffic control strategies, including the following:

- Police cruisers, contractor pilot car and chase vehicle (typically police cruiser)
- Law Enforcement Officers (with or without marked cruisers)/Flagpersons (at all closure points and one Law Enforcement Officer per lane to be controlled)
- Traffic control supervisor (contractor or resident engineer) located at the work site
- CMS (one at each highway access closure, at least one in each direction on roadway being closed)
- Reflectorized drums (at all closure points)

The procedure for the use of RRBs is outlined below:

- A CMS shall be placed on the roadway being closed in advance (upstream) of the planned starting point for the RRB (approximately 1 mile in advance of the start of the RRB. One CMS should be placed for each direction affected by the RRB. All messages shall be approved by RIDOT prior to CMS installation. All CMS shall be placed outside AASHTO clear zone or protected by an existing or temporary barrier (guardrail, concrete barrier, etc.). All barriers shall be installed in accordance with the RIDOT standards and the AASHTO *Roadside Design Guide*.
- All on-ramps to the roadway to be closed between the rolling blockade and the work operation must be temporarily closed, using Law Enforcement Officers with a cruiser. These closures will remain in place until the “All Clear” signal is given by the traffic control supervisor in responsible charge of the work site, or until the front of the rolling blockade passes the closed access point upstream of the work site (to be determined in Contractor’s implementation plan). Detours will not be required for RRB closures due to the short duration.

- Guidance on the location where the traffic control vehicles begin the RRB and the speed at which the rolling blockade is allowed to travel is provided in Table 5-5 below.

Table 5-5. Rolling Roadblock Distances

Speed of Rolling Blockade (MPH)	Speed of Rolling Blockade (miles/minute)	Distance for Traffic Gap* (miles)	Additional Distance for Freeflowing Traffic to Clear Work Area (miles)	Total Distance of Moving Blockade* (miles)
10	0.167	2.50	0.75*	3.25 ±
20	0.330	5.00	1.80	6.75 ±
30	0.500	7.50	3.00	10.50 ±
40	0.667	10.00	3.40	13.40 ±
50	0.833	12.50	5.50	18.00 ±
60	1.000	15.00	5.40	20.00 ±

* Based on 15-minute roadway closure duration. These distances should be adjusted based on the number of minutes the closure is required.

TTCPs and the Project TMP should provide the below note regarding any proposed RRBs:

- Rolling roadblocks shall occur one instance per hour and shall not exceed 15 minutes each instance. Sufficient time to restore traffic to normal operations is required between closure periods.

Specific construction related activities to which RRBs apply shall be determined by the Designer.

5.8 Changes to Regulatory Traffic Controls

When a change to existing regulatory traffic control(s) is proposed, additional TTC devices may be warranted to provide road users with adequate advance warning of the change.

Table 5-6 lists various regulatory control changes on intersection approaches along with stipulations regarding corresponding TTC devices to be specified. Table 5-6 is generally valid whether a change to regulatory controls is short or long term. However, exceptions can be made for special circumstances where the change is short term (e.g., overnight deactivation and reactivation of a traffic signal with police control) or there is no need to warn road users of the change (e.g., road closed with detour). Additional details regarding the design and placement of TTC devices for this purpose are presented below.

Table 5-6. Temporary Treatments for Changes to Intersection Regulatory Traffic Controls

Traffic Control Change on Intersection Approach		TTC to Warn of Change	
FROM	TO	Minimum Device(s) Required[1]	Additional Considerations[7]
No Control	STOP[2] or YIELD	Static Signs[3]	CMS[4]
No Control	Flashing Caution Beacon[5]	None	Static Signs[3]
No Control	Traffic Control Signal[6]	CMS[4]	Static Signs[3]
STOP[2] or YIELD	No Control	Static Signs[3]	CMS[4]
STOP[2] or YIELD	Flashing Caution Beacon[5]	None	Static Signs[3]
STOP[2] or YIELD	Traffic Control Signal[6]	CMS[4]	Static Signs[3]
Flashing Caution Beacon[5]	No Control	None	Static Signs[3]
Flashing Caution Beacon[5]	STOP[2] or YIELD	Static Signs[3]	CMS[4]
Flashing Caution Beacon[5]	Traffic Control Signal[6]	CMS[4]	Static Signs[3]
Traffic Control Signal[6]	No Control	Static Signs[3]	CMS[4]
Traffic Control Signal[6]	Flashing Caution Beacon[5]	CMS[4]	Static Signs[3]
Traffic Control Signal[6]	STOP[2] or YIELD	CMS[4]	Static Signs[3]
Traffic Control Signal[6]	Revised Signal Phase Sequence	None	Static Signs[3] or CMS[4]

Notes:

1. This is in addition to all other TTC devices for the work zone which are required for conformance to the *MUTCD*.
2. Includes a STOP sign and/or a flashing red beacon.
3. Static Signs include one or more temporary warning and/or informational signs posted on the approach to the intersection to inform the road user about the changes both before and after they are implemented; see **Section 5.8.1** for details regarding design and placement.
4. CMSs; see **Section 5.8.2** for details regarding display and placement.
5. A traffic signal where traffic on the approach is warned of some condition via a flashing amber beacon.
6. A traffic signal where traffic on the approach is alternately directed to stop and permitted to proceed.
7. To be considered for use at locations where engineering judgment suggests that high travel demands, speeds, and/or risk of increased crash frequency will warrant.

If work is done on an entrance ramp to a freeway and there is an existing acceleration lane for vehicles to increase speed prior to merging with mainline traffic, the Designer shall consider "yield" control (preferred) for the ramp for temporary traffic control.

If work is done on an entrance ramp to a freeway and there is no existing acceleration lane, the Designer shall perform a capacity analysis to determine the extent of impacts of the ramp closure and potential detour. Based on the capacity analysis, the Designer shall determine whether a detour is appropriate.

If work is done on an entrance ramp to a freeway and there is no existing acceleration lane, and a detour would not be appropriate, "stop" control for the ramp for temporary traffic control may be considered. Safety analyses and supporting documentation for the recommended temporary traffic control shall be submitted to the RIDOT Office of Safety for final determination.

5.8.1 Temporary Warning Sign Considerations

MUTCD Sections 6A.01 - 6P.01

The *MUTCD* allows for a variety of temporary signs to be used to warn road users of a change in traffic control. When warranted, a temporary sign(s) conforming to the *MUTCD* should be called for on each affected approach to the intersection for two (2) weeks prior to and at least two (2) weeks after the date of change in control. The sign legend(s) should, in as few words and/or symbols as possible, inform road users of what the change will be (or is) and when and where it will be (or is) effective. Notes stipulating the required deployment of these special sign(s), along with a detail showing the required sign panel legend/layout for any such sign that is not stipulated by a RIDOT *Standard Detail* and is not included in the FHWA *Standard Highway Signs and Markings* publication, should be included on TTCPs.

5.8.2 Changeable Message Sign Considerations

MUTCD Sections 2L.01 -2L.08

When warranted, CMSs conforming to the *MUTCD* should be called for on each affected approach to the intersection. CMSs should inform road users of what the change will be and when and where it will be effective for a period of two (2) weeks prior to the change in control. A separate message should be called to be displayed on each CMS for at least two (2) weeks after the date of change to warn road users of the new traffic control ahead. Notes stipulating the required deployment of each CMS, along with details of each display message and sequence, shall be included on TTCPs.

CHAPTER 6
TRAFFIC SIGNALS

6.1 General Design Considerations

MUTCD Sections 4C.01 - 4C.10

All proposed new traffic control signals (including existing traffic control signals that are proposed to be entirely replaced) shall be evaluated by the Designer to justify their installation using the warrants included in the *Manual on Uniform Traffic Control Devices* (*MUTCD)* as a guide.

A copy of the Rhode Island Department of Transportation (RIDOT) Traffic Signal Timing Sheet [19]is included in Appendix A. This sheet shall be used by the Designer to document existing traffic signal timings in the field as well as to document any changes that are made. The Traffic Signal Timing Sheet shall be saved as a PDF with the following name convention:

- Replace "XXX" with the 3-digit RIDOT Traffic Signal (TS) Number:

    1. Timing Changes/Verifications: RIDOT TS XXX Timings YYYY-MM-DD
        a. If not a RIDOT signal, replace "RIDOT TS XXX" w/ applicable City/Town name and signal number.

    2. Pedestrian Timing Calculation Sheet: RIDOT TS XXX Ped Timing Calc Sheet YYYY-MM-DD

An electronic copy of each completed sheet shall be submitted to the RIDOT Office of Safety, and a hard copy shall be left in the controller cabinet. The Designer shall not make any traffic signal timing changes within a traffic signal controller without prior authorization from the RIDOT Office of Safety.

[19] https://www.dot.ri.gov/business/contractorsandconsultants.php

6.2 Traffic Signal Plans – General

RIDOT traffic signal plans shall include each of the items listed below, as applicable. The RIDOT Office of Safety requirements and guidelines for designing and/or showing each are presented in the remaining sections of this Manual.

- Signs and Pavement Markings at Traffic Signals (See **Section 6.2.1**)
- Traffic Signal Legend (See **Section 6.2.2**)
- RIDOT Traffic Signal Number (See **Section 6.2.3**)
- Phase and Timing Diagram (see **Section 6.3.2**)
- Phase Sequence and Sequence Diagram (see **Section 6.3.12**)
- Time-Of-Day/Week/Year Timing Program and Signal Coordination Parameter Table(s) (see **Section 6.3.13** and **Section 6.3.14**)
- Vehicular and Pedestrian Signal Head Layout and Signal Face Details (see **Section 6.4.3**)
- Vehicle and Pedestrian Detector Layout and Table(s) (see "Plan Callouts and Details" **Section 6.5.4** and **Section 6.6.3**)
- Signal Wire and Cable (see **Section 6.7**)
- Conduit and Handhole/Manhole Layout for Signal Wiring/Cabling (see "Plan Callouts and Details" **Section 6.8.3**)
- Signal Structure and Controller Cabinet Layout and Location Details (see "Plan Callouts and Details" **Section 6.9.2**)
- Signal Equipment to be Removed and Disposed or Salvaged (see **Section 6.11**)

The base mapping on a RIDOT traffic signal plan shall be in gray scale per the RIDOT *CAD Standards Manual* and shall include the existing intersection layout and features such as edge of pavement or curb line, sidewalks, curb ramps, street name labels, existing-to-remain signs and pavement markings, utilities, Right-of-Way (ROW) lines, traffic signal equipment, and any other pertinent features. All existing and proposed features shall be drawn to scale. All proposed modifications shall be dark lines per the RIDOT *CAD Standards Manual*.

All the necessary items related to traffic signals shall be included on a single traffic signal plan sheet for each intersection with appropriate clarity to display all features. If the traffic signal plan becomes too cluttered, items that are secondary to the actual real-time displays, phasing, and timing at the traffic signal (e.g., wiring/cabling callouts, pole location details, etc.) may be displayed separately on a supplemental plan sheet. The Designer shall refer to Design Policy Memorandum (DPM) "Plan Content Requirements" for additional guidance on plan requirements.

RIDOT DPM 450.02

6.2.1 Signs and Pavement Markings at Traffic Signals

Traffic signal plans shall show all proposed and existing-to-remain traffic control signs on the immediate roadway approaches (e.g. minimum of 100 ft from the stop line) and at/on the traffic signal (including pedestrian pushbutton signs and overhead-mounted street name signs). Traffic signal plans shall also show all proposed and existing-to-remain pavement markings within the same limits described above. Engineering judgment should be used to determine if traffic control signs and pavement markings beyond 100 ft from the stop line should be shown on the traffic signal plans based on roadway features.

If separate Signing & Striping plans are provided, then RIDOT standard callouts for signs and pavement markings shall not be shown on traffic signal plans. In such cases, a graphic of each sign legend shall be shown next to each sign symbol, and only the general layout of markings needs to be shown.

6.2.2 Traffic Signal Legend

A Traffic Signal Legend shall be shown on each traffic signal plan to stipulate the meaning of all callouts used on the plan for traffic signal-related work. The Legend shall list the callout code and symbol, item code number, and description for each item. Callouts, item code numbers, and descriptions shall be consistent with all other contract documents and shall match RIDOT standards for such whenever applicable. Standardized Traffic Signal Callouts are provided in Appendix B. The Legend on each particular traffic signal plan shall include only those items that are called out on that specific signal plan. Typical Standard Traffic Signal Symbols are shown in Figure 6-1 below.

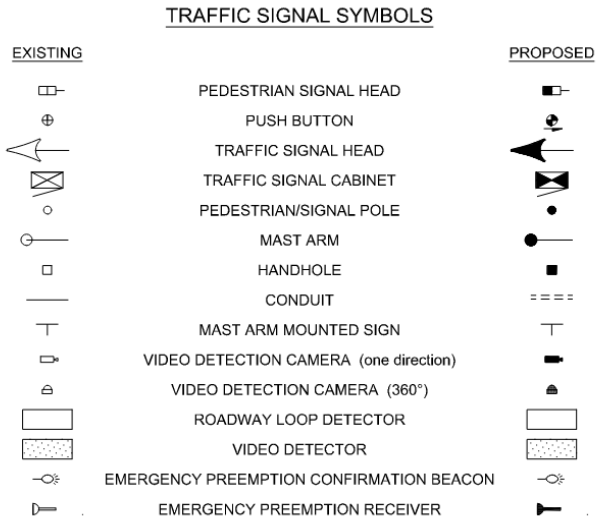


Figure 6-1. Typical Standard Traffic Signal Symbols

6.2.3 RIDOT Traffic Signal Number

The RIDOT Office of Safety assigns a unique number for each new traffic signal that RIDOT will own and/or maintain. The Designer shall request this number from the RIDOT Office of Safety when the Plans, Specifications, and Estimates (PS&E) Submission (or equivalent) is being prepared. The request shall include the following:

1. Exact location of the traffic signal (list all intersecting street names, or other locational information and details if not at an intersection). A Traffic Signal Plan shall be included with the request containing this information.
2. Type of traffic signal (e.g., vehicle traffic control signal, pedestrian/bicycle signal, pedestrian hybrid beacon, Rapid Rectangular Flashing Beacon, etc.).
3. Date of State Traffic Commission (STC) approval for the traffic signal.
4. Rhode Island (RI) Contract Number (construction) or Physical Alteration Permit (PAP) Application Number applicable to the traffic signal construction.

The RIDOT-assigned Traffic Signal Number shall be shown in bold just above the title block in the lower right-hand corner of the traffic signal plan sheet.

6.3 Signal Phasing and Timing

6.3.1 General Design Considerations

Signal timing values determined per the procedures described in this Manual should be considered as a starting point, and adjustment of such values shall be considered by the Designer if field observations or engineering judgment show that adjustment is expected to improve traffic safety and/or operational efficiency.

Unless already included in another document included with a Project submission (e.g., a Traffic Impact Study (TIS), a Conceptual Design Report, etc.), the Designer shall submit separate backup to the RIDOT Office of Safety that clearly shows how each of the following traffic signal timings were determined (including any engineering assumptions or judgment that was used), whenever they are proposed or altered:

- Yellow Change Intervals
- Red Clearance Intervals
- Passage Times
- Pedestrian Signal Timings (using RIDOT's *Pedestrian Signal Timing Calculation Sheet*)
- Coordination Parameters (e.g., Cycle Lengths, Phase Splits, and Offsets)

Refer to **Section 7.6** for additional guidance when red-light running may be a concern.

NCHRP 812
Exhibit 6-1

The Designer should be familiar with the consequences of traffic signal timings that are too short or too long, as well as the variables that affect signal timing determination, as presented in the National Cooperative Highway Research Program (NCHRP) *Report 812 Signal Timing Manual – 2nd Edition*.

6.3.2 Phase and Timing Diagram

The Phase and Timing Diagram shall show the minimum green time, passage time, maximum green times, yellow change interval, red clearance interval, detector memory, recall, and a small movement diagram (showing which movements have the right of way, including phase overlaps for each vehicular phase). For the maximum green times, a row for at least Max 1 and Max 2 shall be shown, but a Max 3 line should also be shown if applicable for one or more phases. For each pedestrian phase, the Phase and Timing Diagram shall indicate the pedestrian walk, pedestrian change (Flashing Don't Walk) and buffer intervals.

The Phase and Timing Diagram shall also indicate the displays for each vehicular and pedestrian signal head for every signal phase, as well as for preemption and flashing operation. The diagram shall account for every signal head at the intersection and the respective movement(s) that each controls.

An example of a Phase and Timing Diagram is shown in Figure 6-2.

PHASE AND TIMING DIAGRAM

			ø1			ø2			ø4			ø5			ø6			ø8			
STREET	DIRECTION	HOUSINGS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	FLASHING OPERATION
WEST MAIN ROAD	NBL	A	~~G~~	~~Y~~	~~R~~[2]	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~[1]	~~FY~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~R~~	~~FR~~
WEST MAIN ROAD	NB	B,K	R	R	R	R	R	R	R	R	R	R	R	R	G	Y	R	R	R	R	FY
WEST MAIN ROAD	SBL	C	~~R~~	~~R~~	~~R~~	~~FY~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~R~~	~~G~~	~~Y~~	~~R~~[1]	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~FR~~
WEST MAIN ROAD	SB	D,J	R	R	R	G	Y	R	R	R	R	R	R	R	R	R	R	R	R	R	FY
NORTH MAIN ROAD	EB	E,F	R	R	R	R	R	R	G	Y	R	R	R	R	R	R	R	R	R	R	FR
NORTH MAIN ROAD	WB	G,H	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	G	Y	R	FR
PEDESTRIAN	NB–SB	P1–P2	DW	DW	DW	DW	DW	DW	W/FDW	DW	DW	DW	DW	DW	DW	DW	DW	W/FDW	DW	DW	OUT
PEDESTRIAN	EB–WB	P3–P4	DW	DW	DW	W/FDW	DW	DW	DW	DW	DW	DW	DW	DW	W/FDW	DW	DW	DW	DW	DW	OUT
TIMING IN SECONDS																					
MINIMUM GREEN (INITIAL)			5			8			8			5			8			8			
PASSAGE TIME (VEHICLE)			2.1			3.0			2.6			2.1			3.0			2.6			
MAXIMUM 1			8			31			31			8			31			31			
MAXIMUM 2																					
YELLOW CHANGE				2.5			5			3.5			2.5			5			3.5		
RED CLEARANCE					3.5			2.5			1.5			3.5			2.5			1.5	
PEDESTRIAN WALK/CHANGE						7/22			7/22						7/22			7/22			
RECALL			OFF			MIN			OFF			OFF			MIN			OFF			
DETECTOR MEMORY			NON–LOCK			NON–LOCK			NON–LOCK			NON–LOCK			NON–LOCK			NON–LOCK			

PHASE AND TIMING NOTES:

1. FLASHING OPERATION PER 2023 MUTCD SECTIONS 4G.01 THROUGH 4G.04.
2. MAXIMUM 1 = NORMAL OPERATION
3. MAXIMUM 2 = NOT USED
4. PED. W/FDW UPON PUSHBUTTON ACTUATION ONLY

Figure 6-2. Example Phase and Timing Diagram

6.3.3 Minimum Green Times

The minimum green time shall be long enough to allow the first vehicle operator waiting in the queue to react to the start of the green interval and enter the intersection.

Ranges of minimum green times that conform with the above for RIDOT traffic signals are shown in Table 6-1, but longer times should be considered where pedestrians may cross the intersection without any pedestrian signals or intervals present, and where bicycles or other types of vulnerable road users (VRU) which operate slower than the motorized traffic routinely use the intersection. At signals where crosswalks are present but pedestrian detection is not, the minimum green time for the adjacent vehicular phase shall allow for a pedestrian to cross the intersection. Minimum green times that are set too low may lead to a risk of increased number of rear-end crashes. For guidance regarding the determination of minimum green times for bicyclists, refer to the NCHRP *Report 812 Signal Timing Manual – 2nd Edition.*

NCHRP 812 Section 6.1.3.4

Table 6-1. Typical Minimum Green Times to Satisfy Motorist Expectancy

Approach and Movement	Typical Minimum Green Time (seconds)
Main Street Through	6 to 12
Main Street Left Turn	5 to 6
Side Street Through	6 to 8
Side Street Left Turn	4 to 5

Controller settings that can vary the minimum green time on a cycle-by-cycle basis based on demands ("variable initial" features) are not used at RIDOT traffic signals and will only be considered for implementation if the Designer documents the reasons why such settings are expected to be warranted at a specific location and upon approval of the RIDOT Office of Safety.

6.3.4 Maximum Green Times

Maximum green times shall be determined based on the vehicle demands and a consideration of the findings from an appropriate analysis of traffic capacity and operations at the signalized intersection. Maximum green times should exceed the green duration needed to clear most of the traffic queues experienced on an average day, allowing the phase to accommodate most fluctuations in demand.

Frequent phase termination by gap out (as opposed to max out) during times with low-to-moderate demands, and by occasional max out during peak demand periods, is a good indication that the maximum green time is set appropriately.

The use of more than one maximum green time shall be considered based on variations in traffic demands (e.g., to best accommodate peak periods, off-peak periods, weekends, special events or seasons, etc.). See **Section 6.3.13** for further guidance.

6.3.5 Yellow Change Intervals

NCHRP 731 Appendix A

Yellow change intervals shall be determined using the following equation (based on guidelines included in NCHRP Report 731 *Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections)*

$$Y = t + \frac{1.47V}{(2a + 2Ag)}$$

where:

Y = yellow change interval in seconds

t = perception-reaction time (1.0 second)

V = 85th percentile approach speed (Miles per Hour (MPH))

a = deceleration rate (10 ft/sec^2)

A = acceleration due to gravity (32.2 ft/sec^2)

g = percent grade in decimal form (+ for upgrade, - for downgrade)

The following guidelines apply when determining the yellow change intervals:

A. The minimum value of the yellow change interval shall be 3.0 seconds.

B. The value of the 85th percentile approach speed to use in the equation shall be determined with consideration of the following conditions:

   1. The speed value used in the equation shall be associated with free-flow conditions and shall be rounded to the nearest whole number.

   2. Where an exclusive left or right turn signal phase is to operate separately from a through phase, unless the Designer provides justification otherwise, a slower speed value may be approximated by subtracting five (5) mph from the posted speed limit for the turning movement.

   3. The actual 85th percentile approach speed at or near a location described in Condition B.4 shall be determined via a speed study as

part of the Project. Where automated enforcement methods to counter "red light running" are under consideration as a potential countermeasure, such speed value shall be determined via a speed study.

4. The location where the 85th percentile approach speed is determined shall be at a point approximately five (5.0) seconds upstream of the stop line, as shown in Table 6-2. Where site conditions (e.g., limited sight distance to the signal heads, significant changes in roadway geometry, or some other roadway condition) warrant a different location, the Designer should use engineering judgment to choose a location where approximately 90 percent of approaching traffic makes the decision to stop at the intersection in response to the yellow signal.

Table 6-2. Approach Speed and Grade Location Reference for Change Interval Determination

Posted or Statutory Speed Limit on Approach (MPH)	Approximate Location Corresponding to 5.0 Seconds Upstream of Stop Line (see Note) (feet)	
	Through Movement	Left or Right Turn Movement
20	200	110
25	240	150
30	280	190
35	310	220
40	350	260
45	390	300
50	420	330
55	460	370
60	500	410
65	530	440

Note: These values are based on calculations using the adjustments to posted speed limits recommended by NCHRP Report 731.

C. The value of the approach grade shall be estimated as the average grade between the stop line and the appropriate upstream location as determined above. The approach grade value used in the equation shall be rounded to the nearest whole percent grade and determined based on existing records where available. If such records are not available, the

value shall be estimated based on measurements or observations in the field or from a geolocation tool such as Google Earth.

D. Calculated values of the yellow change interval shall be rounded to the appropriate half-second, per the following rules:

   1. Values ending in .1 or .6 shall be rounded down to the nearest half-second

   2. Values ending in .2, .3, .4, .7, .8, and .9 shall be rounded up to the nearest half-second

E. Yellow change intervals for adjacent movements (e.g. protected left turn and adjacent through) shall be equal when they will/may terminate at the same time.

F. Once the calculated yellow change interval is programmed and in actual operation in the field, the Designer shall observe traffic operations and consider adjusting the interval as appropriate, subject to approval of the RIDOT Office of Safety.

6.3.6 Red Clearance Intervals

NCHRP 731 Appendix A

Red clearance intervals for traffic control signals shall be determined using the following equation (based on guidelines included in NCHRP Report 731 *Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections*):

$$R = \frac{W + L}{1.47V} - 1$$

where:

W = intersection width measured from the back/upstream edge of the approaching movement stop line to the far side of the intersection as defined by the extension of the curb (or the back of the crosswalk)

L = length of vehicle (20 feet)

V = 85^{th} percentile approach speed (MPH)

The following guidelines apply when determining the red clearance intervals:

A. The minimum value of the red clearance interval shall be 1.0 second.

B. The value of the intersection width (W) to use in the equation shall be determined with consideration of the following:

   1. The width value shall be a measured value, rounded up to the nearest whole number, and determined based on the centerline of the vehicular movement path. The width value shall be determined based

on actual site measurements or existing records where available. If such records are not available, the value shall be estimated based on measurements from a geolocation tool such as Google Earth.

2. The width value shall be the longest vehicular travel path distance between the approach stop line and the furthest point of potentially conflicting but legal traffic movements (typically pedestrian, but vehicle wherever pedestrians are not permitted). At intersections that have documented routine cycle failure (e.g., queued vehicles have to wait more than one signal cycle to pass through the intersection) and "red light running" is documented during peak travel periods, an alternate width that extends only to the upstream point of potentially conflicting vehicle movement may also be considered if approved in advance by the RIDOT Office of Safety.
3. The value of W shall be modified for the following conditions:
    i. If crosswalk with pedestrian signals has its near-side crosswalk line 40 feet or more from the extension of the farthest edge of the farthest conflicting travel lane, W shall be measured from the back edge of the approaching movement stop line to the near-side crosswalk line.
    ii. The value of W shall be measured along the vehicle turn path from the stop line to the no-conflict point for exclusive left-turn movements.

C. The value of the 85th percentile approach speed to use in the equation shall be determined in conformance with the stipulations of **Section 6.3.5**, Condition B, with the following exceptions:

1. If the intersection is used regularly by bicyclists, the Designer shall consider whether a lower speed than that determined via speed study is more appropriate to use in the equation.
2. For left and right turning movements, the speed value should be 20 mph. For turning movements, the Designer shall consider whether the conditions below warrant the use of a different speed value:
    i. Sharp or very large turning radii at the intersection
    ii. Intersections that are observed to routinely experience cycle failure and subsequent "red light running" during peak travel periods and/or excessive lost time due to the length of the red clearance interval.

    If the use of an alternate speed value is deemed appropriate based on the above, such use must be approved in advance by the RIDOT Office of Safety.

D. Calculated values of the red clearance interval shall be rounded to the appropriate half-second, as outlined in **Section 6.3.5**, Item D.

E. Red clearance intervals for adjacent movements (e.g. protected left turn and adjacent through) shall be equal when they will/may terminate at the same time.

F. Once the calculated red clearance interval is programmed and in actual operation in the field, the Designer shall observe traffic operations and consider adjusting the interval if appropriate, subject to the following considerations:

1. A suggested measure of effectiveness for a red clearance interval is the percentage of vehicles clearing the area of any real and routine conflict after they have entered the intersection just upon the start of the red indication.

2. If the above percentage seems acceptable and the intersection experiences significant traffic delays on a routine basis, the Designer should consider adjusting the value of the intersection width (reducing the value) and/or the speed (increasing the value) and recalculating the value of the red clearance interval with intent of enabling more efficient traffic operations

3. The value of the red clearance interval may be adjusted for select movements/phases along signalized corridors or in coordinated systems if it is judged that uniformity in red clearance interval values along the corridor or system will improve expectations and safety for road users.

At locations with a flashing yellow operation, a one (1.0) second red clearance interval shall be provided between the solid yellow arrow indication for the protected turning movement and the flashing yellow arrow indication for the permissive turning movement.

At Pedestrian Hybrid Beacon (PHB) locations, a special “buffer” red clearance interval after the end of the alternating circular red signal indications shall not be called for unless approved by the RIDOT Office of Safety.

6.3.7 Detector Memory

Detector memory shall be called out to be set to "Non-Lock" for presence detectors at the stop line.

6.3.8 Passage Times

The RIDOT-preferred default assumed vehicular time-based headway is 3.5 seconds. Passage times (also referred to as "extension" or "gap" times) shall be calculated as the difference between the RIDOT-preferred headway and the time it takes for the trailing end of a vehicle traveling at the approach speed (determined per **Section 6.3.5**, Item B) to clear the presence detection zone on the approach. Where the RIDOT typical 40-foot-long presence detector layout is in place on the approach being considered, the Designer may select passage time values from Table 6-3 once they have determined the appropriate approach speed.

Table 6-3. Passage Times for 40-Foot Detection Zones

Approach Speed[1] (MPH)	Passage Time[2] (seconds)
15 - 25	2.4
26 - 28	2.5
29 - 32	2.6
33 - 36	2.7
37 - 41	2.8
42 - 49	2.9
50 - 60	3.0
61 - 70	3.1

Notes:

1. Designer to determine per **Section 6.3.5**, Item B
2. Assumes a 3.5-second headway between vehicles

Where different passage times for turning versus through movements are potentially applicable for a single traffic signal phase, the highest value shall be utilized.

Once the calculated or selected passage time is programmed and in actual operation in the field, the Designer should observe traffic operations and consider adjusting the time if premature gap outs are frequently occurring before the queue of stopped vehicles is fully served (including but not limited to where large or heavy vehicles are often present in the queue). In such cases the Designer may

increase the value of the passage time to mitigate this situation, but the increase should be no more than is observed to be reasonably necessary to address the premature gap outs and should be made with consideration of the negative effects that the increase will have on other movements during all times of the day.

Controller settings that vary the passage time during the green interval ("gap reduction" features) are not used at RIDOT traffic signals and will only be considered for implementation upon approval by the RIDOT Office of Safety.

6.3.9 Vehicle Recalls

The vehicle recall setting on the phase that controls the through movement on the mainline shall be set as "Minimum" unless a "Soft" recall is judged to be more appropriate. For all signal phases other than for the mainline through movement, the vehicle recall setting shall be called out to be "Off".

6.3.10 Pedestrian Phasing and Timing

MUTCD Section 4I.06

The default design for pedestrian signal operation at RIDOT traffic signals is for the pedestrian phase to run concurrently with an appropriate vehicular phase. The methods to calculate the pedestrian phase shall be in accordance with the *MUTCD*.

An exclusive pedestrian phase shall be considered where there is a documented pedestrian safety issue, where directed by the RIDOT Office of Safet, or where an exclusive pedestrian phase already exists.

A pedestrian phase at a traffic signal is composed of three different intervals: a Walk Interval, a Pedestrian Change Interval (Flashing Don't Walk time), and a Buffer Interval. The combination of the Pedestrian Change Interval and the Buffer Interval forms a "Pedestrian Clearance Time" which, while not required to be called out on a traffic signal plan, shall be checked for sufficiency during the design of pedestrian signal timings.

Traffic signal plans shall call for appropriate Walk and Pedestrian Change Intervals where pedestrian signals are present or proposed, since these values must be programmed into the traffic signal controller. Requirements and guidelines for appropriately determining these and other pedestrian phase timings appropriately are provided in the following subsections.

6.3.10.1 Walk Interval

The Walk Interval shall not be less than 7 seconds in areas with significant pedestrian activity; however, based on engineering judgment and if documented for and approved by the RIDOT Office of Safety, the Walk

Interval may be reduced due to low pedestrian demands or in order to accommodate cycle length or split timing restrictions on a coordinated corridor. In no cases shall the Walk Interval be lower than the minimum 4 seconds provided in the *MUTCD*. The Walk Interval may also be increased in order to meet minimum pedestrian phase recommendations (see **Section 6.3.10.5**).

6.3.10.2 Pedestrian Change Interval

The Designer shall determine the appropriate Pedestrian Change Interval (Flashing Don't Walk time) for the crossing by subtracting the Buffer Interval from the calculated Pedestrian Clearance Interval for exclusive pedestrian phasing.

6.3.10.3 Buffer Interval

The Buffer Interval is the time when the steady UPRAISED HAND (symbolizing DON'T WALK) pedestrian signal indication is displayed prior to the release of any conflicting vehicular movement. For design purposes at RIDOT traffic signals, the Buffer Interval shall be equal to the sum of the Yellow Change and Red Clearance Intervals for the associated vehicular phase. The *MUTCD* provides alternate methods to calculate the buffer interval; however, to keep from unnecessarily lengthening phases when not required and/or to provide additional time for the walk interval, the buffer interval should be accommodated at the start of the yellow clearance interval for use with concurrent pedestrian phasing. Alternate methods may be considered upon approval from the RIDOT Office of Safety.

6.3.10.4 Pedestrian Clearance Time

This interval is calculated by dividing the distance between the near side curb (or edge of pavement) and the far side of the traveled way (e.g., a white right edge line) by a design walking speed that is assumed to be appropriate for the crossing. The maximum design walking speed to be used for this purpose shall be 3.5 feet/second. Lower speeds shall be considered and used where appropriate, such as locations with young schoolchildren and/or an elderly population, where a walking speed of 3.0 feet/second may be utilized. For young schoolchildren and/or elderly population, a walking speed of 3.0 feet/second should be utilized. Lower walking speeds may be considered on a case-by-case basis based on engineering judgment and approval from the RIDOT Office of Safety.

6.3.10.5 Pedestrian Phase

The Designer shall check that the duration of the overall pedestrian phase (the sum of the Walk, Pedestrian Change, and Buffer Intervals) is in compliance with guidance in the *MUTCD*. If more time is found to be needed to meet this condition, such time can be added to the Walk Interval.

6.3.10.6 Leading Pedestrian Interval

Where pedestrians may have difficulty in establishing the right-of-way over turning vehicles during a Walk Interval that runs concurrently with a vehicular signal phase, the use of a Leading Pedestrian Interval (LPI) should be considered wherever possible.

Where LPIs are proposed, the Designer shall consider the following:

- The protected portion of a protected-permissive left-turn phase that exits across the subject crosswalk shall be a lagging left after the completion of the concurrent pedestrian crossing.
- An exclusive (protected only) left-turn phase that exits across the subject crosswalk may occur as either a leading or lagging left turn, subject to additional analysis of traffic conditions.
- "NO TURN ON RED" (*MUTCD* Sign Designation R10-11) and/or "TURNING VEHICLES YIELD TO PEDESTRIANS" (*MUTCD* Sign Designation R10-15) signs for left/right turns conflicting with LPI shall be used where appropriate.

At new traffic signal installations or replacements, the Designer may consider including LED blank out signs wherever LPI is used. The signs would display "NO TURN ON RED" (*MUTCD* Sign Designation R10-11) during the LPI, and then "TURNING VEHICLES YIELD TO PEDESTRIANS" (*MUTCD* Sign Designation R10-15) during the rest of the pedestrian phase. The "NO TURN ON RED" and "TURNING VEHICLES YIELD TO PEDESTRIANS" displays may also be used during other vehicular phases if warranted.

If an LPI is proposed, the Designer shall consider the impacts of the additional vehicular delays and the potential safety impacts to vulnerable road users, particularly those who are visually impaired and rely on audible cues from pushbuttons. The Designer shall provide documentation to the RIDOT Office of Safety to show why a LPI is warranted. The RIDOT Office of Safety generally recommends that a LPI only be long enough to allow a pedestrian to travel to the midpoint of the near travel lane to establish their position within a travel lane ahead of conflicting turning traffic before such traffic is provided a green signal indication. A typical value for the LPI is 4 seconds but may vary depending on the specific intersection geometry.

To assist the Designer with the determination of pedestrian timings, a RIDOT *Pedestrian Signal Timing Calculation Sheet*[20] is included in Appendix A, with an editable version available on the RIDOT website.

A completed RIDOT *Pedestrian Signal Timing Calculation Sheet* for each intersection where pedestrian timings are proposed to be modified or implemented shall be submitted to the RIDOT Office of Safety.

[20] https://www.dot.ri.gov/business/contractorsandconsultants.php

6.3.11 Left Turn Phasing

The need for and type of left turn phasing at a traffic control signal shall be determined based on a consideration of traffic volumes, crash history (or expected crash performance), lane configuration, and roadway conditions at the intersection. A capacity analysis using appropriate traffic analysis software (see **Section 2.1.2** for guidance) shall be performed to check the adequacy of a proposed change to left turn phasing.

FHWA Section 11.0

NCHRP Exhibit 4-16

Designers shall use the Federal Highway Administration (FHWA) publication *Signalized Intersections: An Informational Guide* and NCHRP's *Signal Timing Manual* as the initial step in considering whether a protected/permissive or protected left turn phase is appropriate on a signalized intersection approach. Deviations from the recommended treatment for left-turn phasing requires approval from the RIDOT Office of Safety.

Based on the findings using NCHRP's *Signal Timing Manual*, the Designer shall prepare a brief report that documents the phasing considerations and the proposed recommendation for left turn signal phasing to the RIDOT Office of Safety. The report should be submitted to the RIDOT Office of Safety as part of the appropriate design stage submission (e.g., Design Study Report, 30%, or equivalent), and should consider each of the following where applicable:

- Unless the Designer can provide justification based on a traffic operational problem or need, protected/permissive left turn phasing from an exclusive left turn lane shall be avoided when:
  - The number of through lanes on the opposing approach is two (2) or more, and/or
  - The 85th percentile speed of opposing traffic is greater than 45 MPH.
- The use of "Lead-Lag" left turn phasing shall be avoided where it results in a left turn "yellow trap" issue.
- The left turn phasing of adjacent traffic signals along a roadway shall be documented, and potential concerns about motorist expectations and/or coordination issues discussed, as they may play a role in ultimate left turn phasing decisions.

  The RIDOT Office of Safety will either accept or request further information regarding the Designer's recommendation for left turn signal phasing. If a recommendation for protected/permissive left turn phasing is accepted, the Designer should use engineering judgment in deciding which *MUTCD*-permitted combination of lane configuration, signal head placement, and signal displays is suitable for implementation at the site (see **Section 6.4.1**

for further RIDOT-specific guidance regarding acceptable signal face(s) for shared versus exclusive turn lanes).

6.3.12 Phase Numbering and Sequence Diagrams

For consistency purposes, the numbering of proposed traffic signal phases shall conform to standard National Electrical Manufacturers Association (NEMA) phasing as shown in Figure 6-3 and Table 6-4 unless otherwise permitted or directed by the RIDOT Office of Safety.

The proposed phase sequence (or "ring structure") for a RIDOT traffic signal that is called for and shown in the Phase Sequence Diagram shall be based on a dual-ring phase sequence with phase numbering conforming to Figure 6-3 and Table 6-7. Phases that are not needed or used shall be omitted from the Phase Sequence Diagram. Figure 6-4 shows examples of some common Phase Sequence Diagrams that may be applicable for a RIDOT traffic signal plan.

The use of a traffic signal phase sequence that varies by time-of-day or day-of-week has not been widely deployed in Rhode Island. It will be considered for approval by the RIDOT Office of Safety if:

- an engineering study shows that such sequence is warranted and
- the proposed varying phase sequence has been approved by the local municipality where the traffic signal is located.

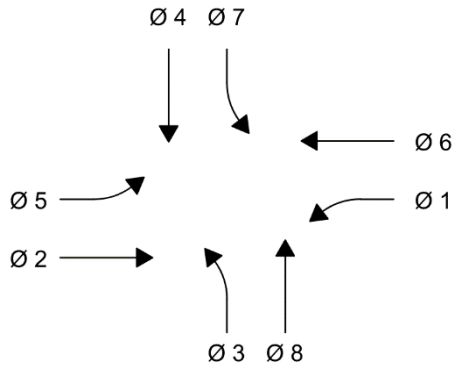


Figure 6-3. Movement Numbering Convention

Table 6-4. RIDOT Traffic Signal Phase Numbering Scheme

Signal Phase No.	Movement/Approach Description (see Notes)
2	Major Street Through most closely aligned w/ eastbound or northbound
6	Major Street Through opposite to Phase 2 (often westbound or southbound)
1	Major Street Left Turn that conflicts with Phase 2
5	Major Street Left Turn that conflicts with Phase 6
4	Minor Street Through clockwise to immediate left of Phase 2 (often southbound or eastbound)
8	Minor Street Through opposite to Phase 4 (often northbound or westbound)
3	Minor Street Left Turn that conflicts with Phase 4
7	Minor Street Left Turn that conflicts with Phase 8

Notes:

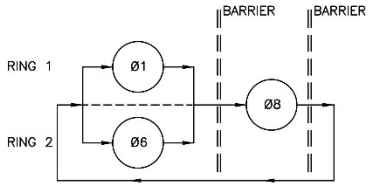
1. The Major Street shall be designated as the roadway having the "highest" functional classification at the intersection (if intersecting roadways have the same functional class, then the higher-volume roadway shall be designated the Major Street), subject to the following exceptions:

    A. For signal systems installed along a corridor, the Major Street shall be designated consistently along the corridor. Where two such corridors intersect, consult with the RIDOT Office of Safety for agreement on how to designate Major vs. Minor streets.

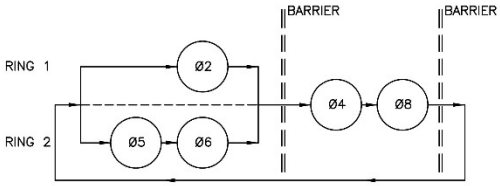
    B. Most freeway or expressway off-ramp or terminus approaches to an intersection shall be considered the Minor Street, although exceptions can be made if such an approach is aligned with and included as part of a coordinated signal system along a corridor and/or has higher daily traffic volumes than the other conflicting movements at the intersection.

2. Phase numbers other than the eight shown above shall be assigned as needed to account for additional signal phases whose movement/approach is not described (e.g., assigning Phase 9 to an exclusive pedestrian phase proposed at an intersection with eight-phase "quad-left" phasing is acceptable).

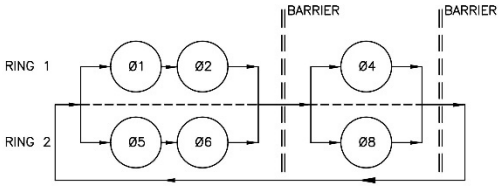
3. Phase overlaps need not be assigned numbers or letters but shall be illustrated on the small movement diagram included as part of the *Phase and Timing Diagram* (see **Section 6.3.2**).



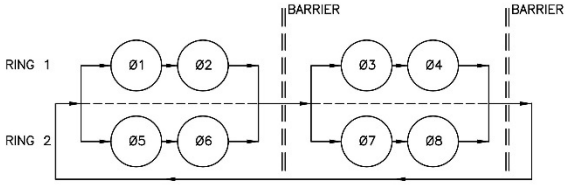
A. T-Intersection, No Protected Left Turns on Major Street Approaches



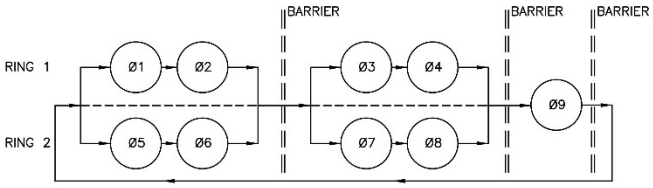
B. Advance Protected Left Turns on One Major Street Approach, Minor Street Phases are "Split"



C. Advance Protected Left Turns on Both Major Street Approaches, Minor Street Phases are Concurrent



D. "Quad-Left" Phase Sequence - Advance Protected Left-Turns on All Major and Minor Street Approaches



E. "Quad-Left" Phase Sequence - Advance Protected Left-Turns on All Major and Minor Street Approaches with Exclusive Pedestrian Phase

Figure 6-4. Example Phase Sequence Diagrams

6.3.13 Signal Timing Variation by Time-Of-Day/Week/Year

Where traffic demands and conditions warrant, signal timings that vary by time-of-day, day-of-week, and/or time-of-year shall be considered and, if justified by an engineering study or analysis, called for on signal plans.

Typical generalized time periods that are often associated with commuter-, retail/shopping-, and beach-related traffic demand surges at RIDOT traffic signals are shown in Table 6-5. In all cases, the specific hours to be associated with these time periods shall be based on actual local traffic demands or observations, and other time periods/situations not explicitly shown in Table 6-5 may be applicable.

Table 6-5. Default Time-Of-Day Program Periods for RIDOT Signals

Period Type	Days of Week	Time of Year	Default Time Periods
Weekday	MON - FRI[2]	ALL	AM Peak PM Peak
Weekend	SAT and SUN[3]	ALL	Mid-Day Peak PM Peak
Beach Season[1]	FRI - SUN	May 15 to September 15	AM Peak Mid-Day Peak PM Peak

Notes:

1. A timing program to accommodate seasonal beach traffic shall only be considered for traffic signals on RI Route 4 in Washington County and on, south, or east of U. S. Route 1 in Westerly, Charlestown, South Kingstown, and Narragansett.
2. The same timing program for each weekday will typically apply to accommodate commuter traffic surges, but exceptions can be made.
3. The same timing program for both Saturday and Sunday may apply to accommodate weekend traffic surges, but shall vary for each day if traffic data, analysis, and/or observations suggest otherwise.

Where a school, church, or other nearby property is associated with routine surges in traffic at times outside of those shown in Table 6-5, additional time periods shall also be considered for implementation.

Where signal timings that vary by time-of-day/week/year are determined to be appropriate for implementation on a Project, such signal timings shall be called for on the traffic signal plan in tabular format. For the simplest of cases, the Phase and Timing Diagram may include appropriate Maximum 2 Green Times in the table, supplemented by notes to describe when timings are to be active. For more elaborate variations in timings (including where signal coordination parameters

will be in effect), a separate table shall be used, such as the example shown in Table 6-5.

6.3.14 Signal Coordination and Systems

Efficient traffic flow at all traffic signals, but particularly along arterial corridors, is desired by the RIDOT Office of Safety. Wherever one or more of the below conditions are met, the Designer shall perform an engineering study to consider the impacts of coordinating the traffic signals, to determine if coordination is recommended, and to determine what coordination timings/settings and adjustments are appropriate at each traffic signal in the system.

- A new traffic signal is proposed within one-quarter (1/4) of a mile of another traffic signal along the same corridor or numbered route or adjacent to an existing coordinated signal system.
- An existing traffic signal that is part of an existing coordinated signal system is being replaced.
- At other locations as directed by the RIDOT Office of Safety.

Coordinated signals can cause unacceptable delays to certain traffic movements, especially on side streets during off-peak periods. Therefore, the Designer shall weigh the advantages and disadvantages of providing coordination during all time periods at each unique intersection being analyzed. Uncoordinated or "Free" operations should be considered during periods of light traffic.

NCHRP Chapter 7

Before implementing coordination parameters in a RIDOT traffic signal controller or preparing Plans that call for coordination, the Designer should be familiar with and have previously reviewed NCHRP's *Signal Timing Manual*.

Corridor traffic progression analyses shall be performed using an appropriate software tool that uses time-space diagrams (see **Section 2.1.2** for more guidance). Where a properly completed traffic analysis shows that adjacent traffic signals should be coordinated, the Designer shall call for coordinated signal parameters that are designed to provide progressive traffic flow along the roadway, with consideration of favoring the heaviest directions of traffic flow during peak travel periods.

Basic signal coordination parameters to be determined include Cycle Lengths, Phase Splits, and Offsets. The Cycle Length during a coordinated time period shall be the same for all intersections in a system, except where:

- it is determined that using a half-, quarter-, or double-length Cycle will improve traffic operations or

- an adaptive traffic signal system that is unburdened by Cycle Length restrictions is or will be used.

Phase Splits shall include the appropriate allocated green time for a phase plus the associated Yellow Change and Red Clearance Intervals. Designers shall consider and check whether proposed Phase Split times are long enough to ensure that the signal will not be thrown out of coordination given any concurrent pedestrian signal timings that may be associated with the phase.

Offsets shall be determined and referenced to the beginning of the first coordinated phase yellow (end of green), since this is typically easier than the beginning of green to observe in the field.

The coordinated phase(s) shall be called out to be "Call Non-Actuated" during coordinated operations unless otherwise approved by the RIDOT Office of Safety.

The "Inhibit Max" parameter shall be called for to prevent the controller from using maximum green values during coordinated operations.

The "Rest-In-Walk" mode of operation (e.g., the signal dwells in the pedestrian walk interval while the coordinated phase is green, regardless of pedestrian calls) shall be called for during coordinated operations unless the Designer determines that traffic demands on the minor street(s) warrant a different mode.

The "Floating" (also known as "plan-based") type of force-offs shall be called for during coordinated operations unless it is determined or observed that an uncoordinated phase(s) routinely needs more green time during a cycle, in which case consideration shall be given for the use of "Fixed" force-offs.

The "Shortway" method of transitioning into coordinated operations (e.g., adding or subtracting time to Phase Splits, depending on which is faster) shall be called for during coordination operations unless the Designer determines that another method is more appropriate.

Where signal coordination is determined to be appropriate for implementation on a Project, the traffic signal plan shall include a table summarizing all of the coordination parameters proposed by the Designer. An example Coordination Parameters Table is shown in Figure 6-5.

Figure 6-5. Example Signal Coordination Parameters Table

COORDINATION PARAMETERS

PLAN NO.	CYCLE LENGTH (SEC.)	OFFSET (SEC.)	SPLIT TIMES (SEC.) Ø 1	Ø 2	Ø 4	Ø 5	Ø 6	Ø 8	TIME-OF-DAY/WEEK/YEAR
PLAN 1	105	22	16	34*	20	16	34*	35	MONDAY - FRIDAY, 07:00 - 09:00
PLAN 2	90	30	12	25*	28	15	22*	25	MONDAY - FRIDAY, 11:30 - 14:30
PLAN 3	110	19	18	35*	36	19	34*	21	MONDAY - FRIDAY, 14:30 - 18:30
PLAN 4	SIGNAL SHALL RUN FREE**								SATURDAY - SUNDAY, 10:00 - 14:00
PLAN 5	SIGNAL SHALL RUN FREE**								SATURDAY - SUNDAY, 14:00 - 20:00
FREE			N/A (MAX 1 GREEN TIMES IN EFFECT)						ALL OTHER

* = COORDINATED PHASE

** = PLAN NO. AND TIME-OF-DAY/WEEK/YEAR PARAMETERS SHOWN SHALL BE PROGRAMMED AS PLACEHOLDERS ONLY

NOTES:

1. SPLIT TIMES SHOWN EQUAL GREEN PLUS YELLOW CHANGE AND RED CLEARANCE INTERVALS.
2. OFFSETS ARE REFERENCED TO THE BEGINNING OF THE 1st COORDINATED PHASE YELLOW AT THE "MASTER" INTERSECTION (SMITH ST. @ FIFTH AVE.)
3. THE FOLLOWING SHALL BE IN EFFECT DURING COORDINATED OPERATIONS:
   A. "CALL NON-ACTUATED" COORDINATED PHASES
   B. "INHIBIT MAX" TERMINATION
   C. "FLOATING" FORCE-OFFS
   D. "SHORTWAY" TRANSITION METHOD
   E. "REST-IN-WALK" MODE FOR PEDESTRIAN SIGNALS ASSOCIATED WITH THE COORDINATED PHASES

There are several proprietary systems and software available that can manage, control, and/or coordinate traffic signals, either on-the-street or remotely. RIDOT has not yet standardized use of any one system but does use several in varying capacities. If the Project scope from the RIDOT Office of Safety or Office of Scoping and Compliance, nor any other RIDOT-issued policy or guidance, does not clearly indicate that integration into and/or use of a particular traffic signal management/control software or system is required as part of the Designer's work and ultimate design deliverables associated with a RIDOT traffic signal, the Designer shall contact the RIDOT Project Manager (where applicable), the RIDOT Office of Safety, the RIDOT Office of Scoping and Compliance and the RIDOT Transportation Management Center (RIDOT TMC) at the earliest opportunity to request a meeting to discuss and jointly agree to the appropriate course of action regarding signal system integration on the Project. The RIDOT TMC can offer suggestions to the Designer regarding the design of and standards for signal system communication and networking if needed.

6.3.15 Advanced Signal Systems

Most traffic signal controllers are furnished with some capability of adapting signal timings in real- or near-to-real-time based on detection inputs, and other proprietary adaptive traffic signal control systems (typically add-on and separate from the signal controller). The RIDOT Office of Safety will consider their use if the Designer is able to justify why the added functionality is beneficial to intersection traffic operations. At minimum, the use of no-added-cost 'Dynamic Max' controller settings on/for signal phases that suffer from large surges/spikes in demand should be considered and called for where warranted. For separate add-on adaptive systems, systems with an algorithm that does not set restrictions on similar cycle lengths for all signals in the system (e.g., the cycle lengths need not be identical or a fraction thereof) should be considered.

6.4 Vehicle Signal Heads and Displays

6.4.1 Mounting and Orientation

Vehicular traffic control signal heads shall be called out to be mounted overhead for greatest visibility to road users. Pedestal-mounted vehicular signal heads shall only be considered where site conditions restrict overhead mounting or as supplemental signal heads.

Mounting vehicular traffic signal heads overhead on mast arms that are placed at the far (downstream) and right side of each intersection approach is preferred, but in some cases, exceptions maybe made (see **Section 6.9.1.1** for details). All vehicular signal heads on mast arms shall be rigidly mounted, not free-swinging. Vehicular signal heads are preferred to be mounted on mast arms in a "1-way" only configuration because 2- or 3-way heads on mast arms can lead to installation, orientation, and/or maintenance difficulties and/or issues for RIDOT.

MUTCD Sections 4E.03-4E.05

Individual signal indications in any single vehicular traffic signal head shall be called out to be arranged vertically unless a horizontal arrangement of indications is deemed to be necessary based on site conditions or is otherwise required by the *MUTCD* (e.g., for a hybrid beacon).

When protected/permissive left turn phasing is approved by the RIDOT Office of Safety (see **Section 6.3.11**), the Designer should consider whether a shared or separate signal face(s) is best suited for the site, but in all cases the signal faces/displays proposed must be compliant with the *MUTCD*.

For a shared left-turn/through lane where a shared vehicular signal face is proposed to be used for a protected/permissive left turn, a four-section signal head with a dual-indication Yellow/Green arrow in the bottom section shall be called for and used (five-section "dog house" configurations shall not be used).

For a shared left-turn/through lane where a separate vehicular signal face is proposed to be used for a protected/permissive left turn, a four-section signal head with solid and flashing yellow arrow indications in the second and third sections, respectively, shall be called for and used.

For exclusive left-turn lanes, a four-section signal head with red, solid yellow, flashing yellow and green turn arrows shall be used for protected/permissive left turns.

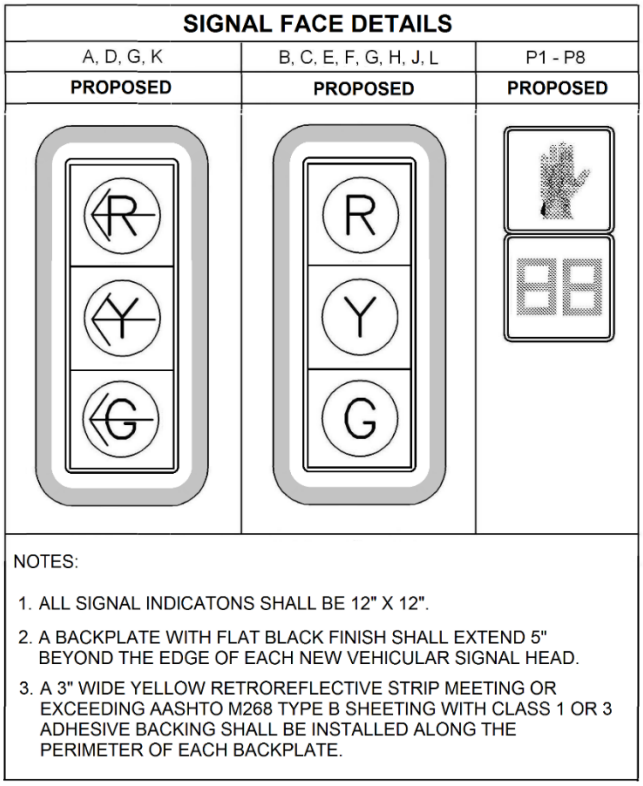
6.4.2 Backplates

Backplates shall be called out for installation on all proposed vehicular traffic signal heads, except where compliance with structural standards cannot be verified. For any signal where new signal poles are proposed, backplates shall be called for. Backplates should be five (5) inches wide with a flat black finish and include a three (3) inch wide yellow retroreflective strip of material installed along the entire perimeter of the backplate, as shown in Figure 6-6.

6.4.3 Plan Callouts and Details

Traffic signal plans shall show the location of all existing and proposed vehicular signal heads in plan view. All proposed and existing-to-remain vehicular signal heads shall be assigned a letter code (A, B, C, etc.) to assist the plan reader and for easy reference purposes.

All traffic signal plans shall include a graphic that shows the required layout of signal indications for each different traffic signal face that is proposed, as well as for each signal face that is existing-to-remain (if any). This detail shall show proposed signal head backplates with retroreflective strips and include a note(s) to specify backplate requirements. An example of a traffic signal face detail is shown in Figure 6-6. Note that where a signal head/face is existing-to-remain, it shall be assigned a letter code but shall be shown in gray scale in the detail and elsewhere on the plans.



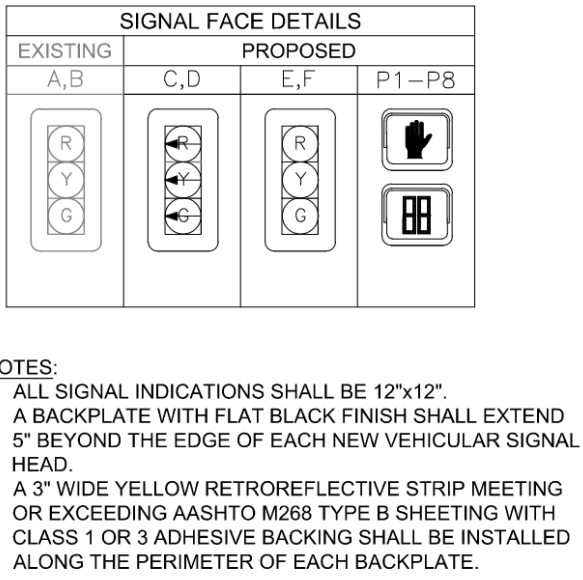


Figure 6-6. Example Signal Face Detail for a Traffic Signal Plan

See **Section 6.9** for additional requirements regarding details showing the proposed spacing of signal heads on traffic signal plans.

6.5 Pedestrian Signals and Detectors (Pushbuttons)

6.5.1 General Warrants

Unless excepted below, pedestrian signals and pushbuttons shall be called for at each pedestrian crossing/movement at:

- all proposed new traffic control signals (including existing traffic control signals that are proposed to be entirely replaced), and
- other existing traffic control signals where the Project scope includes pedestrian accommodations (e.g., curb ramp and sidewalk improvements, marked crosswalks) and/or improvements to traffic signal structures (e.g., a signal pole is being replaced), in accordance with currently applicable accessibility requirements (*Public Right-of-Way Accessibility Requirements (PROWAG)*).

Exceptions to the above include:

- Specific crossings/movements that pedestrians will not be permitted to make or use, or
- When an engineering study shows that pedestrian signalization is not otherwise warranted for a specific crossing/movement (e.g., channelized right-turn lanes, etc.).

6.5.2 Pedestrian Signal Heads and Displays

MUTCD Sections 4I.01-4I.04

All proposed pedestrian signal heads shall include both walking person and upraised hand symbols and a countdown display that conforms with the *MUTCD*.

Unless deemed necessary to match with other existing pedestrian signals in the area or otherwise directed by the RIDOT Office of Safety, the walking person and upraised hand symbols shall be called out for display in the top section of a two-section pedestrian signal head, with the countdown display in the bottom section.

6.5.3 Pedestrian Pushbuttons

MUTCD Section 4I.05

PROWAG R307

Proposed pedestrian pushbuttons (detectors) at RIDOT traffic signals shall comply with the guidance in the *MUTCD* and PROWAG requirements.

In designing the location of new pedestrian pushbuttons, the Designer shall conform to the recommendations included in the *MUTCD*. Extenders for lateral reach should be considered to ensure the necessary pedestrian side reach is achieved. “Stub” poles should be considered and called for if needed and feasible to ensure that the *MUTCD*-recommended minimum separation between pushbuttons will be achieved and/or when pedestal mounted or mast arm

mounted pedestrian pushbuttons would not conform to the maximum distances from curb line and/or crosswalk.

6.5.3.1 Accessible Pedestrian Signal

HDM Section 4K

Proposed pedestrian pushbuttons (detectors) at RIDOT traffic signals shall comply with the RIDOT *Accessible Pedestrian Signal (APS) Implementation Policy*[21]. Designers shall refer to the *MUTCD* for further clarification regarding the need for APS pushbutton installation due to maintenance activities, alterations, and new construction. APS pushbuttons must include both audible and vibrotactile functions.

6.5.4 Plan Callouts and Details

Traffic signal plans shall show the location of all existing and proposed pedestrian signal heads and detectors in plan view. All proposed and existing-to-remain pedestrian signal heads shall be assigned a "PX" code (e.g., "P1", "P2", "P3", etc.) for easy reference purposes. Each pedestrian detector pushbutton shall be shown as a small circle shaded in 2 quadrants with small solid black arrow adjacent to the mounting pole (shown in Figure 6-1) that clearly shows the pushbutton is to be installed in-line with the associated crosswalk (the arrow shall be aligned with the intended vibrotactile arrow orientation at each pushbutton).

MUTCD Section 4I.02

The graphic showing the required display for each different traffic signal face (described in **Section 6.4.3**) shall include graphics for any proposed and/or existing pedestrian signal faces. For proposed pedestrian signal faces, the graphic shall show the walking person and upraised hand symbols as "filled-in" (as opposed to outlined-only) for compliance with the *MUTCD*. Figure 6-6 shows an example graphic.

Where accessible pedestrian pushbuttons are called for, the Designer shall follow the guidance presented in the *MUTCD* and adhere to the following:

- For exclusive pedestrian phasing:
  - A percussive tone shall be provided during LPI (if applicable) and WALK intervals.

[21] http://www.dot.ri.gov/documents/community/safety/Accessible_Ped_Signal_Install_Policy.pdf

- The Designer should consider whether additional speech messages (such as “Walk sign is on for all crossings”) are appropriate based on the adjacent land use(s).

- For concurrent pedestrian phasing:
  - A percussive tone shall be provided where two accessible pedestrian signals on the same corner are separated by a distance of at least 10 feet.
  - Speech walk messages consisting of ““XX Street. Walk Sign is on to cross XX Street” shall be used where two accessible pedestrian signals at one corner are separated by a distance of less than 10 feet or are on the same pole to alert pedestrians of the roadway they are crossing.

Designers shall check for current pedestrian pushbutton guidance and policy from the *MUTCD*, the FHWA, and/or US Access Board. A table (or notes) shall be included on the signal plan to specify the audible and programmable activation confirmation message and WALK indication that is specific to each pedestrian detector. An example of such a table is shown in Figure 6-7.

Figure 6-7. Example Accessible Pedestrian Detector (APD) Table

ACCESSIBLE PEDESTRIAN DETECTOR (APD) AUDIBLE INDICATIONS [1]					
APD NO.	AUDIBLE ACTIVATION CONFIRMATION		AUDIBLE WALK INDICATION		
	TYPE	MESSAGE	TYPE[5]	DETAILS	DURATION
P1	Rapid-Tick Percussive Tone	Eight (8) to ten (10) ticks per sec.	Rapid-Tick Percussive Tone	Eight (8) to ten (10) ticks per sec.	Equal to Duration of Walk Signal Display [2]
P2	Speech Message	"Wait."	Speech Message	"Walk Sign is on for all crossings."	Equal to Duration of Walk Signal Display [3]
P3	Speech Message	"Wait. Wait to Cross Lincoln Street at Jefferson Avenue."	Speech Message	"Lincoln Street. Walk sign is on to cross Lincoln Street."	One (1) Reading of the Message [4]

Notes:

1. See RIDOT *Standard Specifications for Road and Bridge Construction* for locator tone and additional requirements.
2. If "Rest-In-Walk" mode of operation is active, the duration shall only be equal to seven (7) seconds, and afterwards, the audible walk indication shall sound again when the APD button is pressed during the walk interval if the crossing time remaining is greater than the pedestrian change interval duration.
3. Speech message coincides with exclusive pedestrian phase.
4. For concurrent pedestrian phasing, where two accessible pedestrian signals on one corner, or in a median, that are associated with different phases are placed less than 10 feet apart, the audible walk indication shall be a speech walk message.
5. Consider adjacent land uses regarding the volume of the percussive tone/speech messages. Volume may need adjusting after installation.

6.6 Vehicle Detectors

6.6.1 Detector Types and Selection/Applicability

Technology for presence-mode detection of motor vehicles (including bicycles) on an approach to a traffic signal shall be either video image processor-based or inductive wire loops embedded in the surface course of pavement unless otherwise directed or permitted by the RIDOT Office of Safety.

Video detection shall be the Designer's first consideration for use in the following locations:

- areas with frequent or significant pavement disturbance
- areas with frequent or routine bicycle demand
- privately-owned intersection approach or where installation of wire loops is problematic (e.g., concrete bridge decks)

In other areas not listed above, embedded wire loop detection shall receive primary consideration for use, unless the added functionality provided by video detection is required by the RIDOT Office of Safety (see **Section 6.6.2.1** below). Loop detectors are also recommended for use where video detection cannot or should not be implemented due to site-specific issues or constraints (e.g., where vehicle occlusion or other environmental issue is expected to reduce the accuracy or effectiveness of video cameras).

The mixing of different types of detection technology at any one intersection should be avoided.

6.6.2 Design Considerations and Layout

Fully actuated traffic signal operation (with traffic detection on each roadway approach to an intersection) is preferred by the RIDOT Office of Safety. Partially actuated operation (e.g., with detection on side streets and/or turn lanes only) should be avoided unless otherwise directed by the RIDOT Office of Safety.

6.6.2.1 Video Detection

Upon request, the RIDOT Office of Safety can provide example specifications for video detection.

The first consideration for type of presence-mode video detection at a traffic signal shall be for a single 360-degree-view camera that can detect and place controller calls for all vehicular traffic (including bicyclists) on all intersection approaches.

Where a single camera solution is determined to be infeasible (e.g., due to view obstructions at an intersection) or not cost-effective, other types of video detection should also be considered. Such other types include video detection systems that require one video camera per intersection approach. For intersection approaches that experience sun glare or are otherwise poorly illuminated, video detectors that use integrated thermal or radar sensors may also be considered.

If the Designer determines per **Section 6.6.1** that video detection is appropriate on a Project, but RIDOT has not yet indicated the specific functional requirements for a 360-degree-view camera detection system, the Designer shall reach out to the RIDOT Project Manager (where applicable), the RIDOT Office of Safety, and the RIDOT TMC to determine the appropriate course of action regarding video detection functional requirements for the Project, including any traffic counting and/or remote monitoring system coordination/integration that may be required or desired by the RIDOT Office of Safety.

Video detection zones for traffic signal control applications shall be of such size to provide at least the same area of coverage as provided by traditional RIDOT loop detectors at traffic signals; e.g., detection zones six (6) feet wide by forty (40) feet long, with the zone centered within the travel lane and with the trailing (downstream) end of the loop positioned five (5) feet beyond the stop line. However, the size and/or shape of the video detection zones may vary based on site conditions or constraints (e.g., where a roadway throat widens on an approach to an intersection, an expanded detection zone(s) may be warranted to account for turning traffic). The number and/or layout of detection zones for a video-based detection system may also vary if needed to accommodate a particular function or feature of the detection system (e.g., separate detection zones for traffic counting purposes).

Each video detection camera shall be called for mounting at a location that will provide an unobstructed line of sight to the desired detection zones, and for best conformance with video detection system manufacturer requirements and guidelines.

6.6.2.2 Inductive Wire Loop Detection

Inductive wire loop detectors shall only be called out for embedded installation in pavements that are in excellent, good, or fair condition. Pavements that are in poor or failed condition shall be resurfaced or reconstructed prior to installing new wire loops.

The embedded wire loop layout for traffic signal control detectors shall be six (6) feet wide by forty (40) feet long, with the loop centered within the travel lane and with the trailing (downstream) end of the loop positioned five (5) feet beyond the stop line. These parameters will apply in situations where only motor vehicles need to be detected at the stop line (such as at the terminus of a freeway off-ramp) and/or will be placed in a travel lane for a movement that will always be served every signal cycle (e.g., for an arterial mainline signal phase with vehicle recall set to minimum).

However, other loop layout, dimensions, and positioning should be considered where the specific site conditions of the approach and/or travel lanes warrant.

The embedded wire loop layout for traffic signal control detectors at locations other than those described in the preceding paragraph shall be proposed in a way that permits all types of vehicles, including bicycles and motorcycles, to be detected by the traffic signal controller. Unless otherwise directed or permitted by the RIDOT Office of Safety, a quadrupole-loop configuration design shall be used in such locations in place of RIDOT's traditional wire loop design/layout described in the preceding paragraph. This is to ensure that a bicycle or similar vehicle waiting at the stop line can place a call into the signal controller. The Designer shall include a detail and notes on the Plans to stipulate the layout and construction requirements for the quadrupole loop detector(s). Such quadrupole detectors that are to be placed in a lane shared by motorists and bicyclists shall follow the Type C Loop Detector Configuration design shown on California Department of Transportation *Standard Plan RSP ES-5B* approved 10/19/2018[22], with length equal to forty (40) feet (unless a shorter length is needed to fit the site conditions) as shown below in Figure 6-8.

[22] https://dot.ca.gov/programs/design/ccs-standard-plans-and-standard-specifications

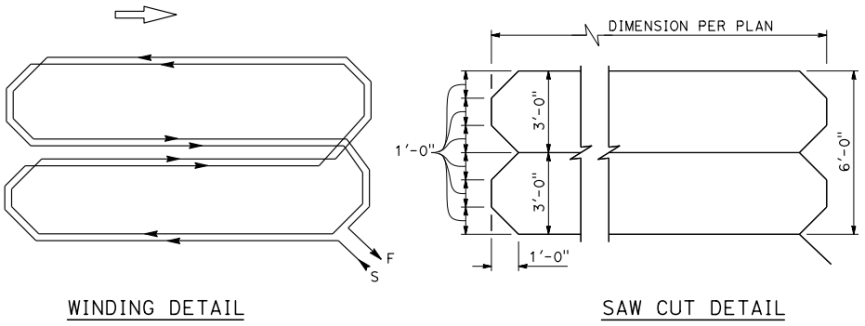


Figure 6-8. Type C Loop Detector Configuration

Note that where such a quadrupole loop takes the place of a traditional RIDOT 6' x 40' wire loop, adjustments to passage time calculations may be needed. The lateral and trailing end positioning of a quadrupole loop in a travel lane shall be consistent with the guidance described in the preceding paragraph unless other positioning is appropriate for the specific site conditions of the approach and/or travel lanes. For additional guidance regarding wire loop detection design for bicycles, refer to the latest FHWA *Traffic Detector Handbook*.

FHWA Chapters 2 & 4

6.6.2.3 Exclusive Bicycle Lane Detection

Loop detectors for exclusive bicycle lanes shall consist of 6'x6' quadrupole loop. Traffic signal detectors shall always be oriented to detect bicyclists on all roads except limited-access highways for either above-ground or in-ground installation.

6.6.2.4 Other Considerations

Wherever wire loop detectors are called out for installation at a traffic signal to ensure bicycles will be detected, a Bicycle Signal Actuation sign along with a Bicycle Detector Pavement Marking shall also be called for installation to show cyclists where they should position themselves in order to place a detector call into the signal controller. Refer to **Section 3.11** and **Section 4.11** for additional details and guidelines.

If a wire loop or other type of physical and intrusive vehicle detector is proposed outside of the public right-of-way (e.g., on a privately-owned intersection approach), either as part of a highway/ intersection improvement Project or as part of a PAP issued by RIDOT for alterations to a state highway, a Permanent Easement will be required. This type of agreement is executed to provide the RIDOT with the right to enter onto the private property to maintain, repair or replace the loop detector(s).

RIDOT HDM Chapter 12

The Designer shall refer to the RIDOT *Highway Design Manual* for the latest procedures for Right-of-Way submission requirements.

Delay times for vehicle detectors set in presence mode at traffic signals shall conform to Table 6-6 unless field observations warrant otherwise. Delay times for minor/side street approach detectors shall be selected with the goal of minimizing overall signal control delay to all traffic at the intersection.

Table 6-6. Presence-Mode Vehicle Detector Delays

Vehicle Detector Location		Typical Delay Time (seconds)
Approach Type	**Specific Location / Movement**	
Major/Main Street	Through Lane	3
	Left or Right Turn Lane (Dedicated or Shared)	3
Minor/Side Street	Through or Left Turn Lane (Dedicated or Shared)	3 to 5
	Right Turn Movement[1]	5 to 10

Notes:
1. Where right turns on red are prohibited, lesser delay times shall be considered.

Higher-speed approaches to traffic signals may warrant additional vehicle detection upstream of the intersection to supplement stop line detection in order to mitigate risks associated with the "dilemma" zone. Designers shall refer to FHWA's *Traffic Detector Handbook* for additional information.

FHWA Chapter 4

6.6.3 Plan Callouts and Tables

Each traffic signal plan shall include a Detector Data Table that stipulates the number, size of detection footprint or zone, call phase, relay number and slot (if applicable), delay time, and any other remarks or notes that are necessary to stipulate programmable features to the Contractor (e.g., when a detector is to call and extend different phases) for each vehicle detector at the intersection.

An example Detector Data Table is shown in Figure 6-9. If there are any existing-to-remain detectors, such shall be included and shown in gray scale in the table. Refer to the "*Loop Detector Numbering Scheme for TS-2 Controllers*" guidance included in Appendix C for guidelines applicable to inductive wire loops. When video detection is used, exceptions can and should be made to the above if/where necessary given the features of the technology.

DETECTOR DATA						
DETECTOR NO.	NO. SECTION/ SIZE	RELAY NUMBER	SLOT	DELAY (SEC)	CALL PHASE	REMARKS
1	1–6'x40'	1	2	3	ø1	PROPOSED
2	1–6'x40'	1	2	3	ø6	PROPOSED
3	1–6'x40'	1	2	3	ø6	PROPOSED
5	1–6'x40'	2	4	3	ø5	PROPOSED
6	1–6'x40'	2	4	3	ø2	PROPOSED
7	1–6'x40'	2	4	3	ø2	PROPOSED
9	1–6'x20'	3	6	3	ø4	PROPOSED
10	1–6'x20'	3	6	5	ø4	PROPOSED
11	1–6'x20'	3	6	5	ø4	PROPOSED

Figure 6-9. Example Vehicle Detector Data Table

NEMA TS2 Spec. Table 5-10

Where inductive loop detectors are being utilized, the detector numbering and assignment should conform to National Electric Manufacturers Association (NEMA) TS2 specifications.

6.7 Signal Wire and Cable

6.7.1 Wire and Cable Types

Wiring for most RIDOT traffic signals and equipment will consist of the appropriate number of copper conductors with insulation rated at 600 volts for compliance with the International Municipal Signal Association (IMSA) Specifications referenced by the RIDOT *Standard Specifications for Road and Bridge Construction*. The appropriate number of conductors for traffic signal equipment shall be determined by accounting for one (1) conductor per output (e.g., per signal indication) plus one (1) ground wire and one (1) spare wire. For example, a three-section vehicle signal head would utilize one conductor for each of the three signal indications (red, yellow, and green) plus one conductor for the ground and another conductor as a spare; therefore, a five (5) conductor cable shall be used for a three-section signal head. Table 6-7 lists typical wire and cable types for signal heads and other types of traffic signal equipment that are often called for on RIDOT construction Projects.

Table 6-7. Typical Wire/Cable Types for RIDOT Traffic Signals

Traffic Signal Equipment or Component	Cable Type[1]
1-Way 1-Section Signal Head	3 Conductor #14 AWG
1-Way 3-Section Signal Head	5 Conductor #14 AWG
1-Way 4- or 5-Section Signal Head	7 Conductor #14 AWG
2-Way 3-Section Signal Head	9 Conductor #14 AWG
3-Way 3-Section signal Head	12 Conductor #14 AWG
1 Way Pedestrian Signal Head	5 Conductor #14 AWG[2]
2-Way Pedestrian Signal Head	7 Conductor #14 AWG[2]
Pedestrian Push Button Detector	3 Conductor #14 AWG[3]
Inductive Loop Detector Lead-In[4] Cable	2 Conductor Twisted Shielded #14 AWG
Electrical Service Connection	1 (Single) Conductor #6 AWG[5]
Preemption and Priority Devices	Manufacturer-Dependent[6]
Preemption Confirmation Beacon	Manufacturer-Dependent[6]
Video-Based Detectors	Manufacturer-Dependent[7]

Notes:

1. AWG = American Wire Gauge
2. Assumes a two-section pedestrian head, with walking person/upraised hand symbols in the top section and countdown display in the bottom section.

3. The cable listed is to be used between the traffic signal cabinet and each pedestrian pushbutton; if additional wiring is needed between the pushbutton and a control unit in the pedestrian signal head, it shall be included in the pushbutton pay item (and therefore not shown separately on the traffic signal plan).
4. The "Lead-In" is the cable between the traffic signal cabinet and each loop detector splice handhole, with one cable needed for each wire loop.
5. For compliance with latest RIDOT and *National Electrical Code* requirements, the traffic signal plan shall call for three (3) of these cables for each connection between the traffic signal cabinet and the power source.
6. The Designer should research the latest available technologies and consult with the RIDOT Office of Safety and the applicable emergency and/or transit agency during the design process to determine appropriate requirements to stipulate as part of the Project specifications.
7. Although many of the latest products use a ruggedized grade of Category 5 cable between the camera and cabinet, the Designer should check the latest RIDOT-approved specifications for video detection and propose appropriate requirements as part of the Project specifications.

For the interconnection of traffic signals, the type of cable (or wireless means, which should be considered alongside traditional wired options) to specify or use will vary and depend on the needs of the specific interconnected system as well as the location of the Project.

With fiber optic systems, RIDOT prefers use of a 12- or 36- strand single-mode fiber optic cable meeting applicable IMSA standards for interconnection. In cases where existing fiber optic lines are installed at/near the Project site, a formal agreement is required to be executed with the fiber owner if other than RIDOT (e.g., the *OSHEAN Beacon 2.0 Network*[23] in Rhode Island).

In cases where an interconnection using traditional copper cable is deemed appropriate (e.g., retrofits or repairs to existing copper systems), a 6-Pair #19 AWG twisted shielded communication cable rated for 300 volts is preferred.

6.7.2 Quantity Estimation

Wire and cable quantity estimates shall account for and be consistent with the guidelines shown in Table 6-8.

[23] See https://oshean.org/services/network-services/ for more information.

Table 6-8. Guidelines for Traffic Signal Wire and Cable Quantity Take-Offs

Traffic Signal Equipment or Structure	"Rule of Thumb" Guidance for Quantity Estimation	Derivation/Assumptions and Notes
Mast Arm Poles	Use 30' for quantity up/down each mast arm pole	20' mast arm pole height + 5' bends on top and bottom
Span Poles	Use 35' for quantity up/down each span pole	25' span pole height + 5' bends on top and bottom
Span and Tether Wires	Assume 10% sag over length of wire	
Vehicle and Pedestrian Signal Heads	Include 5' additional quantity inside each signal head (only where the wire terminates at the signal head)	Do not include additional 5' for wire running "through" a signal head
	Use 15' for quantity up each pole/pedestal	10' mounting height + 5' bend on bottom
	Use 15' for quantity down each mast arm pole	20' mast arm pole height - 10' mounting height + 5' bend on top
	Use 20' for quantity down each span pole	25' pole height - 10' mounting height + 5' bend on top
Pedestrian Push Buttons	Use 10' for quantity up each pole/pedestal	5' mounting height + 5' bend on bottom
	Use 20' for quantity down each mast arm pole	20' mast arm pole height - 5' mounting height + 5' bend on top
	Use 25' for quantity down each span pole	25' span pole height - 5' mounting height + 5' bend on top
Loop Detectors	Include quantity based on entire length of saw cuts	RIDOT *Standard Specifications for Road and Bridge Construction*
Handholes	Include 10' additional quantity for each copper wire inside each handhole	To account for bends + 5' of slack per RIDOT *Standard Specifications for Road and Bridge Construction*
Cabinets	Include 10' additional quantity for each copper wire inside the cabinet	To provide sufficient slack

6.8 Traffic Signal Conduit, Handholes, and Manholes

6.8.1 Conduit Types and Use

6.8.1.1 General Traffic Signal Wire Conduit

All traffic signal designs must include conduit between fixed objects and their associated nearest handhole. All conduits that are proposed to carry copper wiring shall be installed per Table 6-9.

Table 6-9. Guidelines for General Traffic Signal Wire Conduit

2-Inch RSC	Between a handhole and pedestal poles.
3-Inch RSC	Between a handhole and a traffic signal-related foundation (e.g., foundations for controller cabinets, mast arm poles and span poles.
3-Inch PVC (Schedule 40)	Between two handholes (not traversed by motor vehicles) and for inductive loop detector wiring.
3-Inch PVC (Schedule 80)	Between two handholes (traversed by motor vehicles) and for inductive loop detector wiring (e.g., under all roadway pavement, driveways, parking lots and even roadside and sidewalk areas where large turning vehicles may encroach into).

Notes:

PVC = Polyvinyl Chloride

RSC = Rigid Steel Conduit

Wherever PVC conduit is proposed to carry traffic signal wire, one (1) single conductor #6 AWG cable rated for 600 Volts shall be included (called out on the traffic signal plan) to allow the Contractor to properly ground each conduit run at handholes/manholes.

6.8.1.2 Conduit for Detection

If conduit must be used for other types of detection, such conduit shall meet or exceed the requirements (or if none, the recommendations) of the detection equipment manufacturer.

6.8.1.3 Service Connection Conduit and Internet Service Provider /Communication Cable Conduit (From/To Power Source)

Conduit proposed for service connections for a traffic signal, an Internet Service Provider (ISP) or other underground communication power service connections shall be 2-inch RSC from the controller cabinet meter socket/traffic signal controller cabinet foundation to the electric or ISP/communication service provider's handhole or utility pole, unless otherwise directed by the service provider. If the power or ISP/communication source is above ground, the conduit should continue

as 2-inch RSC up the respective utility pole for a length of 10 feet. The remaining segment of conduit up the utility pole shall be 2-inch PVC (schedule 40) conduit.

6.8.1.4 Traffic Signal Interconnect Conduit

Conduit proposed for a fiber optic signal interconnection shall be dual 1¼-inch High Density Polyethylene (HDPE) conduit for the main/trunk line (back bone) cable and a single 1¼-inch HDPE conduit for the tap cables, unless otherwise directed by the RIDOT Office of Safety or the requirements of the interconnect system dictate otherwise.

Conduit proposed for a traditional copper wire interconnection shall be 3-inch PVC conduit, with the Schedule of such PVC Conduit in accordance with the guidelines included in **Section 6.8.1.1** .

6.8.2 Electrical Conduit Fill

The Designer shall check that all proposed wiring and cabling will comply with the conduit fill requirements included in the latest National Fire Protection Association (NFPA) *National Electrical Code (NEC)*. The *NEC* stipulates the maximum allowable percentage of the cross-section (area) of conduit that may be filled by wire/cable.

6.8.3 Plan Callouts and Details

Traffic signal plans shall show the location of all existing and proposed conduit runs, handholes, and manholes that are associated with the traffic signal. The Designer shall only propose conduit, handholes, and other signal items requiring earth excavation after completing an appropriate subsurface investigation (see **Section 6.13.3** for guidance).

6.8.3.1 Special Requirement for Roundabouts

Unless approved otherwise by the RIDOT Office of Safety, underneath/across all multi-lane approaches to and multi-lane departure lanes from a proposed roundabout, the Designer shall design and call for an ample number of conduits and handholes to be installed and reserved for the future use of a RRFB/PHB installation.

6.9 Traffic Signal Structures and Controller Cabinets

6.9.1 General Design Considerations

6.9.1.1 Mast Arms, Span Poles, and Pedestals

For structural design requirements for traffic signal structures not otherwise specified herein or in the RIDOT *Standard Details*, refer to the *Rhode Island Bridge Design Manual*.

MUTCD Chapter 4

Signal structures from which vehicular traffic control signal heads will be mounted shall be proposed with the primary goal of maximizing visibility of the signal heads to the appropriate road users, all in conformance with the *MUTCD*. Therefore, the ideal signal structure will call for such heads to be mounted overhead, and pedestal-mounted vehicular signal heads shall only be considered where site conditions restrict overhead mounting (e.g., an overhead utility conflict).

Because traffic signal poles with mast arms allow for rigid overhead signal head mounting at uniform heights, mast arms shall be the first consideration for overhead mounting of traffic signal heads. However, where it is deemed to be impractical or not cost-effective to use a mast arm due to site conditions (e.g., at a wide intersection where the required mast arm lengths would exceed 50 feet), span poles may also be considered.

For most locations where roadways intersect at or near 90-degrees, the RIDOT preferred new mast arm installation location and orientation shall be at the far (downstream) side of the intersection approach, on the right side of the road, and at a 90-degree angle (perpendicular) to approach traffic. However other mast arm placements and orientations should be considered and may be necessary if the Designer finds that site conditions render the default design impractical or not cost-effective. Installation of mast arms diagonal to traffic should be avoided.

If overhead utilities exist near a proposed new signal structure, the Designer shall ensure that the proposed design will allow for Contractor compliance with the latest Institute of Electrical and Electronics Engineers (IEEE) *National Electrical Safety Code* (NESC) and Occupational Safety and Health Administration (OSHA) requirements for clearances from utilities. The Designer shall locate and identify the horizontal and vertical locations of all potentially conflicting overhead utilities during the design process and use that information in deciding upon the desired placement and orientation of the new structure as shown in Figure 6-10.

6.9.1.2 Controller Cabinets

Traffic signal controller cabinets shall ideally be located such that neither the cabinet/foundation nor the swing path of its open door will encroach into a pedestrian travel path(s), and in a location that seeks to both:

- minimize the risk of the cabinet being impacted by an errant vehicle, and
- maximize the signal technician's view of both:
  - traffic approaching and passing through the intersection and
  - the traffic signal face displays while standing at the open cabinet door.

Where feasible, cabinets shall be oriented such that the external air filter(s), located on the door(s), are least exposed to snow and water throws from passing plows and traffic. Technicians accessing a RIDOT signal cabinet should never have to encroach onto private property unless a real estate agreement is in place.

6.9.1.3 Accessibility Considerations

Where a proposed traffic signal structure or controller cabinet is adjacent to or within a sidewalk or other area where pedestrians travel, the Designer shall ensure that the proposed design is completed in conformance with the latest accessibility regulations and guidelines published by the US Access Board and adopted by the FHWA, United States Department of Justice (US DOJ), and/or the RIDOT Office of Safety. Chapter R3 of the US Access Board's *Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way*[24] provides "best practice" clearances for Pedestrian Access Routes (PARs) around signal structures and controller cabinets.

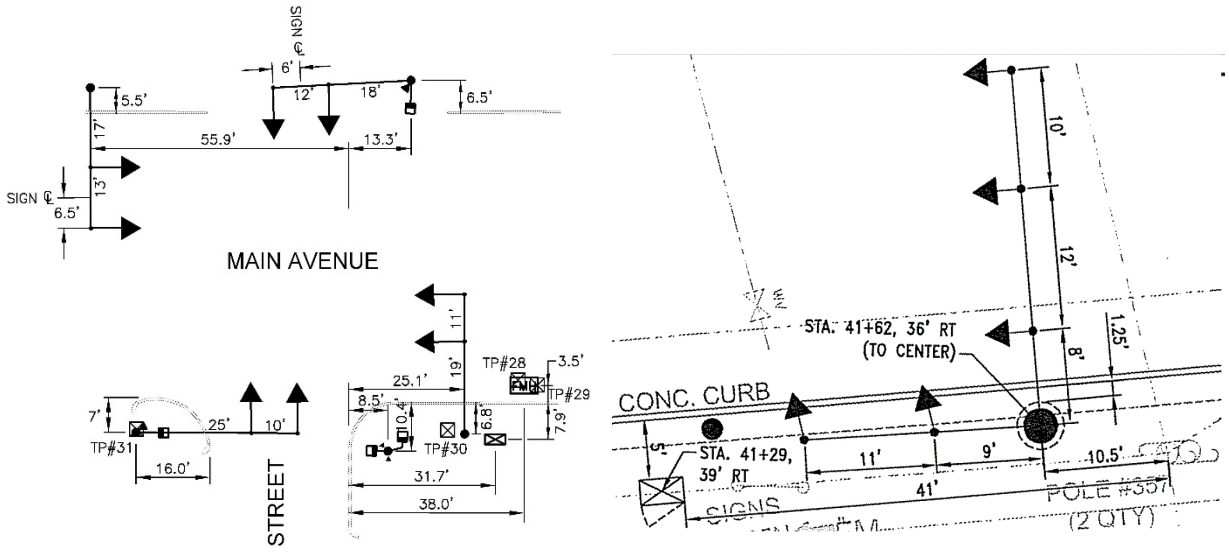
6.9.2 Plan Callouts and Details

The Designer should only finalize the layout of items requiring a structural foundation and earth excavation after completing an appropriate subsurface investigation (see **Section 6.13.3** for guidance).

[24] https://www.access-board.gov/prowag/

Traffic signal plans shall show the location and layout of all existing and proposed traffic signal mast arm structures, span poles and messenger/tether wire, pedestal poles, and controller cabinets. An outline of the expected footprint of the foundation for each of these items that are proposed adjacent to or within a sidewalk or other area where pedestrians travel shall also be shown.

At proposed controller cabinets, the swing path of the main cabinet door(s) shall be shown on the traffic signal plan. See Figure 6-10, Example B for an example of such graphics. Also, a callout requiring an 18-inch-high aluminum cabinet riser base shall be included on the traffic signal plan for all proposed ground-mounted traffic signal controller cabinets unless otherwise directed by the RIDOT Office of Safety.



Example A
(one detail used for entire intersection)

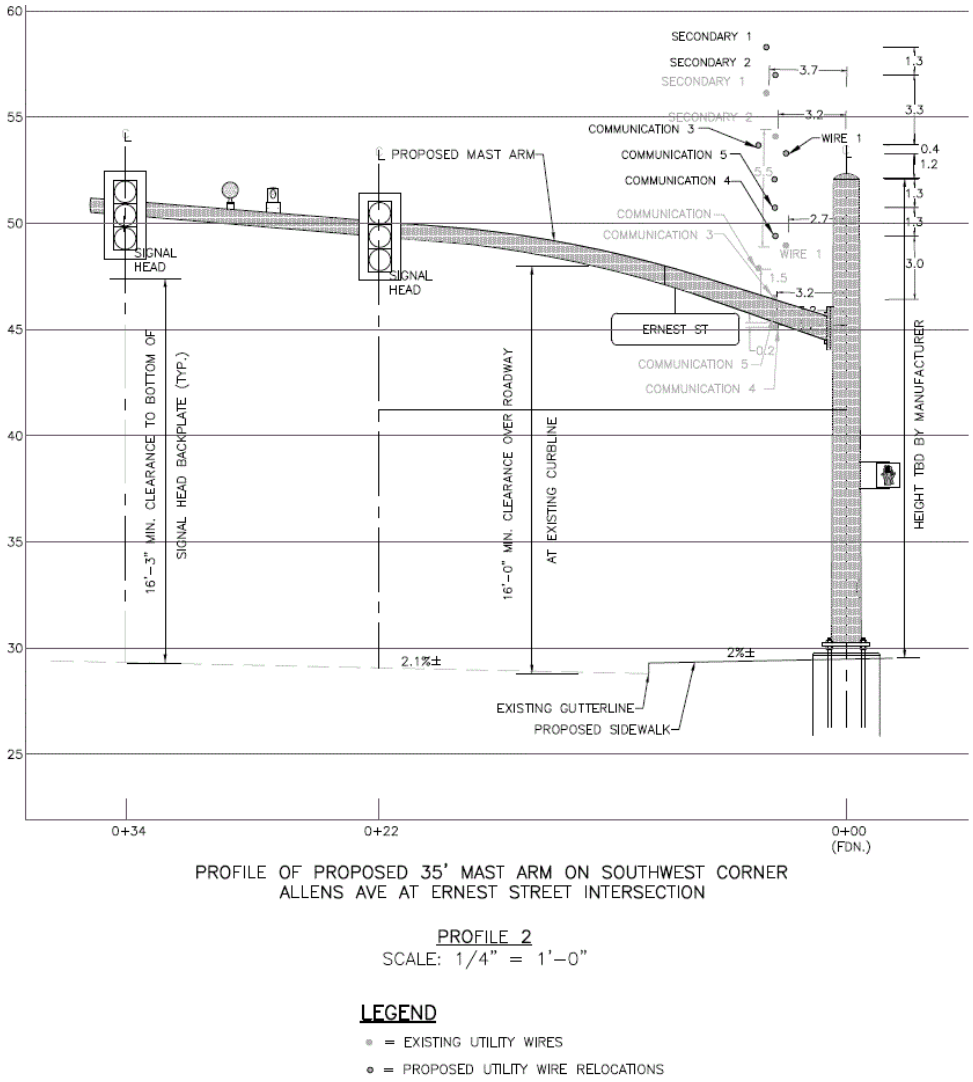
Example B
(separate detail used for each structure/corner)

Figure 6-10. Examples of Traffic Signal Pole Details

In addition to the general layout of signal structures and cabinets described above, traffic signal plans shall also include details (in plan view) showing dimensions from each proposed pole and controller cabinet to nearby fixed objects (e.g., face or back of existing curb, utility poles, etc.) in order to assist the Contractor in properly installing these items at the site. Where available and appropriate, these details may also refer to Station and Offset or latitude/longitude coordinates for each of the signal poles and cabinets to further help ensure proper placement during construction. These details shall show the required spacing between centers of the proposed vehicular signal heads, unless a separate table for such is included elsewhere on the signal plan. Two examples of details are shown in Figure 6-10.

Where overhead utilities are or will be present near a proposed signal structure and it is not clear that the minimum required NESC and OSHA clearances will be met (see **Section 6.9.1.1**), the Designer shall prepare a detail showing a profile view of the overhead utilities and any applicable dimensions from/to the proposed signal structure(s).

An example of a profile view detail is shown in Figure 6-11. Such details shall be used by the Designer during coordination with the RIDOT Office of Safety and utility company representatives to determine the best course of action for the Project. Project plans for construction shall include finalized profile view details that show the minimum or otherwise required horizontal and vertical clearances between such signal structures and overhead utilities. Where overhead utility wire relocations are necessary, the profile view details shall show such.



PROFILE OF PROPOSED 35' MAST ARM ON SOUTHWEST CORNER
ALLENS AVE AT ERNEST STREET INTERSECTION

PROFILE 2
SCALE: 1/4" = 1'-0"

LEGEND
= EXISTING UTILITY WIRES
= PROPOSED UTILITY WIRE RELOCATIONS

Figure 6-11. Example Detail Showing Clearances between Overhead Utilities and Proposed Traffic Signal Mast Arm

Wherever a traffic signal structure or cabinet is proposed adjacent to or within a sidewalk or other area where pedestrians travel, the Designer shall indicate on the traffic signal plan an appropriate minimum required dimension(s) between the edge of the structure or cabinet foundation and the opposite edge of the pedestrian facility to ensure that an accessible pedestrian access route (PAR) will be provided for pedestrians around the structure.

The PAR dimensions shall be shown on either the detail(s) or the general portion of the signal plan, whichever results in the clearest presentation. An example of a PAR dimension is shown in Figure 6-12.

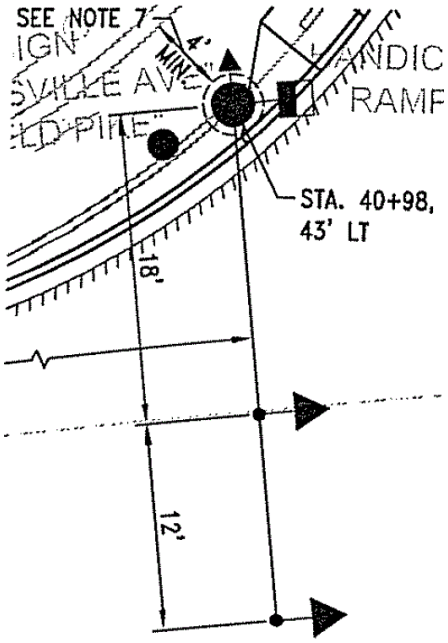


Figure 6-12. Example of a PAR Dimension on Traffic Signal Plan

6.10 Pedestrian Flashing Beacons

RIDOT's *Guidelines for Unsignalized Pedestrian Crossing Treatments*[25] (RIDOT) shall be utilized to determine recommendations for crosswalk enhancements, based on RIDOT Pedestrian Crossing Guidance.

6.10.1 General Design Considerations

A pedestrian flashing beacon provides a warning to motorists about the presence of a crosswalk. Pedestrian flashing beacons shall operate only when a pedestrian is present through either push button or passive detection. This countermeasure is for use at midblock crossings and intersections that do not warrant a signal.

6.10.1.1 Rectangular Rapid-Flashing Beacon

A Rectangular Rapid-Flashing Beacon (RRFB) may also be considered in conjunction with pedestrian crossing warning signs to enhance pedestrian conspicuity and increase driver awareness at the uncontrolled, marked crosswalk. An RRFB is yellow, rectangular, and has a rapid "wig-wag" flash similar to police lights. As there is no threshold regarding a minimum number of pedestrians crossing, installation of an RRFB is based on engineering judgment. According to FHWA, RRFBs are particularly effective at multilane crossings with speed limits less than 40 mph.

6.10.1.2 Pedestrian Hybrid Beacon/High Intensity Activated Crosswalk

PHBs (or HAWKs) are used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a midblock marked crosswalk.

MUTCD Sections 4J.01-4J.03

PHBs must be warranted based on the crossing length, roadway speeds, and pedestrian crossing volumes. The requirements for warranting of a PHB are provided in the *MUTCD*.

MUTCD Sections 4C.01-4C.10

Prior to the installation of a PHB or HAWK, a warrant analysis and study must be performed in accordance with the *MUTCD*. The device consists of three signal sections with a yellow signal head centered below two horizontally aligned red signal heads.

[25] https://www.dot.ri.gov/safety/#tra%C6%AFic_engineering

RIDOT's *Guidelines for Unsignalized Pedestrian Crossing Treatments* manual indicates that PHBs/HAWKs are reserved for high speed and/or multi-lane cross sections.

6.11 Signal Equipment to be Removed and Disposed or Salvaged

All traffic signal equipment proposed to be removed and disposed and/or salvaged shall be called out clearly on the traffic signal plan.

While typical signal items to be salvaged include controller cabinets and components, vehicular and pedestrian signal heads, and signal structures (mast arm poles and arms, span poles, pedestal poles, including any other devices that may be mounted on such structures), the approval of the RIDOT Office of Safety shall be sought before calling for such, as there may be limitations due to the funding source of the removed items and/or of the Project itself. The Designer should receive approval from the RIDOT Office of Safety before calling for signal items to be salvaged.

Where the RIDOT Office of Safety has approved of certain signal items being salvaged and a separate pay item(s) will be used for such, the traffic signal plan shall include a table to summarize such items. The table shall list a description, estimated quantity, and associated unit of measure for each of the items. The table shall be supplemented with notes to specify the salvage location (e.g., RIDOT Maintenance facility at 360 Lincoln Avenue, Warwick, RI) and specific coordination requirements that apply (e.g., requirement for Contractor to contact the appropriate party a certain time in advance of the delivery).

6.12 Traffic Signal Interconnect and System Architecture Plans

If the Project includes or requires implementation of new or integration with existing traffic signal communications-related infrastructure and/or signal management systems, the Project plan set shall include an Interconnect Plan(s) showing callouts for the required system work, as well as a System Architecture Plan(s) and associated details for the traffic signal system(s), both of which shall be separate from other traffic signal plans.

6.12.1 Interconnect Plans

Interconnect Plans shall be in the 40 to 100 scale range and shall include the following:

- Legend
- Roadway/street name labels at all intersections
- Communication-related infrastructure layout (if hard-wired, with sizes and types of communication cable called out)
- Handhole and/or manhole locations (if applicable)
- Traffic signal controller cabinet locations (with "master" controller locations shown if applicable)
- Test pit/vacuum probe locations (if applicable)
- Other Intelligent Transportation System (ITS) equipment and detector locations (if applicable)

6.12.2 System Architecture Plans and Associated Details

System Architecture Plans and associated details pertaining to the construction or alteration of signal system components and interfaces will vary based on the specific type(s) of signal communication and signal management/control system(s) that are or will be in place. Although the content and layout of such plans will vary based on individual Project needs (see the last paragraph of **Section 6.3.14**), such plans and details shall include any associated details and notes that are needed to clearly show the Contractor how the signal system work is to be completed. Clear labeling of all system components and communication channels (e.g., fiber optic strands) is recommended except where such must be determined during construction by the Contractor.

6.13 Traffic Signal Constructability Issues

6.13.1 Temporary Traffic Signals

A temporary traffic signal shall be used wherever a signal is needed to control traffic on a temporary basis only and may also be required to provide for the safe and/or efficient control of traffic during construction at an existing signal. Design considerations for temporary traffic signals shall follow the same requirements and guidelines for permanent signals as presented in this Manual.

The Department holds the Project construction contractor responsible for not only initial furnishing/implementation and eventual removal of any temporary traffic signals that are necessary for the Project, but also for the maintenance and operation of such signals during their entire service lives. Unless other arrangements have been made or otherwise directed by the RIDOT Office of Safety, the Designer shall include special provisions to stipulate that the Contractor is responsible for the operation and maintenance of temporary traffic signals.

6.13.2 Re-Use of Existing Conduit

All new conduit and handholes/manholes should generally be called for in a new traffic signal system. However, existing conduit may be retained and "re-used" for work at a traffic signal if deemed to be cost-effective by the RIDOT Project Manager (usually in order to minimize trenching across pavements) as long as doing so is feasible (see **Section 6.8.2** for Code requirements), and the Designer's proposed sequence of construction appropriately addresses how the signalized intersection(s) can and will remain operational during construction. The Designer shall snake all existing conduits where new traffic equipment is proposed to determine if new cabling can be installed. The Designer shall coordinate with RIDOT Maintenance prior to snaking existing conduits.

6.13.3 Subsurface Investigations

The Designer shall use judgment in deciding what level of subsurface investigation is appropriate during the design process for every location where underground traffic signal-related work is proposed. If preliminary utility investigations show that there may be underground utility conflicts with proposed span pole, mast arm pole, pedestrian pole, cabinet, manhole, and/or handhole foundation locations, at minimum a vacuum probe(s) shall be completed at each such location to help ensure that the foundations can be placed without conflicting with subsurface utilities. A vacuum probe(s) may also be needed where there is a potential for conflict between existing utilities and a proposed conduit run(s).

If the Contractor is to be responsible for the design, fabrication, and construction of new mast arm/span poles and foundations, then in most cases a geotechnical investigation (e.g., soil borings) shall be completed by the Designer at the 30% design stage in order to identify soil types and bedrock locations. Such data and reports should be included in the contract documents for use by the Contractor in the design of the structures and foundations.

In preparing plans for proposed subsurface investigations, the Designer shall specify a specific vacuum probe hole or soil boring depth and width corresponding to the appropriate foundation dimensions or potential conduit conflict area. All subsurface investigation locations shall be dimensioned to nearby fixed objects in the field on plans (as opposed to being fixed to a baseline station and offset) since this allows the utility-locator to quickly and accurately identify work locations without the need of a survey crew.

6.14 Power Service Connections to Traffic Signals/Pedestrian Hybrid Beacons and Hard-Wired Flashing Beacons

Based on requirements set by Rhode Island Energy (RIE) for power service connections to traffic signals (including pedestrian hybrid beacons) and hard-wired flashing beacons (including Rectangular rapid flashing beacons (RRFB), school zone feedback signs, wrong way detection systems, etc.), Designers shall conform to the following:

6.14.1. Traffic Signals/Pedestrian Hybrid Beacons (PHBs)

An electric service request[26] shall be initiated and submitted by the designer during the Project design for the proposed power service connection to ensure constructability when the Project transitions to construction.

The orientation of the hard-wired powered meter sockets on the traffic signal/PHB cabinets shall be installed to avoid having the glass enclosed meter facing oncoming traffic due to the potential for snowplow damage.

6.14.2. Hard Wired Flashing Beacons

The power service connection shall be installed in a separate conduit network from the device cabling so unmetered power cannot be accessed via a handhole or via access plate cover on pedestal poles. The designer shall coordinate with the RIDOT Project Manager and develop a design solution that meets the above criteria while maintaining PROWAG compliance.

For the flashing beacons primary pole (pedestal pole with meter socket and control cabinet) foundation, two (2) 2” rigid steel conduits will be required to be cast in the precast foundation where one of the conduits will be for the power service connection and the remaining conduit for the flashing beacon system cabling to the secondary flashing beacon pole. A flex duct will be required to be installed internal to the primary pole connecting the 2” rigid steel conduit for power service to the meter socket, which will keep the unmetered power service cabling isolated from all other cabling and to ensure that the power service cabling remains inaccessible via the pole’s access opening. The control cabinet for the flashing beacons shall be installed near the top of the pole, above any signage.

[26] https://portalconnect.rienergy.com/RIEC/s/

If site specific conditions allow for a power service connection overhead tap, a second 2" rigid steel conduit will not be required in the foundation. The plans shall call for a weatherhead at the top of the pedestal pole for the power service connection, and flex duct will not be required internal to the pole for overhead service connections. The pole height shall be sufficient enough to allow for adequate separation between any equipment and the weatherhead, while being compliant with any required clearances to overhead utilities. If overhead power service connections are proposed, the designer shall coordinate with the RIDOT Project Manager and a representative from the RIDOT Electrical Construction Division to verify feasibility. The designer shall coordinate with RIE and any other affected utilities as needed for all power service connections. An electric service request shall be initiated and submitted by the designer during the Project design for the proposed power service connection to ensure constructability when the Project transitions to construction.

The orientation of the hard-wired flashing beacons meter sockets on the pedestal poles shall be installed to avoid having the glass enclosed meter facing oncoming traffic due to the potential for snowplow damage. This will need to be evaluated on a site-specific basis, as there are other design considerations such as where the meter socket is best situated on the pole (meter typically installed below the signage) while considering the PARs and US DOJ *2010 ADA Standards for Accessible Design* protruding object scenarios.

Where RRFBs are installed, with 2 pedestrian pushbutton signs per pole and limited space on the pole to allow the pushbutton housing and signs to coexist with the meter socket, this creates challenges with getting all equipment to fit on a single pedestal pole. Consideration may need to be given for installing the meter socket on a separate pedestal pole to ensure constructability.

The pedestal pole foundations shall be designed to be a maximum of 24" diameter or square. The designer shall include a note on the plans stating that it will be the Contractor's responsibility to determine the orientation of conduit sweeps based upon site specific conduit connections into the foundation between the power service connection and connections to handholes. When foundations are installed within sidewalk areas, there shall be no chamfer at the top of foundation so that the top of foundation can be set flush with the surrounding sidewalk grade to allow the exposed top of foundation (outside of pole base footprint) to be included within the PAR measurement.

Depending upon the size of foundations that are proposed for RRFBs, the designer shall include provisions in the contract for pedestrian pushbutton extension brackets if needed to achieve a 10" maximum reach from level landing areas.

The conduit connection from handhole to handhole for the hard-wired flashing beacons shall be 2” Schedule 80 PVC. The conduit connection from foundation to handhole for the hard-wired flashing beacons shall be 2” rigid steel conduit.

CHAPTER 7
SAFETY

7.1 Safety Analysis

The Federal Highway Administration's (FHWA) *Proven Safety Countermeasures*[27] provides countermeasures and strategies that are effective in reducing roadway fatalities and serious injuries. Each countermeasure addresses speed management, intersections, roadway departures, or pedestrians/ bicyclists along with crosscutting strategies that address all four safety focus areas. The Designer should consider all potential countermeasures early on during the Preliminary design process to help identify locations with safety issues and select countermeasures to improve them.

7.1.1 Crash Analysis

RIDOT HDM Section 340.02

Collection and analysis of crash records for all corridors and intersections within a Project area shall be completed where Rhode Island Department of Transportation (RIDOT) is the Project owner and/or manager, on RIDOT funded Projects, and anywhere else RIDOT has jurisdiction at the site of the work (e.g. Traffic Impact Studies (TISs), State Traffic Commission (STC) studies, etc.). The crash analysis shall be prepared in accordance with the Safety Section of the RIDOT *Highway Design Manual*.

The crash data shall be based on the latest 5 years of available data (minimum). Crash data can be requested as follows:

- For a Physical Alteration Permit (PAP) or other non-RIDOT funded Project, the crash data must be obtained from the police department in the municipality where the Project is located.
- For all RIDOT Projects, crash data must be requested from the RIDOT Office of Safety.

7.1.1.1 Crash Summary

Detailed Crash Summary Tables (as shown in Figure 7-1) shall be compiled in a tabular format, and include the following information

[27] https://highways.dot.gov/safety/proven-safety-countermeasures

(at a minimum) for each key intersection and roadway corridors, where appropriate:

- Crash Diagram Reference Number
- Crash Number (based on crash report)
- Crash Date
- Crash Day of the Week
- Time of Day
- Crash Severity
- Collision Type/Manner of Collision (e.g. angle, rear end, etc.)
- Light Condition
- Weather Condition
- Road Surface Condition
- Driver Contributing Code
- Comments providing a brief narrative of the crash

Figure 7-1. Example Crash Summary Table for Collision Diagrams

Crash Data Summary Table
Main Street at Side Road
(2020 - 2024)

Crash Diagram Ref #	Crash Number	Crash Date	Crash Day	Time of Day	Severity (KABCO)	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	Comments
1	18-142-AC	1/12/2021	Thursday	3:49 PM	B	Angle	Daylight	Rain	Wet	Disregarded traffic signs signals, road markings	V1 travelling WB turning left when struck by V2 (EB). Witnesses indicated V2 was travelling at a high rate of speed.
2	18-206-AC	1/19/2022	Wednesday	1:34 PM	C	Rear-End	Dark-Lighted Roadway	Clear	Dry	Inattention	V2 (SB) stopped at red light when struck from behind by V1 (SB). OP1 stated they misjudged the distance and could not stop in time

The severity of a crash shall be assessed based on the KABCO severity index, which assigns a letter rating to a crash based on the most severe injury sustained.

- "K" rating is assigned to a crash that resulted in a fatality
- "A" rating is assigned to a crash that resulted in an incapacitating injury
- "B" rating is assigned to a crash resulting in a non-incapacitating injury
- "C" rating is assigned to a crash when one or more involved parties complain of pain but injury is not immediately evident

- "O" rating is assigned to crashes that resulted in property damage only

For intersections, crashes reported to occur outside of a 200-foot radius are typically not considered to be related to the intersection operations and the Designer shall use engineering judgment when determining whether to include crashes outside of this radius at an intersection under review.

A narrative summary shall be provided in conjunction with the crash summary table which includes discussion of trends, probable causes, and geometric shortfalls (e.g. stopping and intersection sight distance) based on the collected data.

7.1.2 Collision Diagrams

Collision Diagrams are used to provide a visual, detailed crash analysis to examine crash patterns at intersection(s) and along corridors to determine where improvements should be considered based on reoccurring patterns.

Collision diagrams shall be prepared for all RIDOT related studies that require crash analyses in accordance with FHWA guidelines. An example collision diagram for an isolated intersection is provided in Figure 7-2.

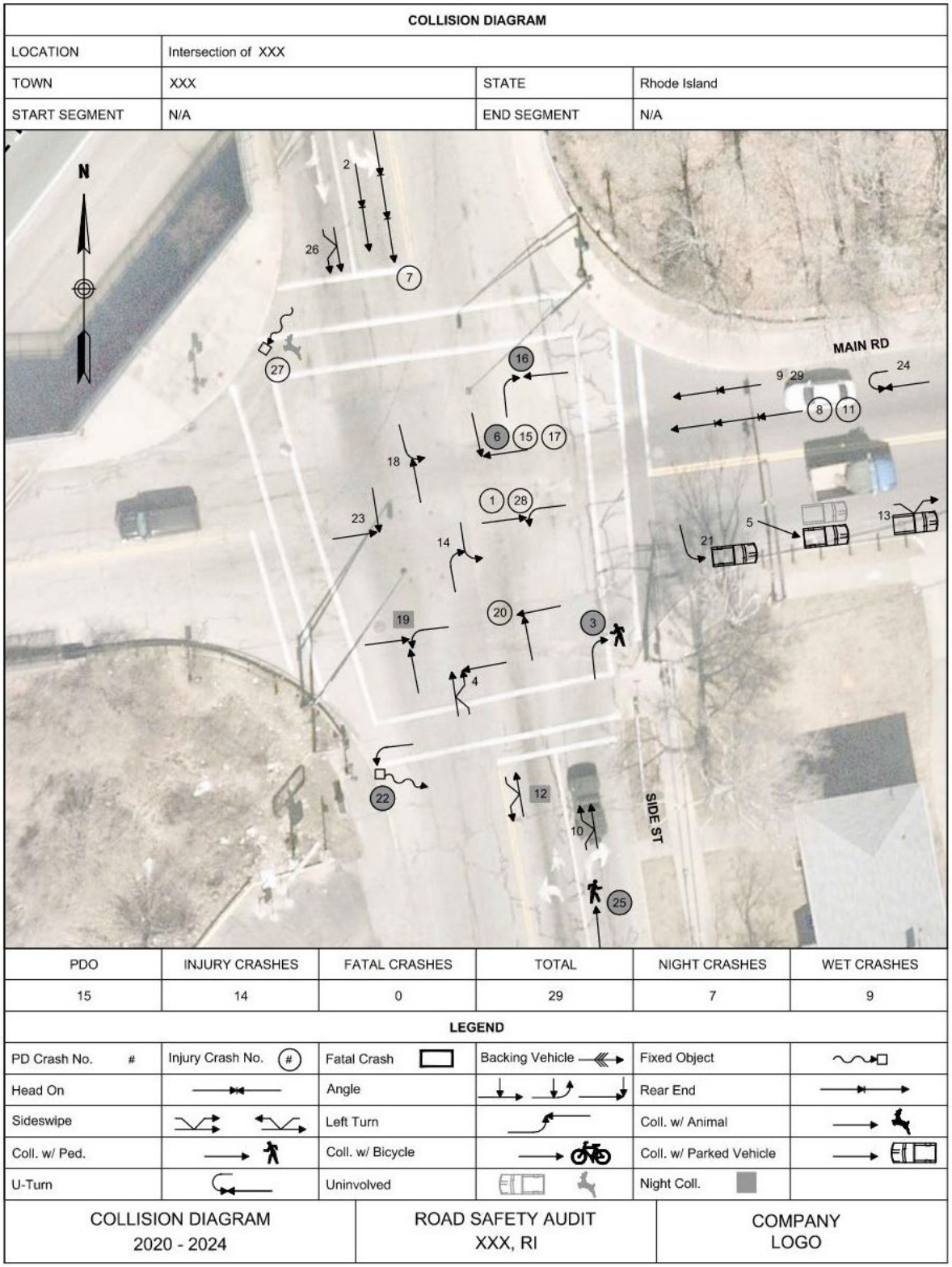


Figure 7-2. Example Collision Diagram

Detailed Crash Summary Tables shall accompany the Collision Diagrams, as outlined in **Section 7.1.1.1**.

7.2 Road Safety Assessment

7.2.1 Introduction

The FHWA defines a Road Safety Assessment (RSA) as a "formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team". The purpose of an RSA is to identify potential safety issues and possible opportunities for safety improvements considering all roadway users. A key objective of the RSA is to identify short-, mid-, and long-term safety improvements that can be made at the study area locations and incorporated in potential improvements.

The RIDOT Office of Safety encourages municipalities to conduct RSAs at the initial stage of their design process to help guide the design and reduce fatality and injury crashes for locations in which safety has been noted to be a factor in determining a need for improvements. The RIDOT Office of Safety will determine whether an RSA is required for RIDOT funded Projects.

7.2.2 Conducting an RSA

The RSA team shall consist of members from multiple disciplines, providing expertise in areas including, but not limited to engineering, planning, school operations, transit, maintenance, and emergency response fields. A representative from the RIDOT Office of Safety is expected to be part of the assessment team. Depending on the size of the study area, an RSA can be conducted in a minimum of three to four hours (e.g. one or two intersections). Larger study areas or corridors may require more time to complete.

As an RSA must be facilitated by a team "independent" of the Project, it is critical that the process be conducted early in the Project stage prior to any preliminary design.

Refer to the FHWA[28] website for more information regarding the RSA process and report preparation. A sample RSA Report can be provided by the RIDOT upon request.

[28] https://highways.dot.gov/safety/data-analysis-tools/rsa/fhwa-road-safety-audit-guidelines

7.2.3 RSA Report

The Designer shall follow FHWA guidelines when preparing the RSA report. The RSA report shall include the following submissions:

a. Initial Draft RSA Report: Designer to submit via email to all assessment participants. Assessment participants will provide comments on the draft report to be incorporated into the Final Draft RSA Report.

b. Final Draft RSA Report: Designer will review any comments received and revise the RSA Report accordingly. Designer to submit a Final Draft RSA Report via email to RIDOT or roadway owner via email (including all received comments).

c. Final RSA Report: Designer to submit a Final RSA report to all assessment participants.

7.3 Speed Studies

7.3.1 Curve Warning (Ball Bank Indicator)

Based on the FHWA *Methods for Establishing Advisory Speed*[29], the Ball Bank Indicator (BBI) measures the combined effect of super elevation, lateral (centripetal) acceleration, and vehicle body roll.

A BBI evaluation may be requested by the RIDOT Office of Safety to determine the recommended travel speed to safely negotiate a roadway curve. A physical BBI is preferred in lieu of a smartphone application or other method.

MUTCD Section 2C.59

AASHTO 3.3.2.2

Each roadway curve shall initially be driven at the posted speed limit to determine if the ball bank indicator exceeds the BBI thresholds set forth in the *Manual on Uniform Traffic Control Devices (MUTCD)* and the American Association of State Highway and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets*.

The following procedures shall then be followed after initially driving the curve at the posted speed limit:

- If the BBI reading is above the threshold for the posted speed limit, the curve is then driven again at a slower speed (typically reduced by 5 mph increments) and the BBI reading is compared again to the given criteria.
- Once the BBI reading no longer exceeds the threshold for the driven speed, this speed is then considered the advisory speed for the curve.
- If a curve is found to have BBI reading below the given threshold for the posted speed limit, a curve advisory speed is not recommended as the curve can be negotiated at the posted limit.
- For each curve, a minimum of three BBI trial runs shall be completed.

The BBI thresholds are shown in Table 7-1 below. RIDOT's preferred guidance is to follow AASHTO as it is more conservative; however, engineering judgment should be used.

[29] https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa1122/ch3.cfm

Table 7-1. BBI Thresholds

Ball-Bank Guidance by Speed (Degrees)			
	Speed (mph)		
Design Manual	≤ 20	25 to 30	35+
MUTCD	16	14	12
AASHTO	14	12	10

MUTCD Table 2C-4

The *MUTCD* also provides standards for installation of other curve warning signage to be used in conjunction with a recommended advisory speed.

7.3.2 Speed Limit

MUTCD Section 2B.21

A speed limit evaluation may be requested by the RIDOT Office of Safety and/or STC. Guidance using the FHWA's online safety tool, US LIMITS[30] (latest version), shall be considered when determining speed limits. US LIMITS is a web-based tool designed to help set reasonable, safe, and consistent speed limits for specific segments of roads. The data utilized by the US LIMITS tool includes route type, route length, 85th percentile speed, 50th percentile speed, Annual Average Daily Traffic (AADT), roadway alignment, crash data, and terrain type.

Based on the FHWA *Appropriate Speed Limits for All Roadway Users Proven Safey Countermeasures*[31], *Methods and Practices for Setting Speed Limits*[32], *and Speed Limit Setting Handbook*[33] advanced warning signage and other traffic control devices that attract the motorist's attention are typically more effective in slowing traffic than implementing a reduced speed zone. Therefore, the following shall also be considered when setting a speed limit:

- Traffic volumes (including vehicles, bicycles, and pedestrians)
- Roadway design elements such as roadway geometry, classification, lane/shoulder width, horizontal and vertical curves, roadside conditions and available sight distances (horizontal/ vertical)
- Crash types and frequencies
- Land use context
- Intersection spacing
- Observed speeds

[30] https://highways.dot.gov/safety/speed-management
[31] https://highways.dot.gov/safety/proven-safety-countermeasures/appropriate-speed-limits-all-road-users
[32] https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa12004/fhwasa12004.pdf
[33] https://highways.dot.gov/sites/fhwa.dot.gov/files/Speed-Limit-Setting-Handbook.pdf

7.4 No Passing Zone Analysis

MUTCD Section 3B.03

AASHTO 3.2.4- 3.2.6

A no passing zone analysis may be requested by RIDOT Office of Safety or the STC (refer to additional guidance provided in Chapter 2). Passing zone lengths and required passing sight distances shall be reviewed in accordance with the methods presented in the *MUTCD* and AASHTO*'s A Policy on Geometric Design of Highway and Streets*.

7.5 Road Diet Analysis

A Road Diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center Two-Way Left-Turn Lane (TWLTL). Prior to evaluating, the designer shall coordinate with the RIDOT Office of Safety to determine if roadways are good candidates for a road diet.

Corridor capacity analyses (refer to additional guidance provided in Chapter 2 of this manual) shall be performed when determining if a road diet is feasible, especially where signalized intersections exist along the corridor. Designers shall consider the guidelines within FHWA *Road Diet Informational Guide*[34] when determining if a road diet is a feasible design alternative.

[34] https://safety.fhwa.dot.gov/road_diets/guidance/info_guide/rdig.pdf

7.6 Red Light Running and Automated School Speed Limit Enforcement Cameras.

For Projects that include signalized intersections, documentation of recommended clearance intervals shall be calculated in accordance with **Section 6.3.5** and **Section 6.3.6** to reduce the potential for red-light running.

RIDOT does not install or maintain red light running cameras or automated school speed limit enforcement cameras on State roadways. Red light running cameras and/or automated school speed limit enforcement cameras may be installed on State roadways upon request of a municipality. A PAP(s) and STC approval is required prior to installation. Red light running cameras and/or automated school speed limit enforcement cameras shall be requested and installed in accordance with the latest RIDOT Office of Safety policy. Designer shall contact the RIDOT Office of Safety regarding installation of these devices. Refer to Rhode Island (RI) General Laws §31-41.2 and §31-41.3.

7.7 Turn Lanes at Intersections

In accordance with FHWA's Proven Safety Countermeasures (*Dedicated Left- and Right-Turn Lanes at Intersections*[35]*)*, "installing left-turn lanes and/or right-turn lanes should be considered for the major road approaches for improving safety at both three- and four-leg intersections with stop control on the minor road, where significant turning volumes exist, or where there is a history of turn-related crashes."

[35] https://highways.dot.gov/media/18526#:~:text=Installing%20left%2Dturn%20lanes%20and,history%20of%20turn%2D%20related%20crashes.

7.8 Wrong Way Driving

MUTCD Sections 2B.48, 2E.59 3B.24

Designers should consider potential countermeasures to reduce the occurrence of wrong way driving on interchange/freeway ramps, as outlined in the MUTCD and FHWAs *Compendium of Wrong-Way-Driving Treatments and Countermeasures.*

Devices shall be capable of integrating into RIDOT's existing Wrong Way Driving Detection System.

Refer to **Section 6.14.2** for guidance on providing hard wired connections.

7.9 Traffic Calming

Traffic calming measures are physical road design elements intended to reduce vehicle speeds and improve driver attentiveness. Potential traffic calming measures include (but are not limited to) installation of roundabouts, median islands, chicanes, curb extensions, etc.

Installation of speed bumps are not preferred by RIDOT due to maintenance issues.

Designers should refer to FHWAs Proven Safety Countermeasures, ITE's *Traffic Calming Measures* and FHWA's *Traffic Calming ePrimer* for additional guidance.

7.10 Roadway Lighting

Designers shall refer to the RIDOT *Highway Design Manual* for guidance related to roadway lighting.

7.11 Roadway Departure Strategies

Designers should review FHWA's *Roadway Departure Safety* and NCHRP Synthesis 515: *Practices for Preventing Roadway Departures* to determine countermeasures to address ways to reduce roadway departure fatalities and serious injuries. The potential countermeasures are focused on keeping vehicles on the roadway, provide for safe recovery and to reduce crash severity. Designers shall refer to the RIDOT *Highway Design Manual* for additional guidance.

7.12 Highway Safety Improvement Program

The Designer shall refer to the latest edition of RIDOT's *Highway Safety Improvement Program (HSIP) Manual* (accessible via the RIDOT Office of Safety website) to determine countermeasures to address a site-specific issue or certain crash types at multiple locations with the same roadway features based on crash frequency and severity.

Crash Modification Factors (CMFs) are used to estimate the expected safety benefits of various countermeasures and are available for many safety improvements. RIDOT uses a Benefit to Cost (B/C) analysis to compare the benefits associated with a countermeasure, expressed in monetary terms, to the cost of implementing the countermeasure. Refer to the latest edition of RIDOT's *HSIP Manual* for additional information regarding RIDOT's CMFs and B/C analysis.

APPENDIX A
RIDOT TRAFFIC SIGNAL TIMING AND CALCULATION SHEETS

- *Traffic Signal Timing Sheet*
- *Pedestrian Signal Timing Calculation Sheet*

Most recent versions are available electronically:
https://www.dot.ri.gov/business/contractorsandconsultants.php

RHODE ISLAND DEPARTMENT OF TRANSPORTATION
TRAFFIC ENGINEERING DESIGN SECTION
TRAFFIC SIGNAL TIMING SHEET

City or town: _____ Traffic Signal #: _____
Major Road: _____ Today's Date: ___/___/___
Minor Street: _____ Last Update: ___/___/___

Controller Make: _____ Model: _____ Serial No.: _____
Firmware: _____

Phase 1 _____ Phase 2 _____ Phase 3 _____ Phase 4 _____
Phase 5 _____ Phase 6 _____ Phase 7 _____ Phase 8 _____
Phase__ _____ Phase__ _____ Phase_ _____ Phase__ _____

BASIC TIMING:

Phase	1	2	3	4	5	6	7	8	
Min Green									
Passage									
Max Green 1									
Max Green 2									
Yellow									
Red									
Ped. Walk									
Ped. Clear									
Recall									
Memory – On/Off									
Delay									

COORDINATION:

Setup		Coordinated phase(s)									
Oper.		D/S/O	Off.	Cycle							
Mode											
Max.											
Corr.											
Ofst.											
Frc. Off											

TIME OF DAY:

Weekdays		Weekends	
D/S/O, Max 2 or 3, etc.	Time	D/S/O, Max 2 or 3, etc.	Time

Comments: _____

These timings have been field recorded or adjusted by _____ Date ___/___/___

Rhode Island Department of Transportation

Pedestrian Signal Timing Calculation Sheet

Version: 1.C, 03/10/25

Date: ______________

Engineer: ______________________________

Traffic Signal #: ______________

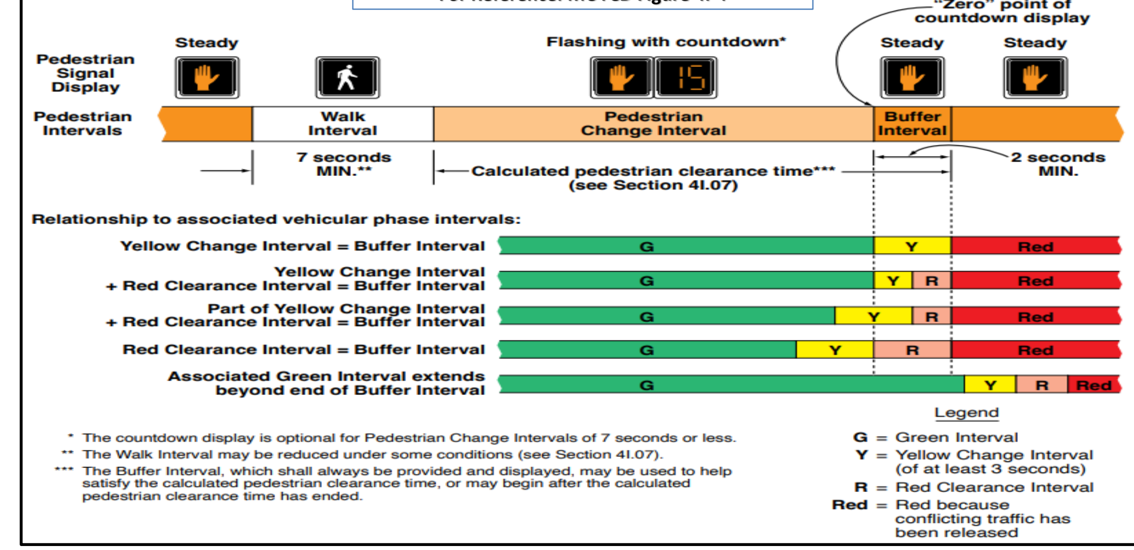
City or Town: ______________________________

Major Road(s): ______________________________

Minor Road(s): ______________________________

Key

- [tan box] = Enter value to permit calculations
- [light blue box] = "Default" value to meet an MUTCD recommendation, for calculations ONLY
- [blue box] = "Default" controller-programmable value, to meet an MUTCD recommendation
- [green box] = Enter Engineer's selected value to enable CHECKS; then choose appropriate values for programming into controller (or indicating on Plans)



For Reference: MUTCD Figure 4I-4

	Street Crossing / Side:												
Step 1: Enter Intersection Info	**Direction:**			From X -> X					From X -> X				
	Associated Vehicle Phase:												
		MUTCD Sec. 4I.06 Provision											
STEP 2: Determine and Enter	**Distance from near side curb to far side of travelway (ft)**		A										
	Distance from the button to near side curb (ft) [see Note 1]		B										
	Yellow Change Interval (s)		C										
	Red Clearance Interval (s)		D										
STEP 3: See Note 2	**Buffer Interval (s)** [C + D, per RIDOT default]	Para. 04	E	0.0					0.0				
STEP 4: Select Appropriate	Pedestrian Speed (ft/s) [see Note 3]	Para. 07-10	F	4.0	3.5	3.0	2.5		4.0	3.5	3.0	2.5	
	Calculated pedestrian clearance time (s) [A / F]	Para. 07	G	0.0	0.0	0.0	0.0	#DIV/0!	0.0	0.0	0.0	0.0	#DIV/0!
STEP 5: Select Appropriate	**Pedestrian Change Interval (s)** [G - C by default, but see Note 4]	Para. 04	H	0	0	0	0		0	0	0	0	
	"Pushbutton Path Check" [(A + B) / F, but see Note 5]	Para. 14	I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Recommended Min. Walk Interval (s) [I - G]	Para. 14	J	4.0	4.0	4.0	4.0	#DIV/0!	4.0	4.0	4.0	4.0	#DIV/0!
STEP 6: Select Appropriate	**Walk Interval (s)** [see Note 6]	Para. 11-14	K	7	7	7	7		7	7	7	7	
	Pedestrian Phase (s) [E + H + K]		L	7.0	7.0	7.0	7.0	0.0	7.0	7.0	7.0	7.0	0.0
STEP 7: Enter and Check, if Applicable (see Note 7)	**Minimum Split to keep controller in sync (s)** [L + 1, **but see Note 8**]		M	8	8	8	8	1	8	8	8	8	1
	Actual Split Time programmed for associated Phase (s)		N										
CHECK #1:	**Is E (Buffer Interval) ≥ 2 sec.?**	Para. 04	Finding:					Error					Error
CHECK #2:	**Is E + H ≥ G?**	Para. 04	Finding:					#DIV/0!					#DIV/0!
CHECK #3:	**Is E + H + K ≥ I?**	Para. 14	Finding:					OK					OK
CHECK #4:	**Is K [Walk Interval] ≥ 4 sec.?**	Para. 12	Finding:					Error					Error
CHECK #5 (if applicable):	**Is N ≥ M?**		Finding:					NO					NO

	Street Crossing / Side:												
Step 1: Enter Intersection Info	**Direction:**			From X -> X					From X -> X				
	Associated Vehicle Phase:												
		MUTCD Sec. 4I.06 Provision											
STEP 2: Determine and Enter	**Distance from near side curb to far side of travelway (ft)**		A										
	Distance from the button to near side curb (ft) [see Note 1]		B										
	Yellow Change Interval (s)		C										
	Red Clearance Interval (s)		D										
STEP 3: See Note 2	**Buffer Interval (s)** [C + D, per RIDOT default]	Para. 04	E	0.0					0.0				
STEP 4: Select Appropriate	Pedestrian Speed (ft/s) [see Note 3]	Para. 07-10	F	4.0	3.5	3.0	2.5		4.0	3.5	3.0	2.5	
	Calculated pedestrian clearance time (s) [A / F]	Para. 07	G	0.0	0.0	0.0	0.0	#DIV/0!	0.0	0.0	0.0	0.0	#DIV/0!
STEP 5: Select Appropriate	**Pedestrian Change Interval (s)** [G - C by default, but see Note 4]	Para. 04	H	0	0	0	0		0	0	0	0	
	"Pushbutton Path Check" [(A + B) / F, but see Note 5]	Para. 14	I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Recommended Min. Walk Interval (s) [I - G]	Para. 14	J	4.0	4.0	4.0	4.0	#DIV/0!	4.0	4.0	4.0	4.0	#DIV/0!
STEP 6: Select Appropriate	**Walk Interval (s)** [see Note 6]	Para. 11-14	K	7	7	7	7		7	7	7	7	
	Pedestrian Phase (s) [E + H + K]		L	7.0	7.0	7.0	7.0	0.0	7.0	7.0	7.0	7.0	0.0
STEP 7: Enter and Check, if Applicable (see Note 7)	**Minimum Split to keep controller in sync (s)** [L + 1, **but see Note 8**]		M	8	8	8	8	1	8	8	8	8	1
	Actual Split Time programmed for associated Phase (s)		N										
CHECK #1:	**Is E (Buffer Interval) ≥ 2 sec.?**	Para. 04	Finding:					Error					Error
CHECK #2:	**Is E + H ≥ G?**	Para. 04	Finding:					#DIV/0!					#DIV/0!
CHECK #3:	**Is E + H + K ≥ I?**	Para. 14	Finding:					OK					OK
CHECK #4:	**Is K [Walk Interval] ≥ 4 sec.?**	Para. 12	Finding:					Error					Error
CHECK #5 (if applicable):	**Is N ≥ M?**		Finding:					NO					NO

	Street Crossing / Side:												
Step 1: Enter Intersection Info	**Direction:**			From X -> X					From X -> X				
	Associated Vehicle Phase:												
		MUTCD Sec. 4I.06 Provision											
STEP 2: Determine and Enter	**Distance from near side curb to far side of travelway (ft)**		A										
	Distance from the button to near side curb (ft) [see Note 1]		B										
	Yellow Change Interval (s)		C										
	Red Clearance Interval (s)		D										
STEP 3: See Note 2	**Buffer Interval (s)** [C + D, per RIDOT default]	Para. 04	E	0.0					0.0				
STEP 4: Select Appropriate	Pedestrian Speed (ft/s) [see Note 3]	Para. 07-10	F	4.0	3.5	3.0	2.5		4.0	3.5	3.0	2.5	
	Calculated pedestrian clearance time (s) [A / F]	Para. 07	G	0.0	0.0	0.0	0.0	#DIV/0!	0.0	0.0	0.0	0.0	#DIV/0!
STEP 5: Select Appropriate	**Pedestrian Change Interval (s)** [G - C by default, but see Note 4]	Para. 04	H	0	0	0	0		0	0	0	0	
	"Pushbutton Path Check" [(A + B) / F, but see Note 5]	Para. 14	I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Recommended Min. Walk Interval (s) [I - G]	Para. 14	J	4.0	4.0	4.0	4.0	#DIV/0!	4.0	4.0	4.0	4.0	#DIV/0!
STEP 6: Select Appropriate	**Walk Interval (s)** [see Note 6]	Para. 11-14	K	7	7	7	7		7	7	7	7	
	Pedestrian Phase (s) [E + H + K]		L	7.0	7.0	7.0	7.0	0.0	7.0	7.0	7.0	7.0	0.0
STEP 7: Enter and Check, if Applicable (see Note 7)	**Minimum Split to keep controller in sync (s)** [L + 1, **but see Note 8**]		M	8	8	8	8	1	8	8	8	8	1
	Actual Split Time programmed for associated Phase (s)		N										
CHECK #1:	**Is E (Buffer Interval) ≥ 2 sec.?**	Para. 04	Finding:					Error					Error
CHECK #2:	**Is E + H ≥ G?**	Para. 04	Finding:					#DIV/0!					#DIV/0!
CHECK #3:	**Is E + H + K ≥ I?**	Para. 14	Finding:					OK					OK
CHECK #4:	**Is K [Walk Interval] ≥ 4 sec.?**	Para. 12	Finding:					Error					Error
CHECK #5 (if applicable):	**Is N ≥ M?**		Finding:					NO					NO

	Street Crossing / Side:												
Step 1: Enter Intersection Info	**Direction:**			From X -> X					From X -> X				
	Associated Vehicle Phase:												
		MUTCD Sec. 4I.06 Provision											
STEP 2: Determine and Enter	**Distance from near side curb to far side of travelway (ft)**		A										
	Distance from the button to near side curb (ft) [see Note 1]		B										
	Yellow Change Interval (s)		C										
	Red Clearance Interval (s)		D										
STEP 3: See Note 2	**Buffer Interval (s)** [C + D, per RIDOT default]	Para. 04	E	0.0					0.0				
STEP 4: Select Appropriate	Pedestrian Speed (ft/s) [see Note 3]	Para. 07-10	F	4.0	3.5	3.0	2.5		4.0	3.5	3.0	2.5	
	Calculated pedestrian clearance time (s) [A / F]	Para. 07	G	0.0	0.0	0.0	0.0	#DIV/0!	0.0	0.0	0.0	0.0	#DIV/0!
STEP 5: Select Appropriate	**Pedestrian Change Interval (s)** [G - C by default, but see Note 4]	Para. 04	H	0	0	0	0		0	0	0	0	
	"Pushbutton Path Check" [(A + B) / F, but see Note 5]	Para. 14	I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Recommended Min. Walk Interval (s) [I - G]	Para. 14	J	4.0	4.0	4.0	4.0	#DIV/0!	4.0	4.0	4.0	4.0	#DIV/0!
STEP 6: Select Appropriate	**Walk Interval (s)** [see Note 6]	Para. 11-14	K	7	7	7	7		7	7	7	7	
	Pedestrian Phase (s) [E + H + K]		L	7.0	7.0	7.0	7.0	0.0	7.0	7.0	7.0	7.0	0.0
STEP 7: Enter and Check, if Applicable (see Note 7)	**Minimum Split to keep controller in sync (s)** [L + 1, **but see Note 8**]		M	8	8	8	8	1	8	8	8	8	1
	Actual Split Time programmed for associated Phase (s)		N										
CHECK #1:	**Is E (Buffer Interval) ≥ 2 sec.?**	Para. 04	Finding:					Error					Error
CHECK #2:	**Is E + H ≥ G?**	Para. 04	Finding:					#DIV/0!					#DIV/0!
CHECK #3:	**Is E + H + K ≥ I?**	Para. 14	Finding:					OK					OK
CHECK #4:	**Is K [Walk Interval] ≥ 4 sec.?**	Para. 12	Finding:					Error					Error
CHECK #5 (if applicable):	**Is N ≥ M?**		Finding:					NO					NO

NOTES:

1. If no pedestrian button is present, enter in a value of **6**.
2. This Sheet by default assumes Buffer Interval = Y + R times, which means NO extension of FDW thru Y or R times. If this RIDOT-default case is applicable then go to Step 4; **But if the FDW time will be extended thru Y and/or R, modify if/as neccesary.**
3. Commonly-assumed speeds are pre-tabulated, but lower may/should be considered based on actual ped. characteristics. **If speed greater than 3.5 or lower than 2.5 ft/s is judged to be appropriate, enter it in the appropriate cell but be sure to explain/justify in Box on Sheet 2.**
4. This Sheet by default assumes the FDW time = the calculated pedestrian clearance time minus only the Y time. If this RIDOT-default option is applicable then go to Step 6; **But if a different MUTCD-allowed option is used (as illustrated in Figure 4I-4 above), modify the Row H cell formulas as necessary.**
5. The Row I value shown in the right-most column for each crossing direction uses a 3 ft/s value in the calculation per MUTCD Sect. 4I.06 Para. 14; all other columns use the corresponding Row F value in the calculation.
6. This Line by default assumes min. Walk time of 7 sec., but MUTCD permits as low as 4 sec. to be used. **If less than 7 sec. is judged to be appropriate, enter it in the appropriate cell, but be sure to explain why in Box on Sheet 2.**
7. If the signal is (or will be) running in a coordinated mode or as part of a coordinated system, the engineer should compare Lines M & N to consider whether or not (and how much) the signal will be thrown out of coordination when servicing a pedestrian call.
8. This Sheet by default asumes the traffic signal controller requires an "L + 1 sec." condition to keep the controller in sync during coordinated operations. **However, this condition VARIES by controller manufacturer and MAY NOT APPLY. If feasible and/or necessary, modify the values in Line M to conform to the actual/specific controller that is (or will be) in place. Confirmation with controller manufacturer may be necessary.**

Date: **1/0/1900**
Engineer: 1/0/1900
Traffic Signal #: **0**
City or Town: 0
Major Road(s): 0
Minor Road(s): 0

Explanation / justification for pedestrian walking speed greater than 3.5 or less than 2.5 ft/s:	

Explanation / justification for Walk time less than 7 seconds:	

NOTE: See latest MUTCD for guidance in completing the above.

APPENDIX B
STANDARD TRAFFIC SIGNAL CALLOUTS

	ITEM NO.	ITEM CODE	ITEM DESCRIPTION	UNIT OF MEASURE
HANDHOLES/ PULLBOXES	1a	T05.0101	PRECAST TYPE "A" Std. 18.2.0	EACH
	1b		PRECAST TYPE "H" HEAVY DUTY HANDHOLE	
	1c		BREAK INTO EXISTING HANDHOLE	
	1d	T05.0321	PULL BOXES	
CONDUIT			**CONDUIT - UNDERGROUND**	LF
	2a	T06.0102	3 INCH POLYVINYL CHLORIDE PLASTIC CONDUIT (Schedule 40)	
	2b		3 INCH POLYVINYL CHLORIDE PLASTIC CONDUIT (Schedule 80)	
	2c		3 INCH RIGID STEEL CONDUIT	
			CONDUIT - UNDER EXISTING PAVEMENT	
	2d	T06.3101	3 INCH POLYVINYL CHLORIDE PLASTIC CONDUIT (Schedule 40)	
	2e		3 INCH POLYVINYL CHLORIDE PLASTIC CONDUIT (Schedule 80)	
	2f		3 INCH RIGID STEEL CONDUIT	
			CONDUIT - OVERHEAD	
	2g	T06.4101	2 INCH POLYVINYL CHLORIDE PLASTIC CONDUIT	
	2h		1-1/2 INCH RIGID STEEL CONDUIT	
	2i		2 INCH RIGID STEEL CONDUIT	
	2j		3 INCH RIGID STEEL CONDUIT	
	2k		4 INCH RIGID STEEL CONDUIT	
CABINET/ CONTROLLER	3a	T12.0208	8-PHASE ACTUATED CONTROLLERS, CABINETS, AND FOUNDATIONS	EACH
	3b	T12.0216	16-PHASE ACTUATED CONTROLLERS, CABINETS, AND FOUNDATIONS	
	3c	T12.0300	MODIFY EXISTING TRAFFIC SIGNAL CONTROLLER/CABINET	
	3d	T12.0310	TRAFFIC ACTUATED CONTROLLERS	
	3e	T12.9901	FIELD MONITORING UNIT	
	3f	T12.9902	TRANSIT SIGNAL PRIORITY EQUIPMENT	
	3g	T12.9903	ADAPTIVE SIGNAL CONTROL	
MAST ARMS/ SPAN POLES/ SIGNAL POSTS	4a	T11.0820	20 FOOT STANDARD LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	EACH
	4b	T11.0825	25 FOOT STANDARD LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4c	T11.0830	30 FOOT STANDARD LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4d	T11.0835	35 FOOT STANDARD LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4e	T11.0840	40 FOOT STANDARD LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4f	T11.0845	45 FOOT STANDARD LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4g	T11.0850	50 FOOT STANDARD LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4h	T11.0930	30 FOOT HEAVY LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4i	T11.0935	35 FOOT HEAVY LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4j	T11.0940	40 FOOT HEAVY LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4k	T11.0945	45 FOOT HEAVY LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4l	T11.0950	60 FOOT HEAVY LOAD STEEL TRAFFIC SIGNAL MAST ARM, POLE AND FOUNDATION STANDARD 19.2.0	
	4m	T11.1020	20 FOOT GAL STEEL MAST ARM TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4n	T11.1025	25 FOOT GAL STEEL MAST ARM TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4o	T11.1030	30 FOOT GAL STEEL MAST ARM TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4p	T11.1035	35 FOOT GAL STEEL MAST ARM TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4q	T11.1040	40 FOOT GAL STEEL MAST ARM TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4r	T11.1045	45 FOOT GAL STEEL MAST ARM TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4s	T11.1050	50 FOOT GAL STEEL MAST ARM TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4aa	T11.1202	DUAL MAST ARM (20X20) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4bb	T11.1203	DUAL MAST ARM (20X25) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4cc	T11.1207	DUAL MAST ARM (20X30) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4dd	T11.1208	DUAL MAST ARM (20X35) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4ee	T11.1253	DUAL MAST ARM (25X25) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4ff	T11.1257	DUAL MAST ARM (25X30) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4gg	T11.1258	DUAL MAST ARM (25X35) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4hh	T11.1303	DUAL MAST ARM (30X30) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	

	ITEM NO.	ITEM CODE	ITEM DESCRIPTION	UNIT OF MEASURE
MAST ARMS/ SPAN POLES/ SIGNAL POSTS	4ii	T11.1304	DUAL MAST ARM (30X35) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	EACH
	4jj	T11.1308	DUAL MAST ARM (30X40) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4kk	T11.1354	DUAL MAST ARM (35X35) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4ll	T11.1358	DUAL MAST ARM (35X40) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4mm	T11.1359	DUAL MAST ARM (35X45) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4nn	T11.1404	DUAL MAST ARM (40X40) GAL STEEL TRAFFIC SIGNAL POST AND FOUNDATION STD 19.2.0	
	4t	T11.2008	TRAFFIC SIGNAL STANDARD,8 FT, STD 19.4.0 ALUMINUM PEDESTAL POLE AND FOUNDATION	
	4u	T11.2010	TRAFFIC SIGNAL STANDARD,10 FT, STD 19.4.0 ALUMINUM PEDESTAL POLE AND FOUNDATION	
	4v	T11.2012	TRAFFIC SIGNAL STANDARD,12 FT,STD 19.4.0 ALUMINUM PEDESTAL POLE AND FOUNDATION	
	4w	T11.2500	TRAFFIC SIGNAL STANDARD GALVANIZED STEEL AND FOUNDATION STANDARD 19.3.0	
	4x	T11.2510	STEEL TRAFFIC SIGNAL SPAN POLE AND FOUNDATION STANDARD 19.3.0	
DETECTION			**VEHICULAR DETECTION**	EACH
	5a	T13.1000	TRAFFIC DETECTORS-LOOP, STANDARD 19.6.0	
	5b	T13.1002	TRAFFIC DETECTOR RELAY-LOOP 2 CHANNEL	
	5c	T13.1004	TRAFFIC DETECTOR RELAY-LOOP 4 CHANNEL	
	5d	T13.9901	VIDEO DETECTION SYSTEM CAMERA (ONE WAY)	
	5e	T13.9902	VIDEO DETECTION SYSTEM CAMERA (360 DEGREE "FISH EYE")	
	5f	T13.9903	ADVANCED VIDEO DETECTION SYSTEM CAMERA	
			PEDESTRIAN DETECTION	EACH
	5g	T13.8200	PEDESTRIAN DETECTOR-PUSHBUTTON W/SIGN	
	5h	T13.8210	ACCESSIBLE PEDESTRIAN DETECTOR - PUSHBUTTON WITH SIGN	
	5i	T13.8220	ACCESSIBLE PEDESTRIAN DETECTOR - CONFIGURATION DEVICE	
	5j	T13.9904	EXTENSION BRACKET FOR PEDESTRIAN DETECTOR	
	5k	T13.9905	PASSIVE PEDESTRIAN DETECTOR W/SIGN AND SADDLE	
TRAFFIC CONTROL FEATURES	5l	T13.9010	OPTICAL DETECTOR CONFIRMATION BEACON	
	5m	T13.9020	OPTICAL DETECTOR	
	5n	T13.9906	VIDEO DETECTION SYSTEM CAMERA (ONE WAY)	
	5o	T13.9907	VIDEO DETECTION SYSTEM CAMERA (360 DEGREE "FISH EYE")	
	5p	T13.9908	ADVANCED VIDEO DETECTION SYSTEM CAMERA	
	5q	T13.9909	VIDEO DETECTION HARDWARE	
	5r	T13.9910	FIBER OPTIC PATCH CORDS	
	5s	T13.9911	METER SOCKET WITH MANUAL BY-PASS	
	5t	T13.9912	BATTERY BACKUP SYSTEM	
	5u	T13.9913	GPS TIME SYNCHRONIZATION SYSTEM	
	5v	T11.9901	VIDEO DETECTION CABLING	LF
VEHICULAR AND PEDESTRIAN SIGNAL HEADS		T14.1000	***MAST ARM MOUNTED***	EACH
	6a		SIGNAL HEAD 1 WAY, THREE SECTION 12 INCH LENS	
	6b		SIGNAL HEAD 1 WAY, FOUR SECTION 12 INCH LENS	
	6c		SIGNAL HEAD 1 WAY, FIVE SECTION 12 INCH LENS	
	6d		SIGNAL HEAD 2 WAY, THREE SECTION 12 INCH LENS	
	6e		SIGNAL HEAD 2 WAY, FOUR SECTION 12 INCH LENS	
	6f		SIGNAL HEAD 2 WAY, FIVE SECTION 12 INCH LENS	
	6g		SIGNAL HEAD 3 WAY, THREE SECTION 12 INCH LENS	
			SPAN MOUNTED	EACH
	6h	T14.1000	SIGNAL HEAD 1 WAY, THREE SECTION 12 INCH LENS	
	6i		SIGNAL HEAD 1 WAY, FOUR SECTION 12 INCH LENS	
	6j		SIGNAL HEAD 1 WAY, FIVE SECTION 12 INCH LENS	
	6k		SIGNAL HEAD 2 WAY, THREE SECTION 12 INCH LENS	
	6l		SIGNAL HEAD 2 WAY, FOUR SECTION 12 INCH LENS	
	6m		SIGNAL HEAD 2 WAY, FIVE SECTION 12 INCH LENS	
	6n		SIGNAL HEAD 3 WAY, THREE SECTION 12 INCH LENS	

	ITEM NO.	ITEM CODE	ITEM DESCRIPTION	UNIT OF MEASURE
VEHICULAR AND PEDESTRIAN SIGNAL HEADS			***PEDESTAL (SIDE) BRACKET MOUNTED***	
	6o	T14.1000	SIGNAL HEAD 1 WAY, THREE SECTION 12 INCH LENS	EACH
	6p		SIGNAL HEAD 1 WAY, FOUR SECTION 12 INCH LENS	
	6q		SIGNAL HEAD 1 WAY, FIVE SECTION 12 INCH LENS	
	6r		SIGNAL HEAD 2 WAY, THREE SECTION 12 INCH LENS	
	6s		SIGNAL HEAD 2 WAY, FOUR SECTION 12 INCH LENS	
	6t		SIGNAL HEAD 2 WAY, FIVE SECTION 12 INCH LENS	
	6u		1 WAY PEDESTRIAN SIGNAL HEAD WITH COUNTDOWN TIMER (12 INCH)	
	6v		2 WAY PEDESTRIAN SIGNAL HEAD WITH COUNTDOWN TIMER (12 INCH)	
VEHICULAR AND PEDESTRIAN SIGNAL HEADS			***PEDESTAL (TOP) MOUNTED***	
	6u	T14.1000	SIGNAL HEAD 1 WAY, THREE SECTION 12 INCH LENS	EACH
	6v		SIGNAL HEAD 1 WAY, FOUR SECTION 12 INCH LENS	
	6w		SIGNAL HEAD 1 WAY, FIVE SECTION 12 INCH LENS	
	6x		SIGNAL HEAD 2 WAY, THREE SECTION 12 INCH LENS	
	6y		SIGNAL HEAD 2 WAY, FOUR SECTION 12 INCH LENS	
	6z		SIGNAL HEAD 2 WAY, FIVE SECTION 12 INCH LENS	
	6aa		1 WAY PEDESTRIAN SIGNAL HEAD WITH COUNTDOWN TIMER (12 INCH)	
	6bb		2 WAY PEDESTRIAN SIGNAL HEAD WITH COUNTDOWN TIMER (12 INCH)	
CABLING/WIRING	7a	T04.5001	6 AWG SINGLE CONDUCTOR CABLE 600V INSULATION	LF
	7b	T04.5002	6 AWG 2 CONDUCTOR CABLE 600V INSULATION	
	7c	T04.5101	8 AWG SINGLE CONDUCTOR CABLE 600V INSULATION	
	7d	T04.5102	8 AWG 2 CONDUCTOR CABLE 600V INSULATION	
			14 AWG CONDUCTOR CABLE	
	7e	T04.5301	14 AWG 3 CONDUCTOR CABLE	
	7f		14 AWG 5 CONDUCTOR CABLE	
	7g		14 AWG 7 CONDUCTOR CABLE	
	7h		14 AWG 9 CONDUCTOR CABLE	
	7i		14 AWG 12 CONDUCTOR CABLE	
	7j	T04.5302	14 AWG 2 CONDUCTOR TWISTED SHIELDED CABLE	
	7k	T04.5401	18 AWG CONDUCTOR CABLE	
	7l	T11.6005	TETHER WIRE 5/16	
	7m	T11.6006	SPAN AND MESSENGER WIRES 6/16	
	7n	T11.6007	SPAN AND MESSENGER WIRES 7/16	
	7o	T11.9902	ABANDON EXISTING CONDUIT AND CABLES IN PLACE	
	11	945.0200	REMOVE AND SALVAGE TRAFFIC SIGNAL EQUIPMENT	LS

APPENDIX C
LOOP DETECTOR NUMBERING SCHEME (TS-2 CONTROLLERS)

Loop Detector Numbering Scheme for TS-2 Controllers

The current specification for TS-2 Controllers and Cabinets calls for an eight-slot detector rack which provides for sixteen channels of detection. Under NEMA TS-2 there is no hard wire connection from the detector amplifier rack to the controller phase inputs. A NEMA TS-2 controller always interprets the inputs from the rack in the following manner:

Slot	1	2	3	4	5	6	7	8
Loop Detector No.	3,4	1,2	7,8	5,6	11,12	9,10	15,16	13,14

To simplify the process of building, programming and troubleshooting controller cabinets, the following guidelines should be followed to ensure the loop detector numbers match the default numbers used in the NEMA specifications. We note this procedure may produce gaps in the loop numbering sequence:

1. Adjacent loop detectors must always be on the same relay.

2. Two-channel relays can be used in any slot. The loop detector number is assigned on the basis of the slot used. For example, any loops connected to a two-channel relay in slot 1 must be numbered as loop detectors 3 & 4. Loops connected to a two-channel relay in slot 4 are numbered as loop detectors 5 and 6.

3. Four-channel relays can only be used in even numbered slots. They utilize the outputs assigned to the even numbered slot and the adjacent lower odd-numbered slot. Loop detectors assigned to a four-channel relay in slot 2 can be numbered 1, 2, 3, and 4. A four-channel relay in slot 4 controls loop detectors 5, 6, 7 and 8. The loop detector number is assigned on the basis of which slot is used.

Slot	2	4	6	8
Loop Detector No.	1,2,3,4	5,6,7,8	9,10,11,12	13,14,15,16

4. Both two and four channel amplifiers can be used in a detector rack. The loop detector number is assigned on the basis of which slot is used by the relay.

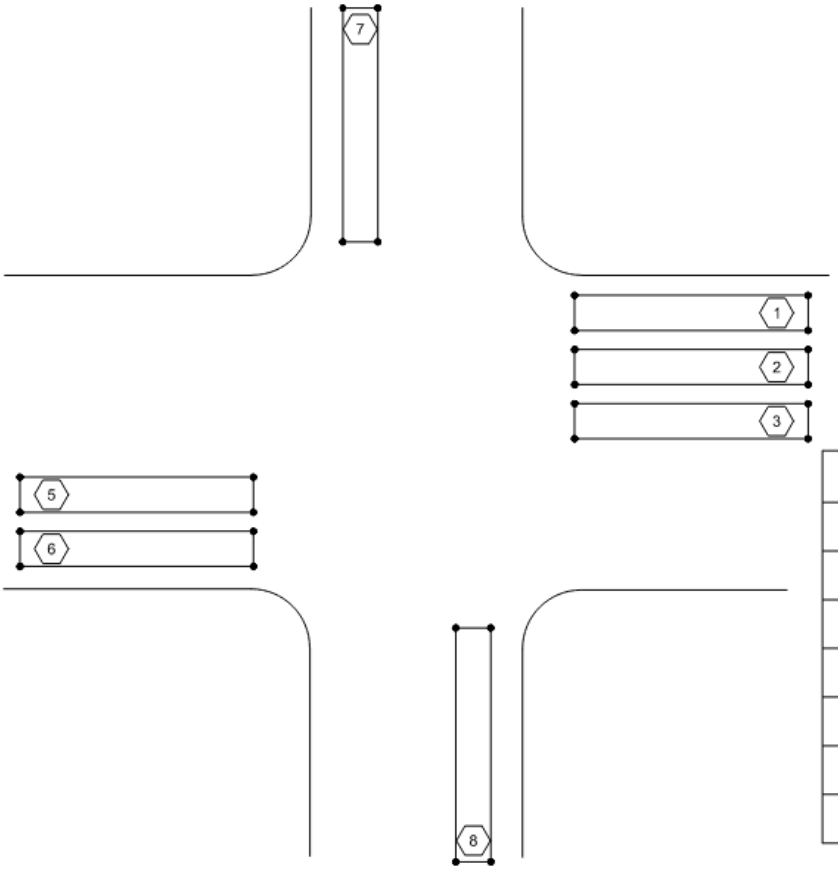
   Attached is an example intersection layout and detector table. The easiest way to manage loop detector numbering is to include a Slot Number column in the detector table. The following discussion is related to the attached example.

The WB approach has three loops. Adjacent loops must be on the same relay to avoid loop crosstalk and false actuations, so these loops must be on a four-channel relay. We have chosen to place this relay in slot 2, and have numbered the loops 1, 2, and 3.

The EB approach has two loops. Because adjacent loops must be on the same relay we have assigned them to a four-channel relay in slot 4 and numbered them as loops 5 and 6.

The N&S loops do not have any adjacent loops. They do not need to be on the same relay. We have a single unused channel on the relay in slot 2 (detector 4) and two unused channels on the relay in slot 4 (detectors 7 & 8). We have chosen to utilize the relay in slot 4, so the loop detectors are assigned the numbers 7 and 8. The detector table lists loops 1, 2, 3, 5, 6, 7 and 8. There is no loop 4 because one channel on the four-channel relay in slot 2 was not used.

Every intersection is different, so many different loop numbering schemes are possible. The above described methodology will help ensure the loop numbering scheme reflects the way controller cabinets are built and the way TS-2 controllers utilize detector rack inputs.



LOOP DETECTOR TABLE

LOOPS	SIZE	RELAY	SLOT	PHASE	DELAY
1	6x40	1	2	2	3
2	6x40	1	2	2	3
3	6x40	1	4	1	3
5	6x40	2	4	2	3
6	6x40	2	4	2	3
7	6x40	2	4	3	8
8	6x40	2	4	3	8