

Oregon Department of Transportation

Traffic Signal Design Manual

Traffic Engineering Section | Delivery & Operations Division

January 2026

ODOT is an Equal Employment Opportunity and Affirmative Action Employer.

This information can be made available in alternative format by contacting 503-986-3568.

ODOT does not discriminate on the basis of disability in admission or access to our programs, services, activities, hiring and employment practices. Questions: 1-877-336-6368 (EEO-ODOT) or through Oregon Relay Service at 7-1-1.

Oregon Department of Transportation

Engineering & Technical Services Branch

555 13th Street NE
Salem, Oregon 97301

503-986-3568

Traffic Engineering Website

Chapter 1

Contents

1 Introduction 1-1

1.1 About Us 1-1

1.2 Availability 1-1

1.3 Updates 1-2

1.4 Change Requests 1-2

1.5 Document Revision Summary 1-2

1.5.1 Revision: December 2013 1-2

1.5.2 Revision: October 2014 1-2

1.5.3 Revision: January 2016 1-3

1.5.4 Revision: June 2017 1-6

1.5.5 Revision: January 2020 1-9

1.5.6 Revision: January 2021 1-13

1.5.7 Revision: January 2022 1-22

1.5.8 Revision: January 2023 1-23

1.5.9 Revision: January 2024 1-28

1.5.10 Revision: January 2025 1-34

1.5.11 Revision: January 2026 1-36

Chapter 2

Contents

2 Design Approval Process..... 2-1

2.1 Traffic Engineering Organizational Structure 2-2

2.2 Design Exceptions, Non-Standard Design, and Experimental Design 2-3

2.3 Overhead Structures and Vertical Clearance Standards 2-4

2.4 Project Types That Require Design Approval 2-4

2.5 Plan Sheets That Require Design Approval 2-5

2.6 Design Approval Process 2-5

2.6.1 ODOT Let Projects 2-9

2.6.2 Non-ODOT Let Projects & Consultant Signal Designers 2-9

2.7 Getting Drawing Numbers & TSSU ID numbers 2-9

2.8 Getting the Design Approval Signature 2-12

2.9 Review by Others 2-13

Chapter 3

Contents

3 Signal Operations and Operational Approval 3-1

3.1 Operational Approval 3-1

3.2 Number of Lanes and Lane Use 3-2

3.3 Normal Phase Rotation 3-3

3.3.1 Ring and Barrier Diagram 3-4

3.3.2 Flashing Yellow Left Turn Arrow 3-6

3.3.3 Flashing Yellow Left Turn Arrow with Negative Ped 3-6

3.3.4 Flashing Yellow Left Turn Arrow Used for Permissive Only Phasing 3-7

3.3.5 Vehicle Overlap Phases 3-8

3.3.6 Negative Ped Overlap Phases 3-9

3.3.7 Pedestrian Overlap Phases 3-10

3.3.8 Split Phases/Exclusive Phases 3-11

3.3.9 Incompatible Left Turn Phases 3-13

3.3.10 Multiple Intersections using a Single Controller 3-14

3.3.11 Dummy Phases 3-17

3.3.12 Overlap Phase with Green Extension Clear-Out 3-18

3.3.13 Unconventional Phases & Sequences 3-20

3.4 Emergency Preemption 3-21

3.5 Railroad Preemption 3-22

3.6 Transit Priority 3-23

3.7 Crosswalk Closures 3-24

3.8 Traffic Signal Communications 3-24

3.9 Other Unique Requirements 3-24

3.10 Example of Operational Approval 3-24

Chapter 4

Contents

4 Starting the Design 4-1

4.1 Scoping 4-1

4.1.1 Traffic Signal Asset Management 4-4

4.1.2 Statewide Goals, Priority, and Implementation 4-4

4.2 Starting the DAP Design 4-7

4.3 What Standards Will Be Used? 4-8

4.4 Intergovernmental Agreements (IGA) and Jurisdictional Transfers 4-9

4.5 Background Information to Gather 4-10

4.5.1 As-Built Drawing Archive (FileNet) 4-10

4.5.2 Electronic Information 4-10

4.5.3 Field Verification 4-11

4.6 Background Information from Others 4-12

4.6.1 Existing Operational & Condition Information 4-12

4.6.2 Base Map and Survey Information 4-12

4.6.3 Roadway Design 4-13

4.6.4 Geotechnical Report 4-14

4.6.5 Utility Hook-ups 4-14

4.6.6 Rail Crossing Order 4-14

4.7 Signal Design Project File 4-15

Chapter 5

Contents

5 Signal Plan 5-1

5.1 Roadway Design 5-1

5.1.1 Number of Lanes and Lane use 5-1

5.1.2 Pedestrian Crosswalks Closures 5-1

5.1.3 Selecting & Locating Curb Ramps for Proper Crosswalk Alignment 5-2

5.1.4 Signal Poles and Pedestals 5-12

5.1.5 Raised Median Islands and Crosswalk Alignment 5-12

5.1.6 Driveway Approaches at Signalized Intersections 5-18

5.1.7 Maintenance Pads 5-21

5.1.8 Truck Turning Templates 5-22

5.1.9 Lane Shift Through Intersection (Off-set Lane Lines) 5-27

5.2 Vehicle Signal Head Layout 5-30

5.2.1 Head Types 5-30

5.2.2 Head Materials 5-32

5.2.3 Head Placement 5-33

5.2.4 Supplemental Signal Heads 5-50

5.2.5 Head Mounting 5-57

5.2.6 Signal Head Louvers and Angle Visors 5-58

5.2.7 Tattletale Indicators 5-59

5.3 Sign Requirements and Layout 5-60

5.3.1 Layout of Regulatory Signs 5-63

5.3.2 Street Name Signs and Guide Signs (Custom Designed Signs) 5-64

5.3.3 Part Time Restriction Signs (PTR) 5-64

5.3.4 Materials and Mounting 5-65

5.4 Pedestrian Signal Equipment Layout 5-66

5.4.1 Use of Pedestrian Detection 5-66

5.4.2 Pushbutton Requirements 5-66

5.4.3 Deviations from Pushbutton Location Requirements 5-67

5.4.4 Incorporating PROWAG Requirements 5-67
5.4.5 Verifying Pushbutton Requirements 5-68
5.4.6 Deviation: Pushbutton Mounted on a Large Pole 5-88
5.4.7 Deviation: Two Pushbuttons Mounted on a Single Pedestal 5-92
5.4.8 Deviation: Use of an Extension Bracket Mount 5-102
5.4.9 Deviation: Vertical Reach of Pushbutton 5-105
5.4.10 Pushbuttons Located Behind Guardrail 5-106
5.4.11 Extended Pushbutton Press Feature 5-106
5.4.12 Pedestrian Signal Location 5-107
5.4.13 Indication Type 5-109
5.4.14 Pedestrian Signal Head Materials 5-109
5.4.15 Audible Pedestrian Signals/Pushbuttons 5-109
5.5 Pole Selection and Placement 5-110
5.5.1 Right-of-Way 5-110
5.5.2 Overhead Structures and Vertical Clearance Standards 5-110
5.5.3 Height Restrictions 5-110
5.5.4 Utility Conflicts 5-111
5.5.5 Roadside Placement Requirements 5-113
5.5.6 Mast Arm Poles 5-114
5.5.7 Strain Poles 5-114
5.5.8 Vehicle Pedestals – No Longer Used 5-114
5.5.9 Pedestals 5-115
5.5.10 Recessed Terminal Cabinet 5-115
5.5.11 Pushbutton Posts – No Longer Used 5-115
5.5.12 Non-Standard Design: Dual Mast Arm Poles, Strain Poles, Sign Bridge, Monotube, Luminaire Poles 5-115
5.5.13 Reusing or Altering the Loading on Existing Signal Supports 5-116
5.5.14 Use of Other Agency (Non-ODOT) Approved Poles 5-117
5.6 Illumination 5-118
5.6.1 Light Emitting Diode (LED) fixtures 5-119

5.6.2 Photo Electric Control Relay 5-119
5.6.3 Illumination Wiring 5-119
5.7 Fire Preemption 5-120
5.8 Power Source 5-121
5.9 Battery Back-Up 5-122
5.10 Controller Cabinets 5-122
5.10.1 Location 5-122
5.10.2 332S Controller Cabinet 5-124
5.10.3 332 Controller Cabinet 5-124
5.10.4 336 and 336S Controller Cabinet 5-124
5.10.5 Controller Cabinet Power 5-124
5.10.6 ATC Controller 5-125
5.10.7 Decorative Controller Cabinet Wraps 5-126
5.11 Service Cabinets 5-127
5.11.1 Base Mounted Service Cabinet (BMC) 5-127
5.11.2 Base Mounted Service Cabinet with illumination (BMCL) 5-127
5.11.3 Base Mounted Service Cabinet, Flashing Beacons (BMCF, and BMCFL) 5-127
5.11.4 Pole Mounted Service Cabinet (SC) and Meter Base (MC) 5-127
5.11.5 Remote Post Mounted Service (RPS) 5-127
5.11.6 Wiring 5-127
5.12 Junction Boxes 5-128
5.12.1 Junction Box Type and Size 5-128
5.12.2 Junction Box Placement 5-128
5.12.3 Use of Existing Junction Boxes 5-130
5.12.4 Elevation Adjustments & Considerations for Existing Junction Boxes 5-131
5.12.5 Deviations From Junction Box Placement Standards 5-133
5.13 Conduit 5-134
5.13.1 Conduit Size 5-135
5.13.2 Conduit Materials 5-140
5.13.3 Expansion Fittings 5-140

5.13.4 Routing Conduit to Pedestals 5-141
5.13.5 Conduit Trenching Depths & Underground Conflicts 5-144
5.14 Wiring 5-145
5.14.1 Wire Types 5-145
5.14.2 Wire Gauge 5-147
5.14.3 Voltage Drop 5-147
5.14.4 Bonding/Grounding Requirements 5-148
5.14.5 Common/Neutral (Shared) Wire 5-148
5.14.6 Wiring Signal Heads (From Head to Terminal Cabinet) 5-149
5.14.7 Wiring Pedestrian Signals and Pushbuttons 5-158
5.14.8 Wiring Signal Phases (from Terminal Cabinet to Controller) 5-160
5.14.9 Wire Fill at the Terminal Cabinet Entrance and Mast Arm Connection 5-162
5.14.10 Wiring Part Time Restriction (PTR) signs 5-165
5.15 Background/Reference Information 5-165
5.15.1 Wiring History 5-165
5.15.2 Type 3LCF Signal Heads for Flashing Yellow Arrow 5-165
5.15.3 Sign History 5-167
5.15.4 Battery Back-up History 5-168

Chapter 6

Contents

6 Detector Plan 6-1

6.1 Detection Type 6-2

6.1.1 Inductive Loop Detection 6-3

6.1.2 Multiple Detection Technologies at a Single Intersection 6-3

6.2 Detection Basics 6-4

6.2.1 Presence Detection 6-4

6.2.2 Advance Detection (or Volume Density Detection) 6-5

6.2.3 Signal Timing Functions That May Be Used with Detection 6-7

6.3 Beyond Basic Detection 6-8

6.3.1 Interchange Ramps 6-8

6.3.2 Temporary Bridge Signals (One-Lane, Two-Direction) 6-8

6.3.3 Bicycle Detection 6-9

6.3.4 Adaptive Signal Timing Detection 6-10

6.3.5 Railroad Detection 6-10

6.3.6 Automated Traffic Signal Performance Measures (ATSPM) 6-11

6.4 Detection Zone Layout Considerations 6-11

6.4.1 Advance Stop Bars 6-11

6.4.2 Bridge Decks 6-12

6.4.3 Wide Corner Radius 6-12

6.4.4 Accesses: Driveways, Streets, and Alleys 6-12

6.4.5 Short Minor Street/Driveway Signalized Approaches 6-14

6.5 Conduit and Junction Box System 6-16

6.6 Synchronous Data Link Control (SDLC) – Bypassing the Detection Input File 6-17

6.7 Detection Input File 6-18

6.8 Radar Detector Unit Placement and Labeling 6-19

6.9 Video Detection Camera Placement and Labeling 6-23

Chapter 7

Contents

7 Interconnect & ITS communication Plan 7-1

7.1 When is Communication Needed? 7-1

7.2 Background and Design Responsibilities 7-1

7.3 Forms of Communication 7-2

7.4 Scoping the Traffic Signal Communication System 7-2

7.5 Use of Communication Equipment Based on Project Type/Location 7-3

7.5.1 Maintained and Operated by ODOT (Projects by Local Agency or Permit) 7-3

7.5.2 Maintained and Operated by Local Agencies on State Highways 7-3

7.5.3 Locations off the State Highway 7-3

7.6 Long Term Communication Planning 7-3

7.7 Design Considerations 7-3

7.7.1 Controller 7-3

7.7.2 Junction Boxes and Conduit Location and Sizes 7-4

7.7.3 Conduit 7-4

7.7.4 Fiber Optic Wiring 7-4

Chapter 8

Contents

8 Existing Utilities plan..... 8-1

8.1 General..... 8-1

8.2 When is this Plan Sheet Needed?..... 8-3

Chapter 9

Contents

9 Details Plan 9-1

9.1 General 9-1

9.2 Pole Entrance Chart - General 9-1

9.2.1 When is a Pole Entrance Chart Needed? 9-1

9.2.2 Detailing Existing Signal Poles/Pedestals on the Pole Entrance Chart 9-2

9.3 Pole Entrance Chart – Mast Arm 9-3

9.3.1 First 3 Columns 9-3

9.3.2 Equipment on the Pole 9-4

9.3.3 Equipment on the Mast Arm 9-13

9.3.4 Foundation Information 9-14

9.3.5 Luminaires 9-15

9.3.6 Orientation Diagrams 9-16

9.3.7 Detailing Dual Mast Arm Pole in the Pole Entrance Chart 9-17

9.4 Pole Entrance Chart – Temporary Strain Pole 9-20

9.4.1 First 4 Columns 9-20

9.4.2 Messenger Cable Attachment Height (MAH) 9-21

9.4.3 Equipment on Pole 9-24

9.4.4 Equipment on Span Wire 9-26

9.4.5 Foundation Information 9-27

9.4.6 Luminaires 9-27

9.4.7 Orientation Diagrams 9-27

9.5 Custom Details Created from Standard Details 9-28

9.5.1 ITS Equipment 9-28

9.5.2 Stand-Alone Luminaire Pole: Light Table 9-30

Chapter 10

Contents

10 Removal Plan 10-1

10.1 When is a removal plan sheet needed? 10-1

10.2 Equipment Salvaging and Stockpiling 10-1

10.3 Abandoning Equipment 10-2

10.4 Removing Equipment 10-2

10.5 Removing and Relocating Equipment 10-2

10.6 When a Removal Plan Sheet is Required 10-4

10.7 When a Removal Plan Sheet is NOT Required 10-6

Chapter 11

Contents

11 Temporary Signal Plan 11-1

11.1 General 11-1

11.2 When is a Temporary Signal Needed? 11-1

11.3 Operational Approval of Temporary Signals 11-3

11.4 Design Approval of Temporary Signals 11-10

11.5 Using Existing or New Signal Equipment as Part of the Temp. Installation 11-10

11.6 Temporary Signal Design 11-11

11.6.1 Poles 11-11

11.6.2 Controller Cabinet 11-13

11.6.3 Service Cabinet and Meter Base 11-13

11.6.4 Junction Boxes 11-14

11.6.5 Use of Detection (Vehicle, Bicycle, Pushbuttons, & Preemption Detectors) 11-14

11.6.6 Vehicle Detection 11-17

11.6.7 Wiring 11-17

11.6.8 Staging 11-20

11.7 Temporary Bridge Signal Design 11-31

11.7.1 Phasing 11-31

11.7.2 Sight Distance 11-32

11.7.3 Stop Line Location 11-34

11.7.4 Signal Head Alignment 11-35

11.7.5 Vehicle Detection 11-36

11.7.6 Bicycle Detection 11-37

11.8 Portable Temporary Traffic Signal 11-38

11.9 Standard Drawings and Specifications Applicable to Temporary Signals 11-38

Chapter 12

Contents

12 Flashing Beacon Plan 12-1

12.1 Operational and Design Approval 12-2

12.2 Design Information at a Glance 12-3

12.3 Speed Feedback Signs (Unintegrated) 12-5

12.4 Power Source 12-6

12.5 Beacon Operation 12-7

12.6 Sight Distance Considerations 12-8

12.7 TSSU ID Numbers for Flashing Beacon Installations 12-9

12.8 Warning Beacon 12-10

12.8.1 Warning Beacons for Obstructions 12-10

12.8.2 Warning Beacons for Warning Signs (Continuous Operation) 12-11

12.8.3 Warning Beacons for Ramp Meter Signs 12-13

12.8.4 Actuated Warning Beacons – Bridges 12-14

12.8.5 Actuated Warning Beacon – Tunnels 12-15

12.8.6 Actuated Warning Beacon – PREPARE TO STOP WHEN LIGHTS FLASH 12-17

12.8.7 Actuated Warning Beacon – Mid-block Crosswalks 12-19

12.8.8 Actuated Warning Beacon – Emergency Vehicles 12-20

12.8.9 Actuated Warning Beacon – TRAWS 12-21

12.9 Rectangular Rapid Flashing Beacon (RRFB) 12-23

12.9.1 MUTCD Interim Approval 12-23

12.9.2 Device Assembly Requirements 12-23

12.9.3 Pushbutton Requirements 12-25

12.9.4 Location of Assemblies 12-32

12.9.5 Advance Sign Assemblies 12-32

12.9.6 Illumination 12-32

12.9.7 Service Cabinet and Wiring to RRFB Controller Cabinet 12-33

12.10 Speed Limit Sign Beacon 12-34

12.11 Stop Sign Beacon 12-35

12.12 Intersection Control Beacon..... 12-36

12.13 Pedestrian Hybrid Beacon 12-40

Chapter 13

Contents

13 Ramp Meters 13-1

13.1 Ramp Meter Operation 13-1

13.1.1 Location of the Ramp Meter Stop Line 13-1

13.2 Ramp Meter Signal Indication Mounting 13-2

13.2.1 Ramp Meter Signal Assembly (Pedestal) 13-4

13.2.2 Overhead Mounted (Mast Arm) 13-7

13.2.3 Ramp Meter Phasing 13-9

13.3 Ramp Meter Signs 13-10

13.3.1 Ramp Metered When Flashing Sign (With Flashing Yellow Beacon) 13-10

13.3.2 Form 2 Lanes When Metered Sign 13-11

13.3.3 Stop Here on Red Sign 13-11

13.3.4 One Vehicle Per Green Sign 13-11

13.3.5 Coordinating Sign Placement on Ramp 13-11

13.4 Ramp Meter Striping 13-14

13.5 Ramp Meter Cabinets and Controllers 13-14

13.6 Ramp Meter Detection 13-15

13.6.1 Detector Functions, Location, and Placement 13-15

13.6.2 334 Controller Cabinet Input Detection File 13-19

13.6.3 Detector Wiring Diagram 13-19

13.7 Wiring 13-19

13.8 Background/Reference Information 13-20

13.8.1 Queue Detection History 13-20

13.8.2 PTR sign History 13-21

Chapter 14

Contents

14 Pedestrian Signal Plan 14-1

14.1 General 14-1

14.1.1 Controller and Service 14-3

14.1.2 Striping and Signing 14-3

14.1.3 Detection 14-3

14.1.4 Phasing and Fire Preemption 14-3

14.1.5 Bicycle Design Considerations 14-4

14.2 Half Signals 14-4

Chapter 15

Contents

15 Red Light Enforcement Plan 15-1

15.1 General 15-1

15.2 Operation and Approvals 15-1

15.3 When is a Plan Sheet Required? 15-1

15.4 Mitigation Requirements 15-1

15.5 Red Light Running Signing 15-2

15.6 Construction 15-2

15.7 Separation of Systems 15-2

15.8 Removal of Red Light Running Systems 15-2

Chapter 16

Contents

16 Railroad & Preemption Plan 16-1

16.1 When is Railroad Preemption Needed? 16-2

16.1.1 Verification of Railroad Interconnection at Existing Traffic Signals 16-3

16.1.2 Evaluating Preemption and Traffic Control Devices at Rail Crossings Further Than 215 Feet from a Signalized Intersection 16-4

16.2 Field Diagnostic Review 16-6

16.3 Rail Crossing Order 16-6

16.4 Railroad Utility Permits 16-7

16.5 Railroad Preemption Operation 16-8

16.5.1 PCOI – Advance Preemption 16-8

16.5.2 PCOI – Advance Preemption Used to Move Vehicles 16-9

16.5.3 VCOI – Simultaneous Preemption 16-9

16.5.4 Return to Normal Operation 16-13

16.6 Required Plan Sheets 16-13

16.7 Signal Plan Sheet References 16-14

16.8 Interconnected Traffic Signal Specific Design Elements and Considerations 16-15

16.8.1 Pre-Signals 16-16

16.8.2 Supplemental Signals 16-19

16.8.3 Queue Cutter Signals 16-20

16.8.4 Queue Activated Warning Devices 16-20

16.8.5 Detection 16-22

16.8.6 Channelized Right Turn Lanes 16-23

16.8.7 Median Islands 16-26

16.8.8 Crosswalk Placement and Stop Lines 16-27

16.8.9 Signs – Part Time Restriction (PTR) 16-30

16.8.10 Signs – STOP HERE ON RED & NO TURN ON RED 16-33

16.8.11 Signs – DO NOT STOP ON TRACKS & High-Level Warning Device 16-36

16.8.12 Signs – Lane Use 16-37

16.8.13 Conduit and Wiring 16-38
16.8.14 Pedestrian Features 16-39
16.8.15 Type 7 Signal Heads 16-40
16.8.16 Permissive Left Turn Phasing Using Flashing Yellow Arrow 16-41
16.8.17 Limited Right-Of-Way for Equipment 16-42
16.9 Traffic Control Devices Activated by The Rail Controller Cabinet 16-43
16.10 Other Work – Railroad Grade Crossing System 16-45
16.11 Other Work – Railroad Preemption Plan Sheet 16-46
16.11.1 Signal Modifications That Require Updating the Preemption Plan Sheet 16-46

Chapter 17

Contents

17 Fire (Emergency) Signal Plan 17-1

17.1 General 17-1

17.2 Operational Approval 17-1

17.3 Fire Signal Located at an Intersection 17-1

17.3.1 Solutions for Existing Fire Signals Located at Intersections 17-1

17.4 Fire Signal Located at Mid-Block Access 17-3

17.4.1 Operation 17-3

17.4.2 Controller and Service 17-3

17.4.3 Signal Head Type and Layout 17-4

17.4.4 Signs 17-7

17.4.5 Tattletale Indicators 17-9

17.4.6 Preemption Devices 17-10

17.4.7 Detection 17-12

17.4.8 Pedestrian Accommodation 17-12

17.5 Emergency-Vehicle Hybrid Beacon 17-12

Chapter 18

Contents

18 Standard Drawings and Standard Details 18-1

18.1 Standard Drawings 18-1

18.1.1 Effective Dates and Updates 18-2

18.1.2 Standard Drawing Reports 18-3

18.2 Standard Details 18-5

Chapter 19

Contents

19 Specifications, Bid Items, & Cost Estimate 19-1

19.1 Preparing the Special Provisions 19-2

19.2 Review & Approval of the Special Provisions 19-4

19.3 Bid Items 19-5

19.3.1 Permanent Signal Bid Items (00990.90) 19-6

19.3.2 Permanent Signal Bid Items - Foundations (00921.90 & 00963.90) 19-8

19.3.3 Removal of Electrical Systems Bid Items (00950.90) 19-9

19.3.4 Temporary Signal Bid Items (00227.90) 19-9

19.3.5 Crosswalk Closure Support Bid Item (00902.90) 19-10

19.4 Letter of Public Interest Finding (LPIF) 19-11

19.5 Cost Estimate 19-14

19.5.1 Anticipated Items 19-14

Chapter 20

Contents

20 Cabinet Print 20-1

20.1 When is a Cabinet Print Required? 20-1

20.2 Responsibilities For Creating a Cabinet Print 20-1

20.3 Procedure for Producing Cabinet Prints 20-2

20.4 Creating the Cabinet Print 20-3

20.5 332S Cabinet Print (Page 1 – Cabinet Layout) 20-3

20.6 332S Cabinet Print (Page 2 – Input File) 20-4

20.6.1 Detector Input Location (Signal Timer Responsibility – Use Excel File) 20-6

20.6.2 AC Isolator Location (Signal Timer Responsibility – Use Excel File) 20-8

20.6.3 DC Isolator Location (Signal Timer Responsibility – Use Excel File) 20-9

20.6.4 Pedestrian Detector Termination 20-10

20.6.5 Fire Preemption Detectors (Signal Timer Responsibility – Use Excel File) 20-11

20.6.6 Fire Preemption Detection Termination 20-12

20.6.7 Detector Input Termination 20-13

20.6.8 Additional Information about the Input File 20-15

20.7 332S Cabinet Print (Page 3 – Output File) 20-16

20.7.1 Main Output File (Front View): 20-18

20.7.2 Main Output File (Back View) 20-19

20.7.3 Conflict Monitor Diode Card 20-19

20.7.4 Auxiliary Output File (Front and Back View) 20-37

20.7.5 Additional Information for the Output File 20-38

20.7.6 Output File & Conflict Monitor Configuration for PHBs 20-39

20.8 332S Cabinet Print (Page 4 – C1 Pin Assignments & Test Switch) 20-42

20.9 332S Cabinet Print (Page 5 – Electrical Diagrams) 20-43

20.10 332S Cabinet Print (Page 6 – Intersection Drawing) 20-43

20.11 332S Cabinet Print (Page 7 – Detection Drawing) 20-49

20.12 332S Cabinet Print (Page 8 – Railroad Preemption Plan Sheet) 20-53

20.13 Background/Reference Information 20-55

20.13.1 Flashing Yellow Arrow and Conflict Monitoring.....20-55

Chapter 21

Contents

21 Contract Plan Development & Drafting 21-1

21.1 General 21-1

21.2 General Drafting Requirements 21-2

21.3 General Plan Sheet Content Requirements 21-3

21.4 MicroStation Traffic Signal Workflow 21-5

21.5 Grooming Reference Files 21-8

21.6 Projects Without Reference Files/Survey Data 21-8

21.7 Traffic Signal Style Drafting – Basic Layout and Information 21-9

21.7.1 Plan Sheet Titles, Size, and Scale 21-9

21.7.2 Order of Traffic Signal Plan Sheets 21-10

21.7.3 Title Block - Traffic Signal Specific Information 21-11

21.7.4 Digital Signatures 21-12

21.7.5 Accompanied by Dwgs. Box 21-12

21.7.6 Upper Right Corner Title Information 21-13

21.7.7 North Arrow, Street Names, & Lane Use Arrows 21-15

21.7.8 Centerline Station or Scale Bar 21-16

21.7.9 Right-of-Way 21-17

21.7.10 New Roadway & Pavement Markings 21-18

21.7.11 Break Lines and Match Lines 21-19

21.7.12 Blow-up Views 21-22

21.7.13 Cross References 21-24

21.8 Traffic Signal Style Drafting – Specific Design Features 21-25

21.8.1 New vs. Existing Symbology 21-25

21.8.2 Showing Conduit Runs 21-26

21.8.3 Pole (and Pedestal) Numbering 21-27

21.8.4 Controller Cabinet Orientation 21-29

21.9 Bubble Notes 21-30

21.9.1 Filling Out Bubble Note Variable Correctly 21-32

21.9.2 Leader Line Information 21-33
21.9.3 Creating and Reading Bubble Note Strings 21-34
21.9.4 Reference Bubble Notes 21-36
21.9.5 Miscellaneous Customizable Bubble Note 21-37
21.9.6 Use of "EX" Bubble Notes 21-38
21.9.7 Use of "RX", "RR", and "RI" Bubble Notes 21-40
21.9.8 Updating Type 3L to Type 3LCF Signal Heads 21-41
21.10 Specific Plan Sheet Content Requirements 21-42
21.10.1 Legend Plan Sheet 21-42
21.10.2 Removal Plan 21-45
21.10.3 Signal Plan 21-49
21.10.4 Detector Plan 21-53
21.10.5 Interconnect Plan 21-57
21.10.6 Railroad Preemption Plan 21-59
21.10.7 Existing Utilities Plan 21-63
21.10.8 Details Plan 21-65
21.10.9 Temporary Signal, Detector, Ramp Meter Plan 21-68
21.10.10 Flashing Beacon Plan 21-72
21.10.11 Ramp Meter Plan 21-77
21.11 MicroStation File Archiving 21-79
21.12 Plan Sheet (PDF) Archiving 21-80
21.13 Revised Plans 21-81
21.14 As-Constructed Plans 21-83
21.15 Final Design/Drafting Checklist 21-85
21.16 Standard Bubble Note List 21-86

Chapter 22

Contents

22 Construction Support 22-1

22.1 Authority over the Contract Work 22-1

22.2 Addenda 22-2

22.3 Pre-Construction Conference 22-2

22.4 Material Submittals and Shop Drawing Review 22-3

22.4.1 Pole and Foundation Submittals 22-3

22.4.2 Blue Sheets and Green Sheets 22-4

22.4.1 Field Verification Forms (For Signal Poles and Signal Pole Foundations) 22-4

22.5 Cabinet Print 22-5

22.6 Requests for Information 22-5

22.7 Contract Change Orders 22-7

22.8 Certified Traffic Signal Inspection Certification 22-8

22.9 Construction Issues 22-9

22.9.1 Detection 22-9

22.9.2 Conduits 22-11

22.9.3 Utility Conflicts 22-12

22.9.4 Poles & Foundations 22-13

22.9.5 Unique Situations 22-14

22.9.6 Temporary Signals 22-14

22.9.7 Signs 22-14

22.9.8 Pushbuttons 22-15

22.9.9 Wiring 22-15

22.9.10 Service Cabinet 22-16

22.9.11 Junction Boxes 22-16

Chapter 23

Contents

23 State Force Work 23-1

23.1 Is Operational Approval Needed? 23-1

23.2 Are Plan Sheets and Design Approval Required? 23-1

23.3 Plan Sheet 23-2

23.3.1 Title Block 23-2

23.3.2 Detailing Work and Referencing Prior Plan Sheets 23-2

23.4 Are Specifications, Standard Drawings and Cost Estimate Required? 23-3

Chapter 24

Contents

24 Moveable Bridges 24-1

24.1 General 24-1

24.2 Design Responsibility 24-1

24.2.1 Bridge Plan Sheets 24-1

24.2.2 Signal Plan Sheets 24-2

24.2.3 Signing Plan Sheets 24-2

24.3 Operational Approval 24-2

24.4 Design Approval 24-2

24.5 Existing Moveable Bridges on the State Highway System 24-3

24.5.1 Non-Compliant Existing Traffic Control Devices (TCD) 24-4

24.6 Bridge Warning Gate and STOP Line Placement 24-8

24.7 Signal Head Type and Placement 24-9

24.8 Mounting Signal Heads and Signs 24-10

24.9 Traffic Control Device Sequence 24-11

24.9.1 No Sight Distance Restrictions to Signal Heads 24-12

24.9.2 Sight Distance Restrictions to Signal Heads 24-13

24.9.3 Sight Distance Restrictions to Signal Heads (Special Application Only) 24-14

24.9.4 Unique Traffic Control Devices: Columbia River (Interstate) NB 24-15

24.9.5 Unique Traffic Control Devices: Columbia River (Interstate) SB 24-18

Chapter 25

Contents

25 Automatic Traffic Recorder (ATR) plan 25-1
25.1 General 25-1
25.2 Design Responsibility for ATR Plans 25-1
25.3 Detection - General 25-1
25.4 Inductive Loops 25-2
25.4.1 Loop Layout 25-2
25.4.2 Lane & Loop Numbering 25-3
25.4.3 Loop/Piezo Wiring Diagram 25-3
25.5 Piezoelectric Sensors 25-8
25.5.1 Piezoelectric Layout 25-8
25.5.2 Piezoelectric Wiring Diagram 25-8
25.6 Non-Invasive Detection 25-9
25.7 Junction Boxes, Wire Entrance, and Pavement Cuts 25-9
25.8 Unique Geometry Considerations 25-13
25.9 Conduit and Wiring 25-14
25.9.1 Service Cabinet to Controller Cabinet Wiring 25-14
25.9.2 Loop Wire and Loop Feeder Cable 25-14
25.9.3 Piezo Cable 25-14
25.9.4 Conduit 25-16
25.10 Controller Cabinet and Service Cabinet 25-16
25.11 Controller 25-19
25.12 Communication 25-20
25.13 Maintenance Pad 25-20
25.14 Anti-Vandalism Treatments 25-20
25.15 Standard Drawing and Standard Details 25-22
25.16 Specifications, Cost Estimates, Bid Items, and Construction Support 25-22
25.17 Drafting Standards 25-23
25.18 Design Approval, Drawing Numbers, and ATR Site Number 25-25

25.19 ATR Cabinet Prints 25-26
25.19.1 Page 1 – Cabinet Layout 25-27
25.19.2 Page 2 – Terminations 25-28
25.19.3 Page 3 – ATR Site Drawing 25-29
25.20 Example Plan Sheets 25-30

Chapter 26

Contents

26 Quick Reference 26-1

26.1 General 26-1

26.2 Basic Wiring Guidelines 26-2

26.3 Loop Detector Information 26-3

26.4 Non-Invasive Detection Information 26-4

26.5 Input File Info 26-5

26.5.1 Input File for 332S 26-5

26.5.2 Input File for 332 26-6

26.5.3 Input File for 336 26-7

26.6 332S and 332 Cabinet Limitations – Output File 26-8

26.7 332S and 332 Cabinet Limitations – Input File 26-9

26.8 332S and 332 Cabinet Limitations – Conflict Monitor 26-10

26.9 Phasing Standards 26-11

26.10 Signal Pole & Signal Head Information 26-12

26.11 Sign Information 26-13

26.12 Junction Box & Conduit Information 26-14

26.13 Electrical Crew Preferences 26-15

26.14 Salvage Cost Estimate Equations (LPIF) 26-16

26.15 Final Design/Drafting Checklist 26-17

1 Introduction

The material contained herein is for information purposes only and may be used to aid new employees and those unfamiliar with ODOT traffic engineering practices in accessing and applying applicable standards, statutes, rules, and policies related to traffic signal operation, design, and drafting.

This manual shall be used to create traffic signal plans and specifications on the state highway system.

1.1 About Us

The traffic standards crew is responsible for maintaining and interpretation of the ODOT Traffic Signal Design Manual. This crew is part of the traffic engineering section which is under the engineering and technical services branch.

Kevin Haas, P.E.

State Traffic Standards Engineer (Manager)

503-986-3583

Kevin.J.Haas@ODOT.oregon.gov

Scott Cramer, P.E.

State Traffic Signal Engineer (Crew Lead)

503-476-7849

Scott.B.Cramer@ODOT.oregon.gov

Katryn Johnson, P.E.

Traffic Signal Quality Engineer

503-302-7853

Katryn.L.Johnson@ODOT.oregon.gov

Barby Golden, General Journeyman Electrician

Traffic Signal Coordinator

503-932-1483

Barbara.C.GOLDEN@odot.oregon.gov

Sarah McCrea, P.E.

Traffic Signal Systems Engineer

971-375-0049

Sarah.A.MCCREA@odot.oregon.gov

1.2 Availability

This manual is a web-only document, which can be accessed and printed in its entirety from the ODOT traffic signal website.

1.3 Updates

This manual is updated on a yearly basis in January. The revised manual becomes effective on the official revision date (month/year format). All design work prior to final plans shall follow the requirements of the current version of this manual. However, we do recognize that making certain changes late in the design process may not always be feasible or result in an unacceptable amount of re-design. As such, the state traffic signal engineer will grant exceptions to following the current version of the manual during the design approval phase on a case-by-case basis.

If you wish to receive notification of future revisions of this manual and other updates for ODOT traffic signal standards, subscribe to our e-mail notification system by e-mailing the traffic signal quality engineer.

1.4 Change Requests

If you would like to suggest changes to the ODOT Traffic Signal Design Manual, please contact the traffic signal quality engineer.

1.5 Document Revision Summary

1.5.1 Revision: December 2013

Complete reformat of document:

- New information on video detection
- New information on roadway design
- New procedure for Railroad Preemption Plan Sheet
- New information on operational approval
- New information on design approval

1.5.2 Revision: October 2014

1. Minor revisions based on comments received during the draft manual release in December 2013

1.5.3 Revision: January 2016

Chapter 2 Design Approval Process:

1. Figure 2-1 (organization chart) – updated chart
2. Section 2.5 (Design Approval Process): Info on plan requirements at each milestone

Chapter 3 Signal Operation & Operational Approval:

1. Section 3.3.1 (ring and barrier diagram) – added bold note clarifying intent of the ring and barrier diagram; to clearly show the conflicts that require conflict monitoring.
2. New Section 3.3.3 (Flashing yellow left turn arrow with NOT-PED) – This section was added to describe the FYA not-ped feature and explain why it is NOT shown in the ring and barrier diagram.
3. Section 3.3.5 (not-ped overlap phases) – added a note to reference new section 3.3.3 (flashing yellow left turn arrow with NOT-PED) to make sure designers go to the right section for FYA not-ped info.
4. New Section 3.3.6 (Pedestrian Overlap Phases) – This section was added to describe pedestrian overlaps. Added new figure in this section.
5. Updated Figure 3-9 (ring & barrier diagrams: Multiple intersections using a single controller, example 1) – revised OLA designations from "," to "&" for consistency. Fixed lane use typo.
6. Updated Figure 3-10 (ring & barrier diagrams: Multiple intersections using a single controller, example 2) – revised OLA designations from "," to "&" for consistency
7. New Section 3.3.11 (dummy phases) – this section was added to describe dummy phases. Added two figures to this section showing a dummy phase.
8. Updated Figure 3-11 (ring & barrier diagrams: Multiple intersections using a single controller, example 3) – revised OLA designations from "," to "&" for consistency

Chapter 5 Signal Plan:

1. Section 5.2 (Vehicle signal head layout) – added two bullets, signal heads should be mounted overhead and they should be aligned vertically.
2. Added new section 5.2.3 (supplemental near-side signal heads) – added info to clarify and show examples of use of near side signal heads.
3. Section 5.2.5 (signal head louvers and cut-off visors) – added cut off visors to this section and a new figure
4. Table 5-3 (standard signal heads for right turn phases) – added 2 rows to the table to describe standard heads for signalized right turn slip lanes (Type 3R only, NOT type 2). Clarified that the opposing left turn CAN NOT be a permissive left turn if there is single receiving lane. Added figure 5-23 (signal head placement for right turn phases – Right turn slip lanes)
5. Table 5-3 (standard signal heads for right turn phases) – added a reference to the MUTCD section that prohibits a permissive opposing left turn movement and protected right turn movement to occur concurrently.

6. New Section 5.3.2 (Street name signs and guide signs – custom designed signs) – moved some info about custom signs into its own section for easier reference. Added info about max size of custom sign.
7. Section 5.6 (illumination) – hyperlinked lighting manuals to illumination webpage
8. Section 5.6 (illumination) – added new section for LED fixtures & changed standard from HPS to LED as per the Illumination Engineer
9. Section 5.6.2 (illumination wiring) – added a bullet point describing TC cable and a bullet describing bond wire
10. Section 5.9 (battery back-up) – deleted erroneous reference to Signal Policy and Guidelines (SP&G) – added information that was once contained in the SP&G.
11. Section 5.10.1 (Controller Cabinets/Location): Info on opening cabinet door off right-of-way
12. Section 5.13.1 (Conduit Size): 2" spare conduit for detection required between signal pole and first JB in the same quadrant. To allow for future retrofit of alternative detection.
13. Figure 5-17 (signal head types) – updated figure to include Type 1R and Type 1Y.
14. Figure 5-27 (signal head placement for right turn phasing) – updated the sign used with the Type 5 signal head (from OR22-14 to OR10-15)
15. Figure 5-31 & 5-32 (common signs used for traffic control) – updated sign AL/12: removed OR22-14 ("right turn yield to peds on green ball symbol") info and replaced with OR10-15 (turning vehicles stop for ped) info. Added sign AL/3T ('No trucks" R5-2) and sign AL/20 ("Except bus" OR3-7a)
16. Figure 5-33 (signs no longer used) – added OR22-14 to the list.

Chapter 6 Detector Plan:

1. New Section 6.3.2 (Overlap Phase Detection) – added this section discuss the need for overlap phase detection to be assigned to a parent phase.
2. Section 6.4 (standard detection layout) – revised this section to be more general and moved the chart into the Inductive loop detection section. Added a figure illustrating the standard layout
3. Section 6.6 (detector input file) – added "stretch" to CO (carryover) definition.
4. Section 6.6.1 (332S cabinet: 2070 controller with a C11 connector) – changed the 8 asterisks locations to include "count" as a function, as per Darren LAWRENCE.
5. Section 6.7.12 (Induction Loop Detection/Conduit): 2" spare conduit for detection required between signal pole and first JB in the same quadrant. To allow for future retrofit of alternative detection.
6. Section 6.7.12 (induction Loop Detection/Conduit): added info as per Region 4 - Regions may have a larger minimum conduit size than the statewide minimum – verify with Region.
7. Section 6.8.3 (Standard video detection zone layout) – revised this section to show new video detection standard layout. Added a figure illustrating the standard layout.

8. Section 6.10 (radar detection) – separated the radar and microwave detection information. Revised and added radar information. Added new radar detection standard layout. Added a figure illustrating the standard layout.
9. Section 6.12 (Use of multiple detection technologies at a single intersection) – added language to limit this to 2 max.
10. Figure 6-43 (camera labeling) and section 6.8.1 (camera placement and labeling) – fixed a typo (clockwise changed to counterclockwise)
11. Figure 6-52 (use of inductance loops and video detection at the same intersection) – updated illustration to reflect current standards for video detection placement.

Chapter 9 Details Plan

1. Section 9.3.3 (equipment on mast arm) – fixed a typo – should be rounded to nearest ½ foot, not 1/10 of a foot.
2. Section 9.3.5 (Luminaires) – changed standard from HPS to LED

Chapter 11 Temporary Signal Plan

1. Section 11.6.3 (Service Cabinet and Meter Base) – Reference to old standard details was removed and reference to revised standard drawing added.

Chapter 19 Specifications, Bid Items & Cost Estimate

1. Section 19.2 (Review & Approval of the special provisions) – added a reference to figure 19-4 as an example of a modification that requires review and concurrence of the technical expert.
2. Added new section 19.4 (letter of public interest finding) – this section was added to explain when and why this is needed.

Chapter 20 Cabinet Prints

1. Section 20.3 (procedure for producing cabinet prints) – revised this section based on the new procedure established in Sept 2014.
2. Section 20.4 (creating the cabinet print) – made a few revisions (file naming convention and added info about FINAL CABINET PRINTS location)
3. Chapter 20 (Cabinet Prints) – reformatted chapter to follow 332S cabinet print layout. Added info about 332S cabinet.

Chapter 23 Quick Reference

1. Chapter 23 (Quick reference) – Added video and radar detection information. Revised layout of detection/input file info.
2. Chapter 23 (Quick reference) – updated sign info (AL/12).
3. Chapter 23 (Quick reference) – added info for cabinet limitations (input, output and conflict monitor constraints)
4. Section 23.3 (loop detector information): added info as per Region 4 - Regions may have a larger minimum conduit size than the statewide minimum – verify with Region.

5. Section 23.6 (sign information): updated chart to include signs AL/3T, AL/20 and the revised AL/12.
6. Section 23.7 (junction box & conduit information): 2" spare conduit for detection required between signal pole and first JB in the same quadrant. To allow for future retrofit of alternative detection.
7. Section 23.13 (junction box and conduit information): added info as per Region 4 - Regions may have a larger minimum conduit size than the statewide minimum – verify with Region.
8. Chapter 23 (Quick reference) – added info about the checklists and hyperlinked examples

1.5.4 Revision: June 2017

1. Updated web link on cover page
2. General, minor wordsmithing on several areas (content and intent remain unchanged).

Chapter 1 Introduction

1. Section 1.1: About Us – Added Jeff Hayes contact information
2. Section 1.2: updated web link to manual
3. Section 1.3: changed updated frequency from twice a year to once a year
4. Section 1.3: added link to our subscribe/unsubscribe list for e-mail notification of changes and updates to the manual

Chapter 2 Design Approval Process

1. Section 2.1: updated Figure 2-1 (organization chart)
2. Section 2.2: added info about Roadway Design Exceptions for ADA pushbutton accessibility and link to section 5.4 for more info.
3. Section 2.5: added "temporary workzone" to list of other disciplines plans that could be helpful during review
4. Section 2.8: Added quick reference section electrical crew preferences form

Chapter 4 Starting the Design

1. Section 4.3.2: updated hwy number cross reference guide web link

Chapter 5 Signal Plan

1. General – added note at beginning to go to quick reference chapter for electrical crew preferences form
2. Section 5.1.2: added language to verify crosswalk closures (even existing closed crosswalks) have been approved by the STRE.
3. Section 5.1.3: added language that doesn't require curb ramps if there is no sidewalk, such as at rural intersections (specifies curb ramps are required if sidewalk is present)
4. Figure 5-1 Standard Closed Crosswalk Signing support and installation (TM490): updated figure to match current TM490

5. Section 5.1.2: changed clearance from barricade from 4′ to 5′ min as per TM490
6. Section 5.1.3: Added information related to new ADA requirements for ramp design and updated figure 5-4, figure 5-5, figure 5-6, and figure 5-7.
7. Added new section 5.1.4: information on Roadway ramp detail sheets and pole locations.
8. Section 5.1.4: Changed requirement for a two-phase pedestrian crossing configuration from "shall be staggered…" to "should be staggered". And added language about countdown heads mitigating the confusion associates with non-staggered two-phase pedestrian crossings.
9. Section 5.2.1: deleted bi-modal and one section signals from list of unique heads (now are listed on TM460)
10. Figure 5-17 Signal Head Types: updated to include new signal head types defined on TM460
11. Table 5-2 Standard signal Heads for Left Turn Phases: Added info for Type 3LCF and Type 3LBF signal heads.
12. Figure 5-27 Signal Head Placement for Left Turn Phasing: Updated figure to include Type 3LCF and 3LBF heads. Deleted illustration that showed using a type 4L signal head with an approach that does not have an exclusive left turn lane (this is not allowed by MUTCD section 4D.17 paragraph 06)
13. Figure 5-40 Common signs used for traffic control: Added "STRE approval required" for signs AL/3U and AL/3T (U-Turn Permitted and No trucks)
14. Section 5.4 (Pedestrian Signal Equipment Layout): completely revised with added information related to ADA pushbutton accessibility from technical bulletin TRS16-01(B). Additional info for two ramps sharing one turning space.
15. New section 5.4.8 Pushbutton located behind guardrail: Revised information allowing pushbuttons located behind guardrail.
16. Section 5.4.10 Indication Type: Changed "shall" to "Should" for upgrading all pedestrian signals for an entire intersection at the same time to allow more flexibility for ADA constraints.
17. Section 5.5.5: changed illumination requirements from "if warranted" to a default standard of including illumination on all mast arm and strain poles at an intersection.
18. Section 5.5.7: removed "signalized right turn slip lanes" from list of typical vehicle pedestal installations
19. Section 5.5: added info about pushbutton mounting (pedestals = yes, big poles =no) with reference back to section 5.4
20. Section 5.6: changed illumination requirements from "if warranted" to a default standard of including illumination on all mast arm and strain poles at an intersection.
21. Section 5.15.6: corrected typo for wiring of Type 6L head.
22. Section 5.6.1: deleted statement about contacting illumination engineer for new LED spec (02926) as it is now published.
23. Section 5.7: modified language for fire preemption for clarity

24. Figure 5-56 Standard Drawing TM470 Signal head wiring: updated to include Types 3LBF and 3LCF. Removed Type 4L
25. Updated Figures 5-57 thru 5-63 and corresponding text (wiring for signal head types) to match updated TM460

Chapter 6 Detector Plan

1. Fixed counterclockwise typos for radar and video camera labeling

Chapter 11 Temporary Signal Plan

1. Section 11.2 – added restriction to allow only one signal mast arm to be installed per intersection at day of turn on.
2. Section 11.6.5 – made reference to section 5.4 for pushbutton accessibility requirements
3. Figure 11-15 – fixed typo in lane use in the phase rotation diagram
4. New Section 11.7.3 Stop Line Location

Chapter 12 Flashing Beacon Plan

1. Section 12.4.6 added reference to new moveable bridges chapter
2. Section 12.2: added Standard Detail references for solar power RRFB to list
3. Section 12.6: deleted reference to an old (no longer accessible) standard detail DET4414

Chapter 13 Ramp Meter Plan

1. Removed references to TM497 (details have since been deleted from this drawing).
2. Removed references to TM497 (deleted) and replaced with TM492

Chapter 16 Railroads

1. Section 16.3: added language, "The Crossing Order must be completed prior to PS&E."
2. Section 16.6.1: added provision for allowing one 10 conductor 12 AWG gauge conductor cable instead of individual conductors at the Region Electrical Crew direction.
3. New section 16.4 Railroad Utility Permits

Chapter 17 Fire Signal Plan

1. Section 17.4.1: added a provision for flashing yellow operation on the mainline if the STRE Operational Approval documents the use. For example a unique application: the fire signal in downtown Roseburg on Douglas Ave uses Flashing Yellow due to the extremely close proximity to a traffic signal and is meant to approaching stop vehicles while the traffic signal clears the queue that blocks the fire entrance.
2. Section 17.4.3: Removed single circular green signal indication as an option for a confirmation light. Only option is a tattletale indicator due to the simplicity of a direct hardwire.
3. Section 17.4.5: revised information for Tattletale indicators and referenced DET4400

Chapter 19 Specifications Bid Items and Cost Estimates

1. Section 19.5.1: added clarification to power hook-up anticipated cost (includes conduit, trenching and wiring from the power source to the service)

Chapter 20 Cabinet Print

1. Section 20.1: added language requiring cabinet prints for temporary signals (for each stage/phase there is a change to interior components)
2. Section 20.4: changed format of prints from 8.5x11 to 11x17
3. Section 20.6: deleted requirement for TSSU to complete the conflict monitor diode card
4. Section 20.6.3: revised section to describe to designers how to complete the conflict monitor diode card
5. Section 20.6.5: fixed typo – A6 (not A4) is not monitored
6. Section 20.9: added Railroad preemption site specific constraints to list of info that should be on the intersection drawing.

Chapter 21 Construction Support

1. Added new section 21.4.1 for Field verification forms (Signal Pole and Signal Pole Foundation)

Chapter 23 Moveable Bridges

1. Added an entire new chapter

Chapter 24 Quick Reference

1. Added section 23.14: electrical crew preferences with forms.

1.5.5 Revision: January 2020

Chapter 1 Introduction

1. Section 1.1 - Changed Traffic Control Systems Engineer from Jeff Hayes to Sarah McCrea

Chapter 2 Design Approval Process

1. Section 2.3 – new section for Overhead Structures and Vertical Clearance Standards as per tech bulletin RD17-02(b).
2. Section 2.5 – minor modifications to the DAP plans information, percent completion for each stage, and name for 100% complete plans.
3. Section 2.5 – added information about the ProjectWise process and a new figure “Project Comment Log Sample”.
4. Section 2.6 – added information about the ProjectWise process
5. Section 2.7 – added information about digital signatures

Chapter 4 Starting the Design

1. Section 4.1 – New section on Scoping, including information on the traffic signal asset management report and goals/priority Improvements.
2. Section 4.5 – Added information about the ProjectWise process.

Chapter 5 Signal Plan

1. Section 5.1 – Deleted reference to 1R preservation projects.
2. Section 5.1.2 – Completely revised to reference new guidance and process for crosswalk closures documented in the 2020 Traffic Manual Update.
3. Section 5.1.2 – moved general info about detailing vs. referencing with other discipline's plan sheets to chapter 19
4. Section 5.1.3 – added information about keeping the crosswalk distance short for railroad interconnected signals.
5. Section 5.2 – changed FYA standard signal head to type 3LCF as per memos from the State Traffic Signal Engineer dated May 16, 2018 and July 23, 2018 in all the locations necessary in this section.
6. Section 5.2.3 – Added info for supplemental signal heads for sun glare with a new figure
7. Section 5.4 – fixed reference section typo
8. Section 5.4 – Added reference to guiding documents: MUTCD, Oregon supplements, ADAAG, and PROWAG and deleted bullet item that pushbuttons should meet MUTCD section 4E-08 requirements.
9. Section 5.4 – changed turning space dimension from 4'x5' to 4.5' x 5.5' as per roadway section
10. Section 5.4.2 – Changed 10 foot minimum separation of buttons to 8 feet minimum.
11. Section 5.4.3 – Added information about priority of requirements/recommendations
12. Section 5.4.4 - Updated figure to include language that the entire pushbutton does NOT need to be included in the horizontal reach range area. Also fixed reference figure typo
13. Section 5.4.4 – added info for pushbutton parallel to crosswalk it serves.
14. Section 5.4.5 – Revised section to reflect new large pole foundation details shown in TM653 (now flat from foundation control point to edge of baseplate with a tolerance of 0"-1/4" between foundation and adjacent concrete or asphalt finish grade)
15. Section 5.4.6 – Added info about use of 8 foot minimum separation and buttons located in the 8 -10 foot separation range
16. Section 5.4.6 – revised figures for 4' minimum dimension for dimension between crosswalk striping and curb for diagonal ramp and added that obtaining this minimum measurement may not be possible with small radii.
17. Section 5.4.7 – added info about producing object (extension bracket) cannot extend more than 4" into the circulation path and a reference to RD720.
18. Section 5.4.9 – new section for info about the extended pushbutton press feature

19. Section 5.4.12 – new section for Audible pedestrian signals – reference to Traffic Signal Policy and Guidelines
20. Section 5.5.2 – New section for Overhead Structures and Vertical Clearance Standards as per tech bulletin RD17-02(b).
21. Section 5.5.3 – Added low voltage utility clearance guidelines with new figure
22. Section 5.10.1 – added info about maintaining the 5' minimum pedestrian clear circulation path when the controller cabinet door is open if possible.
23. Section 5.15 – new section added for Background/Reference information to allow for documentation that was contained in memos from the State Traffic Signal Engineer dated May 16, 2018 and July 23, 2018 about type 3LCF signal heads for FYA. Moved other historical only info into this section as well.

Chapter 6 Detector Plan

1. Revised entire chapter and section layout: Radar is the new default standard detection. Deleted info related to loops. Detector plan sheets are no longer required (all radar info is shown on the signal plan). Cabinet prints will now show detector zone and configuration information.

Chapter 7 Interconnect Plan

1. Section 7.1 – revised section to address central communication (now required for all traffic signals) and local communication (connection of multiple controllers in a corridor for signal progression).
2. Section 7.2 – updated text to state current controller type (ATC) and software (maxtime)
3. Section 7.3 – Revised allowable forms of communication as per ITS unit. Fiber optic is the preferred form. Other options include 4.9 GHz radio, cellular broadband and leased dedicated Ethernet. Twisted pair copper (VDSL) is no longer allowed for new installations.
4. Section 7.7.1 – removed outdated information and updated text to current controller type (ATC)
5. Section 7.7.2 – revised section to emphasize fiber optic installation
6. Section 7.7.4 – revised section to only show fiber optic wiring installation and added a new figure showing the fiber optic cable splice diagram created by the ITS unit.
7. Section 7.7.5 – deleted telephone connection section as per ITS unit.

Chapter 11 Temporary Signal Plan

1. Section 11.2 – added the 5th bullet about TPAR
2. Section 11.6.6 – changed section title to "Vehicle Detection". Added a statement that video and radar are the preferred method of detection. Added a statement that loop detection should be avoided if possible.

3. Section 11.6.8 – minor text modification for better readability

Chapter 12 Flashing Beacon Plan

1. Section 12.1 – updated table to include actuated system for Emergency Vehicles
2. Section 12.4.4 and 12.4.5 – added a reference back to section 5.4 for pushbutton placement and to locate the buttons where they are easily accessible for all intended users (peds and/or cyclists).
3. Section 12.4.7 – added a reference to Chapter 5 for pushbutton placement.
4. Section 12.4.8 – New section for actuated system for Emergency Vehicles

Chapter 13 Ramp Meter Plan

1. Figure 13-7 – Removed reference to TM497 (no longer exists). Removed loops from illustration.
2. Section 13.6 – Revised section to match changes made in chapter 6 (detector plan). Radar is new default standard. Deleted info related to loops.

Chapter 16 Railroads

1. Section 16.7.1 – revised pedestrian features to reference section 5.4.9 for extended pushbutton press feature.

Chapter 17 Fire Signal Plan

1. Section 17.1 – added a highlight box to alert designers that actuated flashing beacon systems for fire trucks are a good alternative to a traditional fire signal and reference to Chapter 12 for design info.
2. Section 17.3 – minor text modification for better readability
3. Entire chapter – changed tattletail to tattletale
4. Section 17.3.1 – This is a new section: Solutions For Existing Fire Signals Located at Intersections
5. Entire Chapter – clean-up of figure call-out notes for consistency throughout whole manual

Chapter 18 Standard Drawings and Details

1. Section 18.1 & Figure 18-1 – updated to text and figure to current method of listing standard drawings on plan sheets (no longer shown in the title block)

Chapter 19 Specifications Bid Items and Cost Estimate

1. Section 19.2 – added Specifications Engineer also is required to review and concur with special provision modifications that fall outside of the normal boiler plate instructions.
2. Section 19.3 - moved general info about detailing vs. referencing with other discipline's plan sheets to chapter 19

3. Section 19.3.5 – New section – added info about bid item for crosswalk closure supports.

Chapter 20 Cabinet Prints

1. Section 20.2 and Section 20.3 – changed timeframe for putting the cabinet print in the INCOMING subfolder from just before testing at TSSU to DAP (this will allow signal timers adequate time to review and comment on new sheet 7 which details the detection unit placement, zones, and zone configuration).
2. Section 20.5.2 – added info for SDLC (e.g. leave detector input location slots 1 thru 10 blank.
3. Section 20.5.8 – added information for 332s cabinet detector input termination using video, radar, or SDLC
4. Section 20.6 – fixed typos and incorrect microstation references
5. Section 20.6 – changed FYA standard termination from ped yellow to overlap as per memos from the State Traffic Signal Engineer dated May 16, 2018 and July 23, 2018 in all the locations necessary in this section.
6. Section 20.10 – new section added for Background/Reference information to allow for documentation that was contained in memos from the State Traffic Signal Engineer dated May 16, 2018 and July 23, 2018 about FYA.

Chapter 21 Construction support

1. Section 21.2 – added information for digital signatures
2. Section 21.7 – added information for digital signatures

Chapter 22 State Force Work

1. Figure 22-1 – updated to current title block

Chapter 24 Quick Reference

1. Deleted video and radar specific info and replaced with: Non-Invasive Detection Information, (consistent with Chapter 6).
2. Removed input file info for 170 and 2070 controllers

1.5.6 Revision: January 2021

Changes applicable to all chapters:

1. Reformatting to ODOT document branding and accessibility standards as per the ODOT SPDB Communications Team.
2. Clean up of text, figures and tables for improved readability
3. Updated the titles of units/sections/position descriptions to current labels.

Chapter 2 – Design Approval Process

1. Updated Figure 2-1 Organization Chart
2. Section 2.2 – added reference to HDM and website for Roadway design exceptions and forms. Corrected the design exception language as per the Senior ADA Standards Engineer.
3. Section 2.7: added "unit file code" as another description of "TRS" Drawing numbers, to be consistent with the new ODOT title block. Revised section title to generic "drawing numbers"
4. Section 2.8: added that digital signatures are the preferred method
5. Figure 2-4: deleted Joe Searcy as an authorized signature at his request due to change in job duties
6. Section 2.8.2 – added information for digital signatures to non-ODOT let projects, as this is our preferred method for all plan sheets.

Chapter 3 – Signal Operation and Operational Approval

1. Entire chapter – deleted reference to Preliminary Signal Operations Review (PSOR) form as it is no longer used.
2. Section 3.1 – added "opening of existing closed crosswalks" to list of items the operational approval typical contains as this is a lot more common now due to current ADA requirements.
3. Section 3.3.8 – added text note as an option under ring and barrier diagram for incompatible left turns.
4. Section 3.3.11 – new section – overlap phase with green extension.
5. Section 3.9 – changed "right turn slip lane" to "channelized right turn lane" to be consistent with the Traffic Manual.

Chapter 4 – Starting the Design

1. Section 4.1 – added a bullet to the scoping guidance for review of roadway geometry for issues that impact traffic signals (lane shift, truck turning issues, pedestrian facilities, etc.)
2. Section 4.1 – added a bullet to the scoping guidance for review of ADA features.
3. Section 4.1.1 – added info about transGIS layer for asset info (including ADA ramps and ADA pushbuttons).

Chapter 5 – Signal Plan

1. Entire chapter – consistent use of "curb ramp"
2. Entire chapter – consistent use of "ADA curb ramp design exception" and "general roadway exception"
3. Section 5.1.2 – deleted "bollards with chains" option for detectible barrier as ODOT roadway does not have any approved configurations for this.

4. Section 5.1.2 – changed terminology of "detectable barrier" to "detectable barrier/feature" to include treatments that are not typically thought of a true "barrier" and clarified the purpose of the barrier as per the Statewide ADA Engineer.
5. Section 5.1.2 – added info about crosswalk closure supports on curb ramp detail sheets and review of the curb ramp detail sheets by the signal designer.
6. Section 5.1.3 – added clarification and changed terminology as per the Statewide ADA Engineer.
7. Section 5.1.3 – added an objective no. 3 for crosswalk alignment (helping sight impaired pedestrians navigate) and a statement that skewed intersection should be fixed to address all three objectives best.
8. Section 5.1.5 – in second bullet after figure 5-9, added info about the difficulties of sight impaired pedestrians using a single phase, two-state pedestrian crossing (more reason to not use this type of design).
9. Section 5.1.6 – added another option for signalized driveway design (using roadway standard drawings with 3 modifications) based on discussions with the Statewide ADA Engineer.
10. Section 5.1.7 – added new section for maintenance pads.
11. Section 5.1.8 – added new section to for truck turning templates
12. Section 5.1.9 – added new section for lane shift discussion
13. Section 5.2 – revised span wire information to apply to temporary signals only
14. Section 5.2 – updated section reference typo for pedestrian signal equipment layout
15. Section 5.2.4 – added spanwire installations are only applicable to temporary signals now.
16. Section 5.2.6 – new section – info on tattletale lights
17. Section 5.3.1 – deleted reference to span wires
18. Section 5.3.2 – deleted reference to TM660 (spanwire –no longer exists) and replaced with TM655 (60-75' mast arm poles). Deleted references to spanwire installations.
19. Section 5.3.4 - added spanwire installations are only applicable to temporary signals now.
20. Section 5.4.2 – changed vertical reach of pushbutton to 42" to 48" – this matches existing TM standard drawings and the new ADA curb ramp design exception criteria.
21. Section 5.4.2 – clarified horizontal reach is a side reach, not a forward reach.
22. Section 5.4.2 – clarified that the clear space shall connect to a pedestrian access route (PAR)
23. Section 5.4.2 – clarified 15 foot maximum from pushbutton to edge of curb is the "travel path".
24. Section 5.4.3 – added a 4th bullet for deviation – vertical reach of pushbutton less than 42" and a new section reference for discussion of when this may be considered. As per discussions with the ADA standards engineer.
25. Section 5.4.4 – added information about placing the pedestal in front of curbs (as opposed to modifying pedestal foundation to fit behind the curb or incorporating the curb into the foundation) and added a new figure after figure 5-50.

26. Section 5.4.8 – new section – deviation: vertical reach of pushbutton as per the ADA standards engineer.
27. Section 5.5 - added spanwire installations are no longer allowed for permanent signals.
28. Section 5.5.6 – added info for 60-75′ mast arm poles and using proper placement so that these longer mast arms are only used when necessary (as they have bigger foundations and are more costly than 55′ and under mast arms). Also added dual mast arms for these longer arms is not an option as per the Traffic Structures Engineer.
29. Section 5.5.7 – Added strain poles are no longer allowed for permanent installations and a reference to chapter 11 – temporary signals.
30. Section 5.5.8 – removed reference to span wires
31. Section 5.5.10 – made recessed terminal cabinets standard, removed reference to standard details that no longer exist.
32. Section 5.5.12 – Added strain poles to the list of non-standard designs as they have been removed from the standard drawings. Also added dual mast arms for 60′ to 75′ mast arms is not an option as per the Traffic Structures Engineer.
33. Section 5.6 – deleted reference to strain poles
34. Section 5.7 – removed span wire installation info for preemption detector.
35. Section 5.12 – added a note about handhole spacing of 1000′
36. Section 5.12 – deleted information junction box info relating to loop detection installation. Added junction boxes should be installed within 50 feet of the nearest signal pole or controller cabinet.
37. Section 5.12.1 – deleted cast iron information and loop detection and interconnection info (fiber optic is the preferred interconnect method and uses handhole boxes, not JBs).
38. Section 5.12.1 – replaced figure 5-83 showing junction box placement for size – not needed due to table 5-5 default minimum junction box type/size simplification (removal of loop detector and interconnect cable) with “ADA softscaping requirements for junction box PCC apron.”
39. Section 5.12.2 – new section for junction box placement
40. Section 5.12.4 – new section – elevation adjustments and considerations.
41. Section 5.12.5 – new section – deviations from junction box placement standards
42. Section 5.13 – For clarity, reworded conduit crossing mainline once requirement and added a figure.
43. Section 5.13 – deleted information about illumination circuit and photo electric cell wiring being contained in its own separate conduit – this was erroneous.
44. Section 5.13.1 – revised text for spare conduit for alternative detection between the pole and JB due to non-invasive being our current standard.
45. Section 5.13.1 – added info about using larger than minimum conduit sizes and additional spare conduits.
46. Section 5.13.1- updated table 5-7 to include more cable/wires (video, radar, etc.)
47. Section 5.13.2 – updated specification and standard drawing references. Corrected information to match TM471, blue sheets, and specifications regarding conduit materials.

48. Section 5.13.3 – updated specification reference.
49. Section 5.13.4 – updated figures 5-86 thru 5-89 to reflect control cable wiring. Removed method 2 (figure 5-87) for routing conduit due to use of control cable, but discuss its use for retro-fit projects.
50. Section 5.13.5 – new section – conduit trenching depths and underground conflicts
51. Section 5.14 – deleted reference to loop wire splicing in junction box exception (loop detection information has been removed from manual and standard drawings as it is no longer ODOT standard).
52. Section 5.14.1 – changed control cable to the standard wire type with single conductor wire allowed for retro fit projects with inadequate existing conduit size only. Updated and reformatted all wiring information. Deleted 6 twisted pair interconnect cable info, as we no longer allow it. Added TC cable description.
53. Section 5.14.2 – deleted info for No. 8 AWG used for traffic signal system neutral and No. 12 AWG used for pedestrian system neutral in pedestals (now the neutral is No. 14 AWG, inclusive to the control cable).
54. Section 5.14.5 – deleted information for single conductor wire installations since control cable is now the standard. Added a reference to Jan 2020 version of manual if using individual conductor wires for retro-fit projects.
55. Section 5.14.6 - Figures 5-91 thru 5-98 (signal/ped head wiring figures) – revised figures to show only using 7 conductor cable. Revised text to show use of only 7 conductor cable and removed permanent span wire installation info. Corrected FYA termination (from ped yellow to overlap green).
56. Section 5.14.7 – figures 5-99 and text updated to show only using 7 conductor cable.
57. Section 5.14.8 – figure 5-100 and text updated to show only using 7 conductor cable. Deleted information on permanent span wire installations.
58. Figure 5-102 wiring phases with individual conductors is deleted – no longer used in new construction.
59. Section 5.14.8 – figure 5-103 updated diagram to show remote pedestrian pedestals.
60. Section 5.14.9 – modified the external terminal cabinet wire entrance information to be only applicable to retrofit projects, as recessed terminal cabinet are now the current standard. Updated figures 5-104 and 5-105 to match TM470 wiring of pedestrian indications/pushbuttons on large pole (single No. 14 AWG THWN).
61. Section 5.14.10 wire economy – individual conductors - this section deleted as 7 conductor cable is the new standard. If individual conductors are used for retro-fit projects, this information can be accessed in the archived Jan 2020 manual.
62. Section 5.14.11 – span wire installations, wiring signal heads – this section was moved to chapter 11 as span wires are only used for temporary applications.
63. Section 5.14.13 spare wires – this section deleted as 7 conductor cable is the new standard. If individual conductors are used for retro-fit projects, this information can be accessed in the archived Jan 2020 manual.

Chapter 6 – Detector Plan

1. Section 6.1 – clarified that radar is the standard for bike detection also.
   Section 6.1.1 – added info about new standard details for loop detection
2. Section 6.1.2 – added a statement that multiple detection technologies may be acceptable (new bike/ped detection as an example) and will be approved by the state traffic signal engineer on a case-by-case basis.
3. Section 6.2.1 – deleted info about presence detection that caused confusion.
4. Section 6.2.2 – clarified 460' detection distance speed (55 mph)
5. Section 6.2.2 – all advance detection devices on the green sheets require 900' of detection, therefore, removed all 600' device information.
6. Section 6.3.3 – added info about rapidly improving non-invasive bike detection technologies and to verify available products with the state traffic signal engineer.
7. Section 6.3.3 – added info about bike box detection.
8. Section 6.3.4 – clarified that the count zone detection for max adapt MAY be recommended for optimal performance and to work with region traffic to determine the site specific detection needs.
9. Section 6.4.1 – deleted section as it mainly pertained to loop design. Moved content about radar using algorithms to protect the dilemma zone to section 6.2.2
10. Section 6.4.2 – added RTE approval is required for advance stop bars (consistent with traffic manual). Also added that detection is not typically used between the advance stop line and crosswalk, but may be used if engineering judgement determines a need (non-invasive detection does not have the same issues as loops).
11. Section 6.4.6 – added standard detection for a signalized private residence driveway is a pushbutton.
12. Section 6.8 – added a statement that if standard placement of radar devices on the mast arm pole or mast arm are not feasible (e.g. retro-fit with conduit fill issues), will not provide the desired detection zone coverage, or there are concerns about occultation, detector units should be installed on stand-alone vehicle signal pedestals. Supplemental detector units may also be considered to get the proper detection zone coverage. Work with the region signal timer during the DAP review of the detector zones on the cabinet print (See Chapter 20) to determine the proper placement and number of detector units needed.
13. Section 6.8 – revised nearside guidance about bike lane occlusion to be applicable to all lanes.
14. Section 6.8 – changed nearside offset from 12' to 14'
15. Section 6.8 – added recommendation for a field visit to ensure there are no obstacles to placement of the detection device (trees, vegetation, or other signal heads)
16. Section 6.8 – added a reference to chapter 13 (ramp meters) for side fire radar units
17. Section 6.8 – all advance detection devices on the green sheets require 900' of detection, therefore, removed all 600' device information.

Chapter 8 – Existing Utilities Plan

1. Entire section – updated guidance based on survey of signal designers and construction office's needs.

Chapter 9 – Details

1. All – revised all references of span wire info to pertain only to temporary installations.
2. Section 9.2.1 – added examples of when a pole entrance chart is not necessary and other options for showing the necessary info.
3. Section 9.2.2 – new section – info about detailing existing signal pole/pedestals on the pole entrance chart
4. Section 9.3.2 – added information about pushbutton mounting degrees. This is due to ADA requirements which has resulted in more exact information needed to ensure the pushbutton placement will pass ADA inspection.
5. Section 9.3.2 – changed terminal cabinet information to reflect recessed terminal cabinets (external terminal cabinets now for temporary applications only)
6. Section 9.3.4 – added info for custom foundations.
7. Section 9.4.2 – deleted info that only pertained to permanent strain poles for MAH calc.
8. Section 9.4.3 - added information about pushbutton mounting degrees. This is due to ADA requirements which has resulted in more exact information needed to ensure the pushbutton placement will pass ADA inspection.
9. Section 9.4.3 - changed terminal cabinet information to reflect external terminal cabinets only for temporary span wire applications)
10. Section 9.4.5 – revised foundation information for temporary wood poles.
11. Section 9.5.2 – new section – stand-alone luminaire pole light pole table info

Chapter 10 – Removal Plan

1. Section 10.2 – added a reference to chapter 19 for LPIF process.

Chapter 11 – Temporary Signal Plan

1. Section 11.2 – added additional information about the benefits of using a temporary signal based on feedback from the Salem PM office.
2. Section 11.6.1 – changed the wood pole submittal review process to be more accurate (contractor submits certifications to the PM office and the traffic structures engineer or EOR will then approve for use on project)
3. Section 11.6.1 –removed language that indicated a difference between temporary span wire installations and permanent spanwire installations.
4. Section 11.6.1 – added information about using a ¼" messenger cable from the large strain pole to the smaller wood post with pedestrian equipment.
5. Section 11.6.2 –removed reference to standard detail 4415 (temporary pre-cast controller foundation) – now a standard drawing.
6. Section 11.6.3 – removed specific standard drawing references and made it generic.

7. Section 11.6.5 – deleted information about consideration for construction staging changes as it applied to loop detection.
8. Section 11.6.5 – removed specific standard drawing references and made it generic.
9. Section 11.6.6 – removed information for loop detection. Added info on coverage issues of non-invasive detection due to limited placement options for the detection units.
10. Section 11.6.7 – revised entire section for better readability
11. Section 11.7.1 – added a statement that dummy phases may not be required to accommodate long red clearance intervals and to verify with Region Signal Timer (matches language in chapter 3).
12. Section 11.7.5 – revised to delete information on loop detection and added information on radar detection.
13. Section 11.7.6 – revised to delete information on loop detection and added information on radar detection.
14. Section 11.9 – updated standard drawing and specification references

Chapter 12 – Flashing Beacon Plan

1. Section 12.1 – Added Through Route Activated Warning Signs (TRAWS) information as it now and ARTS countermeasure.
2. Section 12.4.9 – new section: added some design info for TRAWS
3. Section 12.8 – added a reference to the Traffic Manual for intersection control beacon use and that other treatments may be more effective.
4. Section 12.8 – deleted all references to span wire installations.
5. Section 12.4.6 – radar is default standard now
6. Section 12.9.5 – new section – added info about PHB phasing and use of fire preemption. Also see chapter 20.

Chapter 13 – Ramp Meters

1. Entire chapter – updated standard drawing references and sign sheeting types
2. Section 13.2.1 – revised location of ramp meter assembly related to stop line and edge of pavement to allow for placement of detection unit on the ramp meter assembly on the right hand side of the ramp.
3. Section 13.2.2 – revised lateral location of mast arm pole to allow for placement of detection unit on the mast arm
4. Section 13.3 – removed “be prepared to stop” with “when flashing” sign and replaced it with a supplemental “ramp metered when flashing” sign(s) if sight distance is a concern. Added more info about the purpose of this sign and ramp configuration based on a review of each existing ramp meter in Oregon.
5. Section 13.3 – added flexibility for placing a single ramp meter assemble on either side of the ramp, but preferably on the right. Based on a review of each existing ramp meter in Oregon
6. Section 13.3 – broke this section into subsections

7. Section 13.6.1 – revised mounting locations for radar unit. Deleted queue loop based on information about how ramp meters are currently operated.
8. Section 13.6.1 – added info about using ITS pole for mounting detection equipment and count detection using ITS sites rather than going thru the ramp meter controller.
9. Section 13.6.2 – deleted info about the input file and referenced older versions of the signal design manual.
10. Section 13.7.1 – new section, background reference info added to document reason for no longer using queue detection and PTR signs.

Chapter 14 – Pedestrian Signal Plan

1. Entire Chapter – revised to allow pedestrian signals as an option on the state highway as per discussions with the Traffic Active Modes Engineer. Added design guidance for pedestrian signals.

Chapter 15 – Red Light Enforcement Plan

1. Section 15.2 - Added info stating automated speed enforcement may be included in the red light running system.

Chapter 16 – Railroads

1. Section 16 – deleted outdated info about the Right of way manual and added a reference to the Traffic Manual for additional procedural and coordination information.
2. Section 16.2 – corrected field diagnostic review info as per rail section (removed reference to CFR).
3. Section 16.3 – updated rail crossing order search weblinks
4. Section 16.3 – updated info about private crossings (the STOP sign and PRIVATE CROSSING sign are regulated by rail section).
5. Section 16.4 – updated railroad utility permits contact
6. Section 16.5.3 – added a note that the rail owner may send the simultaneous preemption input to the traffic approx. 5 to 10 seconds earlier than the activating the railroad equipment as per ODOT rail comment.
7. Section 16.7.1 – corrected inaccurate wording about interconnect circuits.
8. Section 16.7.1 – updated wiring requirements (use control cable vs. individual conductors)
9. Section 16.7.1 – added picture of rail interconnect access box on bungalow
10. Section 16.9.1 – new section – added information about signal modifications that require an update to the preemption plan sheet (and in turn require updating the crossing order).

Chapter 19 – Specifications Bid Items and Cost Estimate

1. Updated temporary specification references
2. Delete outdated material specification references
3. Added 00902 crosswalk closure support to the list of specifications indirectly related to traffic signals

4. Added 00962 Metal Illumination and traffic signal supports & 00921 major sign support drilled shafts (for mast arm poles with mast arms 60′ to 75′) to list of specifications directly related to traffic signals.
5. Section 19.3 – added info about 00921.90 bid item for mast arm poles with mast arms 60 to 75 feet.
6. Section 19.3.1 – deleted the "detector installation" bid item – this work is now part of the "traffic signal modifications" bid item.
7. Section 19.3.1 – added "excludes mast arm pole foundations" for "traffic signal installation" and "traffic signal modifications" bid items.
8. Section 19.3.1 – added info about stand-alone luminaire poles being excluded from the traffic signal lump sum bid item. Also include examples of when it might be good to modify this via special provisions.
9. Section 19.3.2 – added 00921.90 bid item for foundations for long mast arms (60′ – 75′).
10. Section 19.3.2 – added info about why foundations are separate bid items
11. Section 19.4 – added ATC controller to list of items requiring an LPIF

Chapter 20 – Cabinet Prints

1. Section 20.1 – added ramp meters and other signal installations with a controller cabinet (e.g. TRAWS), to the list of when a when a cabinet print is required.
2. Section 20.7.6 – new section – information for output file and conflict monitor configuration for PHBs. Developed in conjunction with TSSU.
3. Section 20.7 – figure 20-13 – added info for verifying the typical conflict monitor assignments and following the website instructions if it is different than what is actually used.

Chapter 21 – Construction Support

1. Section 21.5 – revised cabinet print information to reflect new process (submitted at DAP and provided to the contractor via the PM office)

Chapter 24 – Quick Reference

1. Section 24.2 – added note that 2021 new standard is to use control cables.
2. Section 24.8 - Changed FYA output from opposing ped yellow to overlap green. And deleted 4 section FYA head info.
3. Section 24.12 - Removed cast iron junction box info

1.5.7 Revision: January 2022

Chapter 5 – Signal Plan

1. Section 5.10.6 – new section – ATC controller to provide info about agency furnished information based on project type.
2. Section 5.6 – revised illumination information on LEDs, projectwise and photometric analysis.

Chapter 12 – Flashing Beacon Plan

1. Section 12.5.3 – new section – Pushbutton requirements for RRFBs based on discussions with Senior ADA Standards Engineer.
2. Section 12.9 – removed design information for Pedestrian Hybrid Beacons (PHB) and replaced with info about how PHBs are generally not installed on the state highway and a reference to the ODOT Traffic Manual. Stated RRFBs and pedestrian signals are preferred over PHBs.

Chapter 14 – Pedestrian Signal Plan

1. Section 14.1 – deleted info about alternatives to pedestrian signals (PHBs and RRFBs) to be consistent with changes made to section 12.9. Also added a reference to the ODOT Traffic Manual.

Chapter 16 – Railroads

1. Section 16.6: Added info about keeping rail equipment maintained by rail owner separate from equipment maintained by ODOT/local agency.
2. Added new section 16.8 – Traffic Control Devices Activated By the Rail Controller Cabinet.

Chapter 20 – Cabinet Prints

1. Section 20.6 – added reference to Instructions For Signal Timers and Designers.
2. Section 20.6.1 – deleted erroneous reference to chapter 20.
3. Section 20.7.3 – added info about priority order of assigning channels 9 thru 12 when an intersection has a mix of Type 3LCF signal heads, Type 3RCF signal heads, and overlap signal heads.
4. Section 20.7.3 – Updated nomenclature for how to list flashing yellow arrows on diode card channel assignments (to match DGN cabinet prints).
5. Section 20.11 – added reference to Instructions For Signal Timers and Designers.

1.5.8 Revision: January 2023

General

1. Removed references to “pedestrian pedestal”, “vehicle pedestal” and “pushbutton post” as appropriate. Replaced with “pedestal” as per revisions to TM457.
2. Corrected capitalization issues in entire manual.

Chapter 1 – Introduction

1. Section 1.1 – updated phone numbers for all contacts and org chart reference.

Chapter 2 – Design Approval Process

1. Section 2.6 – revised information needed for detector plan sheets (no longer require a separate detector plan sheet if all non-invasive detection is used as per changes made in January 2020)

2. Section 2.7 – added info about getting TSSU ID numbers in addition to getting drawing numbers.
3. Section 2.8.1 – updated name: office of project letting is now project controls office.

Chapter 3 – Signal Operation and Operational Approval

1. 3.3.12 – New Section – Unconventional Phases & Sequences. This section was needed as software options now allow a phase assignments to be on any side of the barrier with unique sequences that do not follow the traditional ring and barrier structure.

Chapter 4 – Starting the Design

1. Section 4.5.1 – added information and link to the ODOT engineering archives for archived dgn files (only accessible for internal ODOT staff) and projectwise.
2. Section 4.6.3 – added clarity that the bridge designer determines the required SM pole foundation depth.

Chapter 5 – Signal Plan

1. Section 5.1.3 – added clarification for crosswalks with no sidewalks: the required level landing area should consist of a pedestrian pad outside of the normal shoulder. Added reference to section 5.1.8 for when a pedestrian pad outside the normal shoulder isn't feasible, the ped access route requires a shoulder that is not encroached by vehicles. As per ADA standards engineer.
2. Section 5.1.3 – added information about when a design exception for a single curb ramp for 2 crosswalks should be used vs. a separate curb ramp for each crosswalk based on discussion at October 2022 TOAST meeting regarding sight line/storage distance issues for ADA curb ramp retrofits at signalized intersections.
3. Section 5.2.2 – Corrected Table 5-2 dual left turn guidance to match the Traffic Signal Policy and Guidelines (dual left turns shall have protected only phasing. Added information about dual left turns on one-way grid systems are typically permissive only phasing.)
4. Section 5.2.2 – Corrected Table 5-3 dual right turn guidance to be clear on intent and also consistent/uniform with changes made in Table 5-2.
5. Section 5.2.2 – corrected typo and references in table 5-4. Deleted a bad reference to figure 5-32 for using the type 4L signal head. Note that in June 2017, the 4L signal head was removed from figure 5-36 for the following reason, "Deleted illustration that showed using a type 4L signal head with an approach that does not have an exclusive left turn lane (this is not allowed by MUTCD section 4D.17 paragraph 06)", however, this has since been interpreted by traffic engineers in the standards unit to not be the case as the federal register indicates that 4D.17 p06 only applies to a protected only left turn phase and not the protected only portion of a protected/permitted phase.
6. Section 5.3.4 – added info about guide sign and street name sign mounts and referenced standard dwgs.

7. Section 5.4.4 – added info about clear space being outside of the vehicle way/roadway shoulder and reference to section 5.1.8 for verifying vehicle encroachment as per ADA standards engineer.
8. Section 5.4.4. – added info and figure 5-57 and figure 5-58 about not designing curb tight around the foundation of the pedestal (leads to trash collection and ponding).
9. Figure 5-53 – added language that centering the pushbutton in the center of the 10" reach range box is optimal/preferred (helps people who are paralyzed and can't move their core to shift weight and reach the pushbutton or have smaller limbs and heights) as per the ADA standards engineer.
10. Section 5.4.7 – added info and figure 5-91 about NOT using extension brackets if they protrude into the circulation path.
11. Section 5.5.4 – added reference to NEC requirements for vertical and horizontal clearance to telcom (low voltage) lines, typically 2' vertical and 3' horizontal. Added text to always verify clearance requirements with utility. Updated figure 5-97 to correspond.
12. Section 5.5.5 – added discussion and Figure 5-98 on placement of mast arm poles near or along the radius
13. Section 5.5.8 – vehicle pedestals are no longer used due to change in standard drawing TM457 that is effective Dec. 2022. This section updated to reflect that change.
14. Section 5.5.9 – Changed this section from "pedestals- pedestrian" to "pedestals" with information reflecting the changes standard drawing TM457.
15. Section 5.5.11 – pushbutton posts are no longer used due to the change in standard drawing TM457 that is effective Dec 2022. This section updated to reflect that change.
16. Section 5.9 – as per discussions with TSSU and electricians about the downsides of battery back-up (maintenance issues and not working as intended), revised this section to inform others of the issues.
17. Section 5.13.1 – Changed values in table 5-8 from RMC to PVC schedule 40. Updated figures 5-108 and 5-109 and table 5-10 to correspond. It was brought to our attention that the NEC values for PVC schedule 40 are less than RMC. The intent of this table was to use the smallest values based on all acceptable conduit materials used on ODOT projects, so that the calculation for fill rate is easy and would work for all conduit materials that may be used on a project (it would then result in conservative fill rate calculation for any materials that have slightly larger values).

Chapter 12 – Flashing Beacon Plan

1. Section 12.1 – removed "actuated system for mid-block crossings" from table. This system is no longer used, RRFB is the system that should be used for this application.
2. Section 12.1 – added note stating there are exceptions to STRE approval of RRFBs as per section 310.3 of the ODOT Traffic Manual.
3. Section 12.2 – new section – Design information at a glance provides a summary table of the major design feature options and design references for each type of flashing beacon installation.
4. Section 12.3 – new section – speed feedback signs (unintegrated)

5. Section 12.4 – revised to state that only certain flashing beacons can be powered by either commercial or solar power with a reference back to new section 12.2.
6. Section 12.4 – updated standard detail references – reference to use table in section 12.2
7. Section 12.6 – new section – sight distance considerations
8. Section 12.7 – new section – TSSU ID numbers for flashing beacon installations
9. Section 12.8.1 – referenced new DET4457 and updated text to match.
10. Section 12.8.2 – referenced new DET4450 and DET4451 and updated text to match.
11. Section 12.8.4 – referenced new DET4453 and updated text to match.
12. Section 12.8.5 – included info that this is not a green sheet item
13. Section 12.8.6 – added information about ground mounted option (W3-4 sign with W16-13p rider) and included info that this is not a green sheet item.
14. Section 12.8.7 – revised this section to state that actuated warning beacons for mid-block crosswalks are no longer used and new installations should be RRFBs.
15. Section 12.8.8 – referenced new DET4459 and updated text to match.
16. Section 12.8.9 – included info that this is not a green sheet item.
17. Section 12.9 – revised text in entire section to match changes made to section 12.8.7
18. Section 12.9.1 – added reference to ODOT Traffic Manual which now has info on RRFBs.
19. Section 12.9.2 – removed info about using RRFB standard details and added standard drawing TM493 info and new bubble note info.
20. Section 12.9.4 – added reference to the ODOT Traffic Manual for additional info on location of assemblies
21. Section 12.9.6 – new section to reference the illumination requirements for RRFBs (Traffic Lighting Design Manual)
22. Section 12.10 – referenced new DET4454 and DET4455 and updated text to match.
23. Section 12.11 – referenced new DET4452 and updated text to match.

Chapter 16 - Railroads

1. Section 16.1 – Added clarification of when preemption may be needed for RxR crossing located farther then 215’ away with a reference to new section 16.1.2.
2. Section 16.1.1 – New Section – Verification of Railroad Interconnection at existing traffic signals (information about using TransGIS).
3. Section 16.1.2 – New Section – Evaluating Preemption and Traffic Control Devices at Rail Crossing Further Than 215 feet.
4. Section 16.4 – updated railroad utility permits contact info
5. Section 16.5.3 – added additional site specific considerations to consider when determining if a VCOI phase is required.
6. Section 16.7 – reformatted information on signal plan sheets, this section now references new section 16.8
7. Section 16.8 – New section added – interconnected traffic signal specific design elements and considerations. This section has several new subsections: pre-signals, supplemental signals, queue cutter signals, detection, channelized right turns, median islands,

crosswalk placement and stop lines, and limited right of way. Also includes reorganized sections on signs, conduit and wiring, pedestrian features and type 7 signal heads.
8. Section 16.9 – fixed typos
9. Section 16.10 – fixed typos and outdated terms
10. Section 16.11 – added reference to the preemption plan now being included with the cabinet print and to see chapter 20 for more info.

Chapter 18 – Standard Drawings and Details

1. Section 18.1.2 – revised section using new term: standard drawing report. Old term was baseline report.

Chapter 19 – Specifications, Bid Items, and Cost Estimate

1. Section 19.1 and section 19.2 – removed reference to TSB 12-01(B) – no longer valid (this has been incorporated into the boiler plate instructions).
2. Section 19.3.1 – referenced chapter 12 and integrated speed feedback signs for flashing beacon installation lump sum bid item.
3. Section 19.3.4 – Added info on new bid item in 00227, temporary flashing beacons.

Chapter 20 – Cabinet Prints

1. Section 20.2 – added information about TSSU reviewing and redlining existing cabinet prints when doing yearly inspections. Also, everyone using the cabinet print should report any errors or omissions they find by redlining the existing print and sending to Traffic Roadway section to create the updated final print. This is to help ensure that existing cabinet prints are up to date and complete and accurate as possible.
2. Section 20.3 – deleted specific information about the folder structure and just refer to the READ ME document instead.
3. Section 20.4 – added info about when using and modifying an existing cabinet print is appropriate (e.g., very minor modifications only and the intersection drawing and phase rotations are in the current format). This is to help get all the cabinet prints updated to current standards in a timely manner.
4. Section 20.4 – updated the info on the base prints available on the web (10 different types now)
5. Section 20.4 – deleted info about axiom importer.
6. Section 20.6.1 – added info on all the possible input file equipment to match what is shown in the excel files.
7. Section 20.7.1 – added info about dummy phases to the main output file (they are not wired to a load switch and not shown in the output file)
8. Section 20.7.3 – added a note to “determining compatible phases for the diode card” that dummy phases are not wired to load switches and therefore are not listed in the channel assignment.
9. Section 20.7.3 – added a note that fire signal confirmation outputs are no longer used.
10. Section 20.10 – changed info about the plan view intersection orientation. This is to help with consistency and ease of cabinet print creation.

11. Section 20.10 – added requirement for the normal phase rotation diagram to be the ring and barrier style. Old styles must be updated.
12. Section 20.10 – removed one bulleted item for railroad items list as it is now better covered by new section 20.12.
13. Section 20.11 - changed info about the plan view intersection orientation. This is to help with consistency and ease of cabinet print creation.
14. Section 20.11 – added passive pedestrian detection zones to the list of items to show on page 7 (detection drawing) of the cabinet print.
15. Section 20.12 – new section added- page 8 rail preemption plan sheet. The rail preemption plan sheet will be added to the cabinet print to help ensure rail specific items are known when the cabinet is chamber tested. This is the start for the process of keeping rail preemption plan sheets up-to-date and accurate without having to go thru the rail crossing order process for minor changes as per ODOT commerce and compliance.

Chapter 21 – Construction Support

1. Section 21 – added bullet point for handing off electronic files to construction office.
2. Section 21.4.1 – added more explanation for the review of pole shop drawings and updated to current procedure.
3. Section 21.8 – added info about the virtual CTSI training.

Chapter 24: Quick Reference

1. Section 24.14 – deleted info about the hyperlinks, they are no longer valid.

1.5.9 Revision: January 2024

General Overall Changes:

1. Revised text throughout the manual as necessary for improved clarity.
2. Changed not-ped to negative ped as per current software nomenclature.
3. Added 2 new chapters:
    a. Chapter 21 Contract Plan Development & Drafting (this chapter replaces the signal drafting manual and provides updated information)
    b. Chapter 25 Automatic Traffic Recorder Plans (this chapter was created at the request of the TSM unit)
4. The 2 new chapters added (see above) required re-numbering of a few existing chapters as follows:
    a. Construction Support (old chapter 21 to new chapter 22)
    b. State Force Work (old chapter 22 to new chapter 23)
    c. Moveable Bridges (old chapter 23 to new chapter 24)
    d. Quick Reference (old chapter 24 to new chapter 26)

Chapter 1: Introduction

1. Section 1 - Removed information on the "ODOT Traffic Signal Drafting Manual" as this drafting manual is being retired due to the new chapter 21.
2. Section 1.1 - Revised crew member information: Joe Searcy retired in spring 2023 (congrats to the Chive!) and Barby Golden has filled his position.

Chapter 2: Design Approval Process

1. Section 2.1 - Updated organization chart, figure 2-1
2. Section 2.6 - Modified reference from old QA/QC checklists to new checklist in Chapter 21
3. Section 2.6 and 2.7 - removed the hard copy submission of plans for review option. All plans must be submitted electronically.
4. Section 2.6 - Revised comment review information to match current traffic-roadway procedure.
5. Section 2.7 - Removed info and just referenced chapter 21 for how/where to show TSSU ID numbers.
6. Section 2.8 - Removed wet signature information. All plan sheets now require digital signatures. Added a reference to chapter 21 for the traffic section approval block and digital signature. Removed subsections 2.8.1 and 2.8.2.
7. Section 2.9 - Removed electrical crew preference forms as this formal process was never really used. Proper communication with maintenance appears to be sufficient.

Chapter 3: Signal Operations and Operational Approval

1. Section 3.1 – Added a link to the traffic approvals website to get STRE approvals and current requests in the queue.
2. Section 3.6 - Updated transit priority information. Added transit phasing info and new example figure.
3. Section 3.10 – updated examples of operational approvals/PSOD.

Chapter 4: Starting the Design

1. Section 4.1 – revised scoping guidelines for reviewing roadway geometry for clarity.
2. Section 4.1 – removed requirement to for signal designer to notify the state traffic signal engineer when statewide goals will not be addressed during scoping. Tracking these goal dates and allocating future funding to meet them is not currently being done due to lack of resources.
3. Section 4.1.2 – removed goal dates for the statewide priorities as the traffic-roadway section does not have any authority over the planning process, funding that is used for projects, or securing funding to address any of the goals. Tracking these goal dates and allocating future funding to meet them is not currently being done due to lack of resources.

4. Table 4-5 – adjusted low priority battery back-up for the railroad interconnected traffic signal to match language in chapter 5 regarding use of battery back-up and included a reference to chapter 5.
5. Section 4.3 – revised text for clarity.
6. Section 4.6.1 – deleted replacement of existing loops as this is no longer standard practice.

Chapter 5: Signal Plan

1. Section 5 – Deleted the requirement to document electrical crew preferences via the electrical crew preferences form from chapter 24. Using this form never really caught on and is therefore discontinued.
2. Section 5.1- revised text with a revision to new chapter 21 for projects without roadway design or survey data.
3. Section 5.1.3 – simplified the three crosswalk objectives info.
4. Section 5.2.1 – added info about standard signal head types vs. signal head types now shown in standard detail DET4401.
5. Figure 5-26 – revised table based on TM460 standard drawing revisions and creation of DET4401 made in Jan 2024 update.
6. New figure 5-27 Non-Standard Signal Head Types (DET4401) – added due to changes made to section 5.2.1.
7. Table 5-2 – stated the type 3LBF head is no longer used. This signal head is no longer necessary as it was a last resort alternative to the type 6L signal head when the type 6L head was the standard option for PPLT phasing. The type 3LBF was smaller than the type 6L and could be used in locations where the type 6L head couldn't. Now that the type 3LCF head is the standard for PPLT, the type 3LBF is not necessary as an alternative because the type 3LCF and type 3LBF are the same size.
8. Table 5-2 – added info for using a type 4L signal head for PPLT phasing with a shared through-left lane.
9. Table 5-3 – removed 170 and ATC controller specific information for right turn phasing as all ODOT owned and maintained traffic signals will have the current controller already installed. Also added the type 3RCF head for protected/permitted right turn phasing.
10. Table 5-4 – deleted type 4L signal head information as it is now contained in table 5-2.
11. Figure 3-35 signal head placement for lanes sharing the same phase – added a single lane approach (left-thru-right movement) example.
12. Figure 3-37 signal head placement for left turn phasing: removed information on type 3LBF and Type 6L signal heads. Added type 4L signal head information.
13. Figure 3-38 signal head placement for right turn phasing – revised illustration to reflect changes made to table 5-3.
14. Section 5.2.3 – added clarification that supplemental signal heads are not an overlap phase, but are hardwired to the phase they are supplementing.
15. Section 5.3 – added a reference to new chapter 21.

16. Figures 5-58, 5-59, and 5-60 modified to illustrate different scenarios for not wrapping the curb tight around the pedestrian pedestal.
17. Figure 5-83 Preferred Pushbutton Placement for Two Curb Ramps That Share a Turning Space (Two Buttons on Pedestal) – changed the turning space requirement to 5.5'x5.5' as per the ADA standards engineer.
18. Section 5.4.7 – added extension bracket recommended maximum length of 12 inches.
19. Section 5.4.11 – Added information and new figure for verifying the pedestrian signal has no potential obstructions.
20. Section 5.4.11 – added information on retrofitting pedestrian signals to new ramps/crosswalk alignment.
21. Section 5.4.11 – added information about pedestrian signal head orientation.
22. Section 5.5 – added links to the Traffic Structures Manual.
23. Section 5.6.3 – updated specification reference for illumination ground/bond wire.
24. Section 5.10.1 – added code requirement of 3' minimum of working space around the controller cabinet with a new figure. This is becoming more of an issue with ADA ramp/pushbutton upgrades.
25. Section 5.10.1 – added information on coordinating with the roadway designer on the walkway for the controller cabinet if there is not sidewalk.
26. Section 5.13.1 – added piezo cable area to table 5-7.
27. Section 5.14.4 – updated specification reference for illumination ground/bond wire.
28. Section 5.14.5 – added link to the 2020 version of the Signal Design Manual.
29. Figure 5-117 7-conductor control cable wiring for signal heads (TM470) – updated figure to reflect changes made to signal head types in section 5.2.1.
30. Figure 5-118 Wiring for type 2, 2B, 2BM, 3L, 3R, and 3LCF signal heads – updated figure to reflect changes made to signal head types in section 5.2.1.
31. Figure 5-121 Wiring for type 4L & 5 Signal heads – updated figure to reflect changes made to signal head types in section 5.2.1.

Chapter 6: Detector Plan

1. Section 6.1 - Deleted information about traffic-roadway section tracking the location of loop installations. Tracking this and allocating future funding is not currently being done due to lack of resources.
2. Section 6.3.6 – added link to ODOT Traffic Signal Management Plan

Chapter 8: Existing Utilities Plan

1. Section 8.3 – Removed section on drafting information. Now contained in new chapter 21.

Chapter 9: Details Plan

1. Section 9.2.2 – revised language to match new chapter 21 for numbering existing poles/pedestals.
2. Section 9.4.1 – removed reference to TM661 (strain pole), no longer a standard drawing.

Chapter 10: Removal Plan

1. Section 10.1 – Corrected specification reference.

Chapter 11: Temporary Signal Plan

1. Section 11.1 – added link to ODOT Traffic Control Plans Design Manual
2. Section 11.7.1 – added TPAR coordination information.
3. Section 11.7.2. – added two figures to clarify sight distance recommendations and information on using a robust back-up plan supported by the region traffic engineer for temporary bridge signal sight distance mitigation. This alternative has been successfully implemented in region 3.
4. Section 11.8 – Corrected specification reference. Added information about using portable temporary traffic signals in lieu of a standard traffic signal.

Chapter 12: Flashing Beacon Plan

1. Section 12.2 summary table – Added information on which flashing beacon types require a BMCF for both the power and the control system. All other flashing beacons using commercial power require a BMC.
2. Section 12.4 – Added information on which flashing beacon types require a BMCF for both the power and the control system. All other flashing beacons using commercial power require a BMC.
3. Section 12.8.1 – added info for using the BMCF
4. Section 12.8.2 – added info for using the BMCF
5. Section 12.8.9 – Changed service requirement from BMCF to BMC
6. Section 12.11 – added info for using the BMCF and deleted erroneous information.

Chapter 13: Ramp Meter

1. Section 13.6.1 – added information about the ITS price agreement for radar units and how to coordinate using the price agreements on a project.
2. Section 13.7 Wiring– NEW section to remind designers of the need to check voltage drop and manufacturer recommendations when radar cable lengths exceed 2000 feet.

Chapter 14: Pedestrian Signal Plan

1. Section 14.1.5 – added information for type 2B and type 2BM signal heads.

Chapter 15: Red Light Enforcement Plan

1. Section 15.2 – added link to Red Light Running Camera Guidelines for State Highways.
2. Section 15.5 – added link to Sign Design Manual

Chapter 16: Railroads

1. Figure 16-1 SSD at Railroad At-Grade Crossings and Signalized Intersections – updated according to the ODOT Traffic Manual.
2. Figure 16-2 Railroad Preemption Required – updated figure to clarify the measurement.
3. Section 16.1 – added link to ODOT Traffic Signal Policy and Guidelines

4. Section 16.5 – revised info about deviations to standard preemption operation to match current process.
5. Section 16.5.1 – Added info about changing an existing PCOI value.
6. Section 16.8.1 – modified pre-signal overlap operation information.
7. Section 16.9 – Added information about who typically maintains and owns rail controller activated traffic control devices and service cabinet/power disconnect guidance.
8. Section 16.11 – removed drafting requirements and made reference to new chapter 21.

Chapter 19: Specifications Bid Items and Cost Estimates

1. Section 19.3 – removed info and added reference to new chapter 21.
2. Section 19.3.4 – corrected specification reference.

Chapter 20: Cabinet Prints

1. Section 20.7.5 – deleted info on using yellow flash plugs for mainline thru phases to be consistent with the current ODOT traffic signal policy and guidelines chapter 9.

Chapter 21 – Contract Plan Development and Drafting: NEW CHAPTER

Chapter 22 Construction Support

1. Section 22.2 – added reference to new chapter 21 for the revised plans process.
2. Section 22.7 - added reference to new chapter 21 for the revised plans process.

Chapter 23 State Force Work

1. Section 23.3.2 – deleted info and added reference to new chapter 21 for using "EX' bubble notes and reference notes.

Chapter 25: Automatic Traffic Recorder Plan: NEW CHAPTER

Chapter 26 Quick Reference

1. Section 26.3 - Revised loop wire entrance, only have sand pocket option now via DET4434.
2. Section 26.8 – updated conflict monitor typical pin assignments illustration.
3. Section 26.10 – added SM6L and SM7L info to mast arm chart
4. Section 26.13 – Deleted the requirement to document electrical crew preferences via the electrical crew preferences form. Using this form never really caught on and is therefore discontinued. Instead, a firm reminder to have the electrical crew involved during design review milestones.
5. Section 26.14 – Removed outdated QA/QC checklists and replaced with "final design/drafting checklist" shown in new chapter 21.

1.5.10 Revision: January 2025

General

1. Updated name from "Traffic-Roadway Section" to "Traffic Engineering Section", and "STRE" to "STE" due to recent reorganization.

Chapter 2: Design Approval

1. Section 2.1 – updated figure 2-1 as per changes made in the general section

Chapter 5: Signal Plan

1. Section 5.2.1 – fixed typo in figure 5-26 standard signal head types (TM460)
2. Section 5.2.2 – new section added: Head Materials. This section provides information on the selection of vehicle signal materials (aluminum, standard duty polycarbonate, and heavy duty polycarbonate) and how to specify specific materials in the signal plans. Includes verification of electrical crew preferences.
3. Section 5.2.3 – updated table 5-3. Added information that a type 2 signal head with louvers can no longer be operated as an independent overlap phase as per MUTCD 4D.22p02 & 4D24p02). A type 2 signal head for permissive only right turn phasing can only be operated as supplemental signal head assigned to the adjacent thru phase.
4. Section 5.4.13 – new section added: Pedestrian signal head materials. This section provides information on the selection of pedestrian signal materials (aluminum and polycarbonate) and how to specify specific materials in the signal plans. Includes verification of electrical crew preferences.
5. Section 5.3 – updated figure 5-53 (common signs used for traffic control, cont.) to include recommending the use R10-12 "left turn yield on green ball" sign with a type 7 signal head as per current practice.
6. Section 5.3.1 – corrected typos in sign info (YIELD to ped changed to STOP FOR ped)
7. Section 5.3.4 – added information on mounting PTR signs (with a vehicle signal bracket).
8. Section 5.4.2 – Added the following to pushbutton "should" criteria: pushbuttons are ideally mounted on the same support as their associated pedestrian signal head. Added a reference to section 5.4.14, audible pedestrian signals.
9. Section 5.4.14 – changed "audible pedestrian signals" to "audible pedestrian signals/pushbuttons" as that is a more accurate way to describe them as we transition the naming convention for the different types of audible equipment used. Requires converting other documentation (standard drawings, green sheets, etc.) which will take time.
10. Section 5.4.14 – added information about audible pedestrian signal wiring that makes mounting the pushbutton and associated pedestrian signal head on the same support better for installation, retro-fits, and maintenance.
11. Section 5.13.1 – added info about coordinating with the electrical crew to determine if it is feasible to add new wiring to any existing conduit.

12. Section 5.10.7 – new section added: decorative controller cabinet wraps. Made reference to the new artwork policy/directive that roadway is still working on.

Chapter 6: Detector Plan

1. Section 6.8 and 6.9 – Added a highlighted box to each section for the critical need of the region signal timer to review and concur with the detector unit placements via the cabinet print process at DAP. This has been an issue on fast-track projects.

Chapter 9: Details

1. Section 9.3.2 – Added a new figure, "terminal cabinet degrees: example of solutions to access issues" to illustrate issues to consider for improving ease of maintenance.

Chapter 12: Flashing Beacon Plan

1. Section 12.8.6 – added a refence to chapter 16, section 16.9 for the railroad application of using "PREPARE TO STOP WHEN LIGHTS FLASH" sign.
2. Section 12.9.1 and 12.9.2 – removed references to MUTCD interim approval of the RRRB and replaced it with the 11th edition of the MUTCD chapter 4L.
3. Section 12.9.7 – new section added: service cabinet and wiring to RRFB controller cabinet. This section states the use of No. 10 AWG XHHW wires from the service cabinet to the RRFB cabinet.

Chapter 13 – Ramp Meter Plan

1. Section 13.6.1 – Added a note to, "contact the ITS standards engineer to coordinate using the price agreement on a project".
2. Section 13.6.1 – added information on the two different ways count detection is provided and who is responsible for the work, either via the ramp meter controller or via a stand-alone ITS controller cabinet.
3. Section 13.6.1 – added information for verifying maintenance access to radar devices with the electrical crew and providing several solutions to consider.

Chapter 16: Railroad & Preemption Plan

1. Section 16.8.15 – Added information to include recommending the use R10-12 "left turn yield on green ball" sign with a type 7 signal head as per current practice.

Chapter 18: Standard Drawings and Standard Details

1. Section 18.1 – Added information about new TM700 series (common electrical systems).

Chapter 20: Cabinet Prints

1. Section 20.12 – Added instructions for including the sealed preemption plan sheet to the end of the cabinet print PDF so that the seal and approval signatures do not "break" and appear blank.

Chapter 21: Contract Plan Development & Drafting

1. Section 21.10.6– Added "ODOT crossing number" to list of items to include in the railroad preemption plan sheet as per the ODOT commerce and compliance division.
2. Section 21.16 – updated the following figures for bubble notes: figure 21-71, 21-74, 21-76, 21-85, and 21-86

Chapter 26: Quick Reference

1. Section 26.5.1 – updated input file for 332S (from cabinet print)
2. Section 26.5.2 – updated input file for 332 (from cabinet print)
3. Section 26.5.3 – updated input file for 336 (from cabinet print)
4. Section 26.11 – updated sign information as per changes made in chapter 5
5. Section 26.13 – added a checklist for electrical crew preferences that should be verified.
6. Section 26.14 – updated drafting checklist as per changes made in the general section.

1.5.11 Revision: January 2026

General

1. Changed "ADA requirements" to "accessibility requirements" as per the senior ADA standards engineer. This term is more accurate as ODOT may be using a more restrictive standard to meet the minimum ADA requirements or an alternative under equivalent facilitation. We've partly incorporated PROWAG 2023 but have not adopted it.

Inside Front Cover:

1. Updated physical address for traffic standards

Chapter 3: Signal Operations & Operational Approval

1. Section 3.3.4 – New section "Flashing yellow left turn arrow used for permissive only phasing" as per revisions made in chapter 5
2. Section 3.7 – added reference to HDM part 802.5 and coordination with roadway designer for crosswalk closure detectable treatments

Chapter 4: Starting the Design

1. Section 4.1 – Added a bullet point to coordinate with agency electricians during the scoping process guidelines.
2. Section 4.1.2 – Added info about including local agency maintained, ODOT owned traffic signals in planning for capital improvement projects.
3. Section 4.1.2 – Added "VDSL surge protectors" to table 4-3 "Statewide Goals High Priority" item no. 5
4. Section 4.1.2 -Revised table 4-4 "Statewide Goals Medium Priority" to include strain poles (was formally a low priority combined with 4-bolt mast arm poles) and revised table 4-5 "Statewide Goals Low Priority" to just state 4-bolt bolt mast arm poles as per the state traffic structures engineer.

5. Section 4.1.2 – Removed battery back up at rail interconnected signals (item no. 14) from table 4-5 "Statewide Goals Low Priority" as per changes made in chapter 5.
6. Section 4.5.3 – Added information about coordinating a field visit with the signal timer and/or agency electricians.
7. Section 4.6.1 – New section "Existing Operational & Condition Information" to add info about verifying existing phasing and controller cabinet prints to ensure the proposed work can be done to current standard or if additional work is triggered (e.g., adding Aux files)

Chapter 5: Signal Plan

1. General – Deleted all language for "finish grade acceptance slope" as the 2027 HDM will be updated to meet PROWAG's additional 1/10th of a percent allowance of 2.1% as per the senior ADA standards engineer.
2. Section 5.2.1 – Updated Figure 5-26 "standard signal head types" type 3LCF head to include the operation of "permissive only left turn phasing with a left turn only lane"
3. Section 5.2.1 – Updated Figure 5-26 "standard signal head types" type 3RCF head to state, "contact the state traffic signal engineer for more information and design approval to use this signal head"
4. Section 5.2.3 – Corrected typos for figure references
5. Section 5.2.3 – Updated table 5-2 "standard signal heads for left turn phases" to use a type 3LCF head for permissive only phasing (FYA only) when a left turn only exists and there is no controller cabinet limitations. This allows the following normal operational benefits: a better understood signal indication for permissive left turns (vs. green ball), no need for a sign to help explain yielding requirements (R10-12) which reduces clutter and driver cognitive load, ability to use negative ped timing feature for enhanced pedestrian protection, and ability to easily change left turn phasing operation as necessary in the future when traffic volumes change. Preemption operation benefits (for EV and rail) include eliminating the yellow trap.
6. Section 5.2.3 – Updated table 5-2 "standard signal heads for left turn phases" to eliminate the requirement to inventory the use of type 3LCF signal heads, as they are now standard in the 11th edition of the MUTCD.
7. Section 5.2.3 – Updated table 5-3 "standard signal heads for right turn phases" to contact the state traffic signal engineer for more information and design approval to use the type 3RCF signal head for PPRT phasing.
8. Section 5.2.3 – Updated table 5-4 "standard signal head for special phasing/lane configurations" to include more specific info about when to use the type 7 head given that a type 3LCF head is now used for permissive only phasing if there is a left turn only lane and no controller cabinet limitations.
9. Section 5.2.3 – Updated figure 5-38 "signal head placement for left turn phasing" given that a type 3LCF head is now used for permissive only phasing if there is a left turn only lane and no controller cabinet limitations.

10. Section 5.2.3 – Updated figure 5-39 “signal head placement for right turn phasing” to state contact the state traffic signal engineer for more information and design approval to use the type 3RCF signal head for PPRT phasing.
11. Section 5.2.3 – Updated figure 5-42 “signal head placement for railroad preemption” given that a type 3LCF head is now used for permissive only phasing if there is a left turn only lane and no controller cabinet limitations.
12. Section 5.2.4 – Added a figure to show another example of where supplemental signal heads can cause confusion and shouldn’t be used (right turn slip lanes that are not controlled by the signal indications).
13. Section 5.3 – Updated figure 5-54 “common signs used for traffic control (cont.)” to match 11th edition MUTCD, specifically signs AL/12 and AL/20 (sign number & size), as per state sign engineer.
14. Section 5.4 – removed ADAAG reference as it is no longer a necessary guide as per senior ADA standards engineer.
15. Section 5.4.2 – added “& single curb ramp serving two crosswalks” to diagonal curb ramp allowed by ADA curb ramp design exception in second to last bullet point for clarity.
16. Section 5.4.4 – New section “incorporating PROWAG requirements” – added info on how the 2023 PROWAG is incorporated in this manual and the process for dealing with any discrepancies between this manual and PROWAG.
17. Section 5.4.5 – Added information and reference to HDM section 815.3.3 for using combination curb ramp, when possible, to help reduce the distance from the pushbutton to the edge of curb (vs. a perpendicular style curb) as per the ADA standards engineer.
18. Section 5.4.5 – added information for when two pushbuttons are placed on a single pedestal, to make sure to verify the recommended 15’ from pushbutton to edge of curb distance for BOTH crosswalks, as it is possible one crosswalk to be within the recommended distance and the other not. A new figure “measuring distance from pushbutton to crosswalk (edge of curb) Example 2” was created to show this.
19. Section 5.4.6 – Added information about the revised curb ramp details for parallel and combo ramps no longer requiring a curb placed at the back of walk (it is only installed “as directed”) and when the curb is not present, it can make using a large pole a more feasible option for pushbutton placement where use of pedestals is restricted.
20. Section 5.4.12 – Added requirement that pedestrian signals are required at all marked crosswalks, consistent with the traffic signal policy and guidelines. Noted the exception for crosswalks marked at channelized right turn lanes that are not controlled by a signal.
21. Section 5.4.15 – Added clarification that when audible pushbuttons are required, they typically required for the entire intersection. In rare cases where only certain crosswalk require audible pushbuttons, one audible device is required at each end of the crosswalk (two total).
22. Section 5.9 – Revised battery back-up guidance: it is no longer supported for use at any traffic signal. Reference to the new history section for the details

23. Section 5.12.1 – Removed the "A" from JB bubble notes and description, as TM702 requires it depending on where it is installed (do not need to call out installing the apron on the plan sheets)
24. Section 5.12.2 – Updated standard drawing references
25. Section 5.12.2 – Updated minimum dimension of softscaping to match standard drawing TM702 (from 3 feet to 2 feet).
26. Section 5.15.4 – New section "Battery back-up history" details for why we no longer support installing battery back-up.

Chapter 6: Detector Plan

1. Section 6.3.3 – Added information to strongly discourage using pushbuttons for permanent bicycle detection. Made reference to chapter 11 for the one specific temporary application of using pushbuttons for bicycle detection.
2. Section 6.8 – Added information about using the options shown in new standard detail DET4420 Radar Cable Splice Installation External Splice Box

Chapter 7: Interconnect Plan

1. Section 7.3 – Revised to state that existing signals with twisted pair copper (VDSL) systems need to be replaced with fiber optic (or one of the other acceptable options). VDSL can no longer be maintained as the manufacturer is discontinuing the switches.
2. Section 7.7.2 – updated standard drawing reference
3. Section 7.7.2 – updated information that hand holes can spaced up to 1000' for consistency with standard drawing.

Chapter 11: Temporary Signal Plan

1. Section 11.7.6 – Added sign PUSH BUTTON FOR EXTRA BIKE TIME sign (sign no. CR10-24 approved in 2024 in the ODOT sign policy and guidelines)

Chapter 16: Railroad & Preemption Plan

1. Section 16.6 – Added a reference to the Railroad Final Drawings Manual (created in 2025) for additional info on creating plan sheets specifically for the crossing order.
2. Section 16.8 – Added a bullet item for a new design element section "permissive left turn phasing using flashing yellow arrow" as per changes made to chapter 5, and guidance included in the new Heavy Railroad Preemption Operation Guide scheduled to be released in early 2026.
3. Section 16.8.6 – Added information about interpolating MUTCD figure 4D-3 to determine the 30' min. distance from the stop line to a low mounted signal head.
4. Section 16.8.15 – Revised to state a type 7 signal head is required for when the vehicle clear out phase is a permissive left turn movement AND there is no left turn only lane or controller cabinet limitations.
5. Section 16.8.16 – New section: Permissive left turn phasing using flashing yellow arrow as per changes in chapter 5.

Chapter 19: Specifications, Bid Items, and Cost Estimate

1. Section 19.4 – Added information about calculating salvage costs for LPIF as per discussion and recommendations from the project controls office.
2. Section 19.4 – Removed LPIF requirements for proprietary/patented materials and sole source materials as per the project controls office.

Chapter 20: Cabinet Prints

1. Section 20.1 – Added information about need to field verify existing controller cabinet conditions with TSSU, region traffic, and/or electrical crew to ensure proposed design will work and all necessary controller cabinet modifications (including components and wire terminations) are identified and shown on the new cabinet print.
2. Section 20.5 – Added requirement to include the project key number in the cabinet print title block "remarks" area.
3. Section 20.6.1, 20.6.2, 20.6.3, 20.6.5 – Updated figures to show maxtime numbers and current style of input file from excel spreadsheet.
4. Section 20.6.1 – Updated list of detector equipment to match the current pull-down list of the excel spreadsheet.
5. Section 20.6.5 – Updated list of preemption detector equipment to match the current pull-down list of the excel spreadsheet.
6. Section 20.6 and 20.7– Corrected typos on all figures referencing "332" instead of "332S". Also added a few key differences between 332 and 332S component placement in the input file.
7. Section 20.7.3 – The illustrations for the 3 basic steps to determine compatible phases for the diode card were not labeled as figures, causing confusion. Changed illustration's format and labeled each one as new figure.
8. Section 20.7.6 – Corrected typos in PHB ring and barrier diagram in both figures in this section.

Chapter 21: Contract Plan Development & Drafting

1. Section 21.10.6 – Added a reference to the Railroad Final Drawings Manual (created in 2025) for additional info on creating plan sheets specifically for the crossing order.
2. Section 21.9.8 – New section "Updating Type 3L to Type 3LCF Signal Heads" to show intended use of associated bubble notes.
3. Section 21.15– Added coordinate with the roadway designer for walkway design to the controller cabinet and BMCL as per TM482 in the final design/drafting check list.
4. Section 21.16 – Updated bubble notes, figure 21-76 (corrected typos to match workspace), figure 21-78 (updated sign number and size for AL/12 and added AL/20), and figure 21-80 (removed "A" notes for junction box apron).

Chapter 22: Construction Support

1. Section 22.4.2 – Revised text for the signal designer's role with the blue and green sheets to state review and assistance to the resident engineer's office as required is desirable.

Chapter 26: Quick Reference

1. Section 26.11 – Updated sign information based on sign design changes made in chapter 5.
2. Section 26.13 – Added "radar cable splice preference when there is no RTC on pole, section 6.8" to the electrical crew design preferences to verify table as per revision made in section 6.8.
3. Section 26.14 – New section "salvage cost estimate equations (LPIF)" as per changes made in chapter 19.
   Section 26.15 – Updated checklist based on changes made in chapter 21.

2 Design Approval Process

The traffic engineering section has reviewed and approved traffic signal plan sheets for many years with the effort becoming formalized in the mid 2000's when ODOT decentralized the design functions of the agency. The main focus of the traffic engineering section's design review and approval is to identify and resolve any errors/omissions so that the design as shown in the plan sheets:

- Is safe for the public
- Meets the requirements of the operational approval documentation
- Meets the requirements of the MUTCD and other applicable ODOT design, policy and guideline documents.
- Is maintainable (ease of maintenance and economical)
- Is constructible (staging, schedule, and economical)
- Is readable and can be understood by those in the industry (drafting standards)
- Contains clear, non-conflicting information
- Results in zero to minimal construction change orders

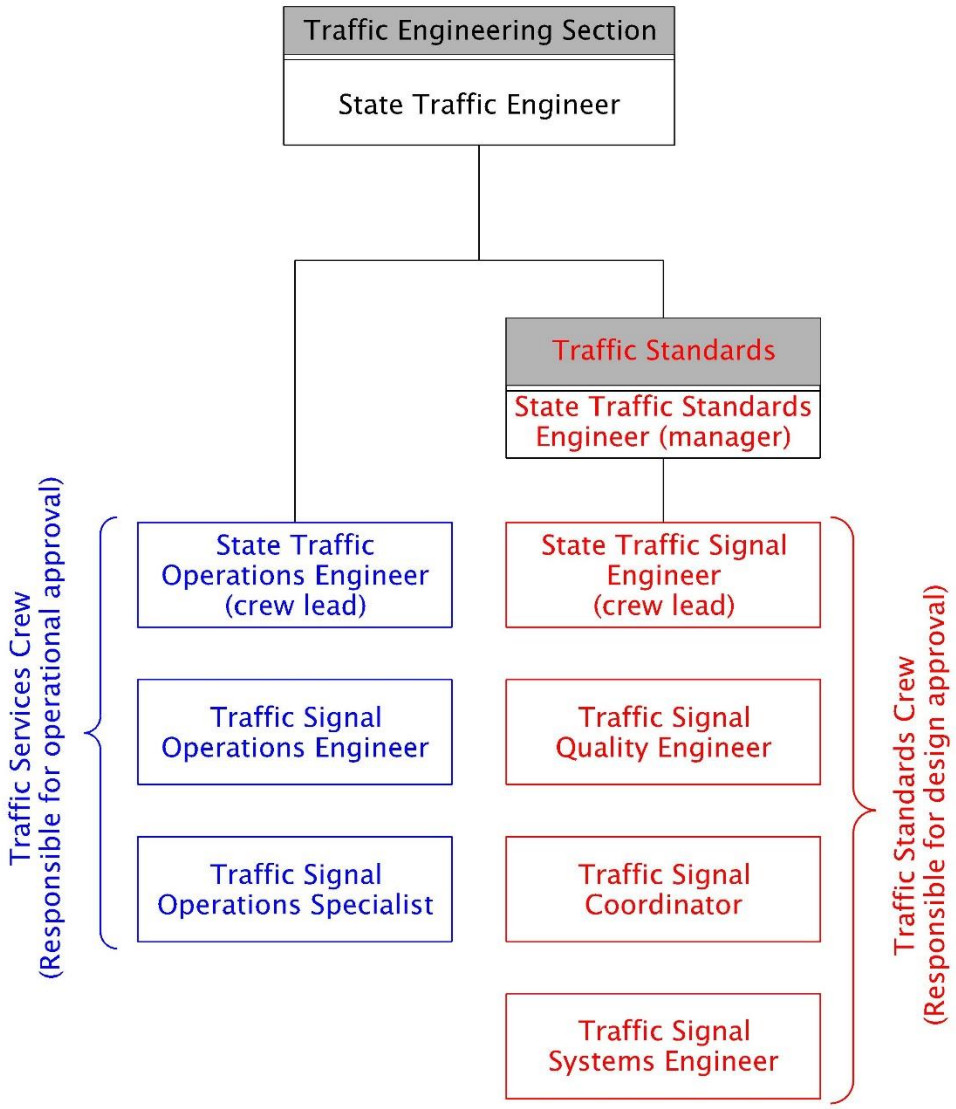
The traffic engineering section's design review will look at big picture issues as well as the details of the design, down to the conduit sizes and wire counts. The design review also includes a review of the signal operation details. As expected, reviews during the early phases of the design process will be more focused on big picture issues, becoming more focused on the details as design phase progresses. Typically a detailed review of the plans cannot be completed until the big picture issues are resolved, so it is important to address the big picture issues as early as possible.

Note: There are two separate types of approvals for traffic signal work – the operational approval and the design approval. See chapter 3 for information on the operational approval.

2.1 Traffic Engineering Organizational Structure

It is helpful to understand how the traffic engineering section is organized and how the key positions will interact with the signal designer during the design review process. The organization chart below shows only the traffic signal related positions.

Figure 2-1 | Organization Chart



2.2 Design Exceptions, Non-Standard Design, and Experimental Design

All traffic control devices installed in the state of Oregon are required to conform to the Manual on Uniform Traffic Control Devices (MUTCD) and the Oregon Supplement to the MUTCD as established by ORS 810.200 and OAR 734-020-0005.

The MUTCD, as well as this manual, contains shall, should, and may language which indicates what is required, recommended, and optional. Traffic design should not deviate from a shall or should statement unless it is prudent to do so, as per section 1A.13 of Oregon Supplement to the MUTCD.

> Section 1A.13 of the Oregon Supplement to the MUTCD: "The decision to use a particular device at a particular location is typically made on the basis of an engineering study at the location. Thus, while this Manual provides standards for design and application of traffic control devices, the Manual is not a substitute for engineering judgment. It is the intent that the provisions of this Manual be standards for traffic control devices installation, but not a legal requirement for installation."

If the design or operation of a traffic control device must deviate from a shall or should statement, the deviation will be addressed by the traffic engineering section in the form of either an operational approval (see chapter 3) or through the design approval process (see section 2.6) depending on the nature of the deviation. The design exception process, used in other disciplines like roadway design, is NOT used for traffic design. However, new requirements for pushbutton accessibility are an exception and will require a roadway ADA curb ramp exception if they cannot be met. See section 5.4, the Highway Design Manual, and the website for roadway design exceptions and forms for detailed information.

Certain deviations may be considered experimental and require an additional approval from FHWA. All requests for FHWA experimental approval are processed by the traffic engineering section. See the ODOT Traffic Manual for more information on exceptions, deviations, and requests to experiment.

2.3 Overhead Structures and Vertical Clearance Standards

Contact the region mobility liaison when any proposed project (new construction, reconstruction, preservation, or maintenance) adds a new or modifies an existing overhead structure (truss sign bridge, monotube cantilever, signal mast arm, and signal strain pole) regardless of meeting the existing minimum vertical clearance standards. In addition, contact the region mobility liaison for any project that reduces the existing vertical clearance regardless of meeting the minimum vertical clearance standards. The region mobility liaison will provide the appropriate coordination with the region, and MCTD. This coordination should address not only project specific mobility requirements, but also any corridor level vertical clearance and mobility needs. Vertical clearance greater than 19'-0" for sign, VMS, and signal support structures are considered non-standard and require a design exception. The signal designer is to follow the procedures outlined in chapter 14 of the HDM. The design exception request process for increasing the vertical clearance greater than the above mentioned 19'-0" will need to consider safety, operations, and impact to other design features in order to support the approval of the design exception.

2.4 Project Types That Require Design Approval

There are four different types of projects which might contain traffic signal work that requires review and design approval of the traffic engineering section:

1. **Projects let for bid by ODOT:** This is the typical method ODOT uses. The plans and specifications are developed within a project team. The work is reviewed and approved by the traffic engineering section before the project is let for bid.
2. **Projects let for bid by a local agency:** The local agency, typically a city or county, lets the contract for bid. The ODOT local agency liaison coordinates reviews of the plans and specifications within ODOT. The work is reviewed and approved by the traffic engineering section before the local agency is allowed to let the contract for bid.
3. **Projects by ODOT permit:** ODOT will issue a permit to work on state right-of-way. A common scenario is a developer wants to improve an area such as building a large retail store. This large retail store will impact the state highway and typically some sort of mitigation is required. The ODOT district office coordinates with the ODOT region traffic engineer and the developer and issues a permit for construction once the work is reviewed and approved by the traffic engineering section.
4. **Projects by state forces:** Plans and specification are created and given directly to state forces for construction. Typically these projects are simple in scope such as upgrading to countdown pedestrian signals or changing left turn phasing. The project is developed similar to "projects let for bid by ODOT" described above, but considerably less formal. See chapter 23 for more information on state force work.

2.5 Plan Sheets That Require Design Approval

Design approval is required for each plan sheet that contains signal work. The traffic engineering section shall approve the following plan sheets for all ODOT owned **or** maintained traffic signals before the project is let for bid:

1. Permanent signals, both new installations and modifications to existing signals. This includes all components of a traffic signal: signal, detector, interconnect, details, railroad preemption, existing utilities, etc.
2. Temporary signals (excluding portable temporary signals)
3. Ramp meters
4. Actuated flashing beacons (includes RRFB, tunnel, and bridge applications)
5. Flashing beacons mounted overhead
6. Pedestrian signals
7. Fire signals
8. Red light enforcement

Review and approval is NOT required for local agency owned **and** maintained traffic signals. However, federally funded local agency projects may request a courtesy review from the traffic engineering section for compliance with federal and state minimum requirements.

2.6 Design Approval Process

Plan sheets should be submitted to the state traffic signal engineer for review at all major project milestones; DAP (design acceptance package), preliminary, advanced, and plans-in-hand. Plans may also be submitted for review independently of the project's major milestones or project leader's official schedule if it makes sense to do so. The design plans should progress in level of detail and completeness at each milestone. The requirements for each milestone, as detailed below, will enable efficient traffic engineering section reviews (faster turnaround, with fewer comments to address) and also should result in less re-work for the signal designer between reviews.

Use the "final design/drafting checklist" in chapter 21 before submitting plans for traffic engineering section review. This will drastically reduce the number of comments to address during the review periods!

1. DAP plans (60% complete):
    a. Signal plan sheet
        i. Number of lanes & lane use (as per the completed operational approval)
        ii. Crosswalks/crosswalk closures (as per the completed operational approval)

iii. ADA ramps (e.g. basic style to be used to identify the amount of right-of-way needed to accommodate proper placement).

iv. Normal signal phasing diagram (as per the completed operational approval)

v. Location of mast arm poles, strain poles, pedestals, controller cabinet, and service cabinet (used to identify the amount of right-of-way needed to accommodate proper placement)

vi. Location of potential commercial power source

vii. Existing and proposed right-of-way lines shown

b. Detector plans (Note: non-invasive detection doesn't require a separate detector plan and the detection zones are shown on the cabinet print instead of a detector plan. See chapter 6 and chapter 20 for more information.)

i. Location and type of detection

ii. Loop numbers

iii. Loop wiring diagram

c. Identification of lane reductions occurring within ½ mile of the intersection and verification that the length before reduction can accommodate standard traffic control devices/signal operation (used to identify the amount of right-of-way needed to accommodate proper placement).

d. Identification of the basic temporary workzone strategy and need for temporary signals. If a temporary signal plan sheet will be required, the DAP requirements listed above for the signal plan sheet also apply to the temporary signal plans.

e. Placeholder signal plan sheets that will be needed with appropriate titles and intersection info (legend, detector plan, interconnect plan, existing utilities, details, removal, railroad preemption plan sheet, temporary signal plan, etc.)

2. Preliminary plans (90% complete):

a. The signal appurtenances should all be detailed with bubble notes for each plan sheet at this stage:

i. Signal heads, pedestrian heads, pushbuttons

ii. Regulatory signs

iii. Junction boxes

iv. Conduit

v. Wiring (signal, detector, and interconnect)

vi. Illumination and photoelectric cell

vii. Fire preemption detectors
viii. Crosswalk closure supports
ix. Detector layout and detector wiring diagram (For loops only)
x. Fire preemption diagram
xi. Right-of-way lines established

b. Photometric analysis complete
c. Railroad preemption plan sheet complete
d. Place holder signal plan sheets for temporary/stage construction

3. Advance plans (99% complete):
    a. Label all poles and pedestals on project
    b. Pole entrance chart completed
    c. Geotech report finished and referenced near pole entrance chart
    d. List of applicable standard drawings in the first sheet of the plan set
    e. TSSU number
    f. Custom notes
    g. Temporary/stage construction plan sheets detailed
4. Final plans (100% complete)
    a. TRS dwg. numbers

The traffic engineering section is available at every step of the way during the design process to help answer questions, evaluate alternatives, and provide assistance.

For projects that are stored in ProjectWise, the designer should forward the distribution set at each project milestone to the state traffic signal engineer. The traffic engineering section will access the design documents from ProjectWise and provide review comments in the project's comment log. The traffic engineering section will inform the designer when all their comments have been entered in the comment log for the designer to address by the project milestone (or sooner).

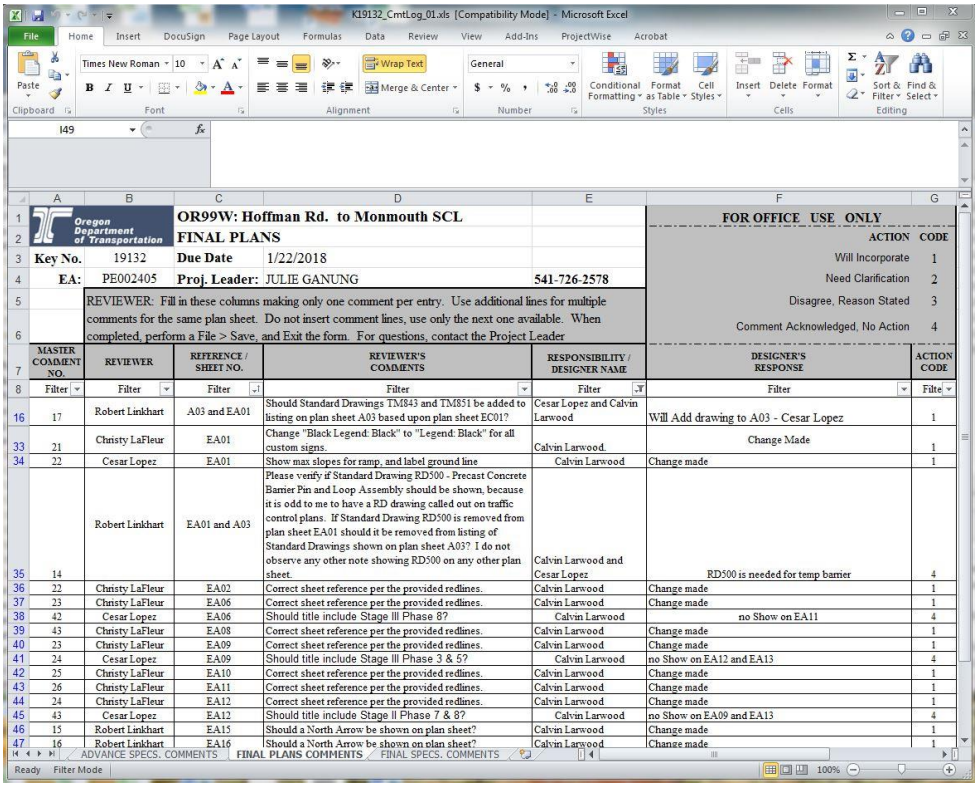
For projects that are NOT stored in ProjectWise, the designer shall submit plans electronically to the state traffic signal engineer. The preferred format is a single PDF of the entire plan set as other discipline's plan sheets for the project (temporary workzone, roadway, signing, striping, illumination, etc.) can be helpful when reviewing the traffic signal plans. Once the review is complete, a list of comments is sent to the signal designer to be addressed by the next project milestone (or sooner).

It is very beneficial to provide a design narrative along with the plan sheets. For complex projects or when the constraints/scope of the project requires non-standard design, the signal designer should set up a meeting with the traffic engineering section to discuss the project and constraints, as this can greatly reduce the amount of time needed for review and the number of comments/questions resulting from the review.

The standard time frame for the traffic engineering section review is two weeks, but this could be more or less depending on the workload/deadlines at the time. There is no limit to the number of reviews that are conducted and they may not correspond to the number of official major project milestone reviews; some projects may only require one (simple, small project) while some projects may require many more (complex, large project or projects with non-standard design).

The comments from the traffic engineering section review are contained in either the project comment log or listed in an e-mail. See Figure 2-2. Red line mark-ups of plan sheets are not provided. All of the comments must be resolved to the state traffic signal engineer's satisfaction prior to getting the approval signature.

Figure 2-2 | Project Comment Log Example



K19132_CmtLog_01.xls [Compatibility Mode] - Microsoft Excel

	Oregon Department of Transportation	OR99W: Hoffman Rd. to Monmouth SCL				FOR OFFICE USE ONLY	
		FINAL PLANS				ACTION	CODE
	Key No.	19132	Due Date	1/22/2018		Will Incorporate	1
	EA:	PE002405	Proj. Leader:	JULIE GANUNG	541-726-2578	Need Clarification	2
		REVIEWER: Fill in these columns making only one comment per entry. Use additional lines for multiple				Disagree, Reason Stated	3
		comments for the same plan sheet. Do not insert comment lines, use only the next one available. When				Comment Acknowledged, No Action	4
		completed, perform a File > Save, and Exit the form. For questions, contact the Project Leader					

MASTER COMMENT NO.	REVIEWER	REFERENCE / SHEET NO.	REVIEWER'S COMMENTS	RESPONSIBILITY / DESIGNER NAME	DESIGNER'S RESPONSE	ACTION CODE
17	Robert Linkhart	A03 and EA01	Should Standard Drawings TM843 and TM851 be added to listing on plan sheet A03 based upon plan sheet EC01?	Cesar Lopez and Calvin Larwood	Will Add drawing to A03 - Cesar Lopez	1
21	Christy LaFleur	EA01	Change "Black Legend: Black" to "Legend: Black" for all custom signs.	Calvin Larwood.	Change Made	1
22	Cesar Lopez	EA01	Show max slopes for ramp, and label ground line	Calvin Larwood	Change made	1
14	Robert Linkhart	EA01 and A03	Please verify if Standard Drawing RD500 - Precast Concrete Barrier Pin and Loop Assembly should be shown, because it is odd to me to have a RD drawing called out on traffic control plans. If Standard Drawing RD500 is removed from plan sheet EA01 should it be removed from listing of Standard Drawings shown on plan sheet A03? I do not observe any other note showing RD500 on any other plan sheet.	Calvin Larwood and Cesar Lopez	RD500 is needed for temp barrier	4
22	Christy LaFleur	EA02	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
23	Christy LaFleur	EA06	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
42	Cesar Lopez	EA06	Should title include Stage III Phase 8?	Calvin Larwood	no Show on EA11	4
43	Christy LaFleur	EA08	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
23	Christy LaFleur	EA09	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
24	Cesar Lopez	EA09	Should title include Stage III Phase 3 & 5?	Calvin Larwood	no Show on EA12 and EA13	4
25	Christy LaFleur	EA10	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
26	Christy LaFleur	EA11	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
24	Christy LaFleur	EA12	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
43	Cesar Lopez	EA12	Should title include Stage II Phase 7 & 8?	Calvin Larwood	no Show on EA09 and EA13	4
15	Robert Linkhart	EA15	Should a North Arrow be shown on plan sheet?	Calvin Larwood	Change made	1
16	Robert Linkhart	EA16	Should a North Arrow be shown on plan sheet?	Calvin Larwood	Change made	1

ADVANCE SPECS. COMMENTS | FINAL PLANS COMMENTS | FINAL SPECS. COMMENTS

Ready | Filter Mode | 100%

Complex project? Constraints requiring non-standard signal design?

Schedule a meeting with the traffic engineering section to discuss.

2.6.1 ODOT Let Projects

For ODOT let projects the project leader or consultant project manager will be in charge of the schedule and plan review distribution for each milestone. In this case, follow the process as stated by the project leader or consultant project manager for plan review distribution. The signal designer should check with traffic engineering section to ensure the distribution has been received. For state force projects, the design phase is not as formal as a standard STIP project and the signal designer will likely be in charge of the schedule for plan review distribution.

It is the signal designer's responsibility to make sure that a set of the plans makes it to the state traffic signal engineer for review; either by adding the state traffic signal engineer to the project leader's plan review distribution list or by sending the plan sheets to the state traffic signal engineer directly.

2.6.2 Non-ODOT Let Projects & Consultant Signal Designers

For non-ODOT let projects (local agency or development projects) and consultant designed plans (ODOT let project that is designed by a consultant) an ODOT point of contact will be responsible for plan review distribution of plans to other ODOT personnel. They are typically not responsible for maintaining the project development schedule, only coordinating the review period when the designer deems the plans ready for review. The main point of contact (region traffic, local agency liaison, project leader, or district office) will vary depending on the project type and which region and district the project is located in.

Submit the plans to the designated ODOT point of contact who will forward the plans to the state traffic signal engineer for review. The traffic engineering section will then submit comments back to the signal designer through the designated ODOT point of contact. Direct contact can be made to the traffic engineering section regarding the plan review and traffic engineering section comments; in fact, the designated ODOT point of contact may encourage direct contact regarding the technical details of traffic signal design rather than being a "middleman". However, the ODOT point of contact should always be kept in the loop of decisions made.

2.7 Getting Drawing Numbers & TSSU ID numbers

Each signal related plan sheet is issued a unique drawing number that is assigned by the traffic engineering section (referred to as either "TRS drawing number" or "unit file code"). This is how the plan sheets are archived. The sheet number directly relates to the age of the project; the lower the number, the older the plan sheet.

TRS drawing numbers should be requested by the signal designer once the final number of plan sheets for a project is known and highly unlikely to change (typically near the end of the design process). For projects stored in ProjectWise, this is done by sending the state traffic signal

engineer a link to the current signal plans in ProjectWise. For projects outside of ProjectWise, this is done by contacting the state traffic signal engineer and sending a separate PDF for each plan sheet on the project that needs a drawing number. Drawing number requests are a high priority; they are processed as soon as possible, often within hours of the request.

TSSU ID numbers are assigned by the traffic engineering section for all new ODOT owned & maintained, ODOT owned & local agency maintained, and local agency owned & ODOT maintained traffic signals and flashing beacon installations. This info is used for maintenance and asset management purposes. For signals, the TSSU ID number is assigned to the entire intersection (e.g. one controller cabinet operates the intersection) and there is a space in the standard title block to enter this info. For flashing beacons, a TSSU ID number is assigned to each pole/pedestal used. See chapter 21 for information on where and how to show TSSU ID numbers on the plan sheets.

TSSU ID numbers for existing signals and flashing beacons can be found in TransGIS using the "equipment-highway" layers which contains "signals" and "flashing beacons". See Figure 2-3 and Figure 2-4.

Figure 2-3 | TransGIS Signal Layer

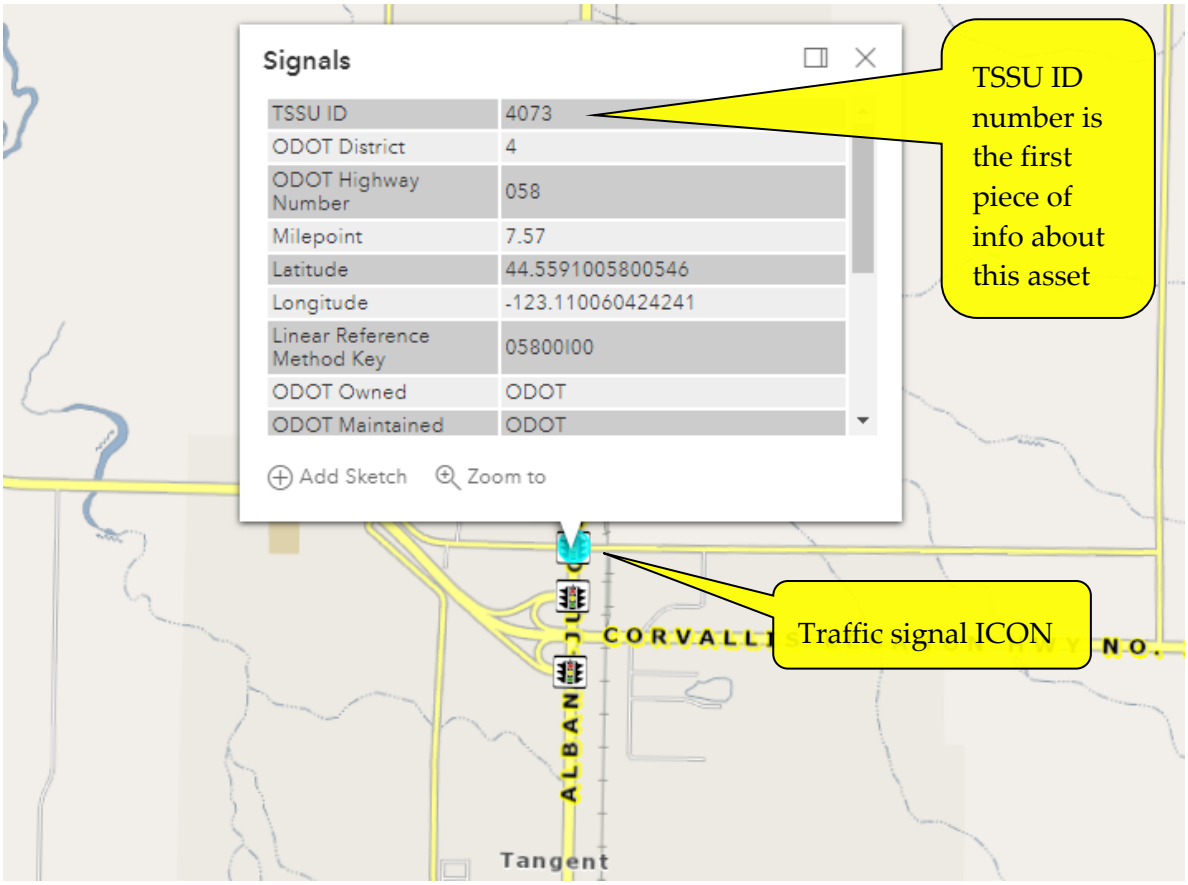
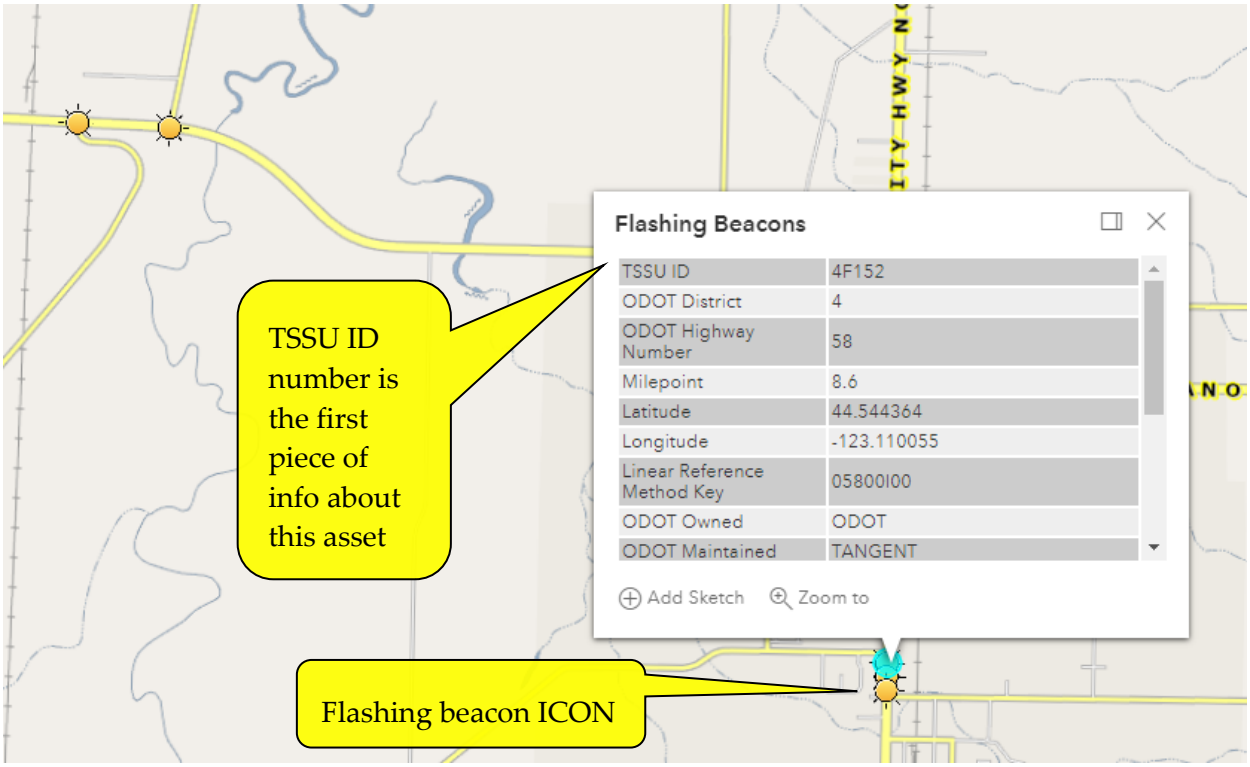


Figure 2-4 | TransGIS Flashing Beacon Layer

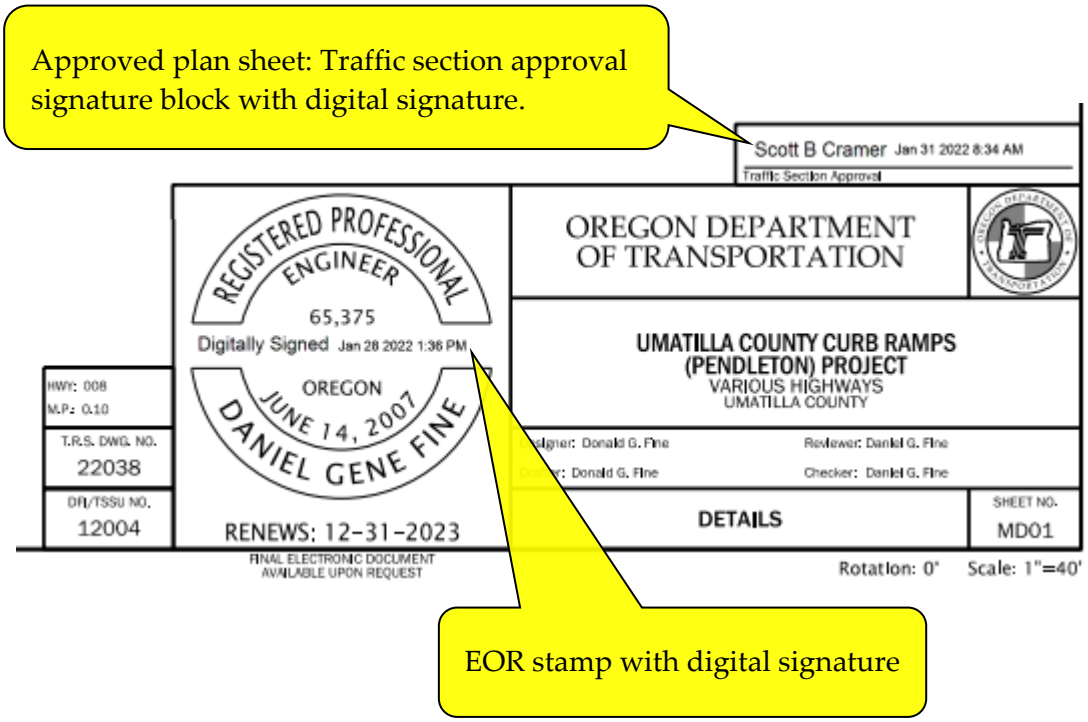


2.8 Getting the Design Approval Signature

Each signal related plan sheet shall contain a signature block for "traffic section approval". When all comments on the signal plans have been resolved to the state traffic signal engineer's satisfaction the final plans are digitally signed by the engineer of record and submitted to the traffic engineering section for the approval signature via a ProjectWise link or PDF. See Figure 2-5 for example and chapter 21 for more information on the traffic section approval signal block and placing the digital signatures.

The approval signature is required to be either the state traffic signal engineer or person(s) that are authorized by the state traffic signal engineer (typically a member of the traffic standards crew). Once signed, the traffic engineering section will inform the designer (ODOT let projects) or send the approved plan sheets back to the signal designer (non-ODOT let projects).

Figure 2-5 | Design Approval Signature Example



Not having an authorized signature on your plan sheets can delay the project bid let date

2.9 Review by Others

In addition to the review and approval from traffic engineering section, plan sheets should also be reviewed by region traffic, region electricians, the construction office, and any other interested parties (e.g. local agency, historic committees, etc.). Due to the flexibility for some design elements based on region electrical crew preferences (as described in this manual), it is critical to coordinate with the electrical crew during the design phase to ensure maintenance concerns are addressed.

The signal designer is responsible for ensuring the plans are distributed to the appropriate parties for review, with one exception; a consultant signal designer working on ODOT let project or a project by permit (e.g. development project) where an ODOT point of contact has been established. The ODOT point of contact will be responsible for ensuring the plans are reviewed by the appropriate **ODOT** personnel.

While the traffic engineering section makes every attempt to produce comments that do not conflict with other ODOT review comments, it does happen occasionally. If other reviewer's comments conflict with the comments received from the traffic engineering section, it is best to discuss the issue with both parties to determine the appropriate action to take.

A review by either the signal designer's crew lead or another designer is recommended for the following items, as they are not included in the traffic engineering section review:

- Quantities and cost estimate
- Special provision boiler plates. Note that the special provision boiler plates are only checked and approved by the state traffic signal engineer (technical owner of the traffic signal specifications) if you have made any non-standard changes. The state traffic signal engineer only reviews and approves the portion of the special provisions where the non-standard change was made. See chapter 19 for more information on specifications.

3 Signal Operations and Operational Approval

3.1 Operational Approval

Traffic signal operational approvals come in two forms:

- State traffic engineer (STE)
- Region traffic engineer (RTE)

The STE can approve any operation on state highways. The STE has delegated some authority to the RTE. For more information on what design features require STE or RTE approval, see the ODOT Traffic Manual. The ODOT Traffic Manual also contains valuable information on many ODOT traffic policies, including the process for obtaining the necessary traffic signal operational approvals. The ODOT Traffic Signal Policy and Guidelines also contains information on signal operations and approvals. These two documents can be viewed online at the engineering manuals website.

Region traffic is responsible for processing any necessary signal operational approvals:

- All RTE approvals are completed by region traffic
- All requests for STE approval are submitted by region traffic to the STE for completion.

The signal designer is responsible for obtaining a copy of the operational approval and designing the signal according to the requirements as stated within. Contact either the region traffic section or the traffic engineering section to obtain a copy of the operational approval. STE operational approvals, both final signed approvals and current requests in the queue, can also be accessed from the traffic approvals website.

The signal designer needs the operational approval(s) before design work is started.
Operational approvals generally come in the form of a letter which will outline specific constraints and parameters to be used in the design of the traffic signal. They are typically accompanied by an engineering study and the preliminary signal operations design (PSOD) form. This form provide a quick glance summary of the operational requirements, which is useful during the design process. The full engineering study is available upon request if more in-depth information regarding the operational requirements is desired. See section 3.10 for examples of operational approvals.

NOTE: The operational approval is **not** the design approval of the plans. See chapter 2 for information on design approval.

The operational approval letter and/or PSOD form contains the following information, as applicable to the project:

- Specific location (highway, milepoint, county)
- Number of lanes & lane use for each approach
- Normal phase rotation
- Crosswalk closures
- Opening of existing closed crosswalks
- Traffic signal communications (Interconnect)
- Emergency preemption
- Railroad preemption
- Transit priority
- Other unique requirements (e.g. the signal at 1st and Main must be removed before the construction of a new signal at 2nd and Main)

It is critical that the signal design, roadway geometry, signing, and striping at the intersection match the requirements shown in the operational approval. Any discrepancies between the design plans and the operational approval must be resolved by either a revision to the operational approval or by modifying the design plans.

NOTE: Failure to have an operational approval or failure to have a signal plan that matches the operational approval is a fatal flaw and will result in major delays to the project.

3.2 Number of Lanes and Lane Use

The number of lanes and lane use needed for each approach of the intersection will be detailed in the engineering study and shown in the PSOD form that accompanies the STE or RTE operational approval letter. Depending on the type of project, projected traffic volumes, and phasing requirements, there are a couple of options:

- No change to the existing number of lanes,
- No change to the existing number of lanes, but a change to the existing lane use,
- Increase in the existing number of lanes; or
- Decrease in the existing number of lanes.

If changes to the number of lanes are necessary on the project, it is important to be in communication with the roadway designer early in the design process as the roadway design is the foundation of the signal design. Also, communication with the striping designer and the sign designer will be important.

If changes to existing lane use (but not to the existing number of lanes) are necessary on the project, it is important to be in communication with the striping designer and the sign designer early in the design process as these types of changes usually necessitate the need for a striping plan and a signing plan.

3.3 Normal Phase Rotation

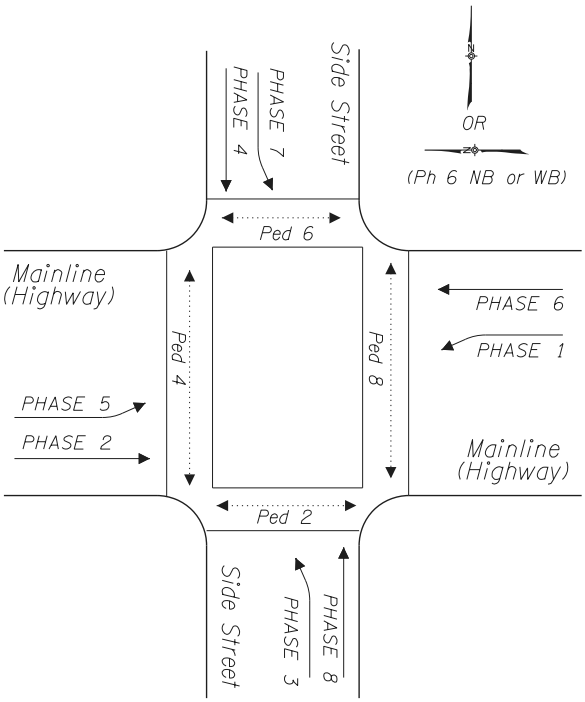
A basic understanding of traffic operations and phasing is required to design a traffic signal. For more detailed information, consult the following resources:

- State traffic operations engineer
- Region traffic operations engineer
- ODOT Traffic Signal Policy and Guidelines

The phasing of the traffic signal is shown on the signal plans. Figure 3-1 shows the standard 8-phase signal configuration used on the state highways and Figure 3-2 shows the corresponding ring & barrier diagram. The standard 8-phase signal configurations have the following characteristics:

- Protected left turns are odd numbered phases (ø1, ø3, ø5, and ø7).
- Through movements and permissive right (or left turns) are even phases (ø2, ø4, ø6, and ø8). Phase 6 is mainline northbound (or westbound).
- Pedestrian phases are even phases corresponding to the compatible through phase (ped 2, ped 4, ped 6, and ped 8).
- The mainline through phases are 2 and 6, with left turn phases 1 and 5. The sum of the phases for each mainline approach equals 7 (2+5=7, and 1+6=7).
- The side street through phases are 4 and 8, with left turn phases 3 and 7. The sum of the phases for each side street approach equals 11 (4+7=11, and 3+8=11).

Figure 3-1 | Standard 8-Phase Signal Configuration



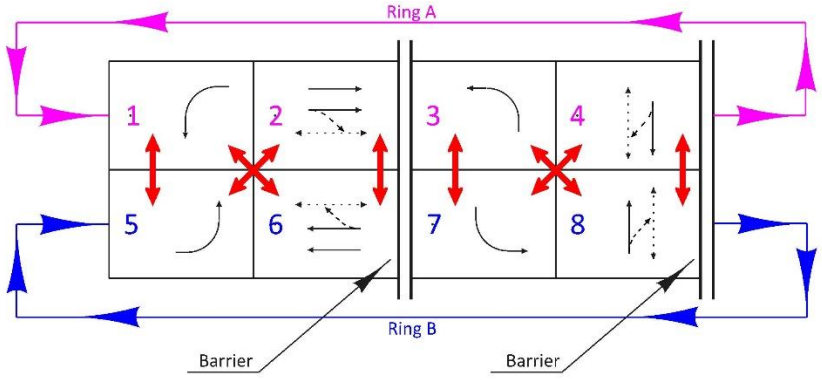
3.3.1 Ring and Barrier Diagram

Modern U.S. practice for signal control organizes phases by grouping them in what is called a ring and separating the crossing or conflicting traffic streams with time between when they are allowed to operate, either by making the movements sequential or adding a barrier between the movements.

A ring consists of two or more sequentially timed and individually selected conflicting phases arranged so as to occur in an established order. In ring A of the normal phase rotation diagram shown in Figure 3-2, phase 1 must terminate prior to phase 2, which must terminate prior to phase 3, which must terminate prior to phase 4, which must terminate prior to returning to phase 1. The majority of traffic signals use two rings.

Barriers assure there will be no concurrent selection and timing of conflicting phases for traffic movement in different rings. Both ring A and ring B cross the barriers simultaneously to select and time phases on the other side. These barriers separate the mainline phases (ø1, ø5, ø2, and ø6) from the side street phases (ø3, ø7, ø4, and ø8). In this example, phase 2 and 6 must terminate at the same time before the next phases (ø3 and ø7) can be serviced. Similarly, phase 4 and phase 8 must terminate at the same time before the next phases (ø1 and ø5) can be serviced. There is no barrier between phases 1 & 5 and 2 & 6; therefore, phase 1 and 5 do not have to terminate at the same time. If phase 1 terminates prior to phase 5, the next phase in ring A may be serviced (phase 2), resulting in phase 2 and 5 being serviced together. Using this same logic, compatible phases can be determined. For example: phase 1 may operate concurrently with phase 5 and phase 6 (but not with phase 2 which is in the same ring as phase 1, and not with any phases located beyond the barrier: 3, 4, 7 & 8), phase 2 may operate concurrently with phase 5 and phase 6 (but not with phase 1, 3, 4, 7, & 8), phase 8 may operate concurrently with phase 3 and phase 4 (but not with phase 7, 1, 2, 5, & 6).

Figure 3-2 | Standard 8-Phase Ring and Barrier Diagram



When reading a ring and barrier diagram, vehicular movements drawn with solid lines do not have any conflicting movements associated with them. In Figure 3-2 that would be phases 1, 3, 5, 7, and thru movements for phase 2, 4, 6, 8. Vehicular movements drawn with large dashed lines have conflicting movements associated with them that require the motorist to yield during a green indication (permissive movement). In Figure 3-2 that would be the right turn movement for phases 2, 4, 6, and 8 (the conflicting movement that the right turn must yield to is the associated pedestrian phase). Pedestrian movements are drawn with small dashed lines with dual arrow heads, because pedestrians can move either direction in a crosswalk. Barriers are indicated by dual vertical lines.

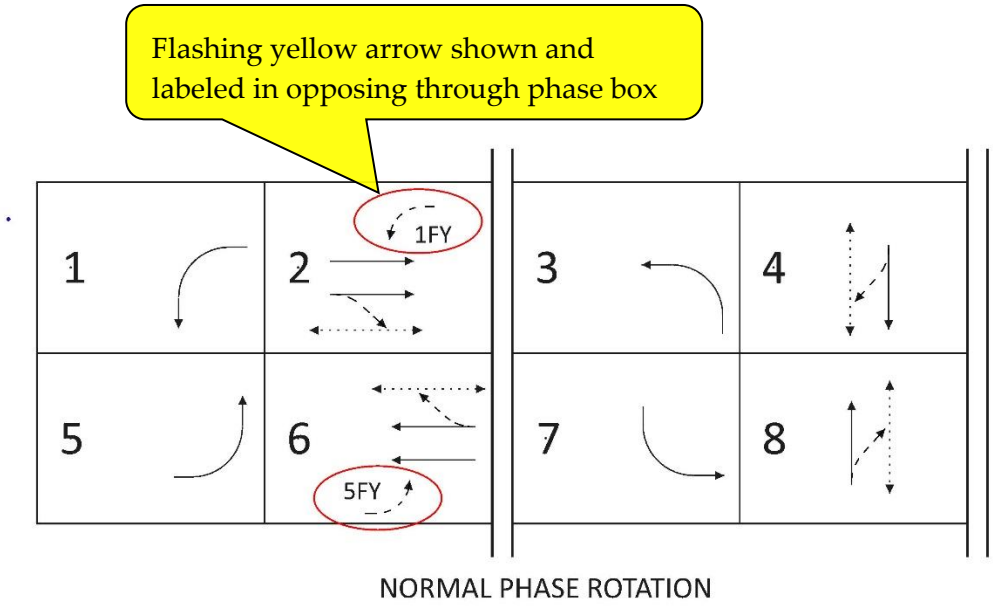
Depending on the operational requirements of the traffic signal, there can be many variations to the phasing and signal timing, and some of these variations might change by time-of-day or day-of-week. It is important to obtain the current STE or RTE approval and to work with the region signal operations engineer regarding proper phasing. If the project has a signal that will have multiple signal timing configurations based on time-of-day/day of week, only the ring and barrier diagram that will be used the majority of the time is shown on the plan sheet (multiple normal phase rotation diagrams are NOT shown on the plan sheet).

NOTE: The main purpose of the ring and barrier diagram is to clearly show which movements are compatible and which movements require conflict monitoring. This diagram is critical for developing proper signal timing and the proper conflict monitor configuration. See chapter 20 for conflict monitoring information.

3.3.2 Flashing Yellow Left Turn Arrow

The flashing yellow arrow display is the current standard for protected/permissive left turn movements. The permissive phase is shown in the opposing through phase box and labeled "FY". See Figure 3-3.

Figure 3-3 | Ring and Barrier Diagrams: Flashing Yellow Left Turn Arrow



3.3.3 Flashing Yellow Left Turn Arrow with Negative Ped

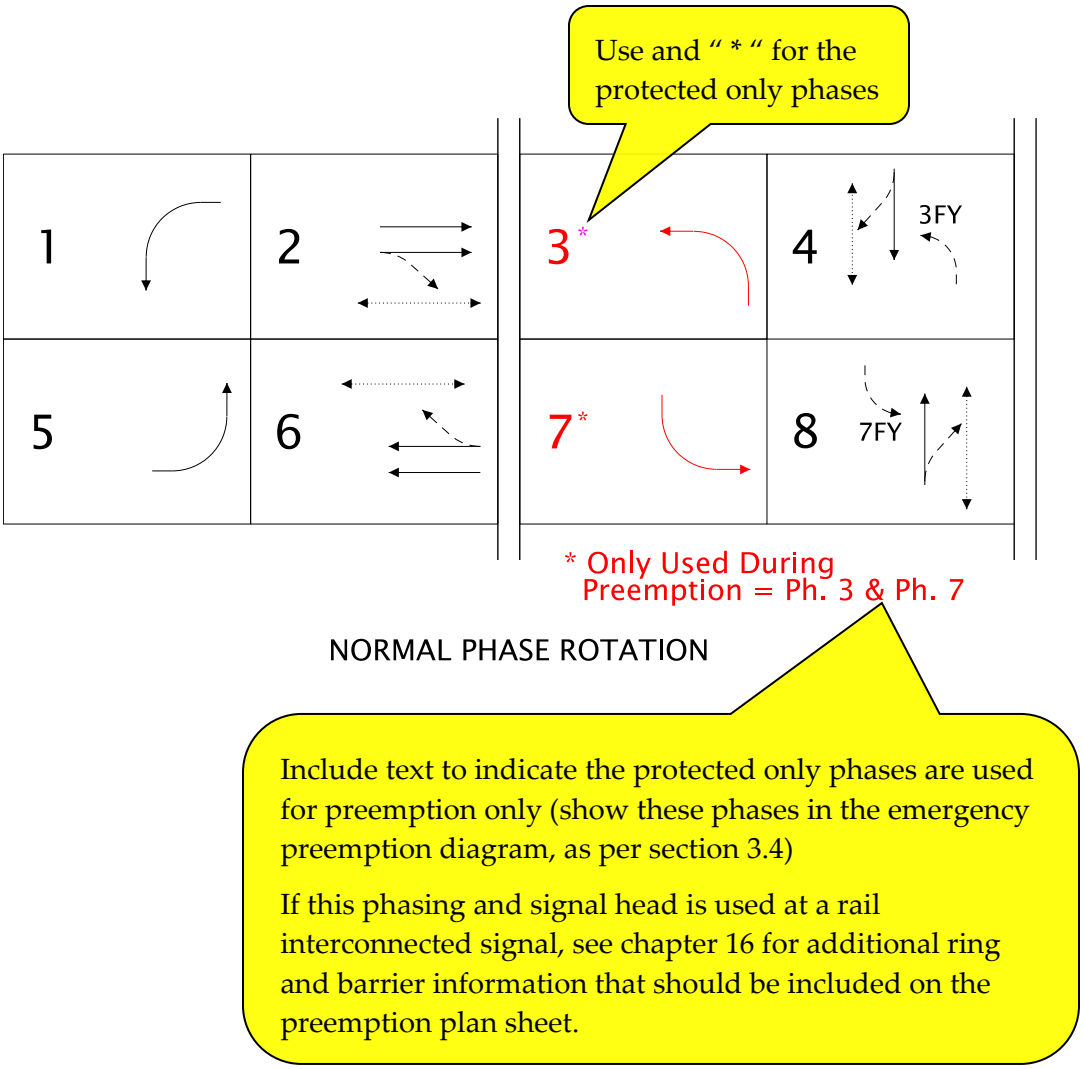
Flashing yellow arrow with negative ped refers to timing that restricts the permissive left turn (flashing yellow arrow) from being served if the pedestrian phase crossing the lane used by the permissive left turn is active (active ped phases options include: 1.) The walk indication only, 2.) The walk indication and a portion of the flashing don't walk indication, or 3.) The walk indication and the entire flashing don't walk indication). For example, if pedestrian phase 2 is displaying the walk indication (or flashing don't walk indication), the phase 1 left turn indication will display a solid red arrow.

The flashing yellow arrow negative ped timing feature is NOT shown in the ring and barrier diagram as it is not a conflict that results in inappropriate signal operations if the flashing yellow arrow and pedestrian phase are served together (MUTCD section 4D.17 paragraph 04 allows a permissive left turn phase and the pedestrian phase crossing the lane used by the permissive left turn to be active at the same time). See Section 3.3.2 for how to show the ring and barrier diagram.

3.3.4 Flashing Yellow Left Turn Arrow Used for Permissive Only Phasing

When a type 3LCF signal head is used for permissive only left turn phasing as per chapter 5, it is necessary to show and note the protected green arrow indications are only used for preemption in the ring and barrier diagram. This ensures the signal timing is implemented as intended by the operational approval (no confusion over use of PPLT or permissive only phasing) and the conflict monitor can be correctly programmed.

Figure 3-4 | Ring and Barrier Diagrams: Type 3LCF Signal Head Used for Permissive Only Left Turn Phasing

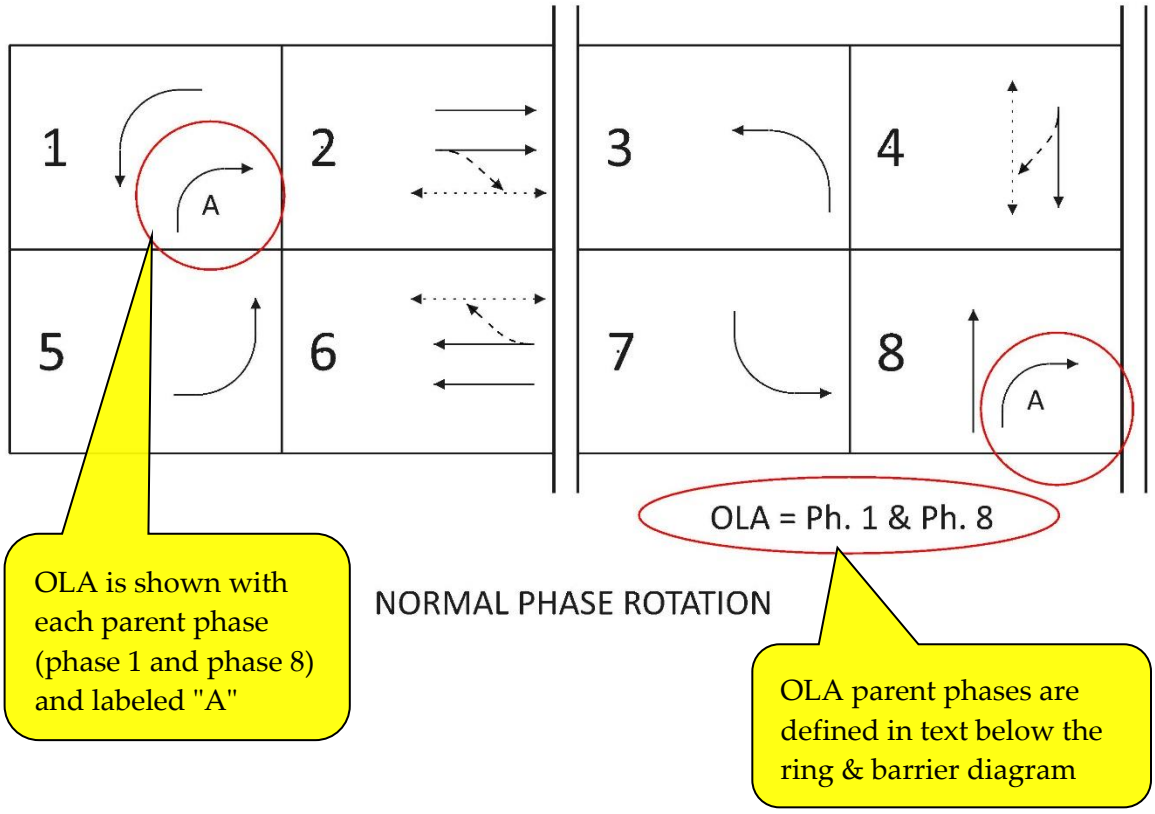


3.3.5 Vehicle Overlap Phases

Overlap phases are typically associated with right turns and become beneficial when right turn traffic volumes are high. They may also be used in other circumstances to address unique intersection geometry or improve signal timing efficiency.

An overlap phase is assigned to "parent phases" such that whenever the parent phase is green, the overlap phase is also green. As shown in Figure 3-5 below, the parent phases for a right turn overlap are the adjacent thru phase (side street thru phase 8) and the non-conflicting left turn phase (mainline left turn phase 1). The overlap phase is shown in each parent phase box and labeled with the appropriate letter (A, B, C, D, etc.). Below the ring and barrier diagram in text, the overlap parent phases are listed.

Figure 3-5 | Ring and Barrier Diagrams: Overlap Phases



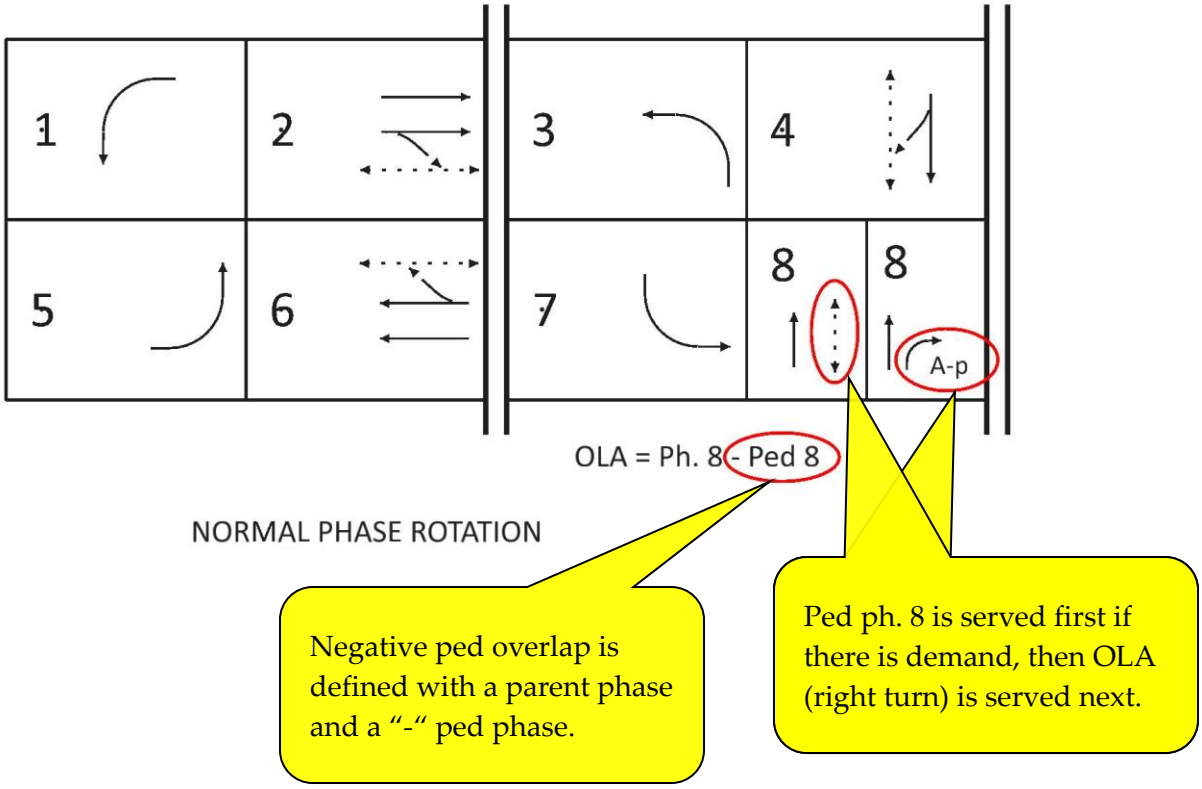
3.3.6 Negative Ped Overlap Phases

Another common overlap phase is called a negative ped overlap. This is used with a right turn overlap when there is a conflicting pedestrian phase (the pedestrian phase located to the right of the right turn lane). A negative ped overlap phase will restrict the right turn green arrow from being served when the conflicting pedestrian phase is active (walk indication and flashing don't walk indication).

Negative ped overlaps are shown by separating out the two possible conditions in the ring and barrier diagram. Below the ring and barrier diagram in text, the negative ped overlap phase is defined. See Figure 3-6.

Note: A negative ped overlap phases is NOT the same as a negative ped used with flashing yellow arrow. See Section 3.3.3 for information about flashing yellow arrow with negative ped.

Figure 3-6 | Ring and Barrier Diagrams: Negative Ped Overlap Phases



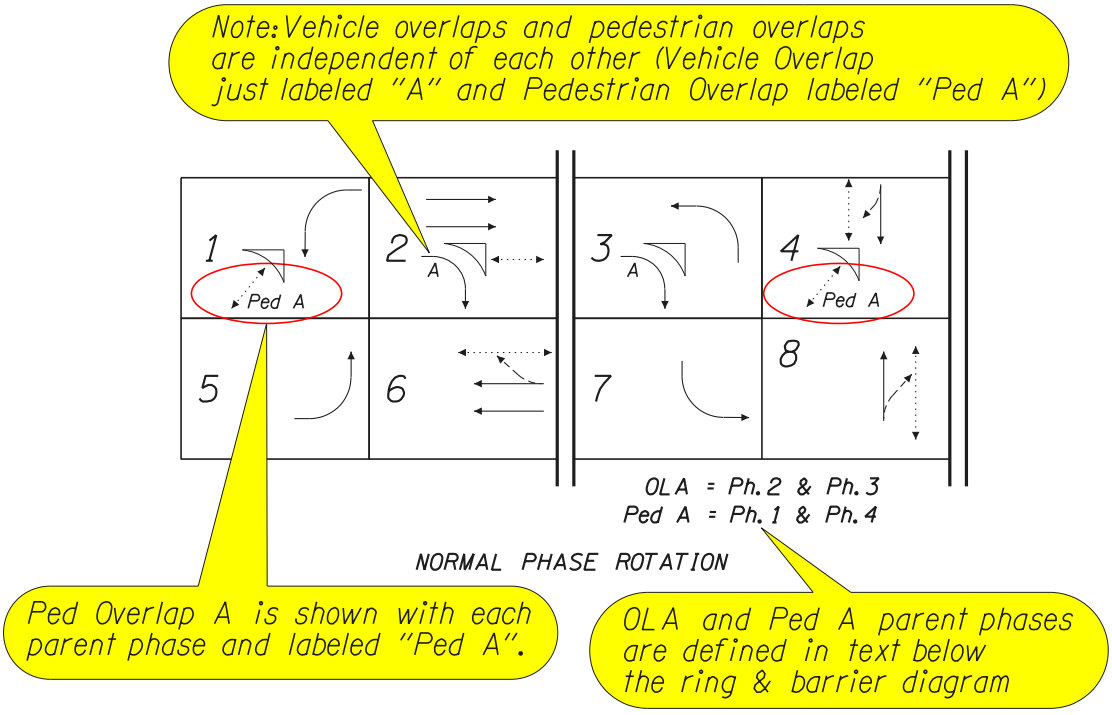
3.3.7 Pedestrian Overlap Phases

Pedestrian overlap phases are typically used when the geometry of the intersection allows the pedestrian crossing to be served by 2 (or more) phases, which can decrease the amount of wait-time for the pedestrian.

The pedestrian overlap phase is assigned to "parent phases" such that whenever the parent phase is green the overlap pedestrian phase is also active (when the pushbutton has been activated). As shown in Figure 3-7 below, the parent phases for a pedestrian overlap that crosses a signalized right turn lane are the non-conflicting mainline left turn phase (phase 1) and the non-conflicting side street thru phase (phase 4).

The pedestrian overlap is shown in each parent phase box and labeled with the appropriate letter (Ped A, Ped B, Ped C, Ped D, etc.). Below the ring and barrier diagram in text, the pedestrian overlap parent phases are listed. See Figure 3-7.

Figure 3-7 | Ring and Barrier Diagrams: Pedestrian Overlap Phases



3.3.8 Split Phases/Exclusive Phases

Split phasing describes an operation where all movements on one approach are served prior to all movements on the opposing approach. This is typically used if the geometry of the intersection, traffic volumes and/or crash history creates a conflict with normally non-conflicting movements. Split phasing requires STE operational approval. Use of split phasing requires specific signal indications depending on the lane use. See chapter 5 for signal head layout examples.

Split phases may be shown as either sequential without a barrier or sequential with a barrier. See Figure 3-8. However, there are cases where exclusive phases shall be shown with a barrier to avoid confusion. See Figure 3-9.

Figure 3-8 | Ring & Barrier Diagrams: Exclusive Phases That Can be Shown With or Without a Barrier

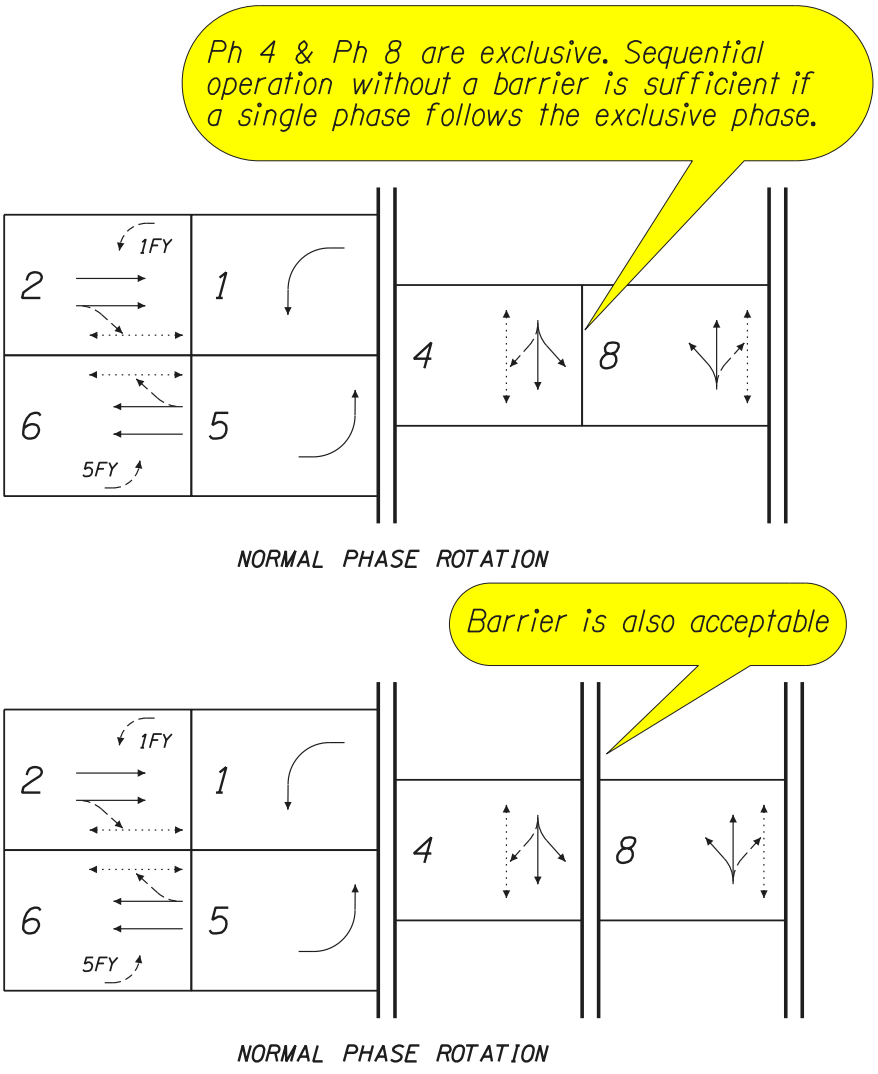
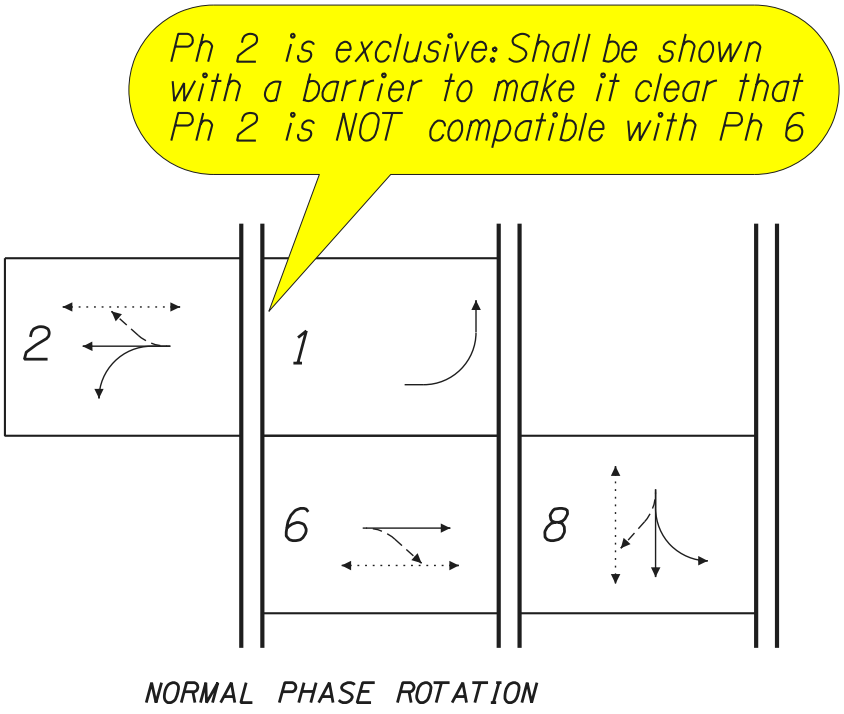
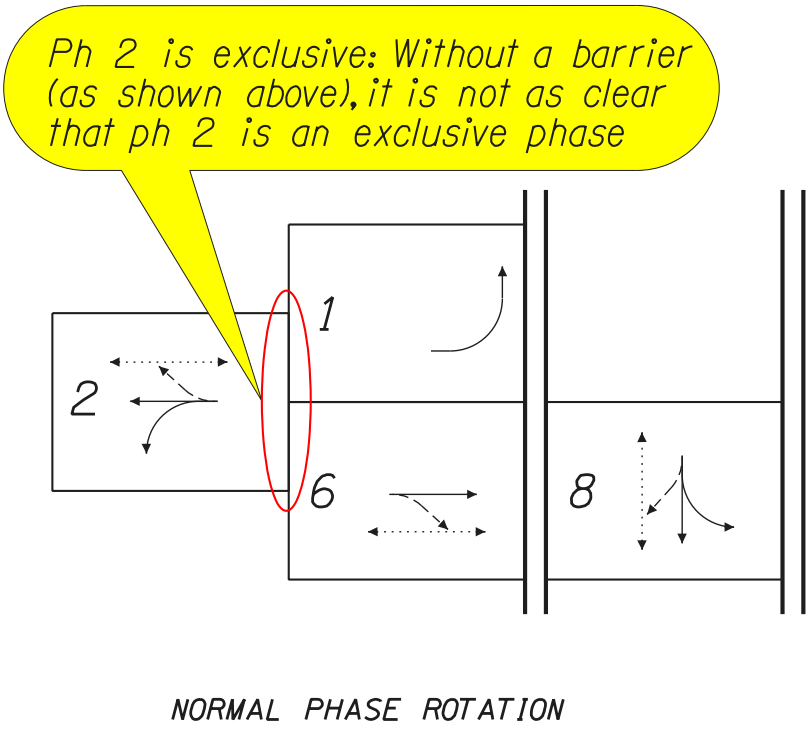


Figure 3-9 | Ring & Barrier Diagrams: Exclusive Phases That Shall be Shown With a Barrier

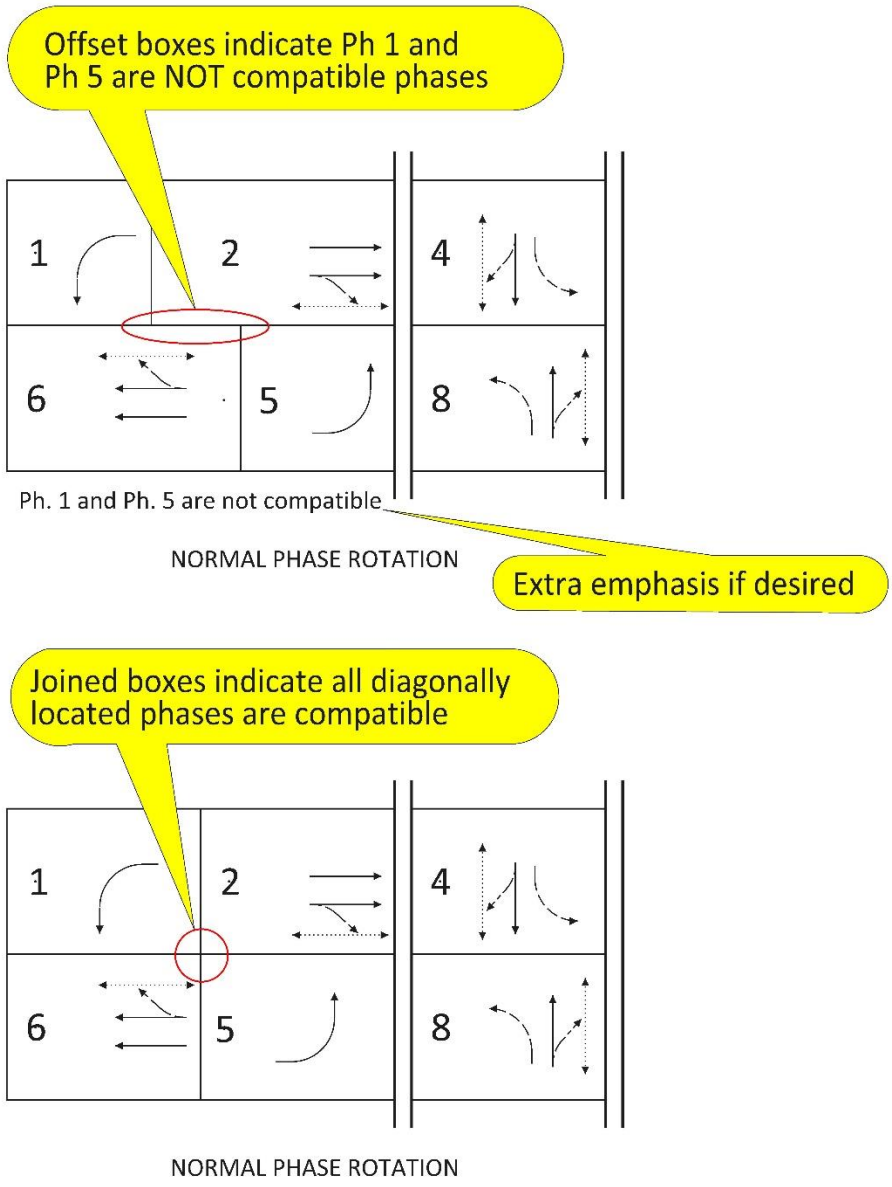




3.3.9 Incompatible Left Turn Phases

Opposing left turn phases are typically compatible, however if the intersection geometry cannot accommodate the truck turning templates from opposing left turns concurrently, then the left turning phases must be separated from each other (either by split phasing - see section 3.3.8, or by lead-lagging the left turn phases and maintaining separation between them). If the lead-lag method is used, it is shown by a physical separation of the ring and barrier phase boxes. It may also be noted in text, below the ring and barrier diagram, if extra emphasis is desired. See Figure 3-10.

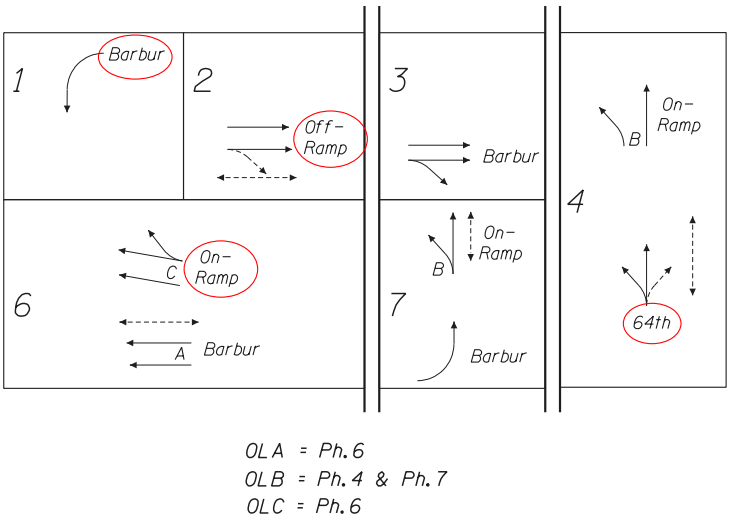
Figure 3-10 | Ring & Barrier Diagrams: Incompatible Left Turn Phases



3.3.10 Multiple Intersections using a Single Controller

Two intersections are sometimes operated with a single controller if the intersections are very close together. The intersection of a divided highway typically operates like two very closely spaced intersections using a single controller. The ring and barrier diagram should combine both intersections into one ring and barrier diagram, with each intersection's cross street labeled in the phase rotation boxes. See Figure 3-11, Figure 3-12, Figure 3-13.

Figure 3-11 | Ring & Barrier Diagrams: Multiple Intersections with a Single Controller, Example 1



OLA = Ph. 6
OLB = Ph. 4 & Ph. 7
OLC = Ph. 6

NORMAL PHASE ROTATION

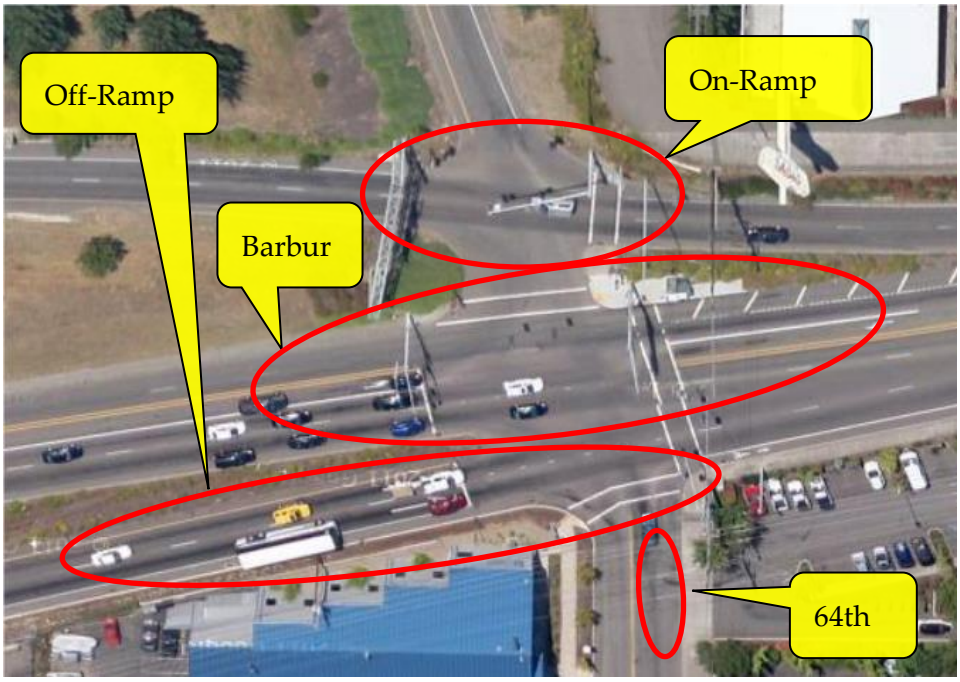
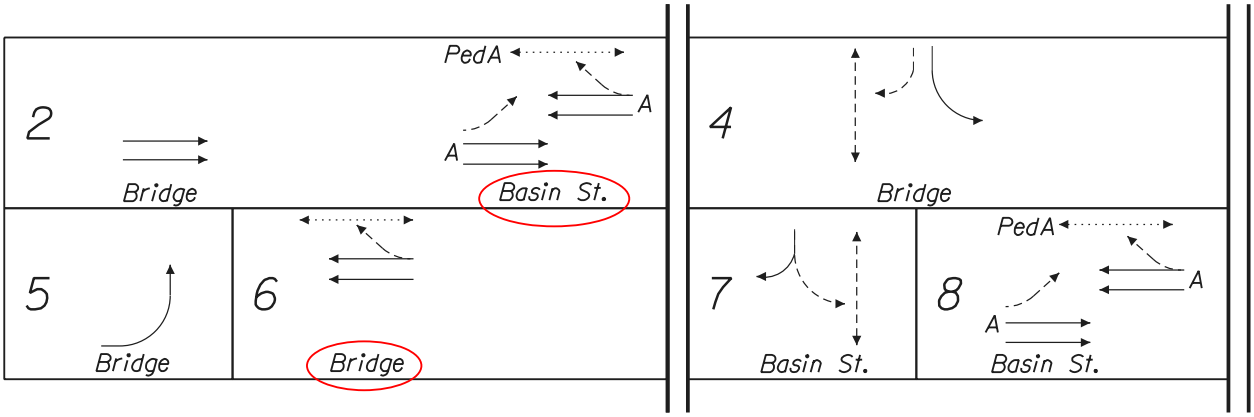


Figure 3-12 | Ring & Barrier Diagrams: Multiple Intersections with a Single Controller, Example 2



OLA = Ph. 2 & Ph. 8
Ped A = Ph. 2 & Ph. 8
Dummy Phase = Ph. 8

NORMAL PHASE ROTATION

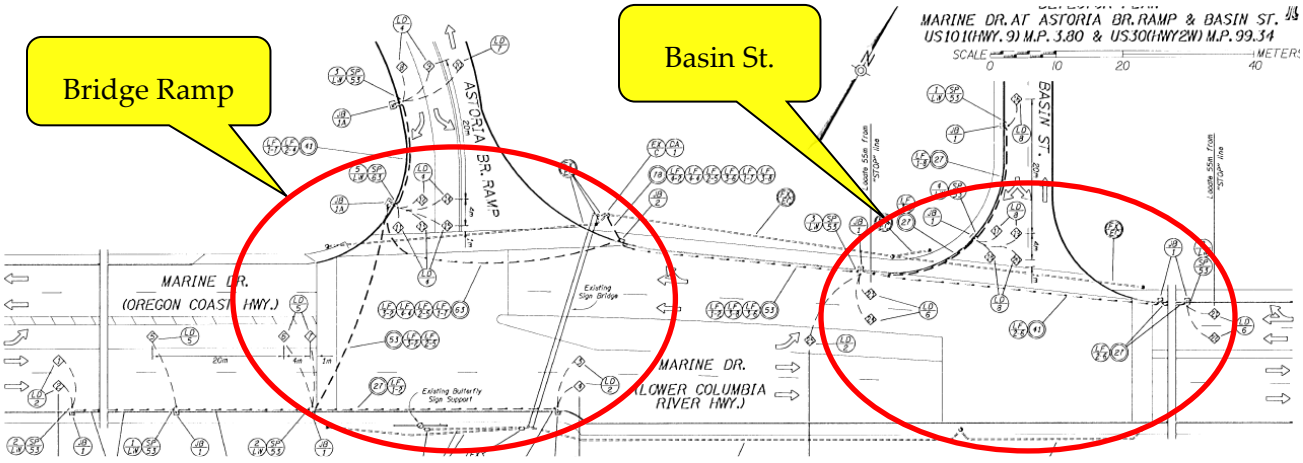
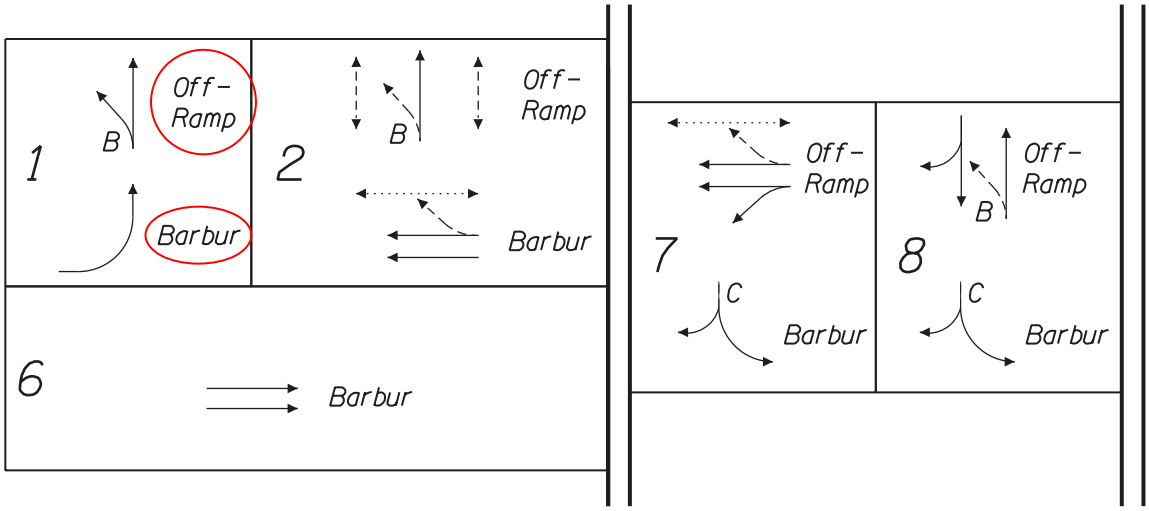
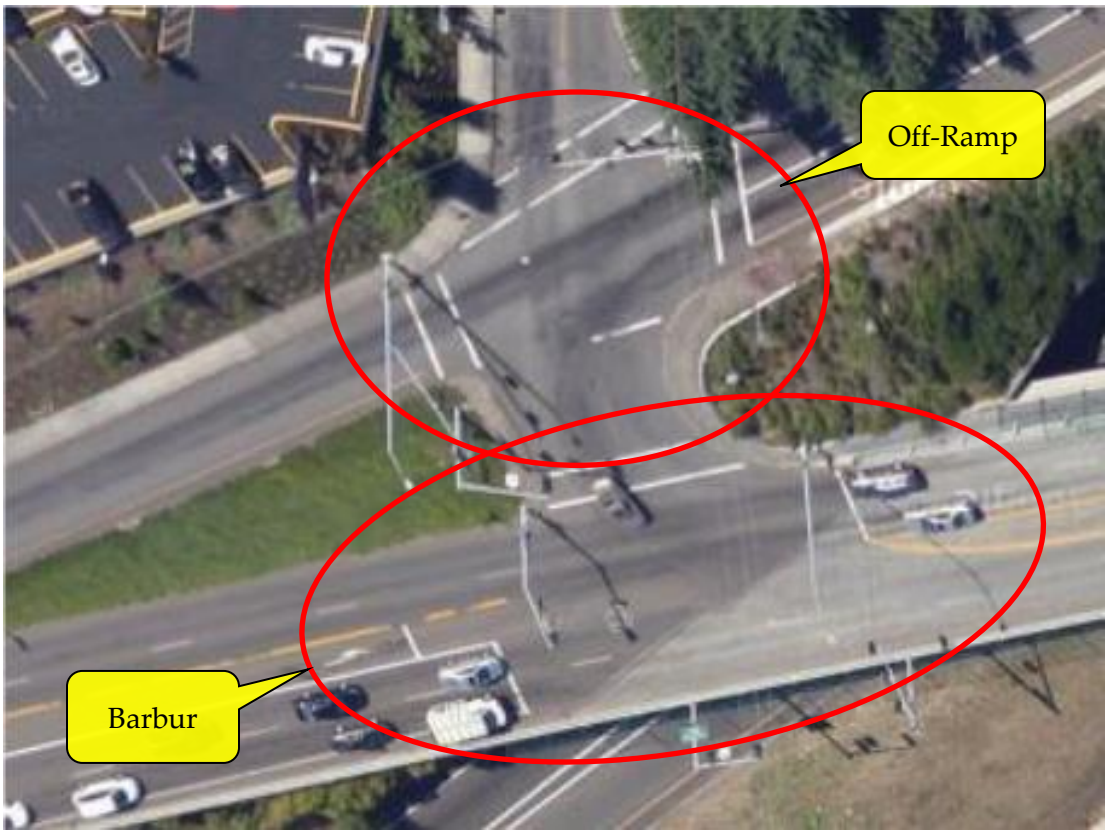


Figure 3-13 | Ring & Barrier Diagrams: Multiple Intersections with a Single Controller, Example 3



OLB = Ph. 1 & Ph. 2 & Ph. 8
OLC = Ph. 7 & Ph. 8

NORMAL PHASE ROTATION



3.3.11 Dummy Phases

A dummy phase is defined as a phase that does not have an output, but is still used in the controller software to achieve a certain operation. Typical applications are complex geometry with overlaps (see Figure 3-14) and one-lane, two-way temporary traffic signals (see Figure 3-15). The movements (or all-red time clearance time, in the case of a one-lane, two-way temporary traffic signal) are shown in the appropriate phase block. Below the ring and barrier diagram in text, the dummy phases are listed. See Figure 3-14 and Figure 3-15.

Figure 3-14 | Ring & Barrier Diagrams: Dummy Phases, Example 1

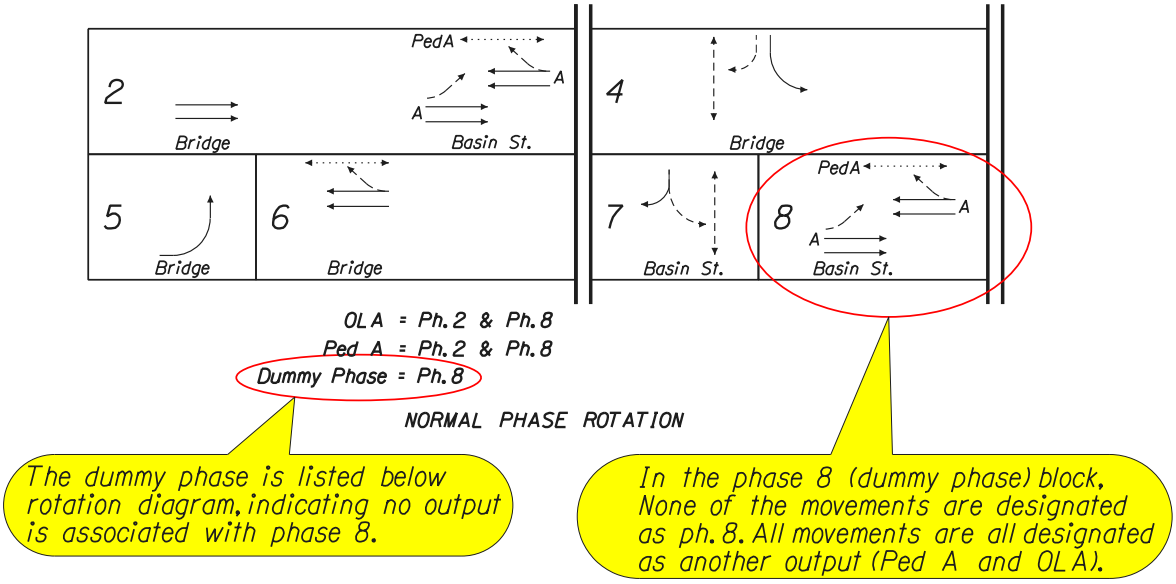
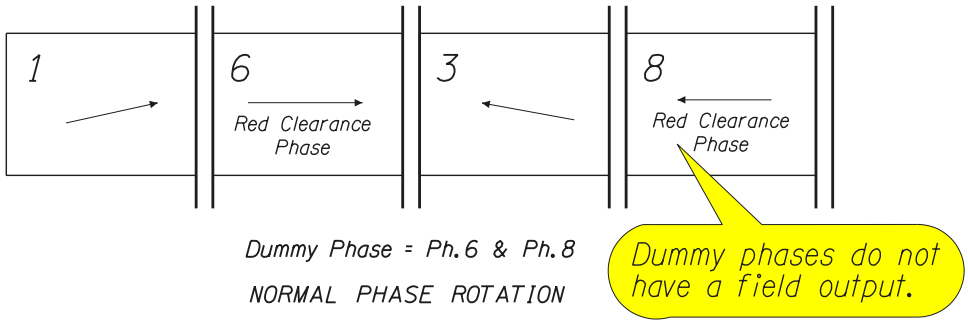


Figure 3-15 | Ring & Barrier Diagrams: Dummy Phases, Example 2



Note:
With current software, dummy phases may not be required to provide a red clearance interval (This phasing was used with older software that had limited red clearance timing, which necessitated a dummy phase in order to provide the proper amount of red clear time). Confirm with the Region Signal Timer.

3.3.12 Overlap Phase with Green Extension Clear-Out

Overlap phases are typically timed to start and end their green phase in sync with their parent phases. For certain complex intersection geometries, it may be necessary to extend the overlap phase green after the parent phase is terminated to clear out the intersection. If the overlap phase green extension clear-out is documented in the operational approval, it is not shown in the ring and barrier diagram, but should be noted below in text. See Figure 3-16 and Figure 3-17.

Figure 3-16 | Overlap Clear Out Interval, Example 1



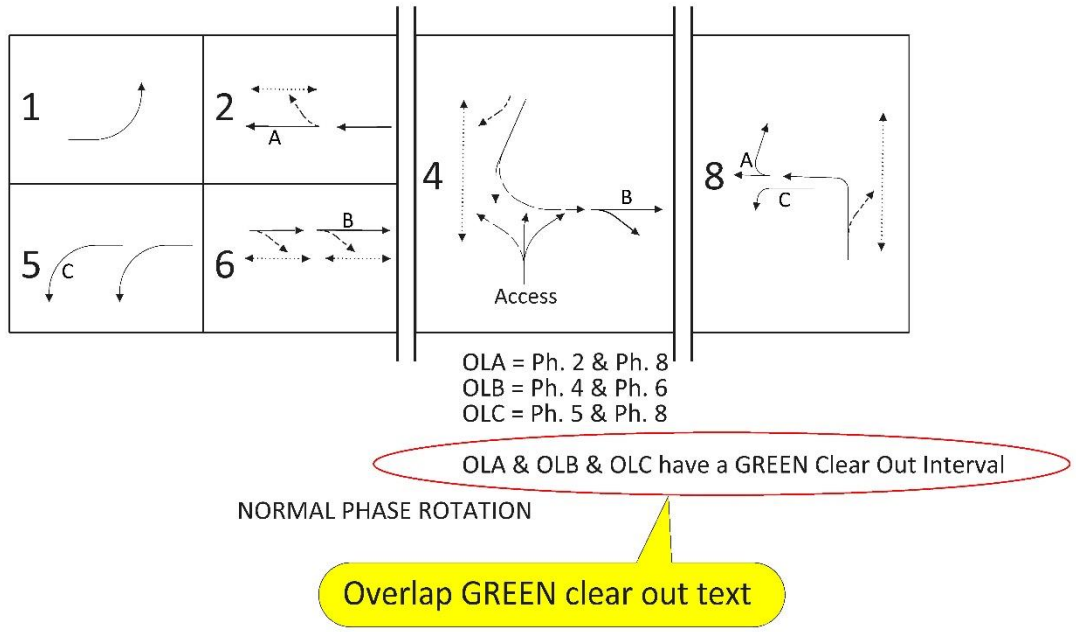
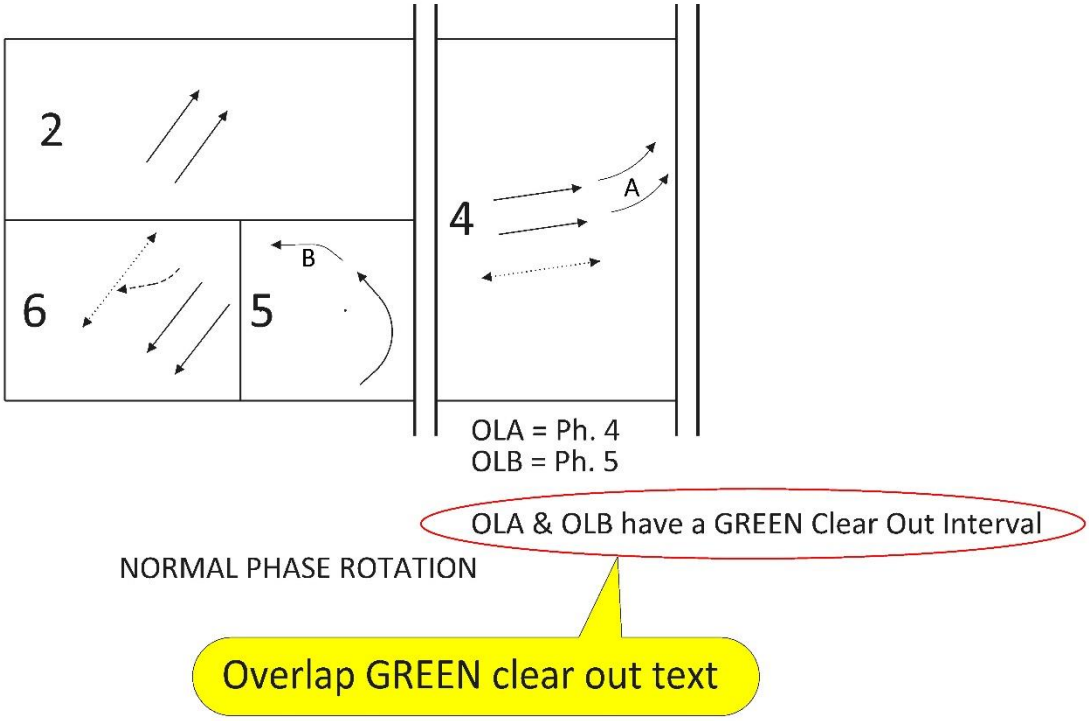


Figure 3-17 | Overlap Clear Out Interval, Example 2



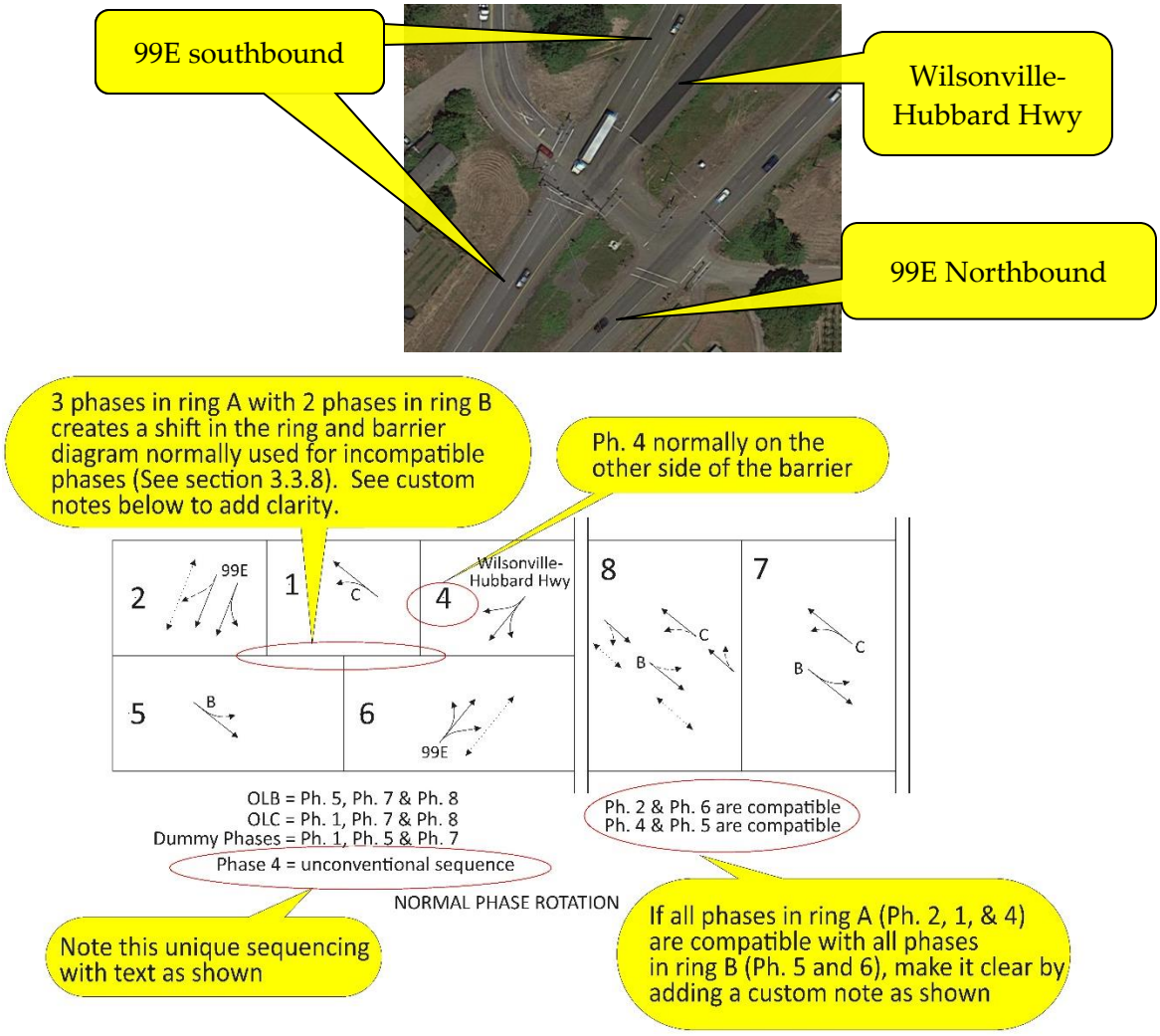


3.3.13 Unconventional Phases & Sequences

Signal timing software now allows the use of phase assignments and sequences that do not follow the traditional, basic ring and barrier phase structure. These unique phases/sequences have the potential to improve the signal efficiency at locations with unusual intersection geometry. Because these unique sequences are rare and may appear to be an error in the plans at first glance (and require extra attention to the signal timing parameters), they shall be noted in text below the ring and barrier diagram to indicate it is intentional. See Figure 3-18.

There is a high variability of unconventional phases or sequences that could be used based on site specifics, therefore it is important to work with the state traffic signal engineer and the state traffic operations engineer on a case-by-case basis to ensure it is the right solution, works properly in the software, works properly with the hardware, and the ring and barrier is drawn correctly to enable proper programming of the conflict monitor.

Figure 3-18 | Unconventional Phase Sequence Example



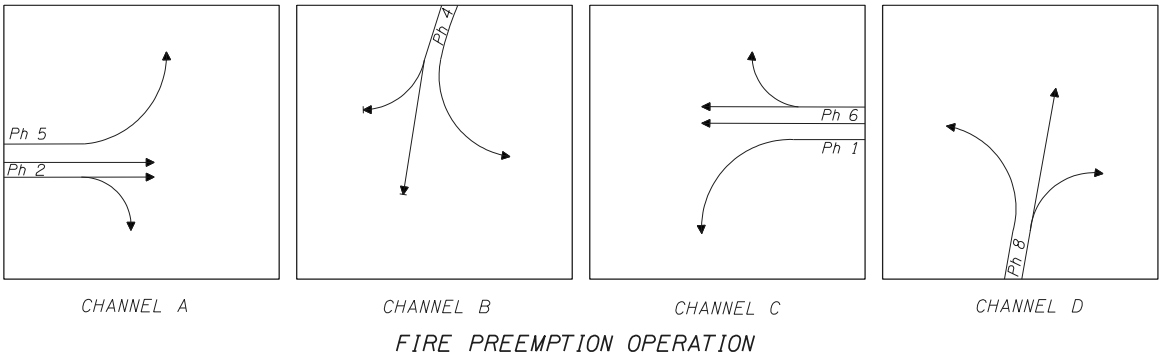
3.4 Emergency Preemption

When an emergency service provider is granted permission by ODOT to use emergency preemption, the traffic signals within the geographic area of service will require emergency preemption. The majority of ODOT signals are within areas requiring emergency preemption. To check if an area has permission to use emergency preemption, contact the state traffic operations engineer.

Emergency preemption alters the normal phasing of the traffic signal to allow green indications for an emergency vehicle (typically fire or ambulance) approaching the intersection. This is shown on the signal plan sheet. Figure 3-19 below shows the standard channel assignments for fire preemption operation:

- Channel A = phase 2 & 5
- Channel B = phase 4 & 7
- Channel C = phase 6 & 1
- Channel D = phase 8 & 3

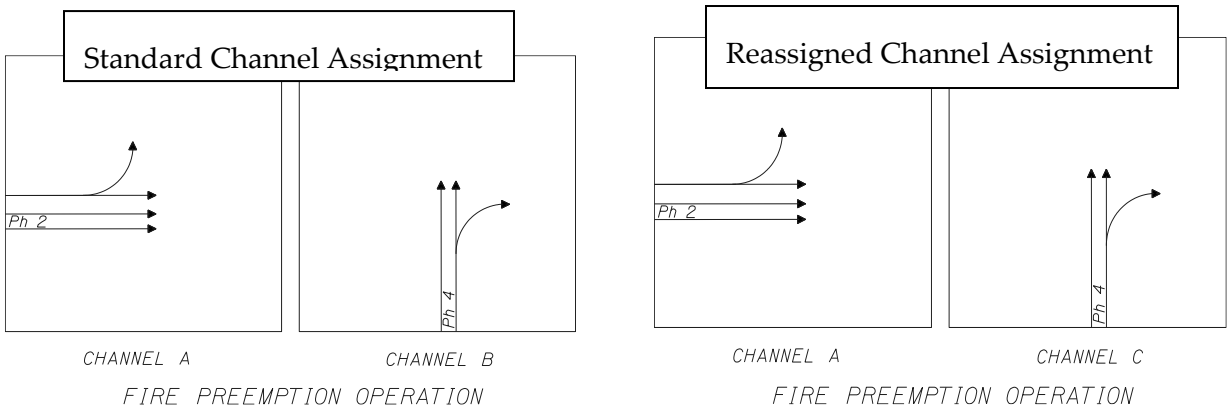
Figure 3-19 | Standard Fire Preemption Channel Assignments



When reading a fire preemption operation diagram, all vehicular movements are drawn as solid lines, indicating that that movement is protected (no conflicting movements requiring the motorist to yield). Pedestrian phases are not serviced during preemption.

There are times when non-standard channel assignments are preferred, such as an intersection that requires use of only two channels. See Figure 3-20. This is due to the termination layout for the fire preemption discriminators located inside the controller cabinet. Each discriminator is able to monitor up to two channels. One discriminator is always used for channels A & C, and one discriminator is always used for channels B & D. To save the expense of installing two discriminators for only two channels (using the standard channel assignments), the phases assigned to the channels will be reassigned in the controller software, thus only requiring one discriminator. For example, if an intersection only had phase 2 and phase 4 (downtown, one-way grid system), channel A should be assigned to phase 2 and channel C should be reassigned to phase 4 (uses 1 discriminator) vs. using the standard channel assignments of A and B (uses 2 discriminators).

Figure 3-20 | Two Channel Fire Preemption Channel Assignments



3.5 Railroad Preemption

If a signalized intersection is located within 215 feet of a rail crossing, rail preemption is required. If a signal requires rail preemption, a rail crossing order is needed. The rail crossing order will state specific design and operational requirements that must be met.

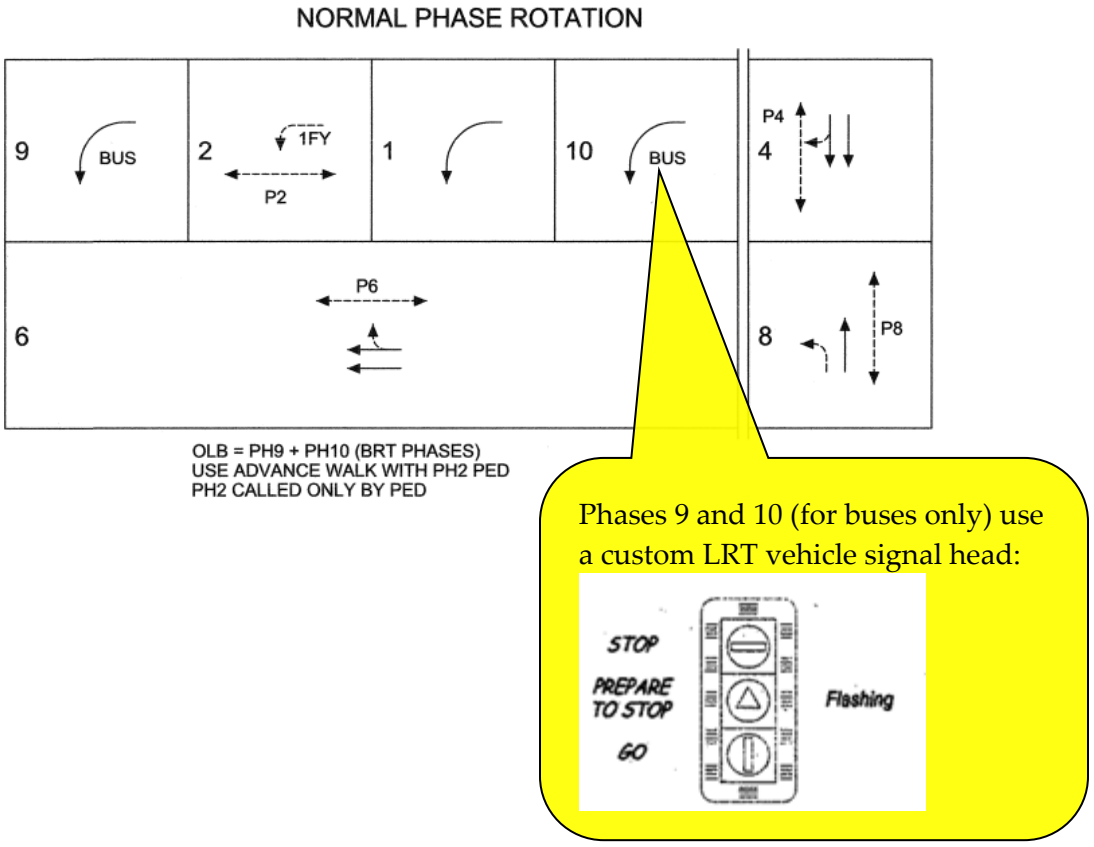
Rail preemption alters the normal phasing of the traffic signal to allow pedestrians to clear the intersection and vehicles to clear the tracks prior to the train arrival. This is the highest order of preemption and takes precedence over all other forms of preemption. See chapter 16 for detailed information on rail preemption operation and how it is shown on the plan sheets.

3.6 Transit Priority

When a transit provider is granted permission by ODOT to use transit priority, the traffic signals within the service routes will require transit priority signal timing. This typically occurs in large metropolitan areas (e.g., Eugene, Portland).

Transit priority does not have the ability to alter the normal phasing of the traffic. Instead, transit priority just alters the cycle of the normal phasing by extending or delaying green time for the appropriate approach or using transit only phasing to allow minimal to no delay for the transit vehicle. Transit priority that extends or delays the green time is NOT shown in the phase rotation diagram. Transit phasing is shown in the phase rotation diagram and may also require the use of special custom vehicle signal indications (strictly for the use of the transit driver) similar to the LRT signals shown in the Oregon Supplements to the MUTCD. See Figure 3-21.

Figure 3-21 | Queue Jump Phasing with LRT Vehicle Signal Head Example



3.7 Crosswalk Closures

It is ODOT policy to provide pedestrian crossings for all approaches at a signalized intersection unless an engineering study and STE approval deem a crosswalk closure is necessary. Often, the need to close a crosswalk is due to unusual roadway geometry, certain lane use (such as dual turn lanes), certain signal phasing (such as a single point urban interchange), and/or crash history. Closing a crosswalk requires specific signing and detectable treatments. The details for this signing are typically shown on the signal plan. Coordinate with the roadway designer for including the crosswalk closure detectable treatments in the plan sheets as required by the operational approval. See the crosswalk section in chapter 5 of this manual and the Highway Design Manual Part 802.5 for more information.

3.8 Traffic Signal Communications

Closely spaced signals in a corridor typically require central or local communications for the signals to function in a coordinated manner. When communications are required, either an interconnect plan or communication plan is needed. See the chapter 7 for more information.

3.9 Other Unique Requirements

Other requirement may be listed on the operational approval, specific to the project. Some unique requirements in the operational approval include the following:

- Audible pedestrian signals
- Channelized right turn lane control (yield, stop, or signal control)
- Non-traversable medians/island to restrict/channel turn movements
- Advanced flashing beacons on signs
- U-turns

3.10 Example of Operational Approval

See Figure 3-22 through Figure 3-24 for an example of an STE operational approval.

Figure 3-22 | STE Approval Example Page 1 of 3 – Memo Stating Requirements

INTEROFFICE MEMO

TECHNICAL SERVICES
Traffic-Roadway Section, MS#5
4040 Fairview Industrial Drive SE
Salem, Oregon 97302-1142
Office Phone: (503) 986-3568

TO: Kathleen Freitag, P.E.
Region 1 Traffic Engineer

File Code: TRA 07-08
HWY 029, MP 8.32
LRM 02900I00
Key No. N/A
Approval No. 2019-030.1

Michael Kimlinger Apr 26 2019 12:02 PM

FROM: Michael Kimlinger, P.E.
State Traffic-Roadway Engineer

SUBJECT: Request for Signal Modifications
Tualatin Valley Highway No. 029 (OR 8) at Cornelius Pass Road, MP 8.32
City of Hillsboro

I have reviewed your request to add dual left turn lanes from southbound Cornelius Pass Road to eastbound Tualatin Valley Highway, permit U-turns from the leftmost lane of the dual left turn lanes on southbound Cornelius Pass Road, and channelization and signalization of the westbound right turn lane on Tualatin Valley Highway No. 029 (OR 8) at Cornelius Pass Road in Hillsboro. In accordance with Oregon Administrative Rule 734-020-0410, I approve your request with the following conditions:

1. The design and operation of the traffic signal at the subject intersection shall be according to the current edition of the Manual on Uniform Traffic Control Devices, ODOT's Traffic Signal Policy and Guidelines, and ODOT's Traffic Signal Design Manual.
2. Lane configuration and phasing shall be designed according to the attached Preliminary Signal Operations Design signed by the Region Traffic Operations Engineer.
3. Ensure ADA compliance by following ODOT's ADA-related design standards, design exceptions, and inspection process.
4. The Traffic-Roadway Section must approve the final signal design plans.
5. This approval is rescinded if the approved features are not advanced to construction within 5 years of this interoffice memo's signature date.

If you have any concerns regarding this approval, please contact Scott Cramer at 503-986-3596.

cc: Tiffany Slauter, Region 1 Traffic Operations Engineer
Joseph Totten, Region 1 Traffic Technician
Brian Sloane, Region 1 Signal Manager
Rick Garrison, Region 1 Project Manager
Scott Cramer, Traffic Signal Engineer
Eric Leaming, Traffic Investigations Engineer
Joe Searcy, Traffic Signal Standards Specialist

Attachments: Preliminary Signal Operations Design

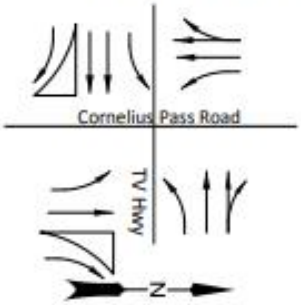
SBC/esl/tac

Figure 3-23 | STE Approval Example Page 2 of 3 – PSOD Form, Existing Conditions

Project: South Hillsboro Signal Upgrades
Location: Cornelius Pass Road and Tualatin Valley Highway
Highway: OR8 - Tualatin Valley Highway
City: Hillsboro
Hwy No: 029
Date: 01/11/19
County: Washington
Mile Point: 8.32

Existing Information

Lane Configuration



Crosswalks

- ☑ North Approach
- ☑ South Approach
- ☑ East Approach
- ☑ West Approach

Bike Lanes

- ☑ North Approach
- ☑ South Approach
- ☑ East Approach
- ☑ West Approach

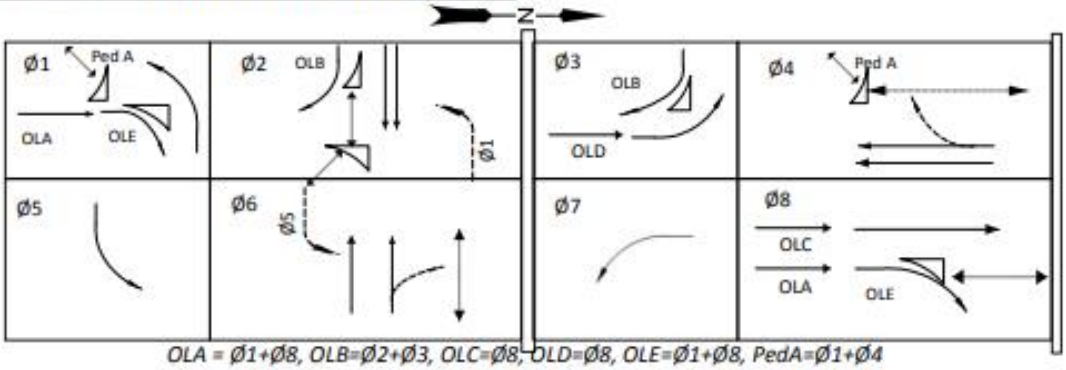
Traffic Control

- ☐ 2-Way Stop
- ☐ All-Way Stop
- ☑ Signalized

Posted Speed Limit

Highway: 45 mph
Side Street: 35 mph

Existing Vehicle and Pedestrian Phasing (if Signalized)



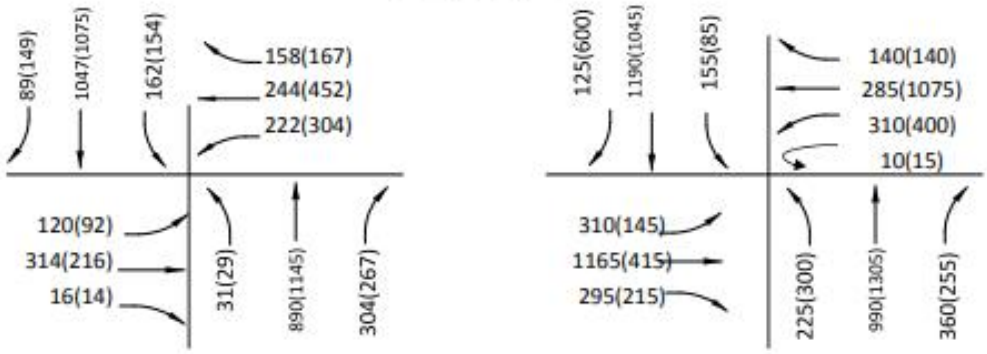
OLA = Ø1+Ø8, OLB=Ø2+Ø3, OLC=Ø8, OLD=Ø8, OLE=Ø1+Ø8, PedA=Ø1+Ø4

Traffic Volumes

Existing Counts
2018

AM(PM)

Future Year
2036

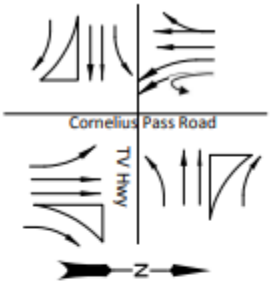


Other Relevant Information

Figure 3-24 | STE Approval Example Page 3 of 3 – PSOD Form, Recommended Signal Design

Recommended Signal Design

Lane Configuration



Crosswalks

- ☑ All crosswalks provided
- ☐ Following crosswalks closed
  - ☐ North Approach
  - ☐ South Approach
  - ☐ East Approach
  - ☐ West Approach

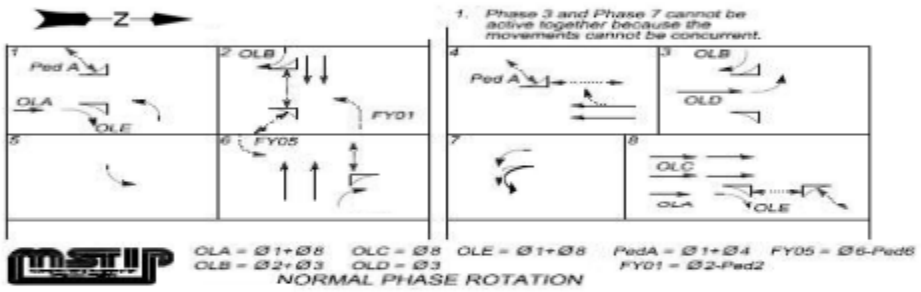
Bike Lanes

- ☑ North Approach
- ☑ South Approach
- ☑ East Approach
- ☑ West Approach

Other Required Features

- ☑ Signal interconnect to: 209th, 229th
- ☑ Communication type: Ethernet over Copper
- ☑ ATC controller
- ☑ Illumination
- ☐ Audible/accessible pedestrian signals
- ☑ Railroad preemption
- ☐ Other: _____

Recommended Vehicle and Pedestrian Phasing



Notes regarding right-turn lane control

Westbound to northbound right turns are signal controlled because southbound to northbound U-turns in phase 7 conflict with the movement and it allows for signal protection of the pedestrian phase. The eastbound to southbound and northbound to eastbound right turns are signal controlled due to the proximity to the railroad

Primary considerations used to determine left-turn phasing

Phases 3 and 7 cannot be active together because they conflict. Eastbound to northbound and westbound to southbound left turns have protected-permissive phasing due to moderate volumes. Southbound to eastbound left turns are protected due to dual left turn lanes, and the northbound to westbound left turn is phased to match.

Considerations for mitigating bike-vehicle conflicts (if any)

Bicycle lanes are to the left side of all dedicated right turn lanes as they enter the intersection.

Design Vehicle Information (to be confirmed with Roadway Designer)

☑ Design for

☐ Accommodate

Design Vehicle: WB-67

U-turns movements are only designed for passenger vehicles.

Recommended by: _____ Jan 11 2019 5:24 PM

Region Traffic Operations Engineer — Date

4 Starting the Design

4.1 Scoping

Scoping is the very first step to forming and funding projects. The formal scoping process involves multiple disciplines working together and requires the signal designer and signal operations staff to provide a detailed assessment of needs, requirements, risks, and cost estimates for all traffic signal work within the defined project limits. A project leader coordinates the scoping effort. Each region has specific processes/forms that should be used.

When scoping traffic signal work, the following guidance should be used:

- Note any operational approvals that will be required
- Verify the condition rating of existing traffic signals (see section 4.1.1)
    - A condition rating of less than 70% should be scoped for complete replacement.
    - A condition rating of 70% or greater may be scoped for modifications in lieu of complete replacement.
- Coordinate with agency electricians to determine their needs and priorities. Agency electricians have a wealth of information because they are responsible for regular maintenance and emergency repairs of all the traffic signals in their area. Their perspective and knowledge of reoccurring issues and undesirable signal conditions that are not captured by the signal asset condition rating system (such as conduit condition, equipment in cabinets, frequent knock-downs, etc.) is important to consider and address during the scoping process.
- Signal work that requires extensive modification (e.g., moving three out of four poles, replacing/rerouting majority of conduit, etc.) should be scoped for complete replacement regardless of the condition rating.
- Verify existing signals meet current statewide goals (see section 4.1.2)
    - Signals that do not meet current statewide goals and priority improvements should be scoped to include every listed upgrade.
- Review the intersection geometry and note any roadway work that will improve traffic signal operation and safety. For example:
    - Accommodating or designing for truck turning swept path(s)
    - Reducing or eliminating lane shifts through the intersection
    - Consolidating, eliminating, or restricting turn movements of nearby accesses
    - Adding or improving existing pedestrian/bicycle facilities
    - Reducing or eliminating skewed roadway alignments

  - Removing or adding lanes
  - Modifying existing lane use
  - Extending turn lane storage distance
  - Modifying stop bar/crosswalk location (i.e., curb ramp location)

  See chapter 5 for more details. Identifying and addressing non-ideal roadway geometry issues whenever feasible is preferred vs. using traffic control devices to mitigate the issue.

- Verify curb ramps, pushbuttons, and pedestrian signal heads meet current accessibility requirements (see section 5.4, Engineering For Accessibility website and Accessibility at ODOT website). This also includes verifying CQCR requests (a typical request is for audible pedestrian signals) and incorporating the goals and features outlined in ODOT policy to meet the ADA transition plan for ODOT. Contact the state traffic signal engineer for any questions, as issues and solutions are often site specific.
  - Signal equipment that does not meet current accessibility requirements should be scoped to include upgrading all necessary features. Note: this can often trigger other work that may result in the need for a complete signal replacement.

Scoping for projects usually takes place several years before the DAP design work begins. As such, it is important to clearly document the design features, assumptions, and judgement used in the scoping notes to ensure they are useful for future reference. It is highly recommended to provide a basic sketch of the proposed design(s) or to clarify assumptions used (in addition to text only descriptions that are provided in the scoping notes). Sketches may not be necessary for all scoping projects, but they can help other disciplines better visualize how the traffic signal equipment impacts their features, improve the accuracy of the cost estimate, and convey design information more efficiently than text only. See Figure 4-1 and Figure 4-2.

Figure 4-1 | Scoping Sketch Example 1

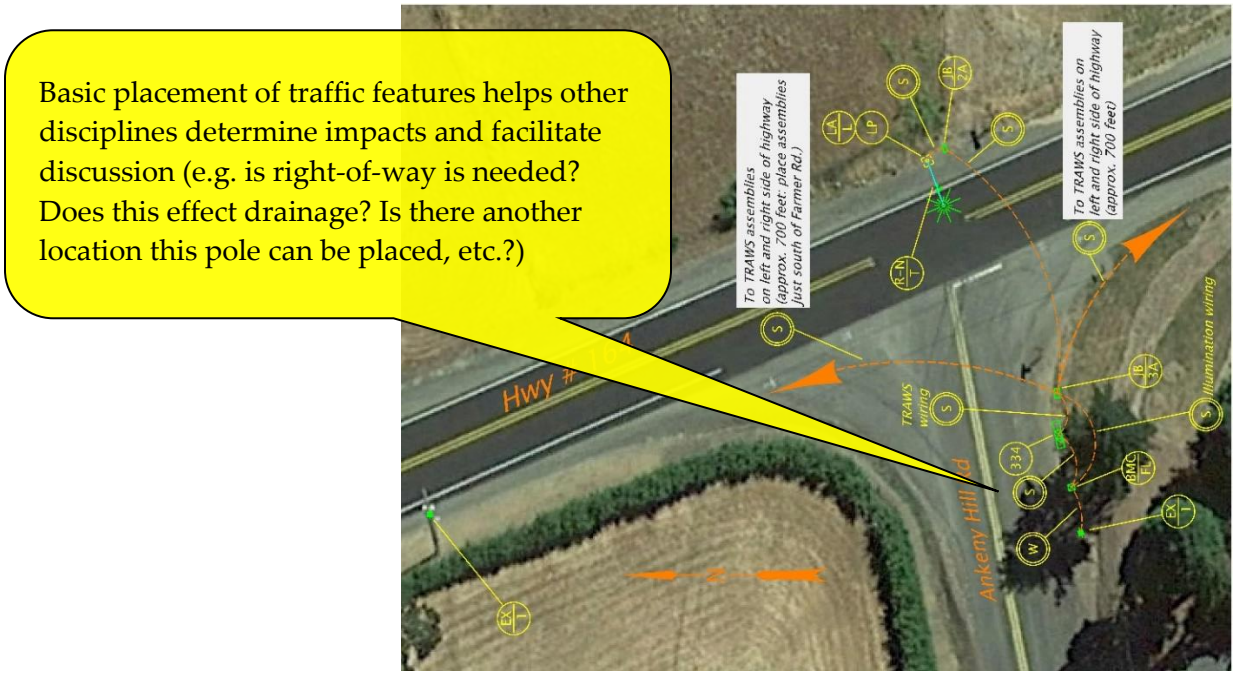
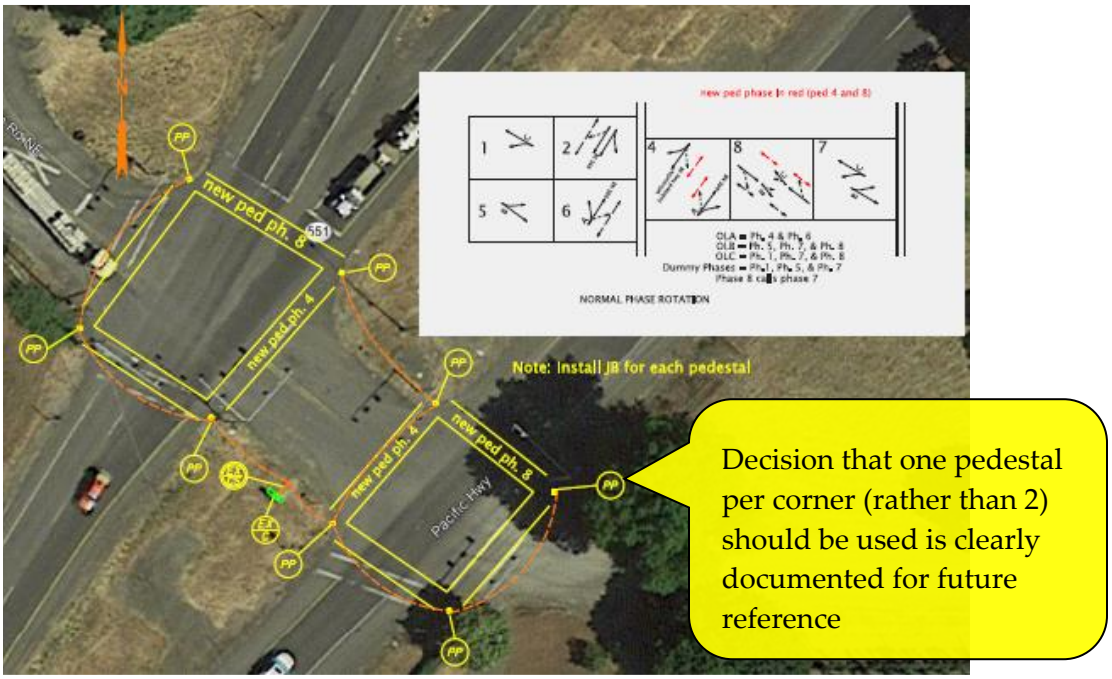


Figure 4-2 | Scoping Sketch Example 2



4.1.1 Traffic Signal Asset Management

The traffic standards crew produced the first traffic signal condition report in 2017. This report is updated every year in September. It contains a condition rating for every ODOT owned or maintained traffic signal expressed as a percentage (from 0% to 100%) with three classification categories:

- Fair or better (70% +)
- Poor (50-69%)
- Very poor (49%)

You can find the traffic signal condition reports on the ODOT Traffic Signal website. The ODOT TransGIS also has the condition rating of each signal under the "Equipment-Highway" category, then "signals" layer.

The roadway crew maintains the ADA ramp and pushbutton conditions which can be found on the ODOT TransGIS under the "roadside" category, then "ADA ramps" and "ADA pushbuttons" layer.

4.1.2 Statewide Goals, Priority, and Implementation

Planning traffic signal upgrades and replacement requires consideration of many factors, such as crash data, operational data, annual maintenance costs, planning documents, etc. Completing all of the recommended upgrades listed in Table 4-3, Table 4-4, and Table 4-5 below in one project is desirable, but may not be possible due to limited scope or funding. Therefore, each upgrade has been prioritized (high, medium and low), given associated design impacts, and reasons to implement goal to help assist in decision making. The region traffic engineer/manager should determine how the priorities are implemented and secure funding as necessary.

Local agency maintained, ODOT owned traffic signal assets are easy to overlook when planning traffic signal upgrades and replacement (out sight out of mind). However it is important that these ODOT assets get proper attention from ODOT staff for capital improvement projects, as the IGAs with the local agency are only for normal, routine maintenance. The local agency is NOT responsible for planning or funding capital improvement projects on assets they do not own (e.g., replacement of major structures at the end of their service life or when damaged, replacing conduits with damage/fill rate issues, upgrading operations/roadway geometry, etc.). When local agency maintained, ODOT owned traffic signals fall into disrepair beyond normal maintenance measures, local agencies have terminated the IGA agreement. This results in hardship for both parties that could have easily been prevented by proper planning and prioritization of ALL ODOT assets.

ODOT is responsible for planning and funding capital improvement projects for ALL ODOT owned traffic signals, regardless of who maintains it.

Table 4-3 | Statewide Goals High Priority

Statewide Goals			Potential Design Impacts	Reason for Goal
High Priority	1	Change existing controller cabinet with a PDA1 to a 332S cabinet	May require a signal rebuild to properly address all impacted features	Safety: PDA1 is fire hazard
	2	Change existing controller (170, 2070, etc.) to an ATC controller	N/A	Safety and operations: 170 and 2070 controller software is unsupported and unmaintainable
	3	Change existing "words" or non-countdown pedestrian signals to countdown LED modules	Likely to require a signal rebuild to address accessibility issues	Safety: FHWA Crash Reduction Countermeasure
	4	Replace existing loop detection with non-invasive detection (radar or video)	May require a signal rebuild to address conduit issues	Safety and operations: See chapter 6 & FHWA Every Day Counts 4 Initiative (ATSPM)
	5	Replace existing copper interconnect (including VDSL surge protectors) with fiber optic and install network communication equipment	May require a signal rebuild to address conduit issues	Safety and operations: FHWA Every Day Counts 4 Initiative (ATSPM)
	6	When required, install type 7 signal heads at railroad interconnected signals	May require a signal rebuild to address structural issues	Safety: Clears the RxR tracks faster during a preemption
	7	Change existing 8" lens vehicle signals to 12" lens	May require a signal rebuild to address structural issues	Safety: FHWA Crash Reduction Countermeasure
	8	Add backplates or change existing backplates to reflectorized backplates for the vehicle signals	May require a signal rebuild to address structural issues	Safety: FHWA Crash Reduction Countermeasure

Table 4-4 | Statewide Goals Medium Priority

Statewide Goals			Potential Design Impacts	Reason for Goal
Medium Priority	9	Change existing ¼" pushbuttons and H-frame to standard mounts & buttons	Likely to require a signal rebuild to address accessibility issues	Accessibility and uniformity
	10	Replace strain poles with 8-bolt mast arm poles. Note: strain poles no longer an option for permanent traffic signals due to new 75' mast arm length.	Likely to require a signal rebuild to address all poles at an intersection	Lower maintenance cost (less labor, less materials)
	11	Change existing controller cabinet (336, 336S, 337) to a 332S cabinet	May require a signal rebuild to properly address all impacted features	Operations, uniformity, and lower maintenance costs (less labor, less materials)
	12	Condition rating of signal is 70% or greater	May require a signal rebuild depending on deficiencies	Lower maintenance costs (less labor, less materials)

Table 4-5 | Statewide Goals Low Priority

Statewide Goals			Potential Design Impacts	Reason for Goal
Low Priority	13	Replace 4 bolt base vehicle signal poles (mast arm) with 8-bolt mast arm poles.	Likely to require a signal rebuild to address all poles at an intersection	Lower maintenance costs (less labor, less materials)
	14	Change existing power service (RPS & service/meter base mounted to poles, etc.) to BMC/BMCL service	May require a signal rebuild to properly address all impacted features	Lower maintenance costs (less labor, less materials)

4.2 Starting the DAP Design

Before starting the design, follow the simple check-list below. Design work should not begin until every item on the check list is complete. Starting a design with incomplete check-list items usually results in wasted time through unnecessary rework.

- Operational approval is complete (see chapter 3),
- Standards applied to the project are known (see section 4.3), and
- Applicable background information has been compiled (see sections 4.5 and 4.6)

The signal designer should also take a few moments to plan out what design work will be required:

- Will there be any unique details that are not covered in the standard drawings? The most current standard drawings (updated every 6 months in January and July) should be reviewed for any changes that may affect the design. If unique details are anticipated, these details will need to be included in plan set. See chapter 9 and chapter 18 for more information.
- Will any existing signal equipment need to be removed? If equipment will be permanently removed, where will ODOT want that equipment stockpiled? Check with the region electrical crew.
- Will a temporary signal be needed for any stage of construction? Existing signals need to remain in service until the re-built signal is turned on and certain lane use configurations should not be open to traffic unless they have proper signalized control (e.g. dual turn lanes). Check with the roadway designer and workzone traffic control designer. See chapter 11 for more information.

4.3 What Standards Will Be Used?

This question MUST be answered before starting the design and specifications. Failure to determine which standards will be used could result in complete failure of the project. In extreme cases, plans and specification will not be approved for construction and the entire project might be terminated. Every traffic signal within the state of Oregon, regardless of jurisdiction, is required to meet the minimum standards as stated in current, adopted editions of the Manual on Uniform Traffic Control Devices (MUTCD), the Oregon Supplement to the MUTCD, and the National Electric Code. There are levels of standards that apply to signal design:

- **Full ODOT design standards and specifications:** This is required if ODOT owns and maintains the traffic signal. Full ODOT standards are contained in the ODOT Traffic Signal Design Manual and the ODOT Traffic Signal Policy and Guidelines.
- **Partial ODOT design standards and specifications:** This is allowed if a local agency maintains an ODOT owned traffic signal. This also applies to local agency owned traffic signals maintained by ODOT. The portions of the design and specifications that are not full ODOT standard are negotiated in the intergovernmental agreement (IGA) or directly with the traffic engineering section during the design approval process. Generally the variance to ODOT standards is minor (e.g., the use of interior illuminated lane use signs).
- **Full local agency design standards and specifications:** This standard only applies to local agency owned and maintained traffic signals. As stated above, if the local agency will maintain an ODOT owned traffic signal then some of the local agency standards might be allowed through negotiation.

4.4 Intergovernmental Agreements (IGA) and Jurisdictional Transfers

An intergovernmental agreement (IGA) is a legally binding document that defines the obligations of each party involved in a project. An IGA is typically needed for a state highway intersection with a local county road or city street. Depending on the scope and nature of the project there could be a lot of responsibilities to define, some of which have a direct impact on the design of traffic signal, for example; maintenance responsibility (what design standards should be used), signal timing responsibility (what type of controller and type of detection should be used), and aesthetics (what decorative treatments are to be used).

Jurisdictional transfers allow agencies to legally redefine who has ownership of the roadway (typically changing from ODOT owned to local agency owned). They are rare, but if one is being considered on the project, it is imperative that jurisdictional transfer agreement is complete and final prior to any design work. The fundamental question of what design standard should be used cannot be answered until then.

Unfortunately, the IGA or the jurisdictional transfer is sometimes processed simultaneously with the design the traffic signal. If this is the case, the signal should be designed using the standards that currently apply, not the standards that are anticipated as past history has shown IGAs and especially jurisdictional transfers often do not go forward as expected given the many negotiated factors and political nature. Also, the design approval process becomes more complicated due to the uncertainty of the standards that should be applied.

Designing a signal according to anticipated standards is risky. This will result in wasted time and effort should the IGA or jurisdictional transfer fall through.

4.5 Background Information to Gather

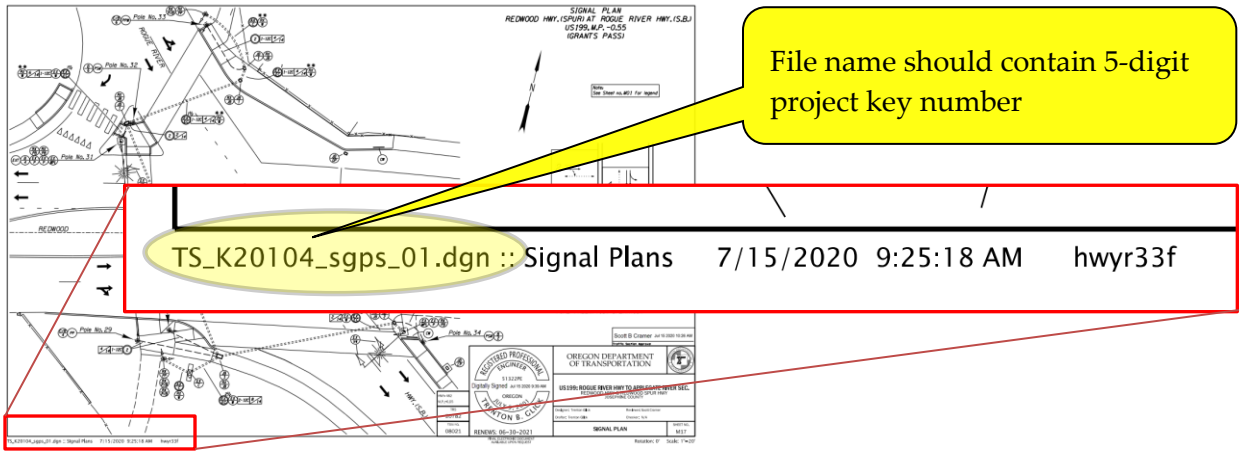
4.5.1 As-Built Drawing Archive (FileNet)

As-built PDF plan sheets should be downloaded from FileNet at the signal standards website under "Drawing Archive". There is a "Getting Started Guide" for help in using FileNet.

When searching for drawings, it best to search with the ODOT highway number. Note that ODOT uses a unique numbering system for all the highways; use the cross-reference guide to find the ODOT highway number. Also, leave the search as generic as possible. This is because many of the more specific fields are not consistently populated. Searching these specific fields may result in missing certain drawings.

If you need the dgn file(s) of a particular project, they can usually be found either in projectwise (for newer projects) or in the ODOT engineering archive. You will need the key number of the project to be able to search in projectwise and the ODOT engineering archive, which is located in lower left corner of the plan sheet outside the border. See Figure 4-6. Note that archived dgn files are not directly available to staff outside of ODOT. If you are unable to find archived dgn files, contact the EOR or designer of the project for assistance.

Figure 4-6 | Key Number of Project



4.5.2 Electronic Information

Prior to the field verification discussed in section 4.5.3 below, it is good to get familiar with the project area using the available electronic sources of information: ODOT digital video log and google/bing maps. This can help the signal designer zero in on issues/questions to address during the field verification, resulting in an efficient use of time when on-site. Note that ODOT uses a unique numbering system for all the highways; use the cross-reference guide to find the ODOT highway number.

4.5.3 Field Verification



Field verification is the one of the most important steps in the process of traffic signal design and should not be skipped. Thousands or tens of thousands of dollars can be saved during construction by simply making a field visit during the design phase and verifying the existing conditions. Being on-site is more valuable than just looking at photos or a base map because photos and drawings only provide limited perspective and can be incomplete.

When conducting the field visit, bring a camera and take a lot of photos. Photos will be helpful throughout the design and construction support phase the project. If in doubt, take a photo; something that seems insignificant now may prove to be extremely useful in the future. Photos can save an additional trip in the field to re-verify or might be useful in resolving a construction claim. Some tips for taking photos:

- Take photos of the same area from different perspectives
- Get specific, micro detail photos – inside of junction boxes (conduits and wire), inside the controller cabinet (front and back), existing signal equipment and attachments
- Get "bigger picture" photos – each approach (approximately 500' feet back from the intersection), each quadrant of the intersection, slopes, and utility locations

Measurements are also helpful, especially if the project has limited or no survey information:

- Existing conduit sizes and number of wires (critical if attempting to re-use them or add additional wire)
- Pushbutton measurements (for ADA ramp work)
- Sight distance measurements

Other useful information to gather in the field includes:

- Posted speed in the vicinity
- Location and nature of any accesses/streets that are close by
- Potential locations for all of the signal hardware (poles, pedestals, & cabinets)
- Power source location (typically nearest transformer)
- The driver's perspective – drive each approach, note any sight distance issues (e.g., vegetation that may block sight distance when leaves return).
- Information on the signal pole tag

Coordinating a field visit with the signal timer and/or agency electricians (or having them field verify and report back on certain topics such as conduit fill rate, equipment condition, terminal cabinet wiring, controller cabinet equipment, signal phasing) is highly recommended.

A field visit is ALWAYS cost effective and well worth the effort. At least one field visit should be done during the design phase.

4.6 Background Information from Others

4.6.1 Existing Operational & Condition Information

For existing signal modification work it is critical to verify the existing operation (e.g., phasing and controller cabinet print) and condition (e.g., conduit integrity, equipment issues, etc.) of the traffic signal with region traffic and agency electricians. Even minor modifications that seem simple may turn out to be a problem that triggers additional work for a proper installation. For example, there are several different ways to wire and operate PPLT phasing that do not meet current standards but still exist in the field for various reasons. If a project just updates an outdated PPLT signal head, additional cabinet equipment such as an AUX file and signal timing changes may be required to fully meet the current standards for PPLT phasing.

Never assume the existing controller cabinet, signal timing, or equipment condition can accommodate the proposed design changes – always verify.

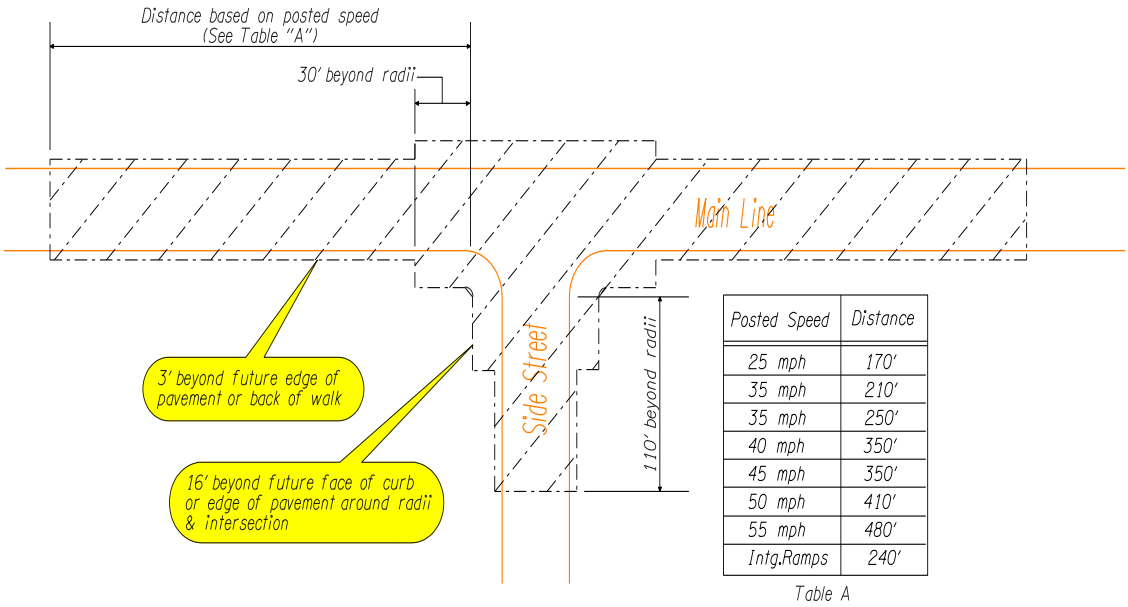
4.6.2 Base Map and Survey Information

Survey data is needed on most projects. To determine the amount and type of survey needed, the scope of the design must be defined. Below are a few examples:

- **Rebuild of detection system** – Typically as-built plans and field visit are all that is needed. If utilities appear to be an issue a simple survey is needed.
- **Installation of pedestals, controller cabinets, service cabinets** – A simple survey is needed
- **Installation of SM poles** – Full survey is needed with geotechnical report

Figure 4-7 shows the recommended minimums for a survey within the intersection area. If the intersection has not yet been surveyed or additional information is required, this figure will help guide you in getting the necessary data.

Figure 4-7 | Survey Area for Traffic Signal



Posted Speed	Distance
25 mph	170'
35 mph	210'
35 mph	250'
40 mph	350'
45 mph	350'
50 mph	410'
55 mph	480'
Intg.Ramps	240'

Table A

Data to collect within the survey area shown in Figure 4-7:

- Underground utilities in the 16' wide survey areas around the radii (pole foundation conflicts)
- Underground utilities less than 3' deep in the 3' wide survey areas beyond edge of pavement or back of walk (conduit and junction box conflicts)
- Above ground utilities and wire attachment heights in 16' wide survey areas around the radii (mast arm and span wire conflicts)
- Power poles/cabinets with transformers (potential power source). Note: this may be located outside of survey area
- All striping within survey area: lane lines, centerline, fog lines, crosswalks, stop bars, and legends
- Any existing signal features within survey area: controller cabinet, poles, junction boxes, loops, etc.

4.6.3 Roadway Design

If the project is rebuilding the roadway, then there will be a roadway design base map. The signal designer must communicate with the roadway designer throughout the entire design phase. The roadway designer's final product is the base for the traffic signal design. Good communication will help ensure the most current roadway design base map is always used for the traffic signal design.

4.6.4 Geotechnical Report

If new SM poles are proposed, then a geotechnical report is required to determine the foundation depths. Standard loading, not actual loading, is shown in the TM600 series standard drawings. The geotechnical report in conjunction with the standard drawings are used by the bridge designer to determine the foundation depth. The foundation depth with a reference to the geotechnical report is shown on pole entrance chart. See chapter 9 for more information.

As soon as the pole locations are defined, contact the region geo/hydro manager for a foundation investigation of the proposed site.

4.6.5 Utility Hook-ups

New signals require a connection to commercial power and may require other connections (e.g. telephone). The project may also involve moving existing utilities. The signal designer must coordinate with the region utility specialist when connecting to a power source (or any other utilities) as early as possible in the design process.

4.6.6 Rail Crossing Order

If a rail crossing order is required for an intersection, it will be processed simultaneously with the design the traffic signal. The final rail crossing order will be issued prior to letting the project. The signal designer will provide a sealed railroad preemption plan sheet early in the design phase (DAP) for inclusion into the rail crossing order. See chapter 16 for more detailed information.

4.7 Signal Design Project File

A project file for the signal designer's personal use should be created and maintained for the project in ProjectWise. It should contain all the supporting documentation, calculations and major decisions related to the traffic signal design and construction. The items listed below, if applicable, are typically included in the signals file:

- Project narratives
- Operational approval letters
- Photometric data for illumination
- Calculations for:
    - Wire size
    - Wire fill
    - J-Box size
    - Wire count
    - "AH" for strain poles
- Cost estimates (itemized breakdown for each bid item, total bid item cost, and anticipated item cost)
- E-mails and memos concerning design decisions
- Photos
- Field verification information
- Geotechnical report
- Rail crossing order
- Pole submittals and shop drawings
- Manufacturer's cut sheet or submittals
- Correspondence between project managers, consultants or contractors
- Existing as-builts

Other documentation related to signals, such as special provision boiler plates, review comments and their resolution, etc. will be also created and maintained in ProjectWise, but will not be stored in the signals file. They will be stored in the appropriate folders as designated by the ProjectWise standards.

Good record keeping can save time and effort when issues/questions arise during the design, construction, or even maintenance phase.

5 Signal Plan

This chapter will discuss all the design elements that are shown on a sign plan sheet, in order of the recommended process for designing a new traffic signal.

There are many ways to design a traffic signal. In this chapter, there is flexibility for some design elements based on the region electrical crew preferences. It is critical to coordinate with the region electrical crew during the design phase to ensure maintenance concerns are addressed.

5.1 Roadway Design

The signal design work starts with the roadway base map and geometric design. It is important to review the roadway geometric design and work with the roadway designer early in the process, as fundamental roadway features such as the number of lanes, the lane use, horizontal/vertical alignment, and the curb ramp locations all have a direct impact on how the signal will be designed.

For projects without any roadway design work or survey data, see chapter 21 for information on drafting the necessary roadway features.

5.1.1 Number of Lanes and Lane use

The operational approval for the traffic signal will show the required number of lanes, lane use, and signal phasing. The roadway design must match what is shown in the operational approval. Any discrepancy between the roadway design and the operational approval must be resolved, either by amending the operational approval (typically requires an additional engineering study) or by correcting the roadway design.

5.1.2 Pedestrian Crosswalks Closures

The operational approval for the traffic signal will indicate where the signalized pedestrian crossings are located and will identify any crosswalk closures. Crosswalk closures will normally be approved in a separate approval letter where the requirements for closure treatments will be specified. Closure treatments will normally be required in both visual and detectable formats. Sign OR 22-7 is the standard visual treatment for a crosswalk closure; this sign will nearly always be required at crosswalk closure at a signalized intersection. The crosswalk closure support shown in standard drawing TM240 is a typical treatment to meet the requirements for a detectable barrier/feature, but other treatments may be used such as a buffer strip or a railing. The detectable feature must convey that the crossing is closed to all pedestrians (including those with visual impairments) to comply with ADA. A detectable barrier/feature will nearly always be required when there is a sidewalk at a closed crosswalk. See the ODOT Traffic Manual for additional information on crosswalk closures.

Crosswalk closure supports (TM240) and "CROSSWALK CLOSED" signs (OR22-7) used at signalized intersections are typically shown on the signal plan sheet, NOT on the signing plan sheet. Crosswalk closure supports are also required to be shown on the curb ramp detail sheet. The signal designer should review the curb ramp detail sheet to ensure it matches what is shown in the signal plans. Crosswalk closure supports are no longer included in the traffic signal lump sum bid item. Instead, use the bid item in specification 00902 (see chapter 19).

It is likely that a project will include crosswalk closure supports at unsignalized intersections. These are typically shown on the signing plan sheet and will use the same 00902 specification and bid item. Coordinate with the sign designer to determine the EOR for the 00902 specifications and ensure the bid item quantity is correct.

Verify that all crosswalk closures (even existing closed crosswalks) have been approved by the state traffic engineer. If there is no documented operational approval for the closure, either the crosswalk must be opened OR a request for closure will need to be submitted by region traffic.

Follow the requirements stated in the crosswalk closure operational approval. If these requirements are not met, the crosswalk closure will not pass ADA inspection.

5.1.3 Selecting & Locating Curb Ramps for Proper Crosswalk Alignment

Each signalized crosswalk shall:

- Be marked with appropriate crosswalk pavement markings as per the ODOT Traffic Line Manual.
- Have a separate curb ramp at each end of the crosswalk if sidewalk is present. If no sidewalk is present, (e.g. rural locations and interchange ramps), a level pedestrian pad outside the normal roadway shoulder in lieu of curb ramps should be used. If a pedestrian pad outside the normal roadway shoulder isn't feasible, a level landing area within the shoulder that will not be encroached by vehicles is acceptable. See section 5.1.8, Figure 5-21 and Figure 5-22 for more information on verifying the vehicle swept path does not encroach on the pedestrian access route.

Note that an ADA curb ramp design exception is required when a single curb ramp is used for more than 1 crosswalk, a level area is not provided, or fails to meet the clear space dimensions. The signal designer or the roadway designer will need to prepare the design exception request – contact the roadway designer for assistance. While having separate curb ramps at the end of each crosswalk is the default standard because it provides better information for a visually impaired pedestrian to line-up and navigate the crossing, there are situations where providing this standard may result in the following:

- Crosswalk alignment that has extremely poor driver visibility to pedestrians when making permissive right or left turns. See Figure 5-1 and Figure 5-2 for examples. This requires a solution that will maximize the available sight distance or mitigate the concern in an acceptable manner.
- Extremely poor driver visibility to other vehicles that requires the addition of NO TURN ON RED signs. See Figure 5-3 for example. This requires further evaluation from region traffic to determine if restricting right turns on red is acceptable. Overuse of NO TURN ON RED have a higher risk of being disregarded and drivers may block the crosswalk to increase their line of sight. Correction of this behavior requires regular enforcement, which is difficult to get with limited resources.
- A significant reduction in left/right turn storage. See Figure 5-4 for example. This requires further evaluation from region traffic to determine if a decrease in storage length is acceptable. Inadequate storage lengths for turning movements can result in an increased risk of rear-end, run-off the road, or sideswipe crashes due to spill back into through lanes.

These situations tend to occur at intersections with small radii and/or where buildings or vegetation are close to the back of curb as it is very difficult to install two adjacent curb ramps on a small radius without pushing the crosswalk alignments further away from the intersection. In these situations, the sight lines and potential safety/operational impacts (for all modes or travel) must be evaluated to determine the best placement of curb ramp(s) and crosswalks. Solutions could include using different ramp styles, closing crosswalk(s), and changing signal phasing/timing, but the best solution may be one single curb ramp on the radius. A design exception is still required, but should be approved with brief documentation of the sight line issues or inadequate storage distance that would result if using two adjacent curb ramps.

Evaluate sight lines when revising any existing or adding any new curb ramp locations/crosswalk alignments.

Intersections with tight radii or buildings/vegetation close to the back of curb deserve additional attention. The best solution is likely one single curb ramp on the radius (design exception is required).

Figure 5-1 | Poor Visibility to Pedestrians (Permissive Right Turn) Example

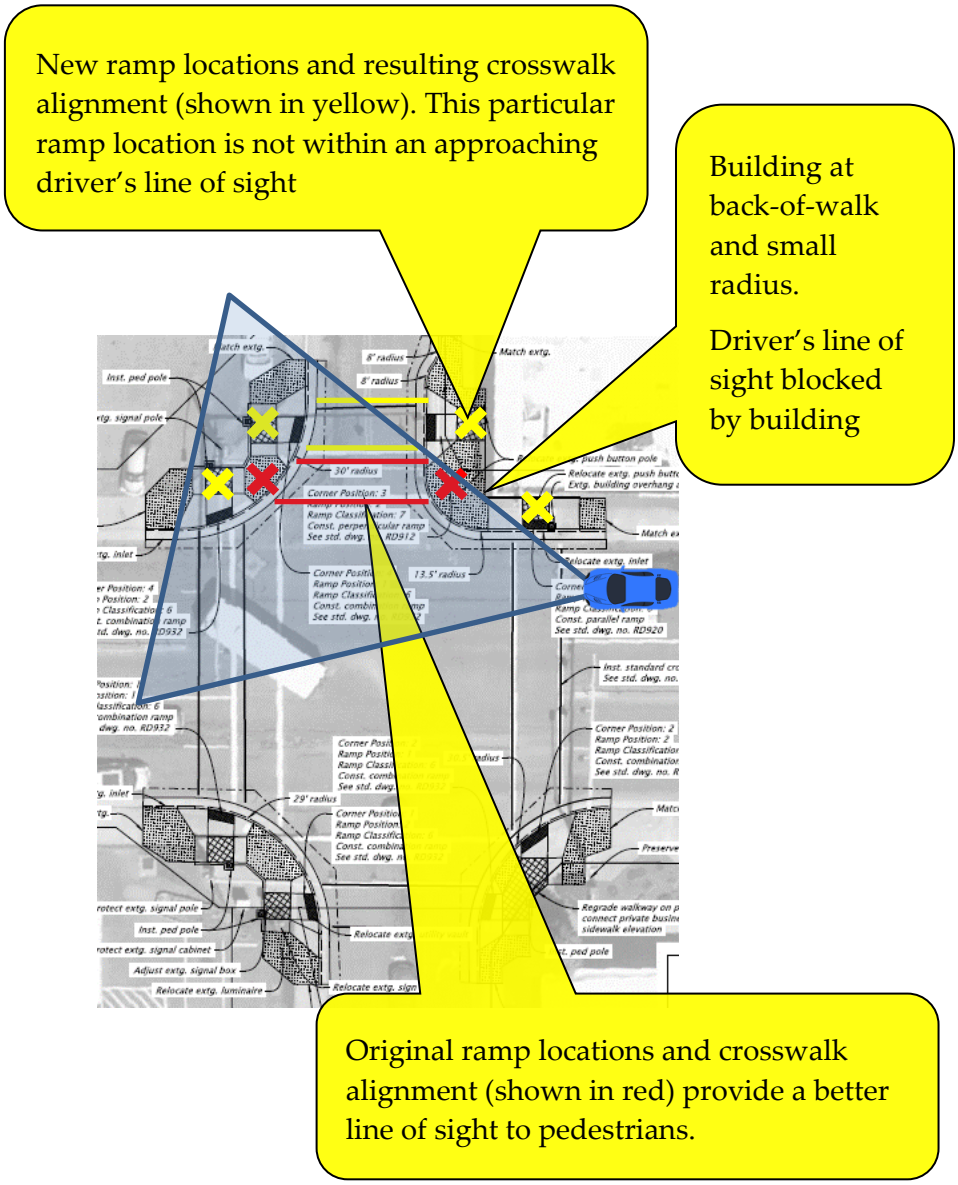


Figure 5-2 | Poor Visibility to Pedestrian (Permissive Left Turn) Example

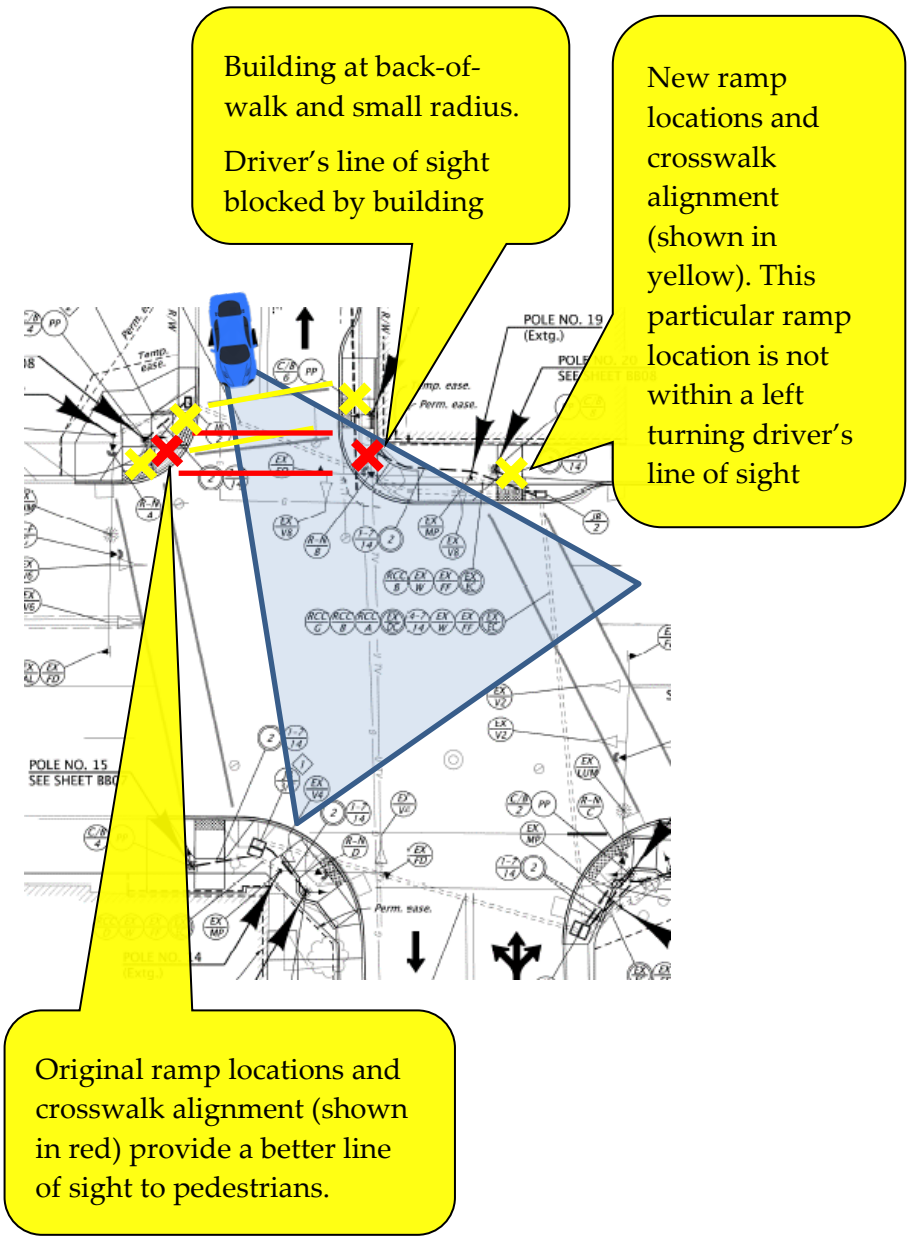


Figure 5-3 | Poor Visibility to Vehicles (NO TURN ON RED Signs) Example

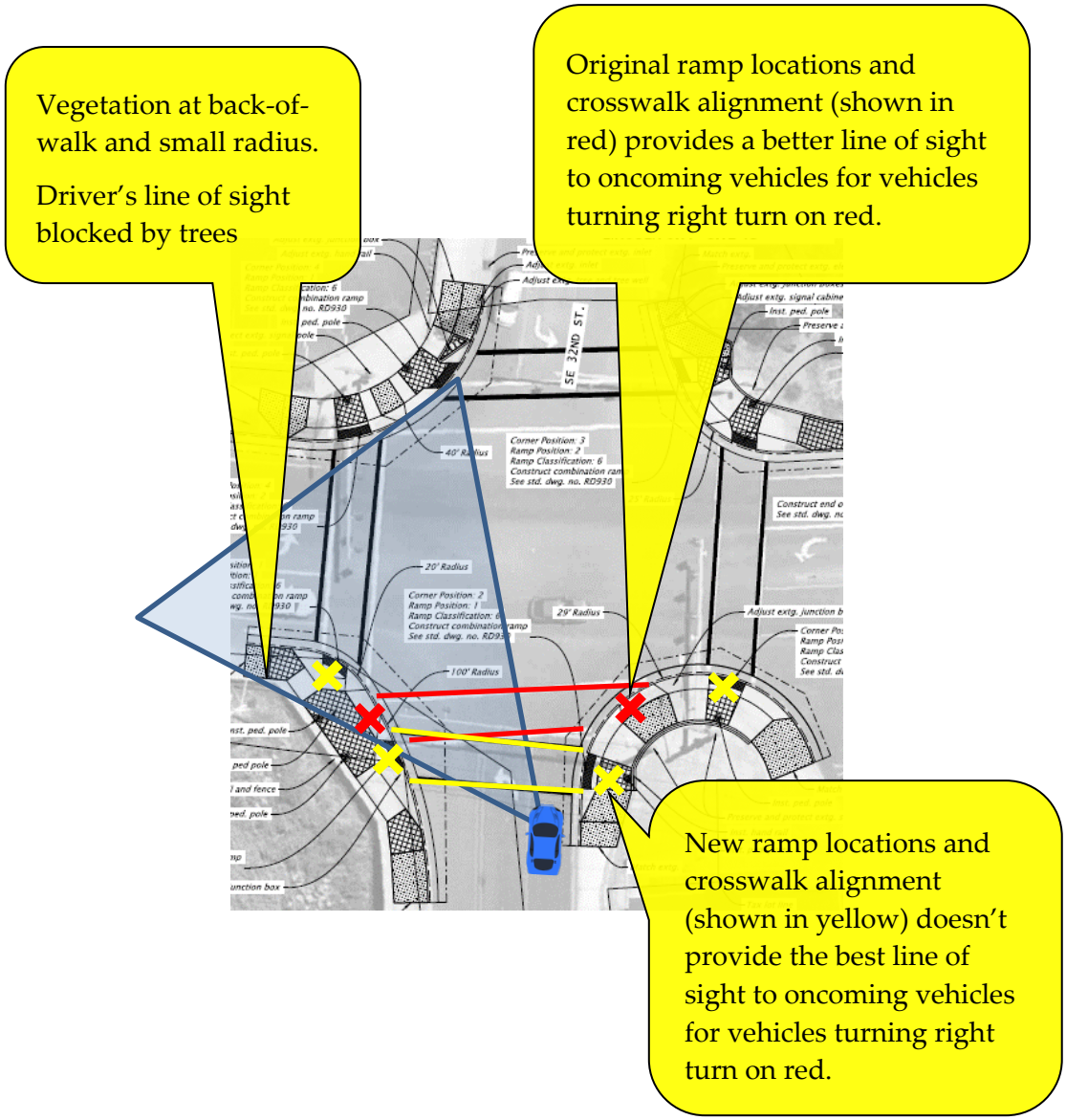
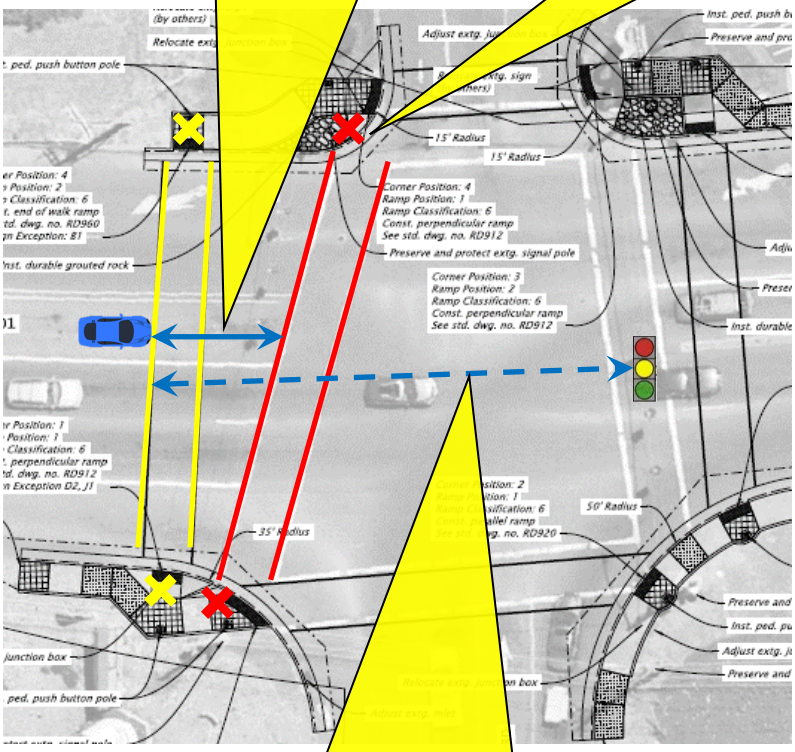


Figure 5-4 | Significant Reduction in Turn Lane Storage Example

New ramp locations and crosswalk alignment (shown in yellow) significantly reduce storage for left turns - especially if the existing storage length is already short (75 feet or less) or over capacity.

Original ramp locations and crosswalk alignment (shown in red) provide approx. 25′ more storage for left turn.

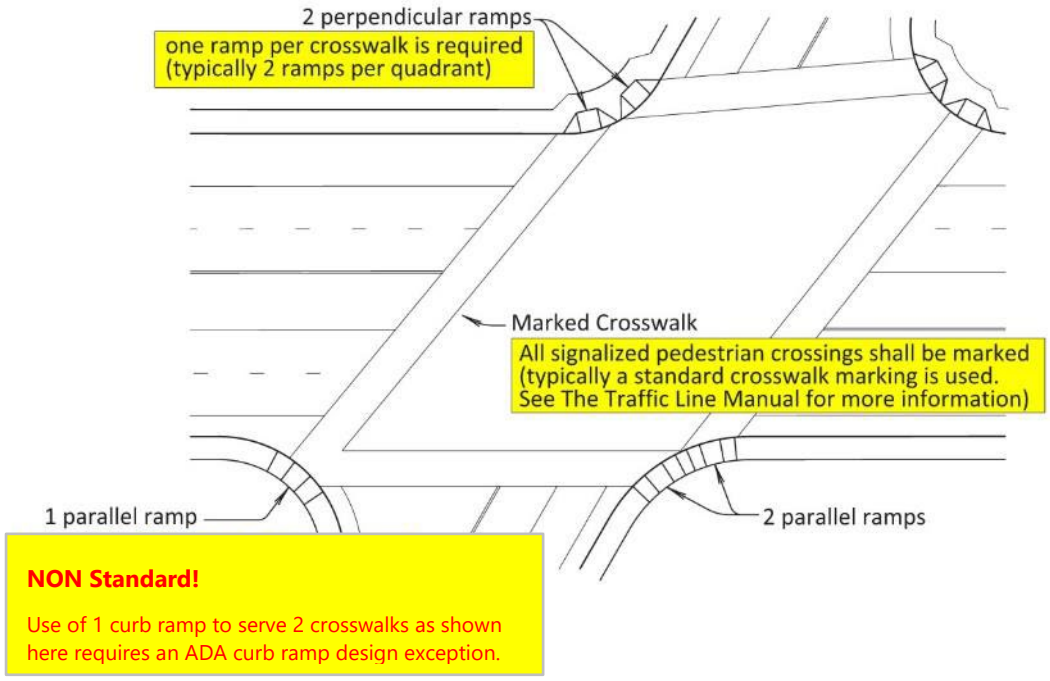


In addition, if the intersection is already large, the additional distance from the new vehicle stopping location to the signal heads may require supplemental signal heads (See section 5.2 for more info).

When locating curb ramps and crosswalks, consult the latest roadway standard drawings for current curb ramp configurations and discuss with the roadway designer. See Figure 5-5 for an example showing the basic curb ramps requirements. The roadway designer is responsible for the curb ramp design, but the signal designer should be involved in the selection and placement of the curb ramps as the following signal design features are dependent on curb ramp type and placement:

- Crosswalk alignment and stopping location for vehicles (affects line of sight, storage lengths, signal timing parameters, and detection system)
- Location of signal poles
- Location of pedestals
- Location of pushbuttons

Figure 5-5 | Basic Curb Ramp Requirements for Signalized Intersection



There are three main objectives for proper crosswalk alignment:

1. **To maximize the visibility of the pedestrian and maintain a good line of sight between the pedestrian and the motorist.** To accomplish this, place the crosswalk as close to intersection as possible (as opposed to crosswalk located beyond the intersection radii). Figure 5-6 illustrates this crosswalk placement. Note: this configuration may result in needing advance stop lines at heavily skewed intersections.
2. **To reduce the amount of exposure the pedestrian has in the intersection.** To accomplish this, place the crosswalk perpendicular to the travel lanes that are crossed. This results in the shortest path for the pedestrian and the most efficient signal timing. Figure 5-7 illustrates crosswalks this crosswalk placement. Having the shortest path is a very important consideration when the traffic signal is interconnected to a rail crossing, as it may not be feasible to obtain extra seconds from the rail equipment to accommodate the pedestrian clear-out interval (PCOI). However, this configuration does not really meet the first objective (especially for the side street right turning vehicles in Figure 5-7 which will be able to pick up quite a bit of speed before the crosswalk).
3. **To provide proper alignment cues for visually impaired pedestrians.** To accomplish this, place the crosswalk parallel to the concurrent vehicular traffic movement. Figure 5-6 illustrates this crosswalk placement. Note: skewed intersections are move difficult for those with vision impairments to align and orient themselves to cross the street compared to 90-degree intersections.

As Figure 5-6 and Figure 5-7 illustrate, the first two objectives will often be in conflict with each other. The benefits of each strategy will need to be considered to determine the right balance. Figure 5-8 shows a good compromise. When possible, fixing the skew of the intersection is the preferred option to best address all three objectives (90-degree intersections are ideal for many reasons). Coordinate with region traffic concerning the needs of the pedestrian signal timing and the roadway designer for fixing or improving the intersection skew.

Selection and placement of curb ramps shall be done with the assistance of the roadway designer to determine the curb ramp type that best addresses all ADA and geometric design issues, while still addressing the signal design needs.

Figure 5-6 | Crosswalk Example 1

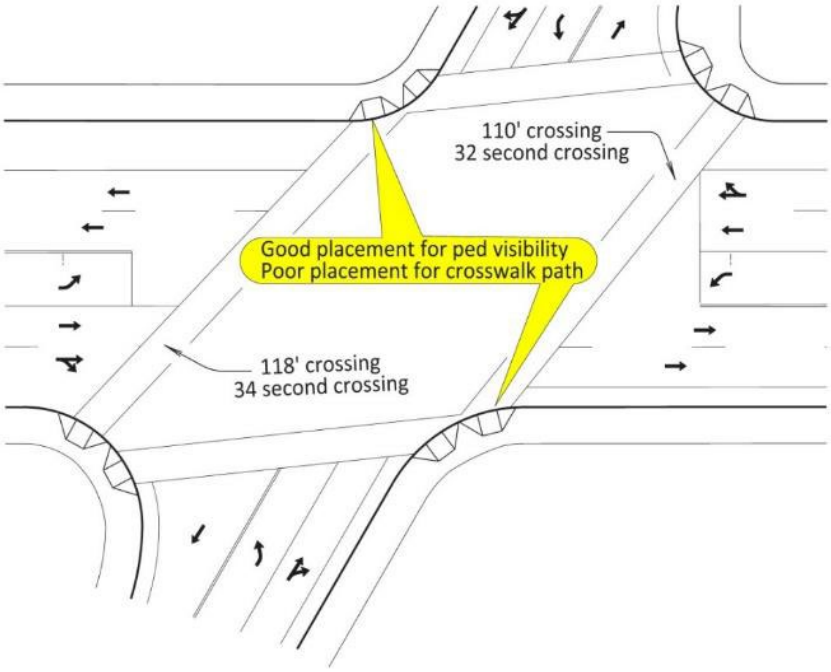


Figure 5-7 | Crosswalk Example 2

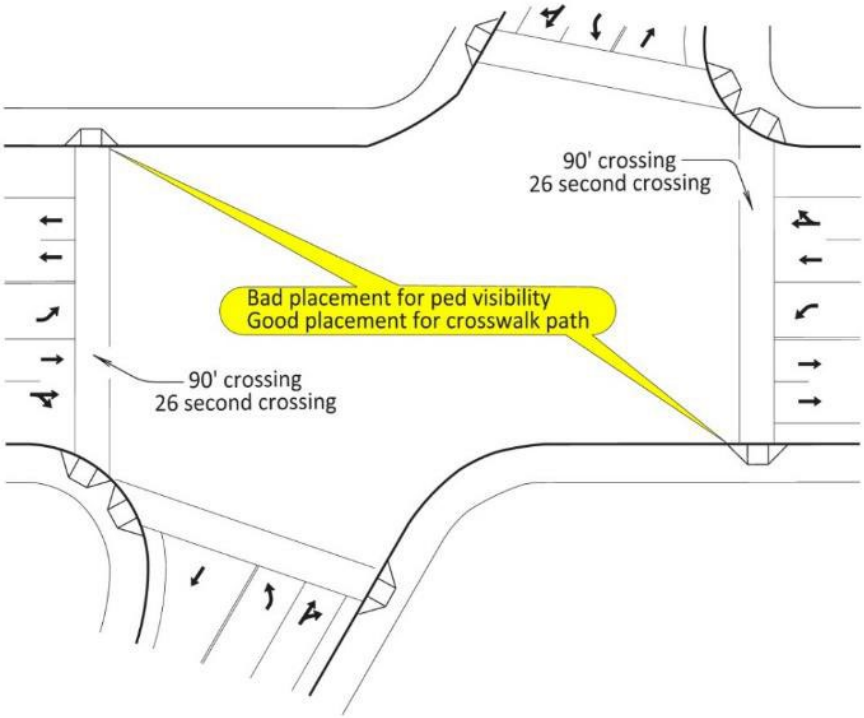
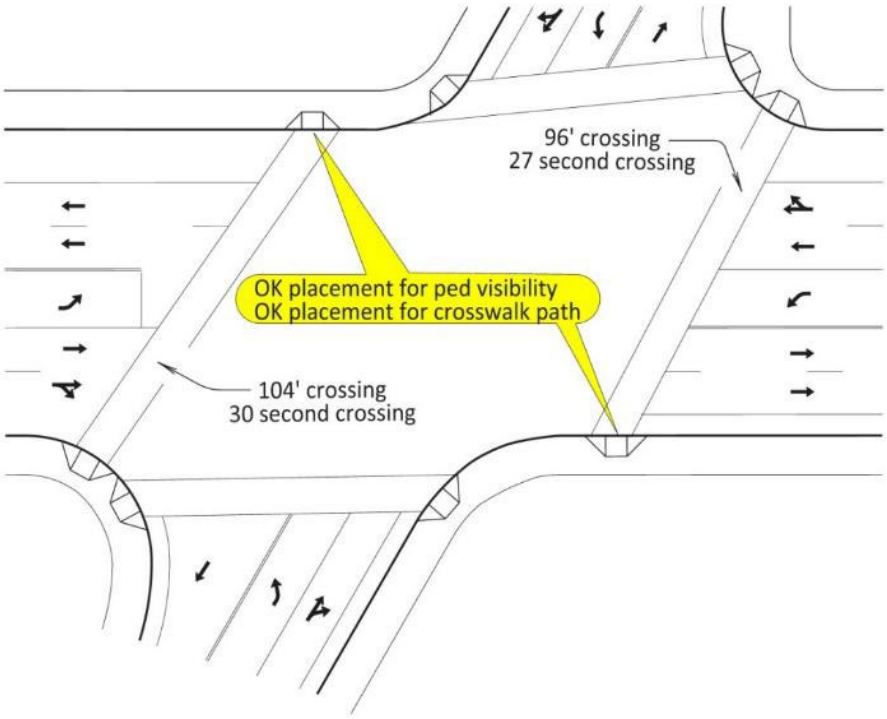


Figure 5-8 | Crosswalk Example 3



5.1.4 Signal Poles and Pedestals

As per technical bulletin RD17-01(B), ADA sidewalk curb ramp detail – minimum requirements in construction plans, roadway designers are required to show full detail of each curb ramp in the contract plans. This includes showing the exact location and critical elevations for signal poles, pedestals, and pushbutton locations. See roadway standard details DET1720 and DET1721 for examples of curb ramp details. The signal designer will need to work closely with the roadway designer during curb ramp design, following the guidance in section 5.4 to provide accurate pole and pedestal locations. The signal plan sheets should reference the curb ramp detail plan sheets.

5.1.5 Raised Median Islands and Crosswalk Alignment

Raised median islands are recommended by the ODOT Highway Design Manual and Oregon Highway Plan based on the highway classification (e.g., statewide NHS routes) and to address certain safety, operational, and access concerns. The type of end treatment for the raised median island at signalized intersections should be carefully considered as it directly impacts the design of the pedestrian equipment and signal phasing.

Two-Phase Pedestrian Crossing

If a two-phase pedestrian crossing is required (according to the operational approval) the crosswalk configuration should be staggered with enough distance such that each phase of the pedestrian crossing is clearly defined. The pedestrian indications for the first phase of the crossing should not be visible to pedestrians using the second phase of the crossing (and vise-versa). See Figure 5-9 and Figure 5-10. This eliminates the potential confusion of which signal indication pertains to which crossing and the pedestrian using the wrong indication. Louvers and programmed heads are not an option for pedestrian indications. Count down heads can eliminate the confusion associated with non-staggered two-phase crossings (if the time for each of the two-phases is the same), but non-staggered two-phase crossings should be avoided when possible. Pushbuttons for each phase should also be separated and clearly indicate which crossing they apply to, preferably located on the same pedestal as the applicable pedestrian indication.

Figure 5-9 | Two-Phase Pedestrian Crossing (Staggered Crosswalk Alignment) Example 1

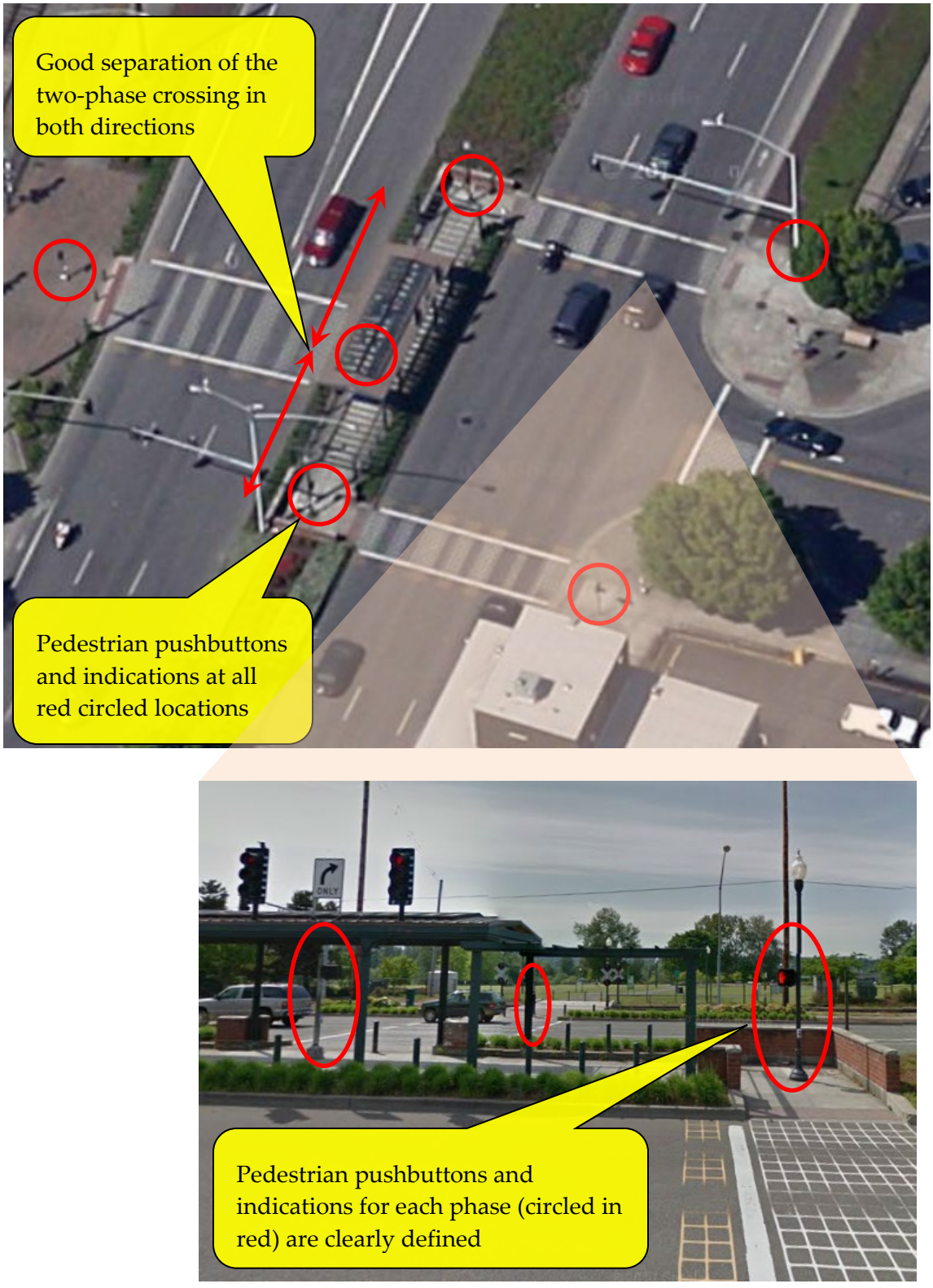
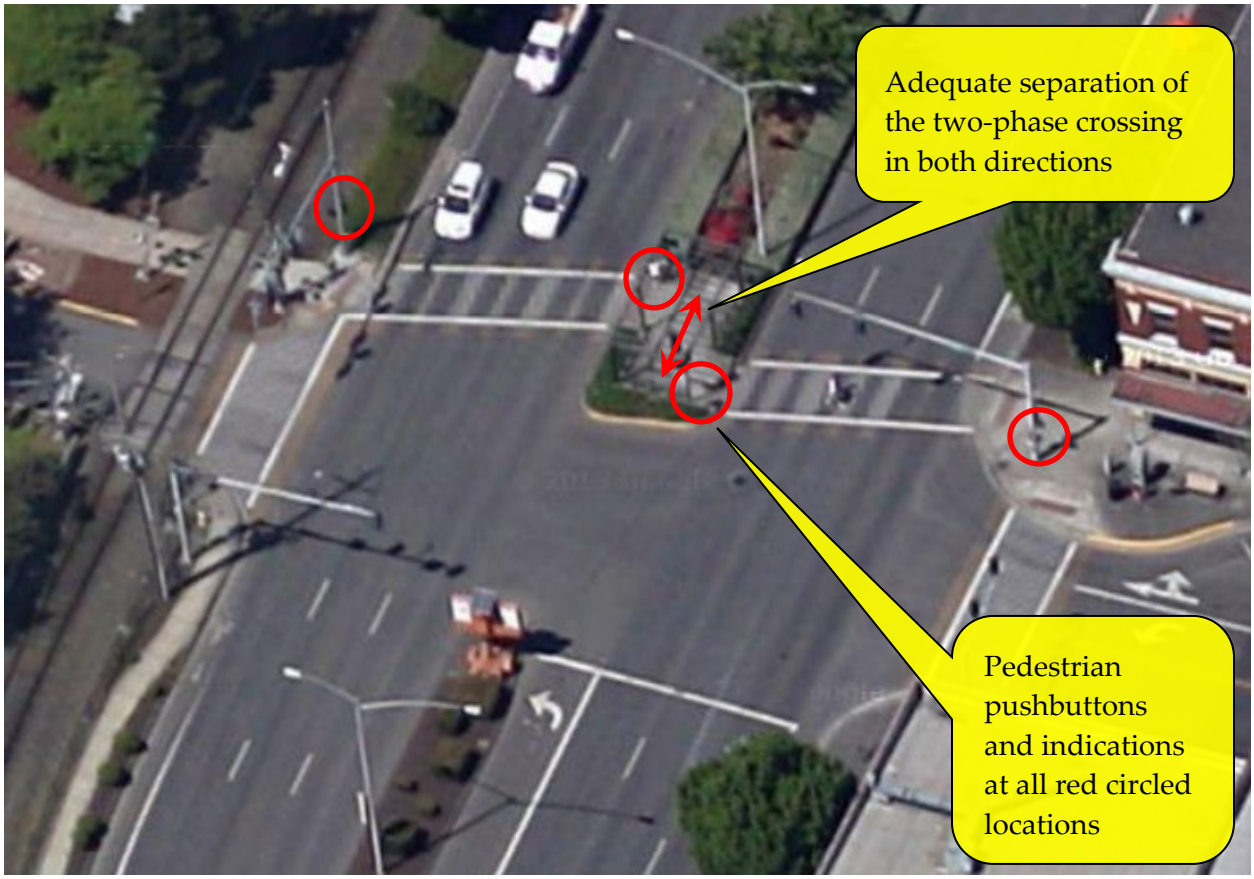


Figure 5-10 | Two-Phase Pedestrian Crossing (Staggered Crosswalk Alignment) Example 2



Single Phase Pedestrian Crossing

If a two-phase pedestrian crossing is NOT required (according to the operational approval) the crosswalk should be aligned as per section 5.1.3 with a median that ends prior to the crosswalk. This eliminates the need for a pushbutton located in the median as the design provides clear direction to the pedestrian that they will be crossing the entire crosswalk in one stage. See Figure 5-11 and Figure 5-12. Pushbuttons in the median, as shown Figure 5-13, in shall NOT be installed for a single phase pedestrian crossing where the raised median ends prior to the crosswalk (pedestrians should not be encouraged to take refuge where there is no pedestrian refuge).

Figure 5-11 | Single Phase, One Stage Pedestrian Crossing (Recommended Crosswalk & Median Design) Example 1



Figure 5-12 | Single Phase, One Stage Pedestrian Crossing (Recommended Crosswalk & Median Design) Example 2

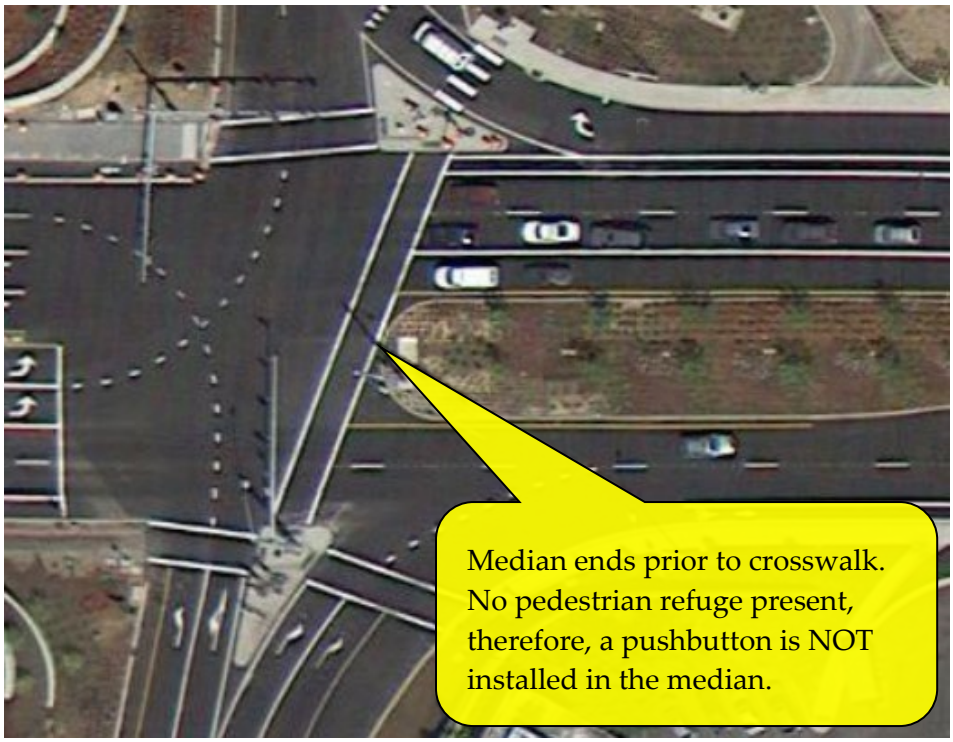
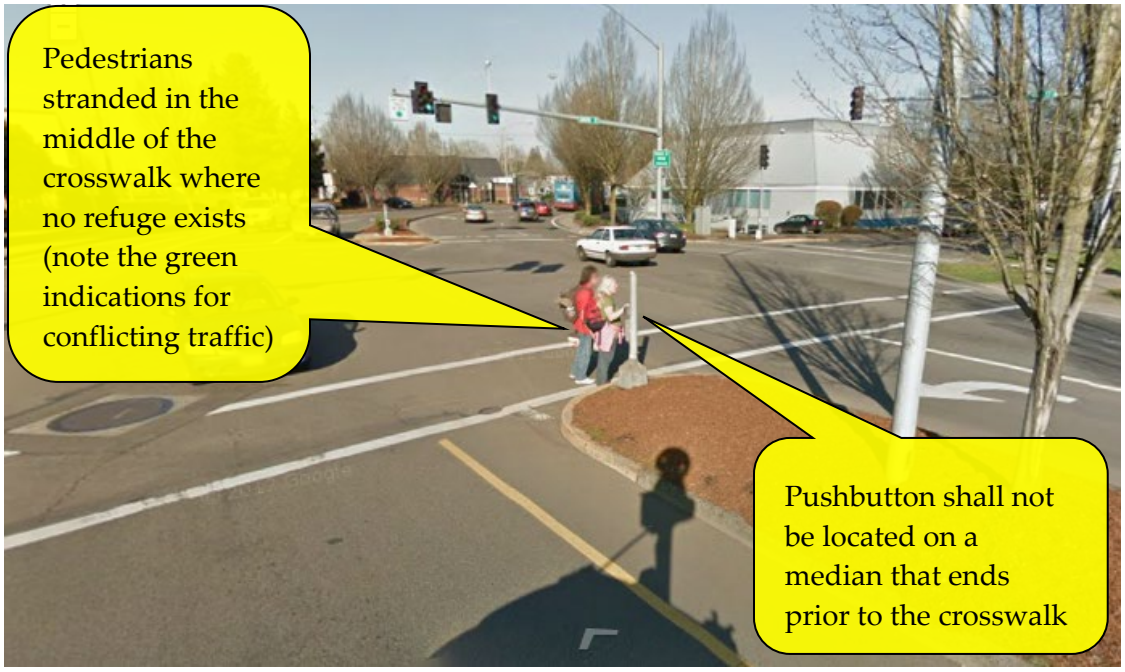


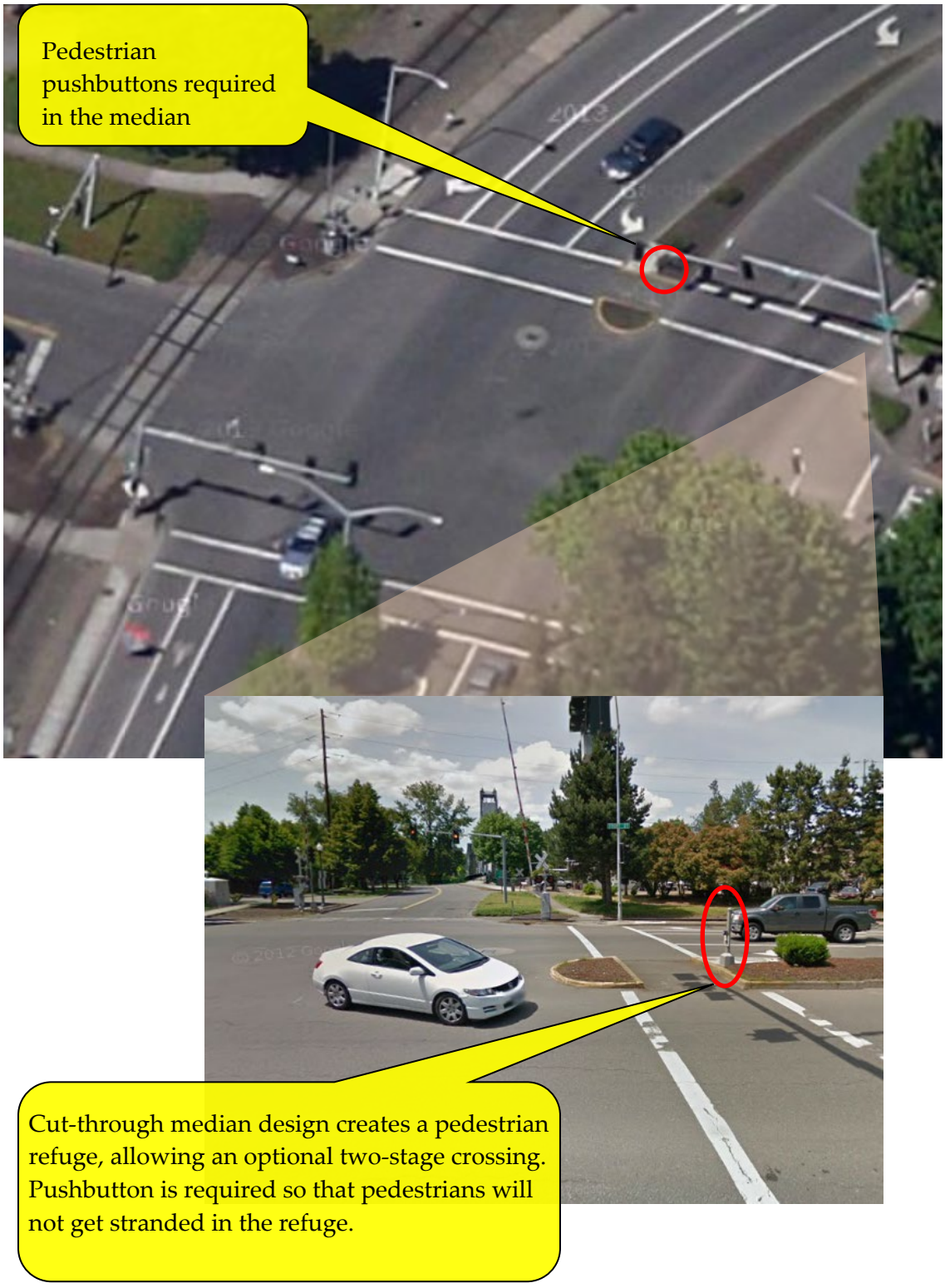
Figure 5-13 | Single Phase, Two Stage Pedestrian Crossing (Incorrect use of Median Pushbutton)



If the median is extended beyond the crosswalk with an accessible island (which may be cut-through), a pushbutton is required. See Figure 5-14. This is because the cut-through design allows pedestrians the option of a two-stage crossing, even though the pedestrian crossing is only a single phase (e.g., the pedestrian phase is timed to allow a pedestrian to cross the entire crosswalk, not just to the median). **A straight aligned crosswalk with a median cut-through should not operate as a two-phase pedestrian crosswalk (see two-phase pedestrian crossing requirements above).** Single phase, two-stage pedestrian crossings are not desirable and should be avoided for two reasons:

- The pushbutton in the median is often pushed by pedestrians even if they have no intention of making a two-stage crossing. This results in inefficient signal operations due to the pedestrian phase being serviced again in the next cycle when there is no demand. This is especially problematic if the signal is operating near, at, or over capacity.
- By placing a pedestrian refuge with a pushbutton in the median, pedestrians may be unsure if they should stop in the median and wait for the next walk/flashing don't walk to finish the crossing. The use of countdown pedestrian signal heads has largely eliminated this concern, as pedestrians now have info about the duration of the pedestrian phase and can make an informed decision whether they should wait in the pedestrian refuge or not. However, this remains a concern for visually impaired pedestrians as audible information about the pedestrian phase duration is not provided by audible pedestrian signals.

Figure 5-14 | Single Phase, Two-Stage Pedestrian Crossing (Avoid This Crosswalk & Median Design)



5.1.6 Driveway Approaches at Signalized Intersections

All approaches of an intersection shall be signalized, even if an approach is only a driveway or alley and serves a very limited amount of traffic.

Figure 5-15 shows an example of a driveway forming the fourth approach of an intersection. Half signals or an unsignalized approach at the intersection are not allowed (this excludes right turn slip lanes which may be signalized, STOP or YIELD controlled as specified in the operational approval).

Figure 5-15 | Signalized Driveway Example



Typically, a driveway approach is designed according to the roadway standard drawings RD715 (non-sidewalk driveways) or RD725 thru RD750 (sidewalk driveways). Sidewalk driveway options shown in RD725 thru RD750 may only be used for a signalized driveway approach with the following modifications (see Figure 5-16 for example):

1. Truncated domes are required at each end to define the signalized pedestrian crossing. Coordinate with the traffic engineering section to determine the proper site-specific location of the truncated domes and to address any slope/elevation issues.
2. Asphalt is required between the truncated domes (e.g. do NOT continue the sidewalk concrete)
3. Standard crosswalk striping is required

Figure 5-16 | Signalized Sidewalk Driveway Using Modified Roadway Standard Drawings



Another option that may be used when a driveway approach will be signalized is a small radius with curb ramps (and standard crosswalk striping) as shown in RD756. See Figure 5-18. Keep in mind that it may be difficult to get the geometrics to conform with roadway requirements and design exceptions are likely with this option.

Both options (driveway approach with the three listed modifications or a small radius with curb ramps) will make the approach look and feel like a typical signalized approach; drivers should be more likely to stop at the proper location and watch for pedestrians and pedestrians should be more likely to notice the pedestrian indications and comply. For comparison purposes, see Figure 5-17 showing the before photo of a signalized sidewalk driveway that lacks the "feel" of a typical signalized approach and Figure 5-18 showing the after photo with a new small radius, curb ramps and crosswalk striping.

Figure 5-17 | Signalized Sidewalk Driveway (Before Photo) – Avoid This Approach Design

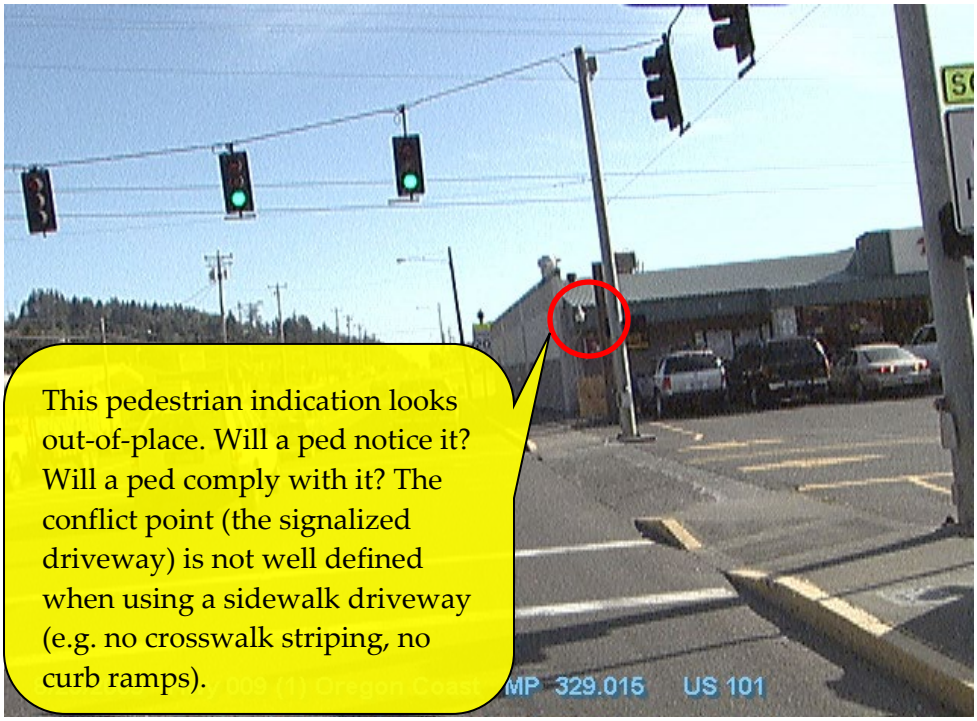
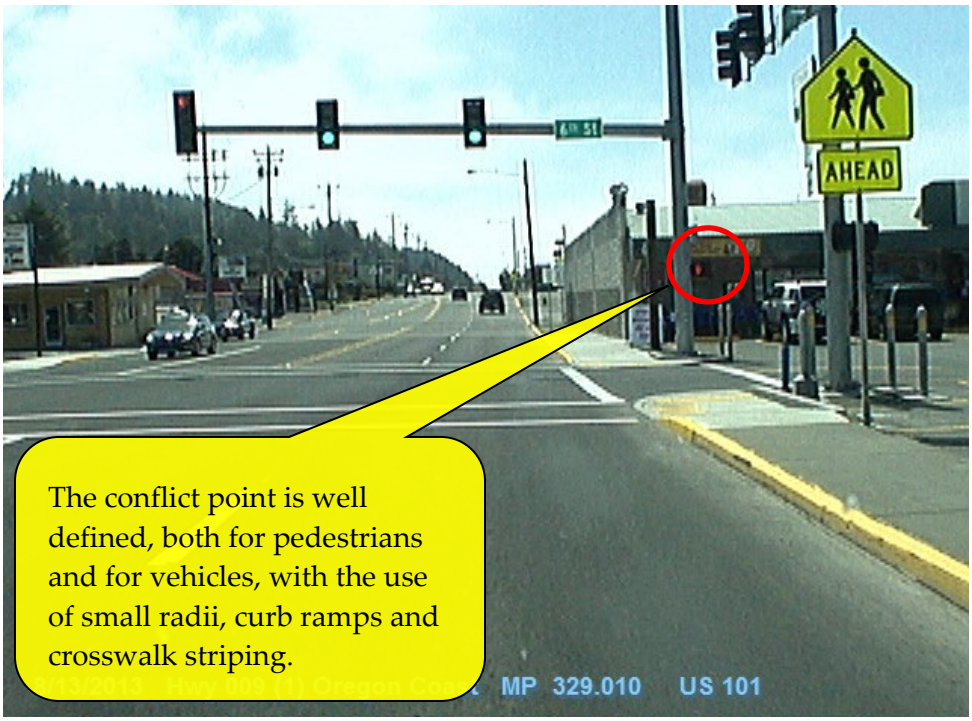


Figure 5-18 | Signalized Driveway with Small Radius and Curb Ramps (After Photo) – Use This Approach Design



5.1.7 Maintenance Pads

A maintenance pad provides a safe parking spot near the intersection for electrical crews, TSSU and signal timers to use. See standard drawing RD160. Maintenance pads should be considered when requested by signal maintenance staff or under the following conditions:

- There are no parking lots near the signal
- There are steep slopes near the signal
- A maintenance vehicle could get stuck in mud during poor weather conditions
- A maintenance vehicle could block sidewalk, bike lanes, and/ or curb ramps
- Signal locations with high ADT (such as interchange ramps)
- Inadequate shoulder width

When used, work with the roadway designer and maintenance staff to determine the best location for the maintenance pad. It is also important to consider the location and design features that will discourage/minimize use by the public (intentional or non-intentional). For example, a maintenance pad might be construed as an extension of the pedestrian sidewalk/facility for those with vision impairments. Consult the ADA design team for assistance.

5.1.8 Truck Turning Templates

Truck turning templates of the design vehicle's swept path should be provided to verify the signal can operate as intended. It is best to verify the truck turning templates with a conceptual design as part of the operation approval. However, it is still necessary to check the actual design during the design phase and address any issues that may come up (either revise the design or revise the operational approval). The templates are provided by the roadway designer and should be verified by the signal designer and/or the region signal operations engineer.

If the truck turning templates identify any problems, the preferred solution is to fix the roadway geometry. Unfortunately, this may not always be feasible depending on right-of-way, scope, and/or budget constraints. If the roadway geometry cannot be fixed, other less desirable solutions that may be considered are discussed in the bullet points below.

The following movements should be verified:

- **Verify opposing left turns have enough room in the intersection to complete their movement and do not encroach on stopped vehicles**. Heavy skew angles, narrow lane widths, offset lane lines, and small intersections may have issues with overlapping swept paths or encroachment. If the roadway geometry can't be fixed, other solutions include spilt phasing (for overlapping swept paths) or adding advance stop lines (for encroachment). Advance stop lines shall be no more than 20 feet offset from the adjacent staggered stop line. The downside to these options should be considered before moving forward (split phasing is a very inefficient operation. Advance stop lines may have issues with compliance and detection coverage may be shortened). See Figure 5-19 and Figure 5-20.
- **Verify dual turns do not encroach on adjacent lanes or on stopped vehicles**. The same problems and solutions discussed in the above bullet apply. See Figure 5-19.
- **Verifying right turns do not encroach on sidewalk or pedestrian landing areas.** Tight radii, narrow sidewalks, or narrow shoulders can result in the design vehicle off-tracking where pedestrians wait to use the crosswalk. In addition, signal equipment that is placed along the radius (e.g. pedestrian signal indications, pushbuttons, pedestals/poles) can be vulnerable to damage. A minimum area of 4 feet for is needed for pedestrians, more is desirable. See Figure 5-21. If the roadway geometry can't be fixed (e.g., revise sidewalk, add shoulder width, or add a pedestrian landing area), another solution is pavement marking adjustments to define the pedestrian area and help modify the driver's path. See Figure 5-22. The downside to this option should be considered before moving forward (compliance issues and added cost of maintenance).

Figure 5-19 | Truck Turning Templates – Verifying Opposing Left Turns and Dual Turns

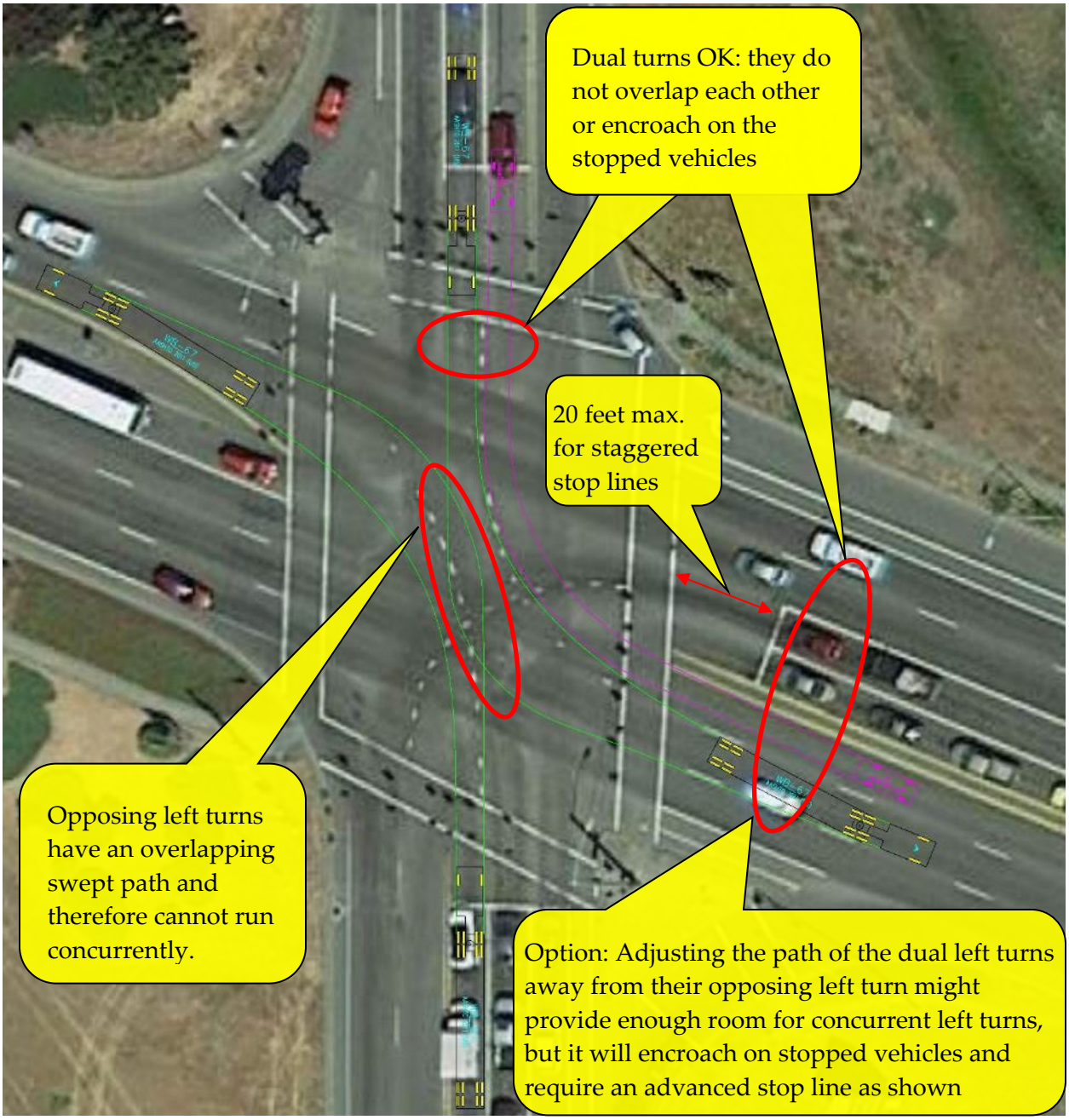


Figure 5-20 | Truck Turning Templates – Verifying Left Turns

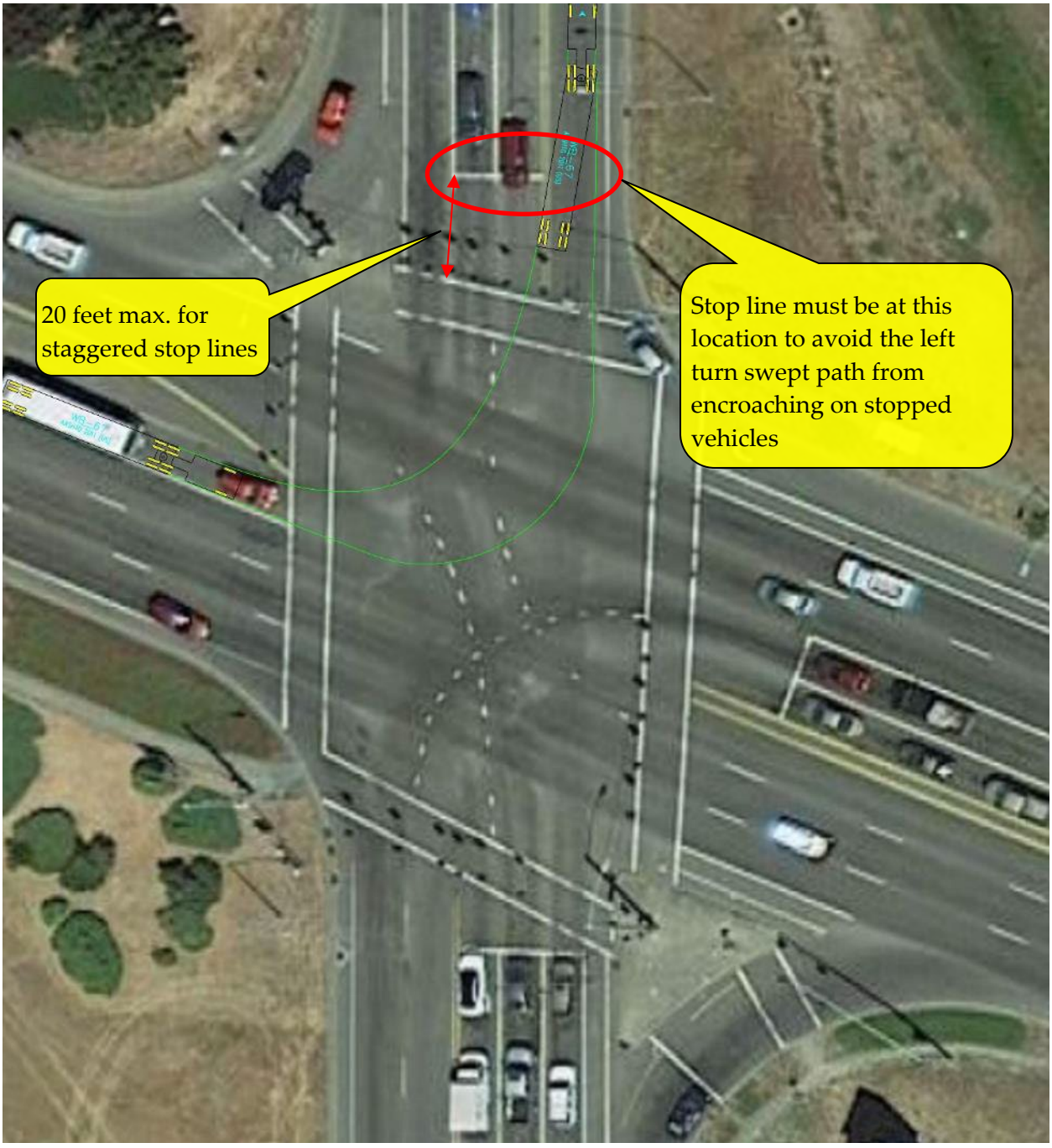
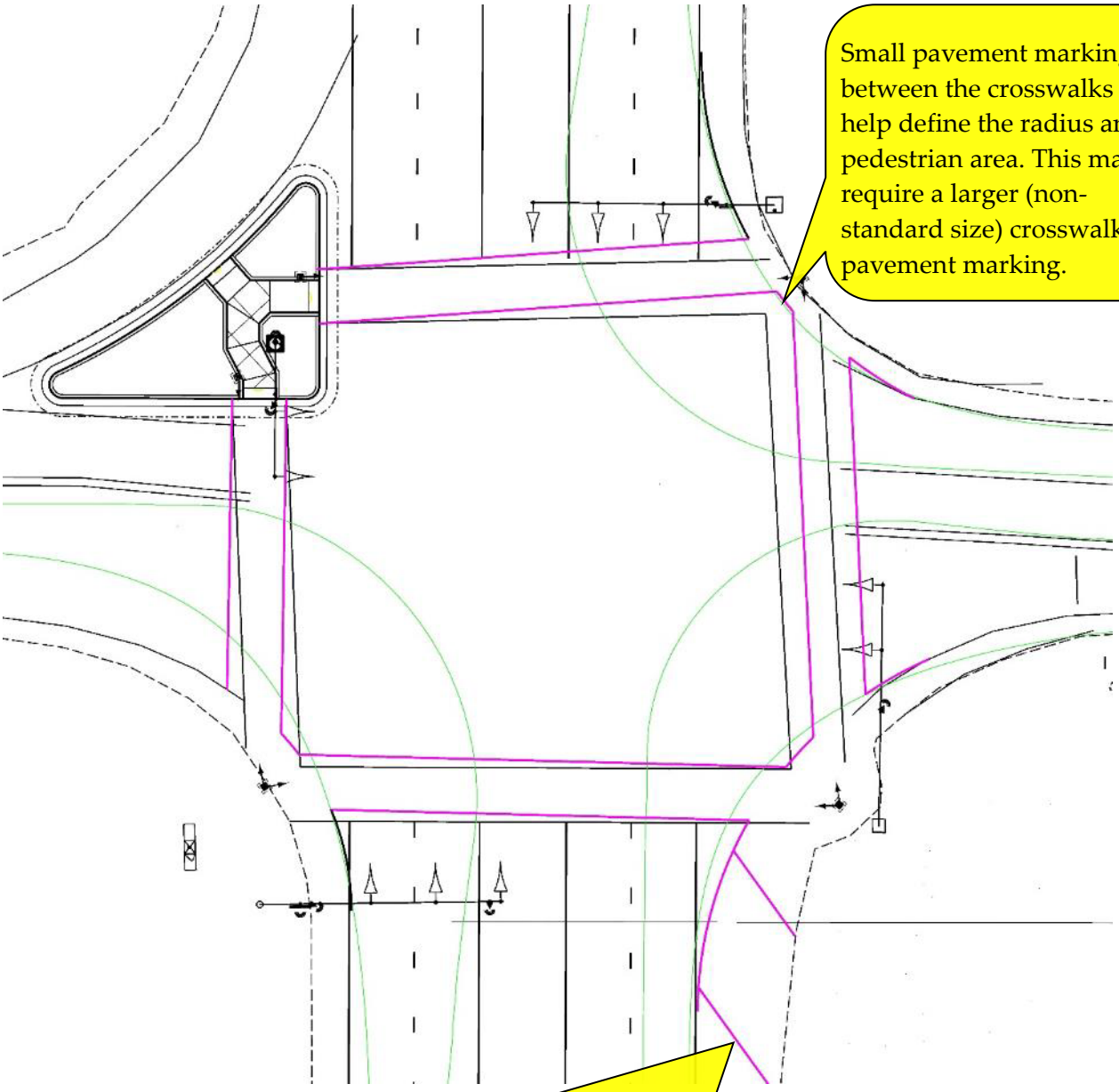


Figure 5-21 | Truck Turning Templates – Verifying Right Turns



Figure 5-22 | Truck Turning Templates – Verifying Right Turns, Pavement Marking Adjustment



5.1.9 Lane Shift Through Intersection (Off-set Lane Lines)

It is important that approach lanes align well with their receiving lane. Drivers do not expect to make a steering correction when traveling through an intersection and may end up driving in areas they shouldn't if they don't recognize the lane shift in time. It also can be challenging to place signal heads in the correct location resulting in decreased visibility to the signal indications. Ideally there should no offset from the approach lane to the receiving lane through the intersection. The ODOT Highway Design Manual states a maximum of 4 feet offset is allowed through the intersection. If there is more than 4 feet of offset, fixing the roadway alignment or changes to lane use are recommended. See Figure 5-23 and Figure 5-24. If this is not feasible, a roadway general design exception and approval by the state traffic signal engineer is required. Extension pavement markings through the intersection may also be helpful, but these markings tend to wear fast and require more maintenance. See Figure 5-25.

Figure 5-23 | Lane Shift – Example 1

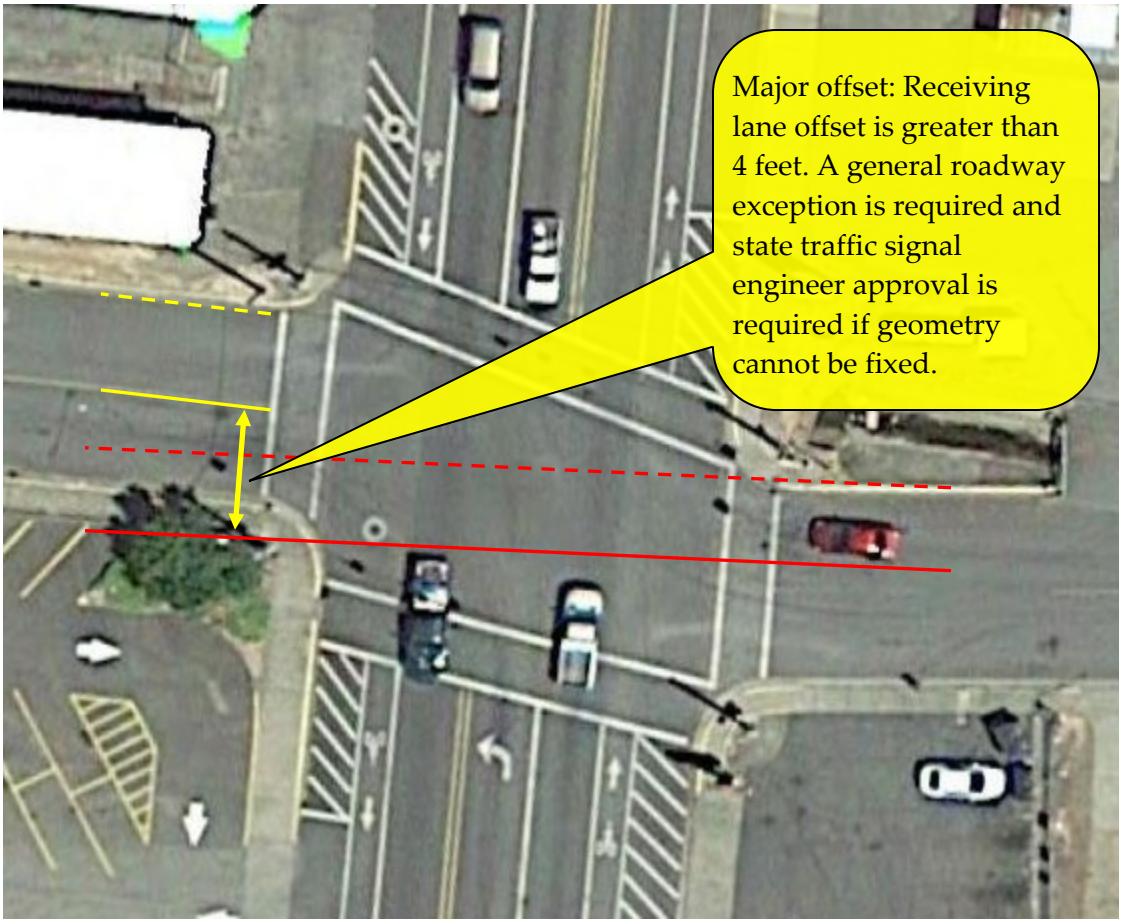


Figure 5-24 | Lane Shift – Example 2

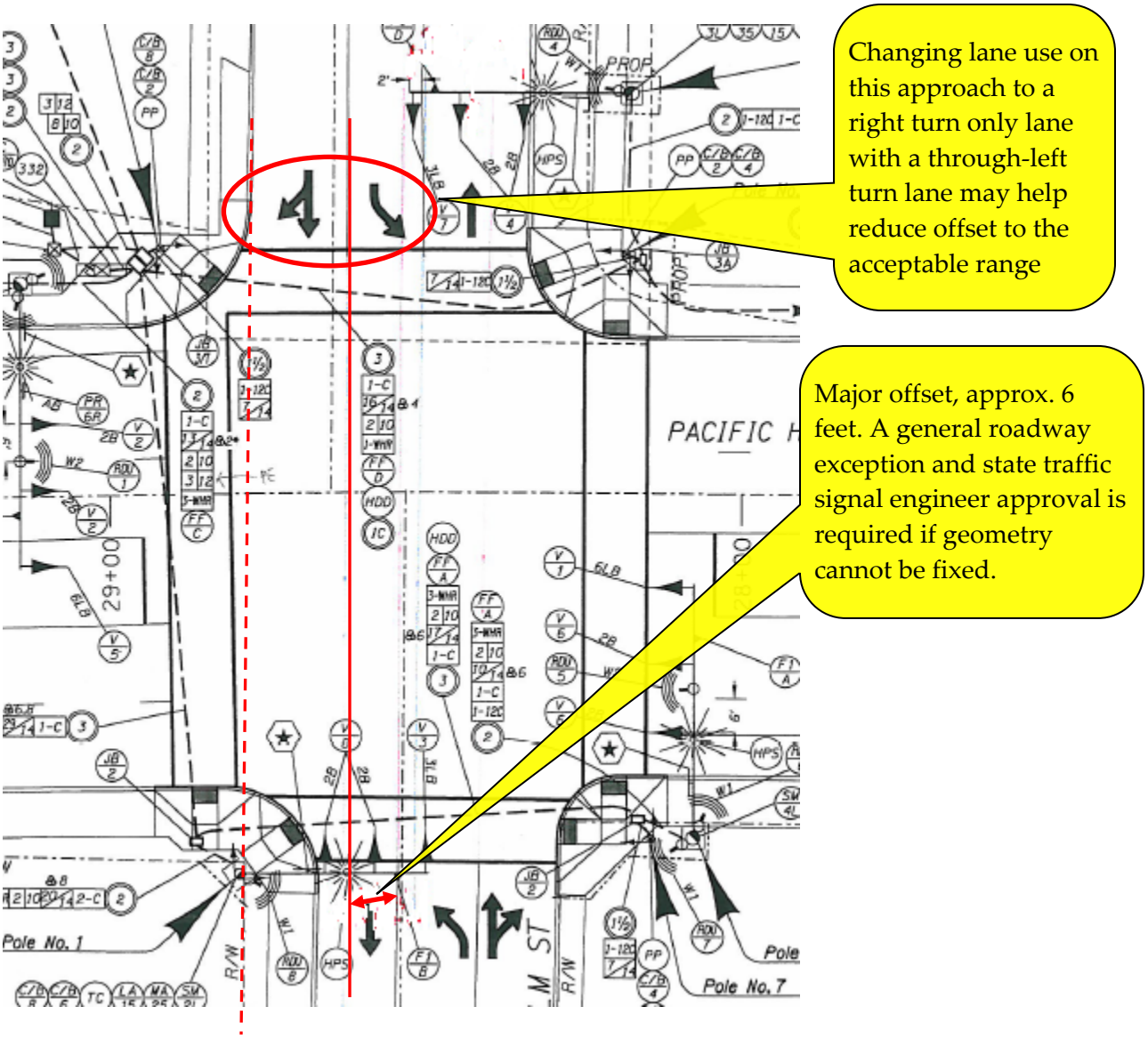
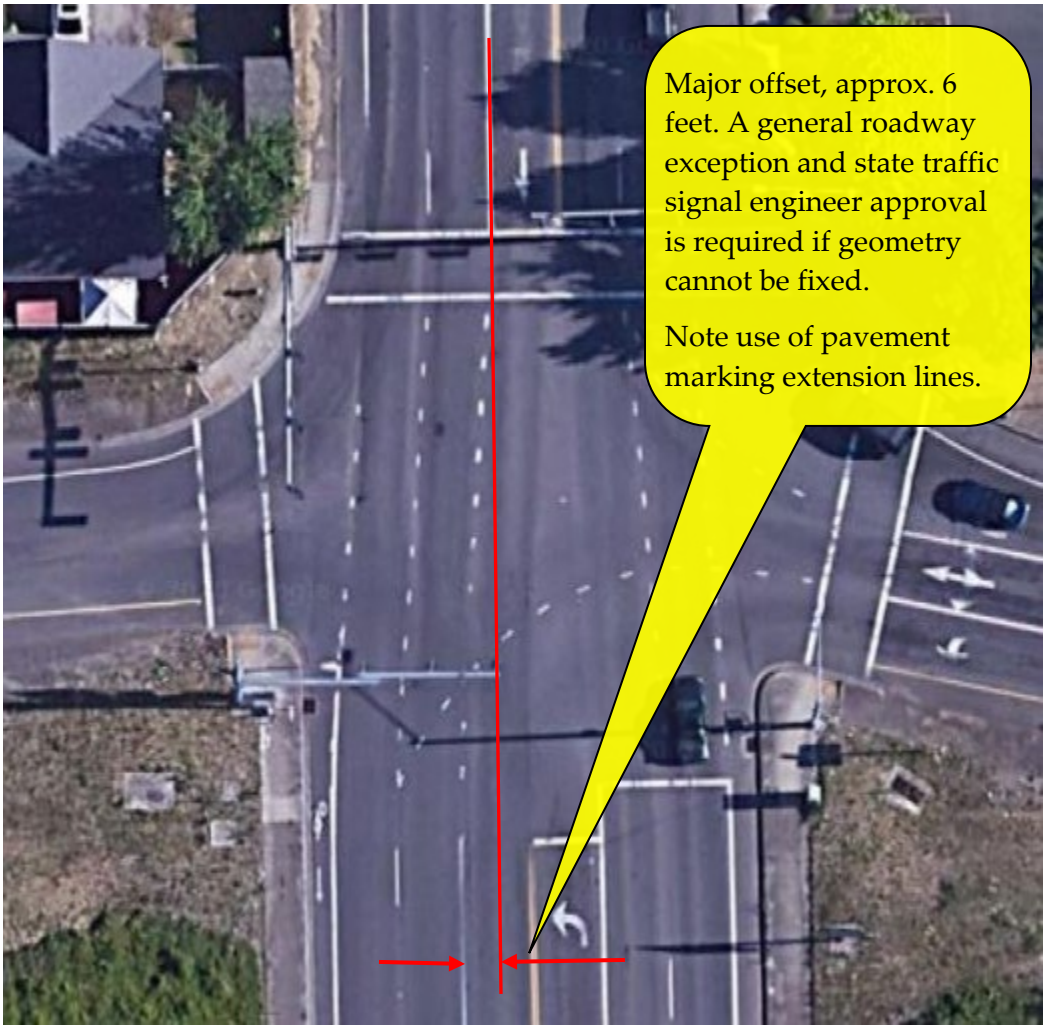


Figure 5-25 | Lane Shift – Example 3



5.2 Vehicle Signal Head Layout

Signal head location is guided by the Manual on Uniform Traffic Control Devices (MUTCD) and the Oregon Supplement to the MUTCD. Once the number of lanes, lane use, location of crosswalks, signal phasing and roadway geometry are known, the vehicle signal heads can be laid out. This, in conjunction with the pedestrian signal equipment layout (see Section 5.4), will be the basis for determining what type of signal support structures (mast arms, pedestals, or custom design) should be used at the intersection.

The operational approval and the roadway geometry MUST match!

Some basic guidelines per approach:

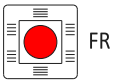
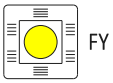
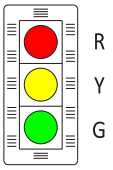
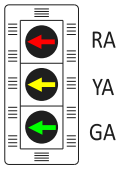
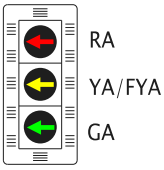
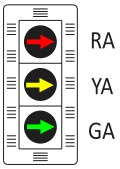
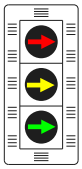
- Signal heads should be mounted overhead on mast arms (or span wires for temporary signals) for all movements. Supplemental signal heads may be ground mounted on pedestals.
- Signal heads should be aligned vertically (vs. horizontally).
- A minimum of two signal faces shall be provided for the through movement on the approach. If no through movement exists, a minimum of two signal faces shall be provided for the major movement from the approach.
- A signal face per lane shall be used when there are 3 or more through lanes on the approach.
- Heads for the same phase shall not be located closer than 8 feet apart (horizontally from each other). They should be located at least 10 feet apart when possible.
- Heads shall not be less than 45 feet (based on the standard 18 to 19 foot mounting height) from the "STOP" line (or nearside crosswalk line if there is no stop line). Heads located greater than 180 feet from the "STOP" line require a near-side supplemental head.

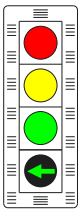
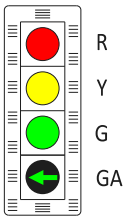
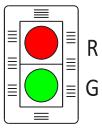
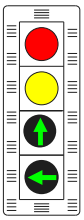
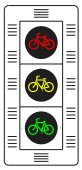
5.2.1 Head Types

The standard signal heads types that can be used for new construction are defined in standard drawing TM460 and shown in Figure 5-26. Head types are designated by a number or a combination of number and letter(s). Each signal head type has a specific use. Standard detail DET4401 contains signal head types that are either no longer used for new construction or their use is for a site-specific operation that is typically discouraged. See Figure 5-27. Use of this standard detail should only be necessary when replacing existing signal heads in-kind due to a very limited project scope that makes installing the current standard signal heads infeasible.

If the need arises to use a signal head type or layout that that is not covered by this manual, contact the state traffic signal engineer to discuss and resolve the unique situation. Also, see chapter 2 for more information on non-standard and experimental design.

Figure 5-26 | Standard Signal Head Types (TM460)

<table>
<tr>
<td><u>TYPE 1R</u>
Red flashing beacon
 
</td>
<td><u>TYPE 1Y</u>
Yellow flashing beacon
 
</td>
<td colspan="2"><u>TYPE 2</u>
Basic signal
(allows through and permissive left & right turns)
 
</td>
</tr>
<tr>
<td><u>TYPE 3L</u>
Left turn signal
(protected only)
 
</td>
<td><u>TYPE 3LCF</u>
Left turn signal
(protected/permitted and permissive only w/a left turn only lane)
 
</td>
<td><u>TYPE 3R</u>
Right turn signal
(protected only: overlap phase)
 
</td>
<td><u>TYPE 3RCF</u>
Right turn signal
(protected/permitted)
 

Contact the state traffic signal engineer for more info and design approval to use this signal head</td>
</tr>
<tr>
<td><u>TYPE 4</u>
Split phasing signal
(protected left turn & through move)
 
</td>
<td><u>TYPE 7</u>
Railroad preemption signal
(ONLY used when the track clearance phase has a permissive left turn)
 
</td>
<td><u>TYPE 8</u>
Ramp meter
 
</td>
<td><u>TYPE 9</u>
Split phasing signal
(ONLY used with a specific lane use configuration)
 
</td>
</tr>
<tr>
<td><u>TYPE 12</u>
Bike signal
(ONLY used for bike phases)
 
</td>
<td><u>TYPE 12M</u>
Mini bike signal
(ONLY used near-side for bike phases)
 

4" diameter indications</td>
<td colspan="2"></td>
</tr>
<tr>
<td colspan="4">Color Indication Abreviations. All Indications are 12" diameter unless otherwise noted.

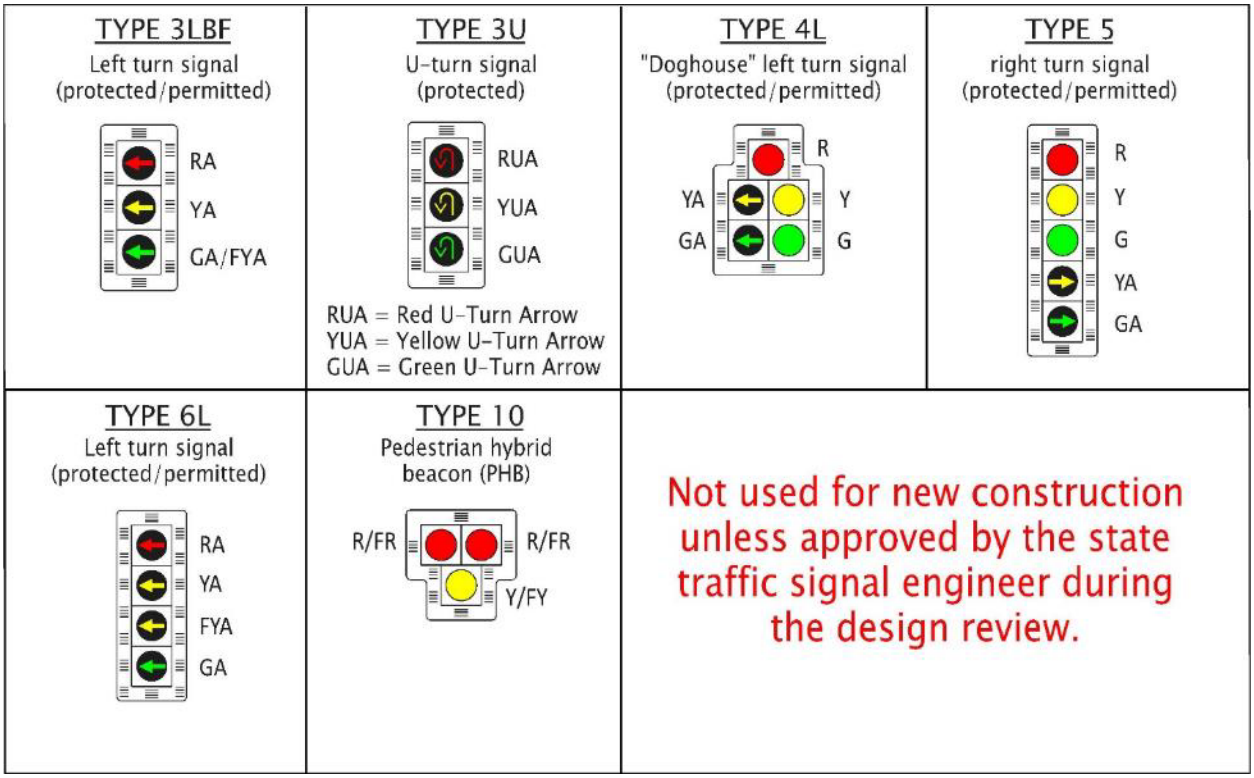
R = Red Circular Ball
Y = Yellow Circular Ball
G = Green Circular Ball

RA = Red Arrow
YA = Yellow Arrow
GA = Green Arrow

FYA = Flashing Yellow Arrow
FR = Flashing Red Circular Ball
FY = Flashing Yellow Circular Ball

RB = Red Bike Symbol
YB = Yellow Bike Symbol
GB = Green Bike Symbol</td>
</tr>
</table>

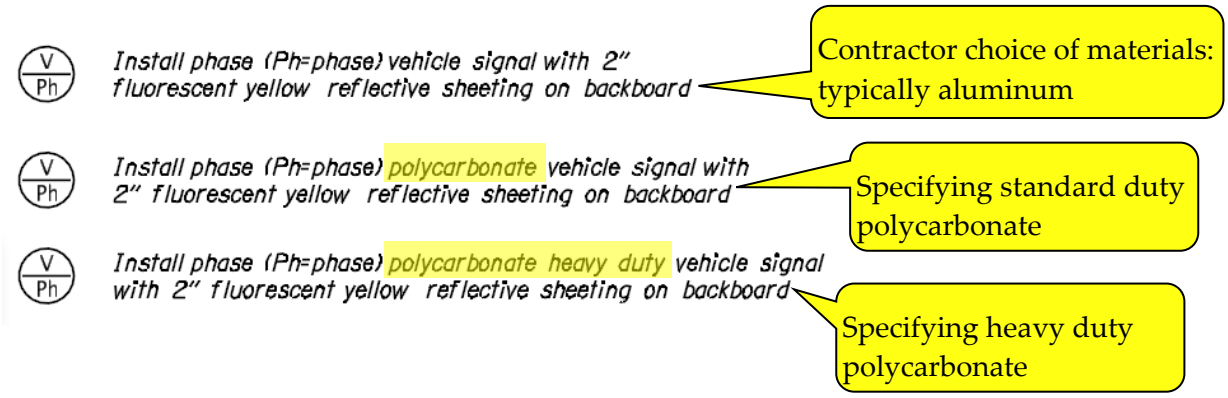
Figure 5-27 | Non-Standard Signal Head Types (DET4401) – Not for New Construction



5.2.2 Head Materials

The vehicle signal head material is the choice of the contractor (all items listed on the blue sheets are acceptable) UNLESS the signal designer specifies a particular material in the signal plan via the bubble notes. See Figure 5-28. The material choices are aluminum, polycarbonate (standard duty), or polycarbonate (heavy duty). Typically aluminum is the chosen material as it is cost effective and performs well. However, in harsh or windy environments such as the coast and the gorge, heavy duty polycarbonate performs better than aluminum and is recommended. Verify if electrical crew has any material preferences.

Figure 5-28 | Specifying Vehicle Signal Head Material in the Signal Plan



5.2.3 Head Placement

The even phases (ph. 2, ph. 4, ph. 6, and ph. 8) are typically the through movements. These phases typically require two type 2 heads. The location of the heads depends on the number of receiving lanes and the roadway geometry. See Table 5-1. The alignment of the through signal heads is based on the receiving lanes (Figure 5-29), NOT the projected approach lanes (Figure 5-30). See Figure 5-36 and Figure 5-37 for example layouts.

Table 5-1 | Standard Signal Heads for Through Movement Phases

Standard Signal Heads for Through Movement Phases	
Number of receiving lanes	**Number and placement of signal heads**
Single receiving lane	Two type 2 signal heads, placed one foot inside the projected receiving lane lines
Two receiving lanes	Two type 2 signal heads, one placed in the center of each receiving lane
More than two receiving lanes	One type 2 signal head for each receiving lane, placed in the center of each receiving lane

Signal head alignment for THROUGH movements are based on the RECEIVING lane lines (See Figure 5-29).

Signal head alignment for TURN movements are based on the PROJECTED lane lines (See Figure 5-33 and Figure 5-34).

Figure 5-29 | Signal Head Placement for Through Movement Using Receiving Lane Lines (CORRECT METHOD)

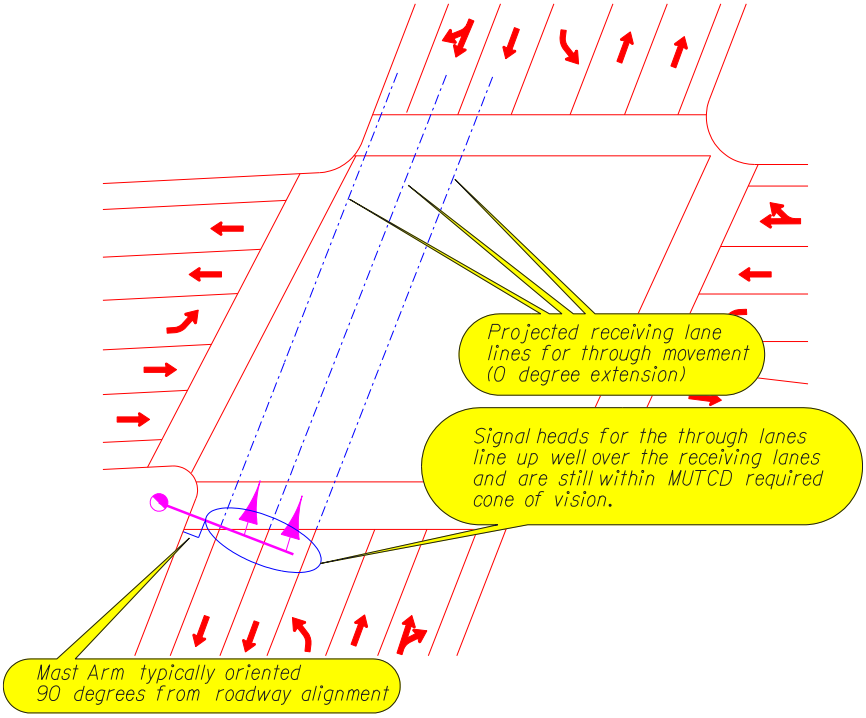
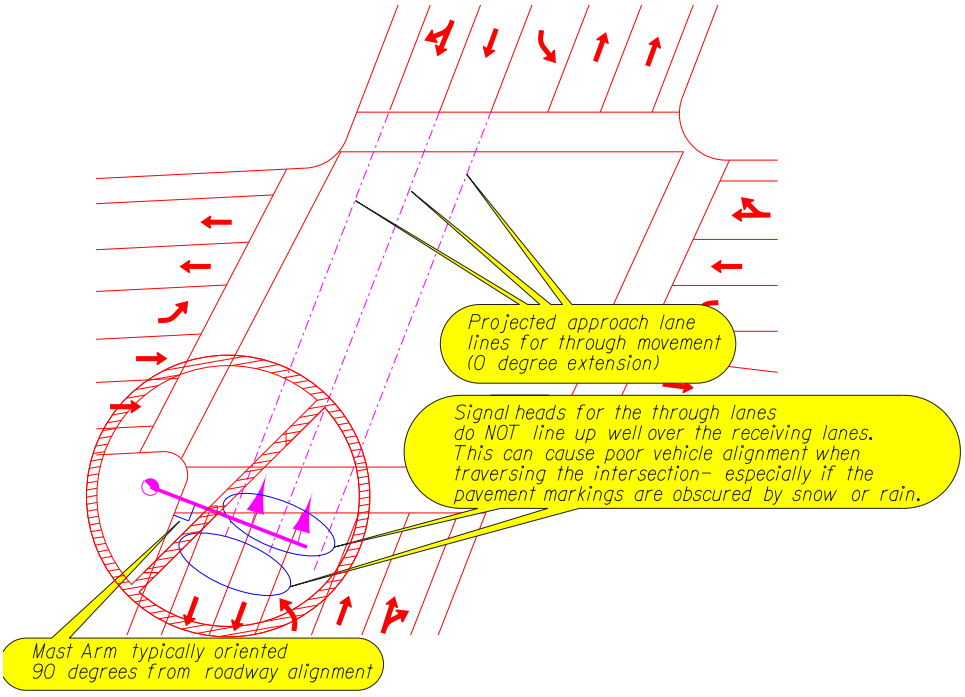


Figure 5-30 | Signal Head Placement for Through Movement Using Projected Lane Lines (INCORRECT METHOD)



When the intersection is located within a horizontal curve, strict adherence to signal alignment based on the receiving lane lines (through movements) and projected lane lines (turn movements) may not be possible; it could result in the left turn heads being located to the right of the through movement heads in one direction and the left turn heads being located to the left of the through movement heads by a ridiculous distance in the other direction. In these cases, the signal head alignment for the through phases takes precedence and should be determined first, according to the receiving lane lines. This is because the through movements are more likely to be approaching and proceeding through the intersection at speed, while the turn movements are more likely to be coming to a stop and will proceed through the intersection at a slower speed. The turn signal head alignment is determined next, with the left turn head always located to the left of the through movement heads and the right turn heads always located to the right of the through movement heads, regardless of the projected lane lines. The turn signal heads should be kept within a reasonable distance of the through movement heads if possible, approximately 6 to 12 feet. See Figure 5-31 and Figure 5-32.

Figure 5-31 | Horizontal Curves and Signal Head Alignment, Example 1

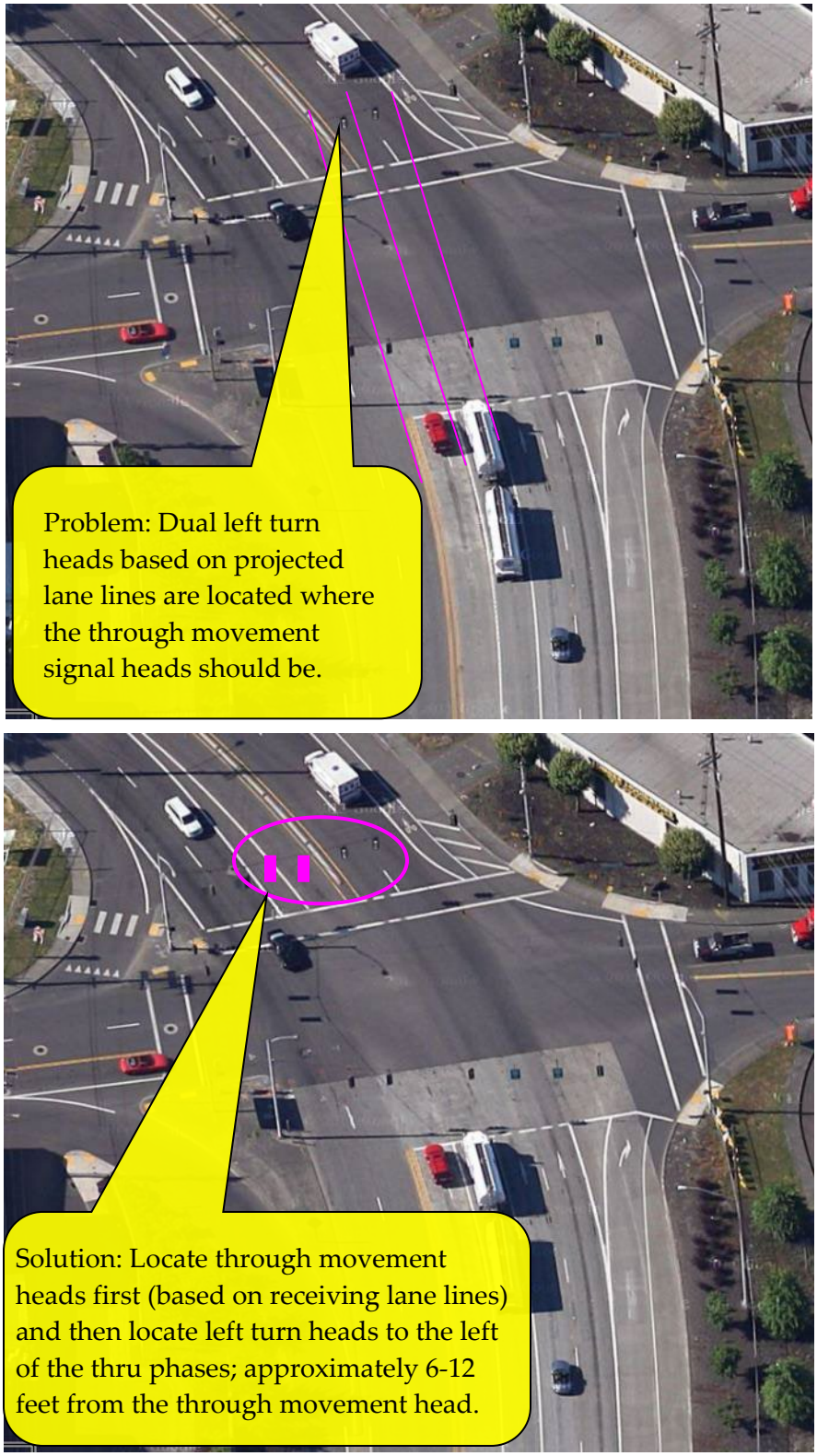
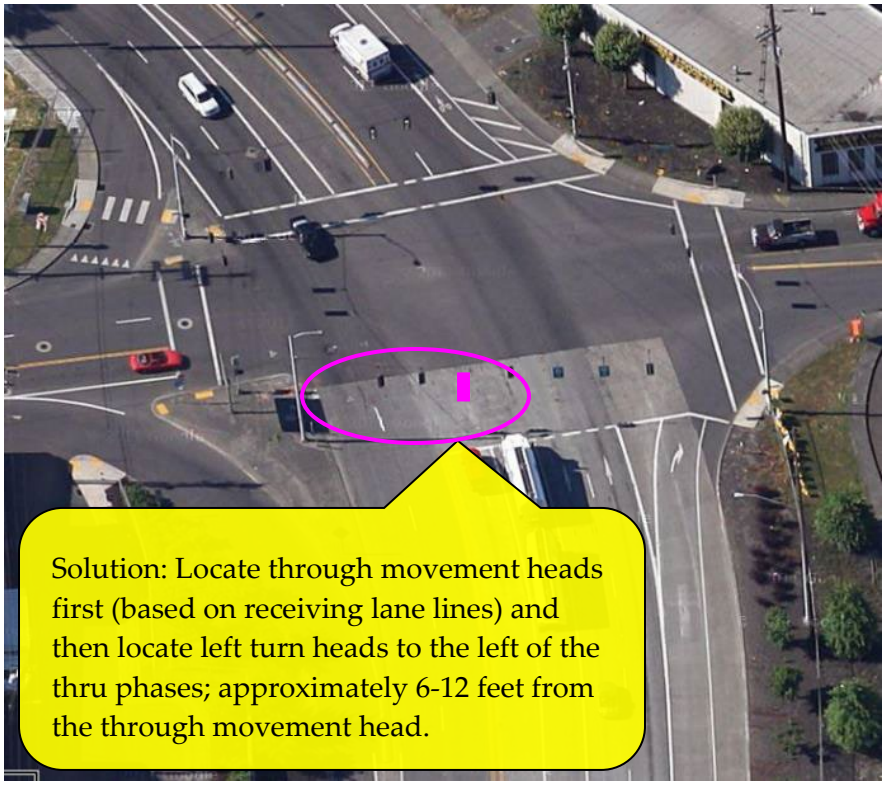


Figure 5-32 | Horizontal Curves and Signal Head Alignment, Example 2





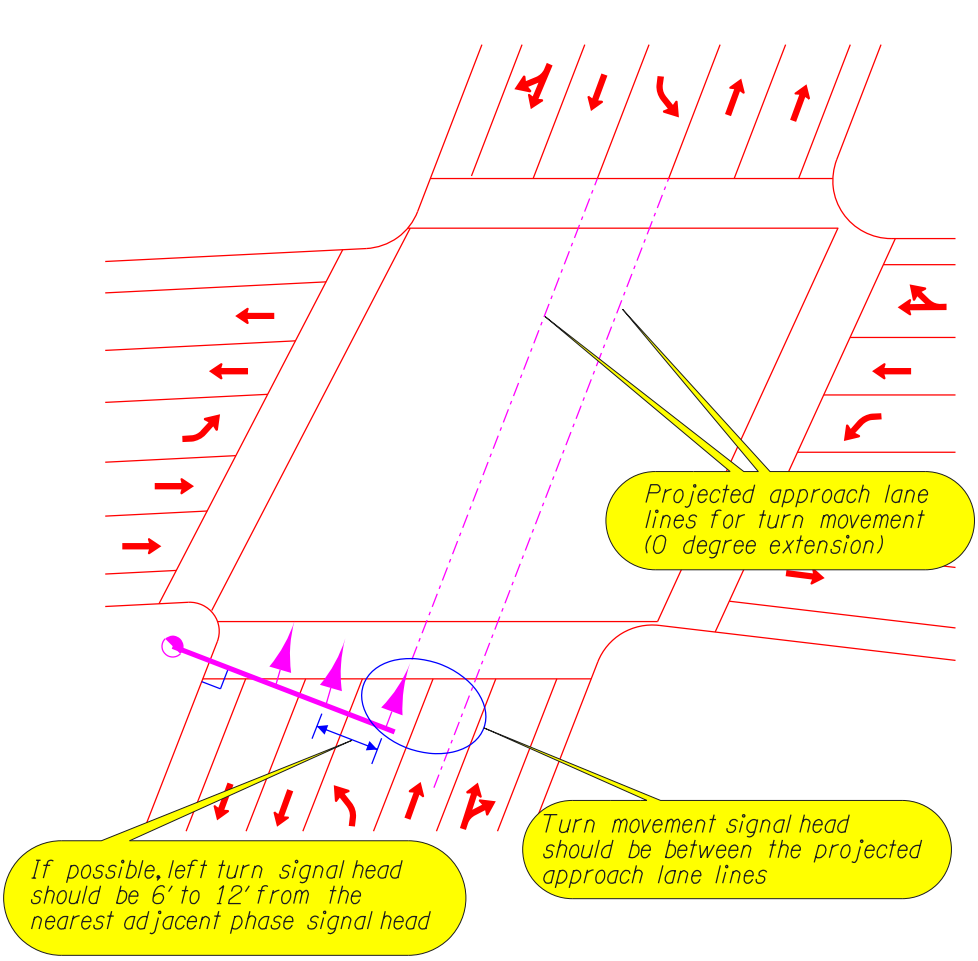
The odd phases (ph. 1, ph. 3, ph. 5, and ph. 7) are typically the left turn movements. These phases typically require one signal head. Dual turn movements require two signal heads. The signal head type will depend on the operation of the left turn phase as stated in the operational approval. The alignment of the left turn signal heads is based on the projected approach lanes. See Table 5-2, Figure 5-33, and Figure 5-38.

Table 5-2 | Standard Signal Heads for Left Turn Phases

Standard Signal Heads for Left Turn Phases	
Type of Operation	**Number and placement of signal heads**
Protected only phasing	One type 3L signal head, placed in the center of the projected lane lines*
Protected/permitted phasing	One type 3LCF signal head, placed in the center of the projected lane lines.* The type 3LBF, 4L and 6L heads are no longer used.
	Only for a shared through-left turn lane: One type 4L (doghouse) signal head, use signal head placement as described for through movement phases. Note: This operation and use of a type 4L head is discouraged – providing a left turn only lane with a standard type 3LCF signal head is preferred.
Permissive only phasing (Note: applicable when dual left turns are allowed at an intersection where both streets are one-way)	**When a left turn only lane EXISTS and there are no controller cabinet limitations:** One type 3LCF head (only displaying FYA during normal operation), placed in the center of the projected lane lines* The phase rotation diagram should show protected/permitted phasing with the protected left turn movement(s) labeled as "*only used during preemption" NOTE: The 332S controller cabinet has limitations for the total number of FYA and overlap phases that can be used (4 max. total. See section 20.7.5). Region must prioritize which FYA or overlap phases will be used when the desired total number is greater than the maximum allowed.
	When a left turn only lane DOES NOT EXIST or there are controller cabinet limitations: Use signal head placement as described for through movement phases. NOTE: a type 2 signal head is PROHIBITED from being located within the left turn only lane projected lane lines.
Dual left turns (protected only phasing)	Two type 3L signal heads, one placed in the center of each projected lane lines*

* If possible, left turn phase signal heads should be located within 6 to 12 feet of the nearest adjacent phase signal head.

Figure 5-33 | Signal Head Placement for Left Turn Phases Using Projected Lane Lines



Right turn movements are typically permissive only, and as such require no additional signal heads. However, the signal head type will depend on the desired operation as stated in the operational approval. Dual turn movements require two signal heads. The alignment of the signal heads is based on the projected approach lanes, with the exception of right turn slip-lanes. See Table 5-3, Figure 5-34, Figure 5-35, and Figure 5-39.

Table 5-3 | Standard Signal Heads for Right Turn Phases

Standard Signal Heads for Right Turn Phases	
Type of Operation	**Number and placement of signal heads**
Protected only phasing (Overlap)	One type 3R signal head, placed in the center of the projected lane lines*. NOTE: A type 2 signal head with louvers can no longer be operated independently as an overlap phase as per MUTCD 4D.22p02 & 4D.24p02.
Protected/permitted phasing Use of this operation is discouraged (for operational and/or hardware issues). Preferred options include: • Providing the requirements to use a type 3R signal head • Operating the right turn as permissive only	One type 5 signal head, placed in the center of the projected lane line*. This is a 2-phase signal head.
	One type 3RCF signal head, placed in the center of the projected lane line*. Contact the state traffic signal engineer for more information and design approval to use this signal head.
Permissive only phasing (Note: applicable when dual left turns are allowed at an intersection where both streets are one-way)	No signal head required. Use signal head placement as described for through movement phases. NOTE: If a separate type 2 signal head is used for a right turn lane, it shall be assigned to the adjacent thru signal phase (i.e. as supplemental signal head).
Dual right turns (protected only phasing)	Two type 3R signal heads, one placed in the center of each projected lane lines*.
Signalized right turn slip lanes, single lane (protected only phasing)	Two type 3R signal heads, placed one foot inside the approach lane line.
Signalized right turn slip lanes, dual lanes (protected only phasing)	Two type 3R signal heads, one placed in the center of each approach lane.
NOTE: When installing a type 3R signal head these requirements apply (see Figure 5-39): • Negative ped phasing is required, or the conflicting crosswalk must be closed. • If the opposing left turn phasing is permissive only or protected/permissive, a separate receiving lane for the left and right turn movements is required (MUTCD 4D.05F, 1)	

* If possible, right turn phase signal heads should be located within 6 to 12 feet of the nearest adjacent phase signal head.

Figure 5-34 | Signal Head Placement for Right Turn Phases Using Projected Lane Lines

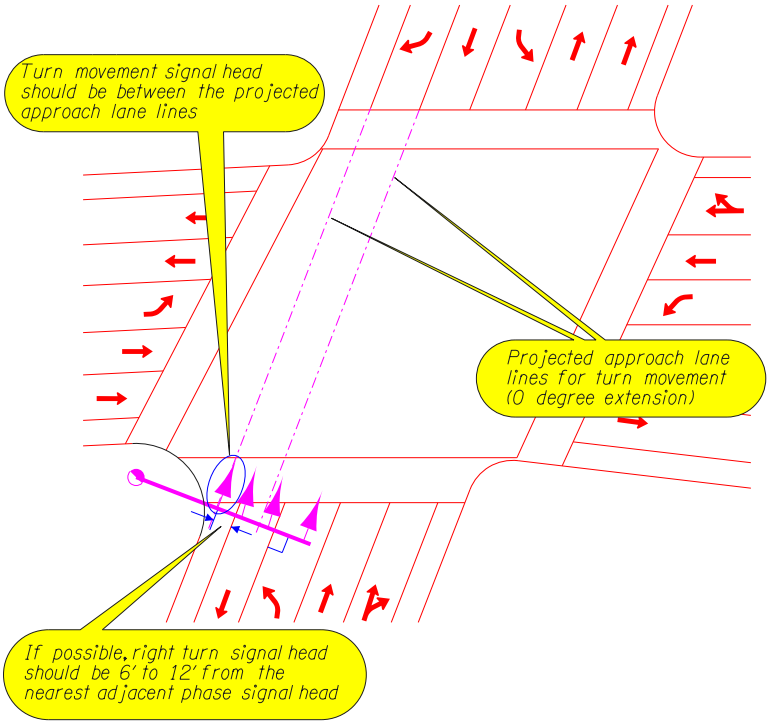
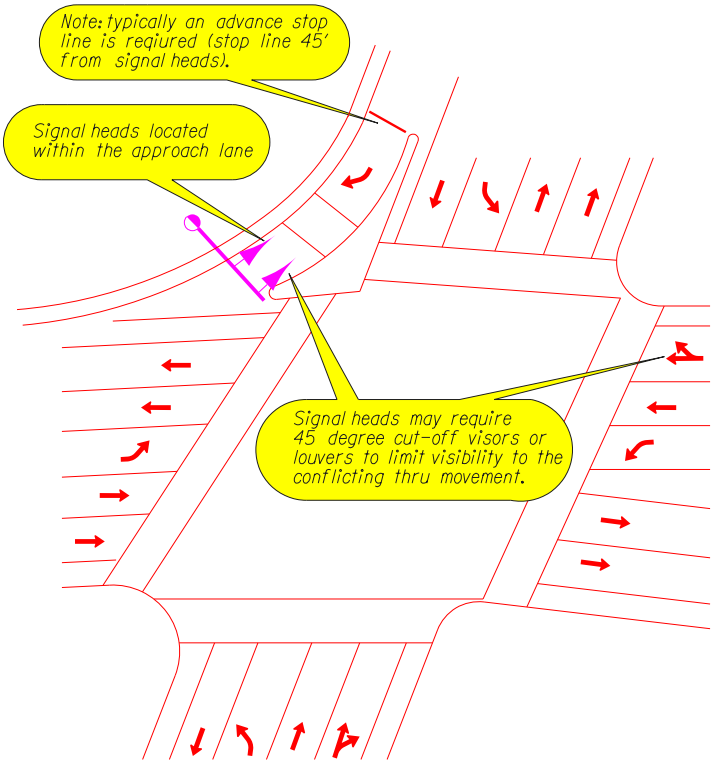


Figure 5-35 | Signal Head Placement for Right Turn Phases –Right Turn Slip Lanes



There are a few special signal phasing/lane configurations that are noted below. While they are not used frequently, they are not uncommon and therefore have standards associated with them. See Table 5-4 and Figure 5-40 thru Figure 5-42.

Table 5-4 | Standard Signal Heads for Special Phasing/Lane Configurations

Signal Heads for Special Phasing/Lane Configurations	
Type of Operation	**Number and placement of signal heads**
Split phasing	A type 4, 3L or 9 signal head is required if the approach has a left turn movement. The signal type is dependent on the lane use. See Figure 5-40 and Figure 5-41
Approach with a vehicle clear-out interval (railroad preemption) AND a permissive left turn phase.	A type 7 signal head is required, placed as shown in Figure 5-42 when: • A left turn only lane does not exist or • There are controller cabinet limitations

Figure 5-36 through Figure 5-42 show examples of typical signal head placements.

Figure 5-36 | Signal Head Placement for Lanes Sharing the Same Phase

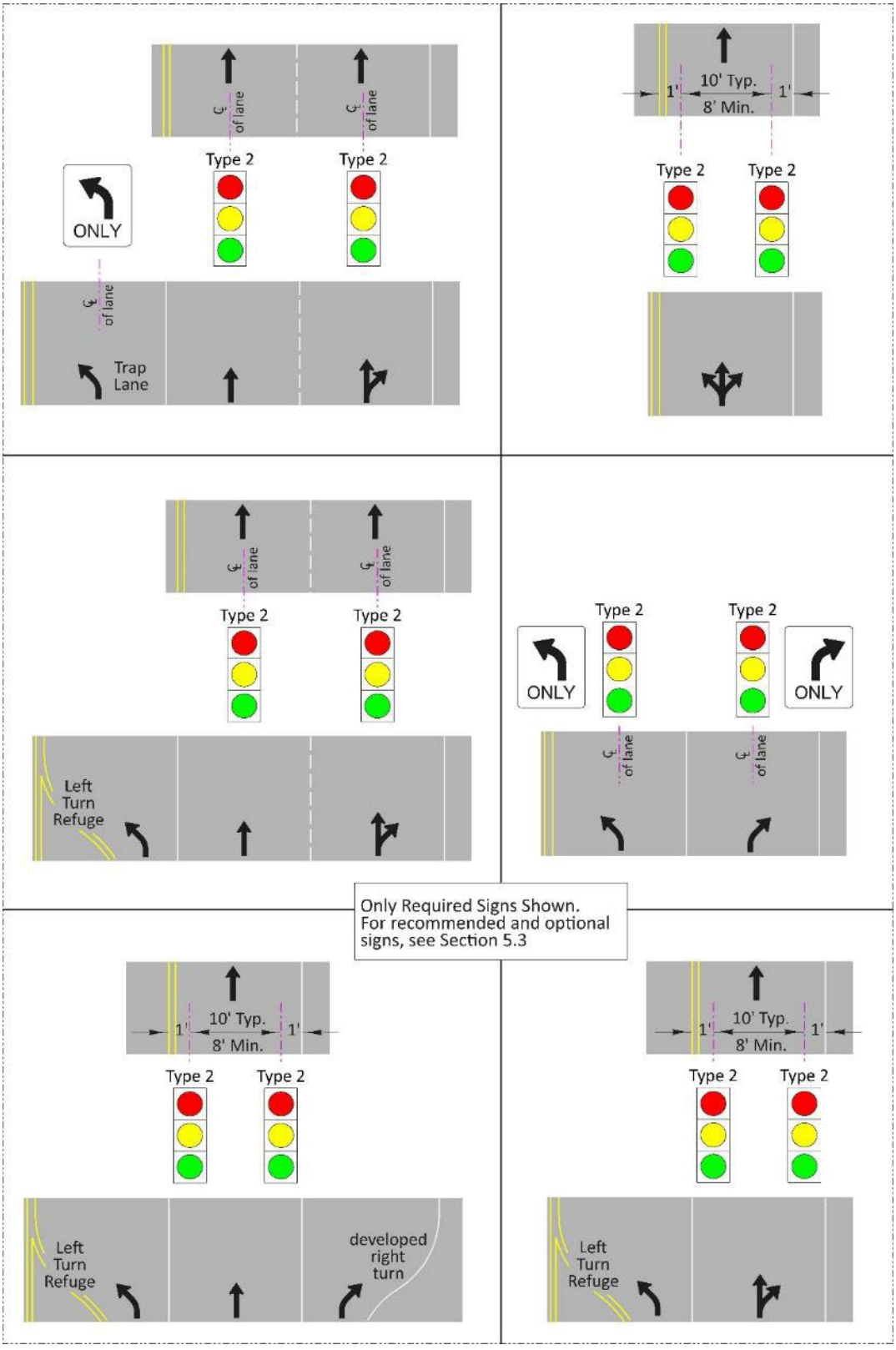


Figure 5-37 | Signal Head Placement for Lanes Sharing the Same Phase (cont.)

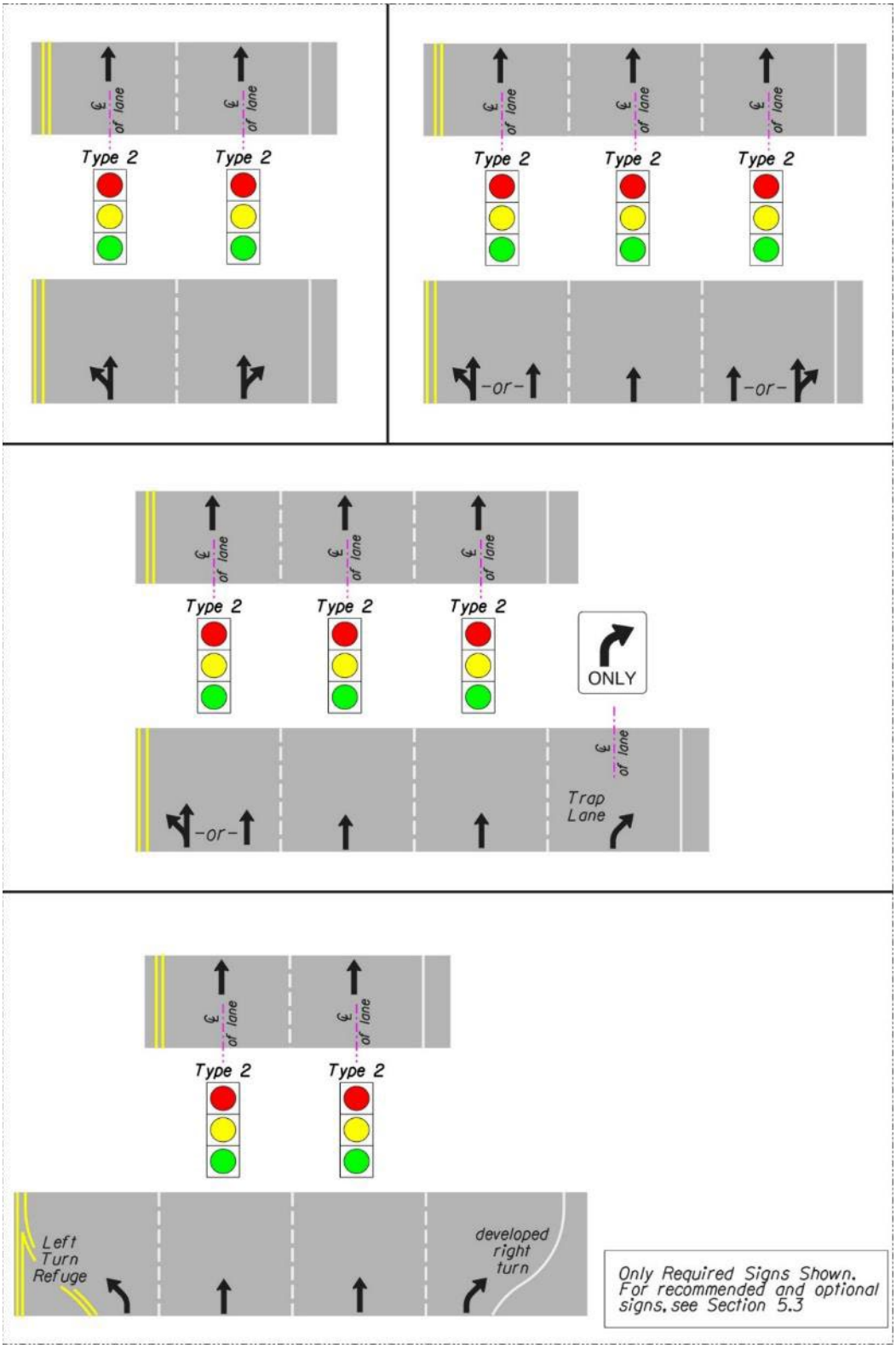


Figure 5-38 | Signal Head Placement for Left Turn Phasing

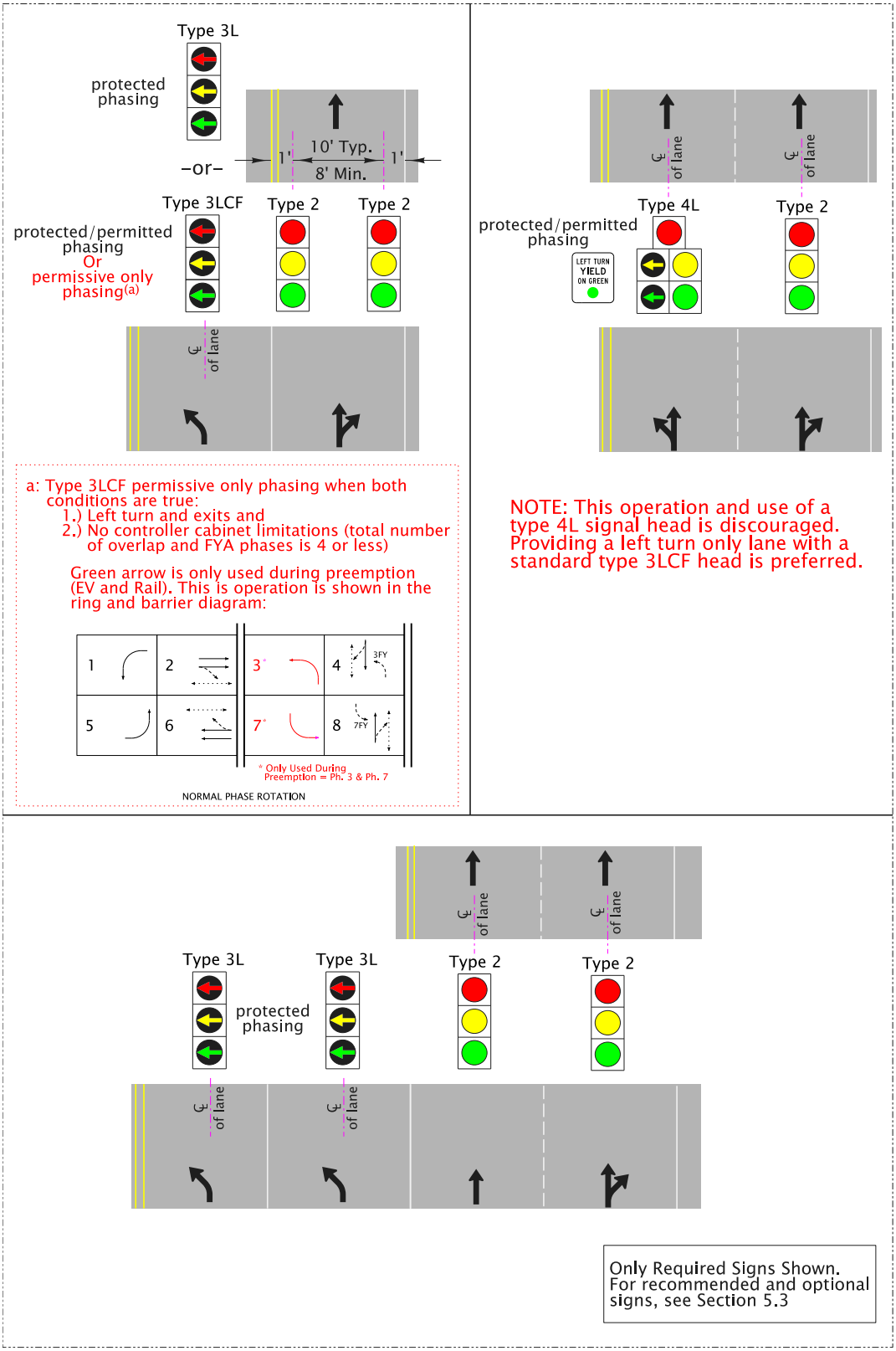
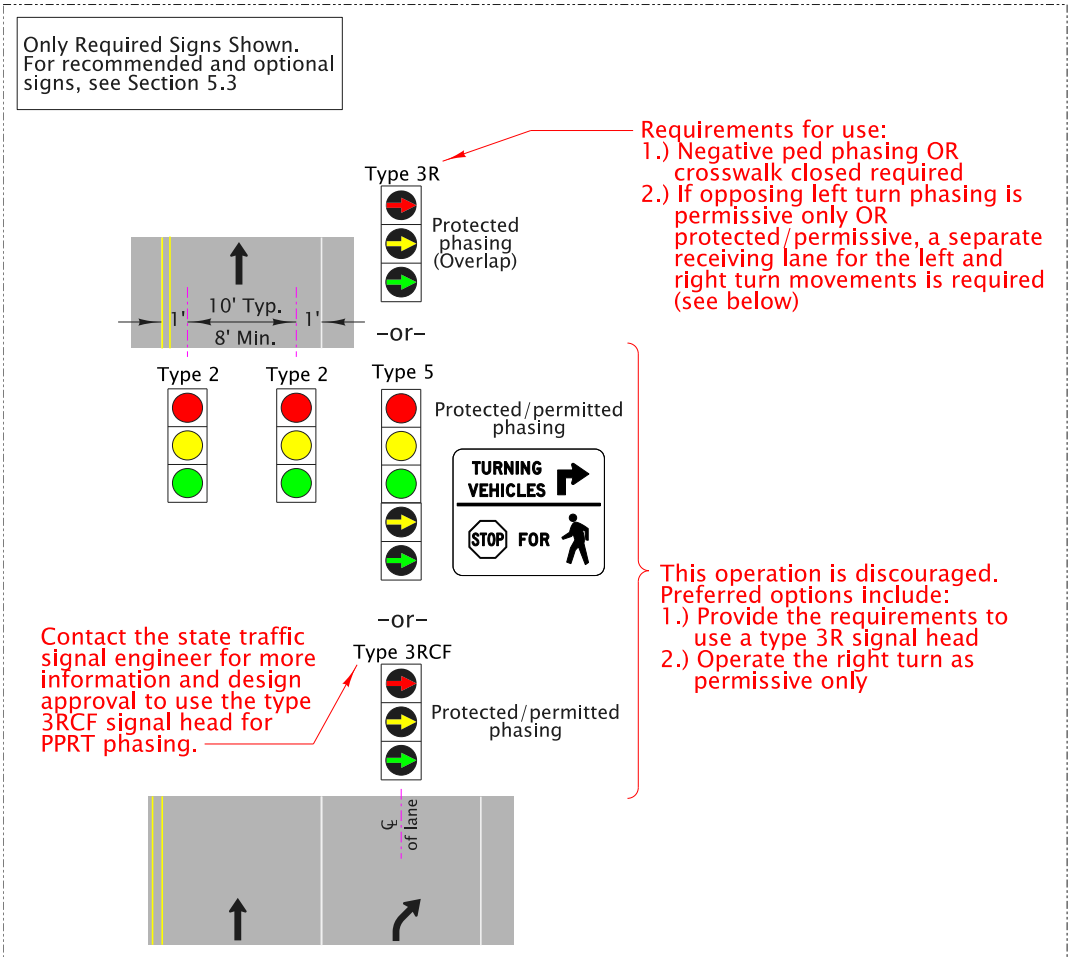


Figure 5-39 | Signal Head Placement for Right Turn Phasing



Lane Use and Phasing Limitations for the Type 3R Signal Head

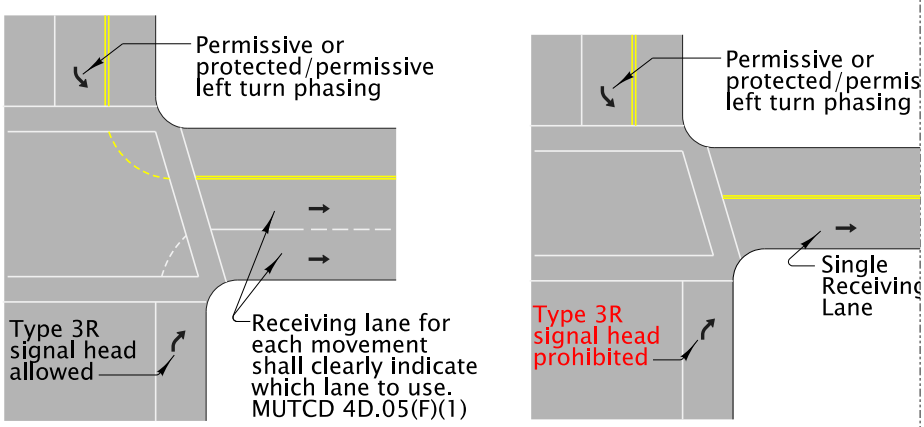


Figure 5-40 | Signal Head Placement for Split Phasing

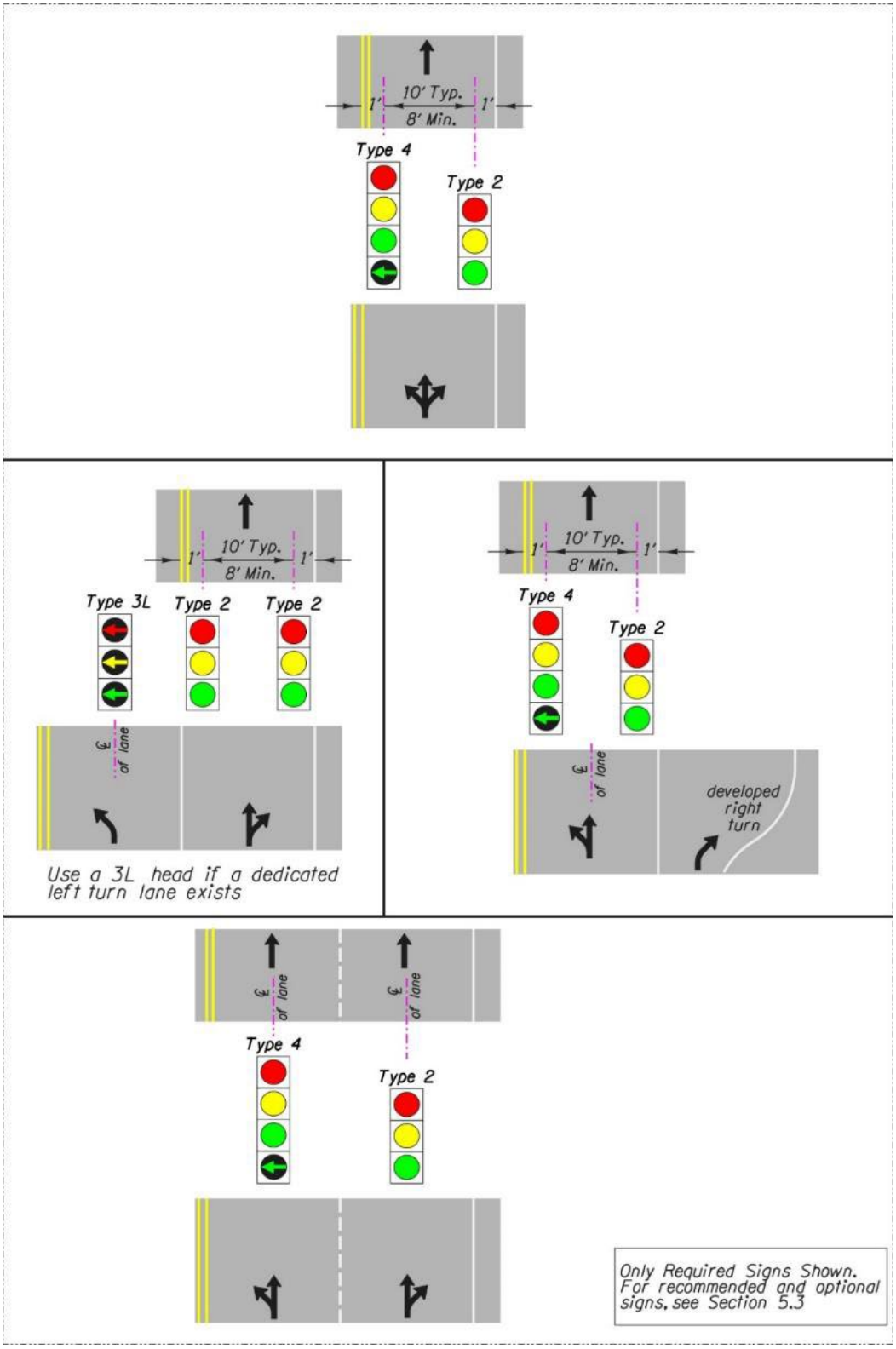


Figure 5-41 | Signal Head Placement for Split Phasing (cont.)

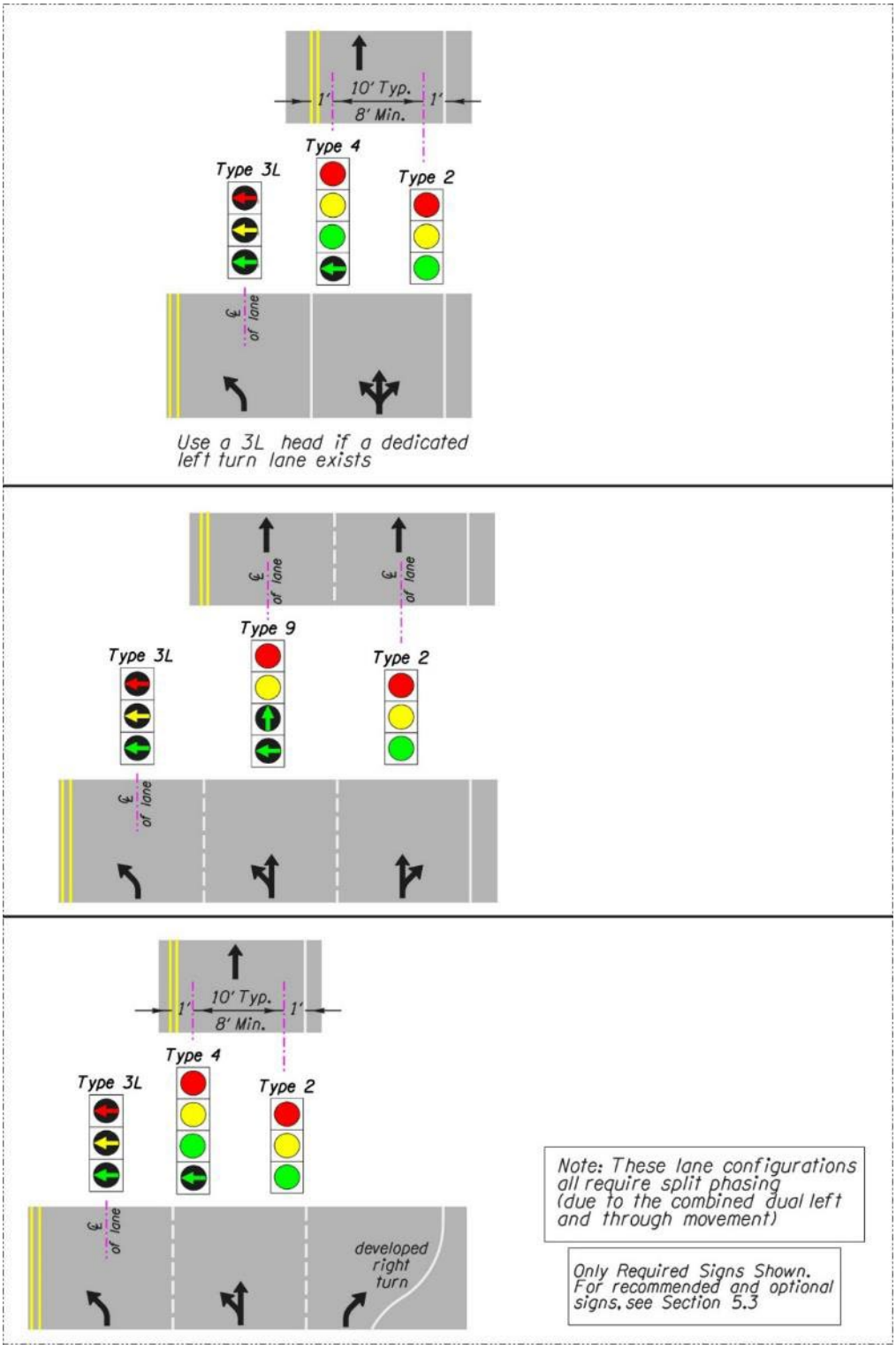
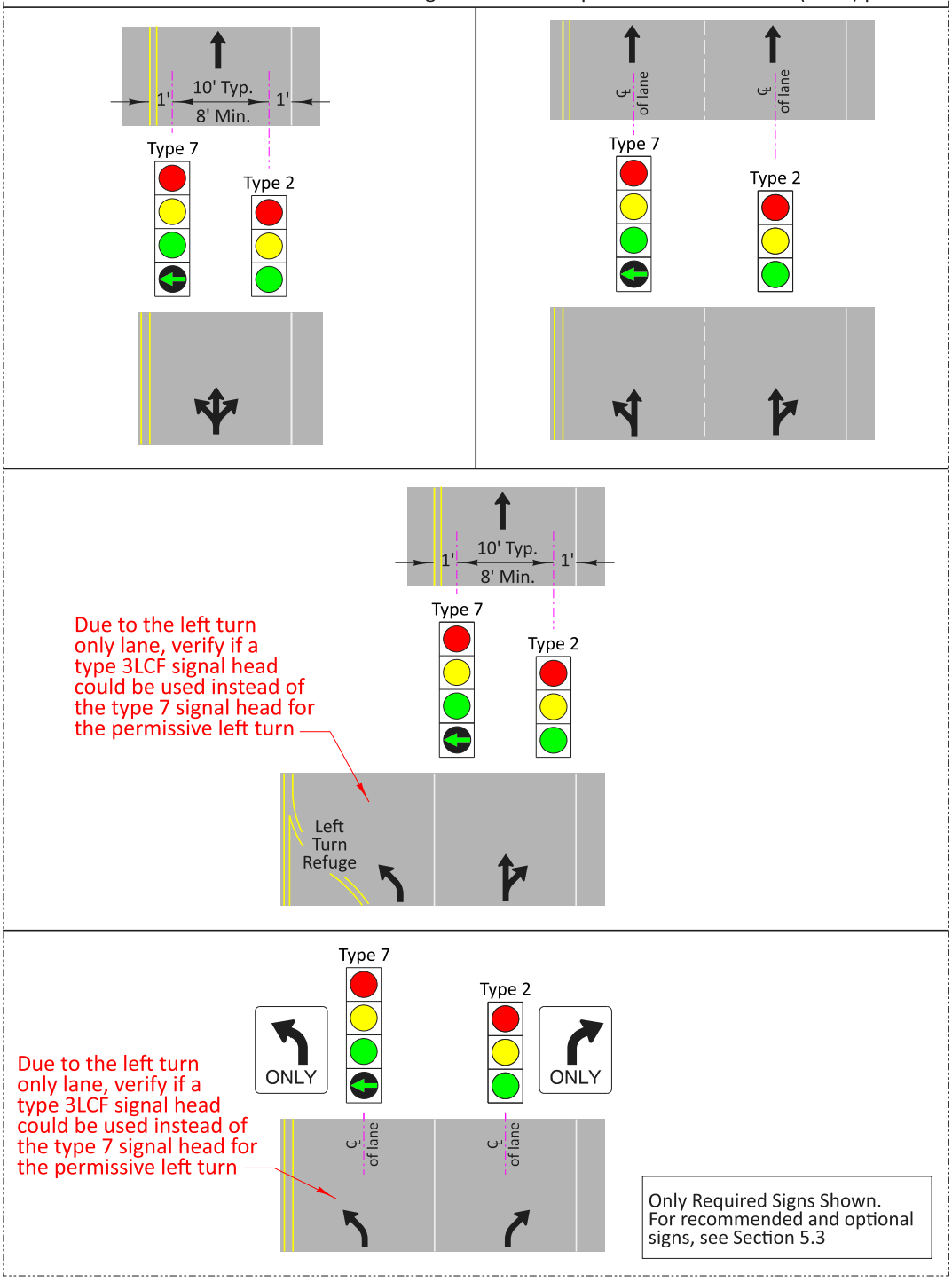


Figure 5-42 | Signal head Placement for Railroad Preemption

Note: The type 7 head is ONLY used for the track clearance phase IF the track clearance phase has a permissive left turn movement and a left turn only lane does not exist or there are controller cabinet limitations. See chapter 5, table 5-2 for more info.

The type 7 head has ball indications wired to the adjacent thru phase with the green arrow indication wired to the corresponding "unused" left turn green phase. This allows the green arrow indication to ONLY be activated during the RxR Preemption vehicle clear-out (VCOI) phase.



5.2.4 Supplemental Signal Heads

As per the MUTCD, supplemental near side signal heads are required when signal heads are located greater than 180 feet from the stop line. They may also be used to improve conspicuity and visibility to the signalized intersection. Supplemental signal heads are not wired to an independent phase (overlap phase), they are hardwired to phase they are supplementing. There are two main locations where supplemental signal heads can be placed:

- Near-side supplemental heads: signal heads are located before the intersection. This is the most common location, and typically will be for the thru phase. See Figure 5-43. It may also be used for left turn phases. See Figure 5-44. The head will be on the vertical signal pole (left or right side of the road, depending on the roadway curvature) or overhead if the supporting structure allows proper alignment (e.g. the mast arm is long enough).
- Far-side supplemental heads: signal heads are located across the intersection. This location is not as common as the near-side location. The typical application is for left turn phases. See Figure 5-46. It may also be for thru phases. See Figure 5-45. The head will be on the vertical signal pole (on the left side for a left turn phases, or on the right side for a thru phase).

Figure 5-43 | Supplemental Near-Side Signal Heads – Typical Placement for Thru Phase

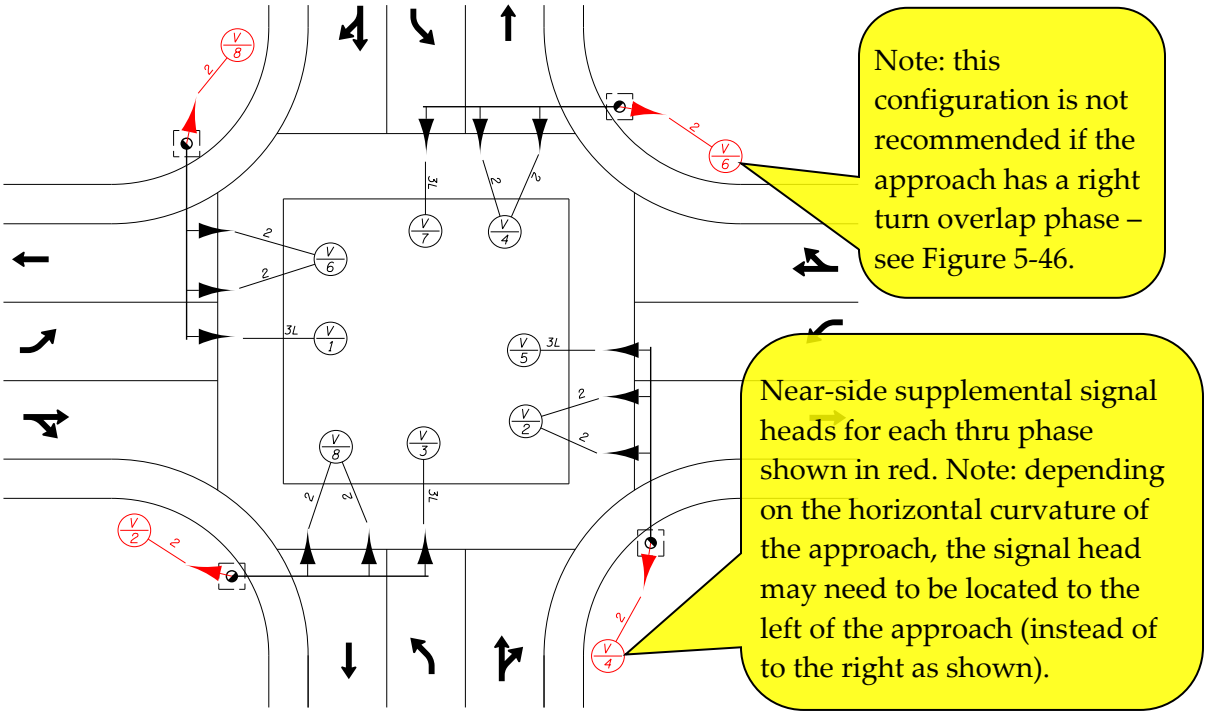


Figure 5-44 | Supplemental Near-Side Signal Heads – Typical Placement for Left Turn Phase

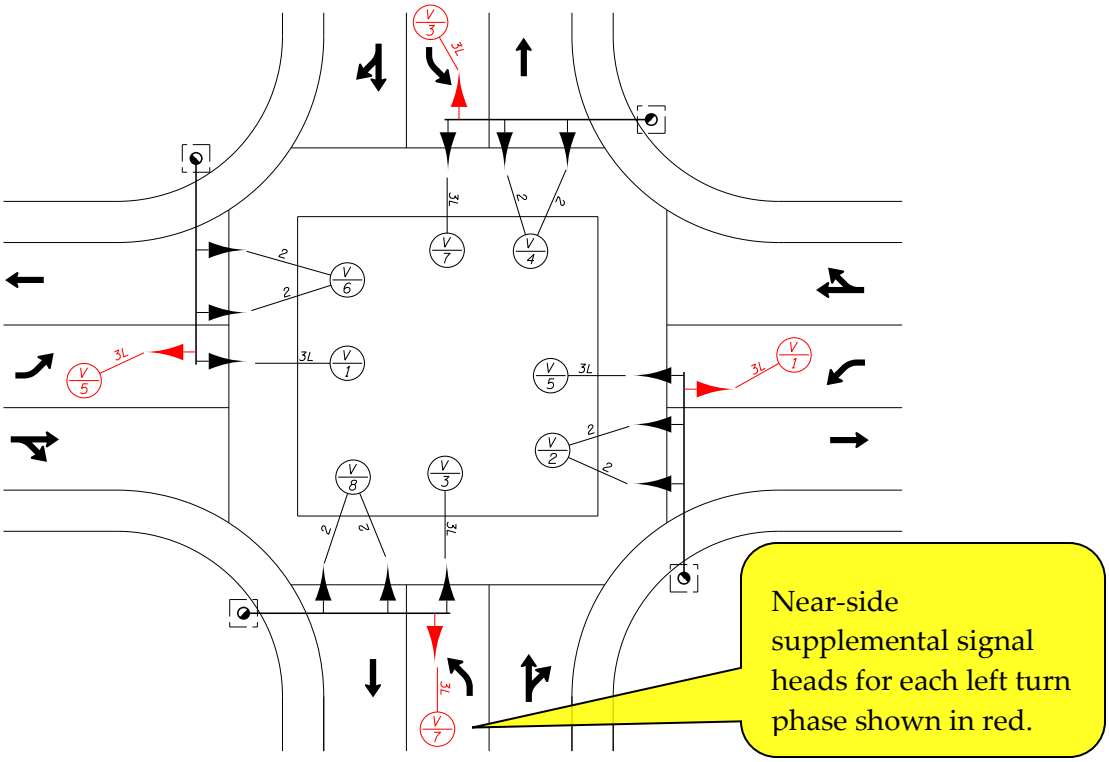


Figure 5-45 | Supplemental Far-Side Signal Heads – Typical Placement for Thru Phase

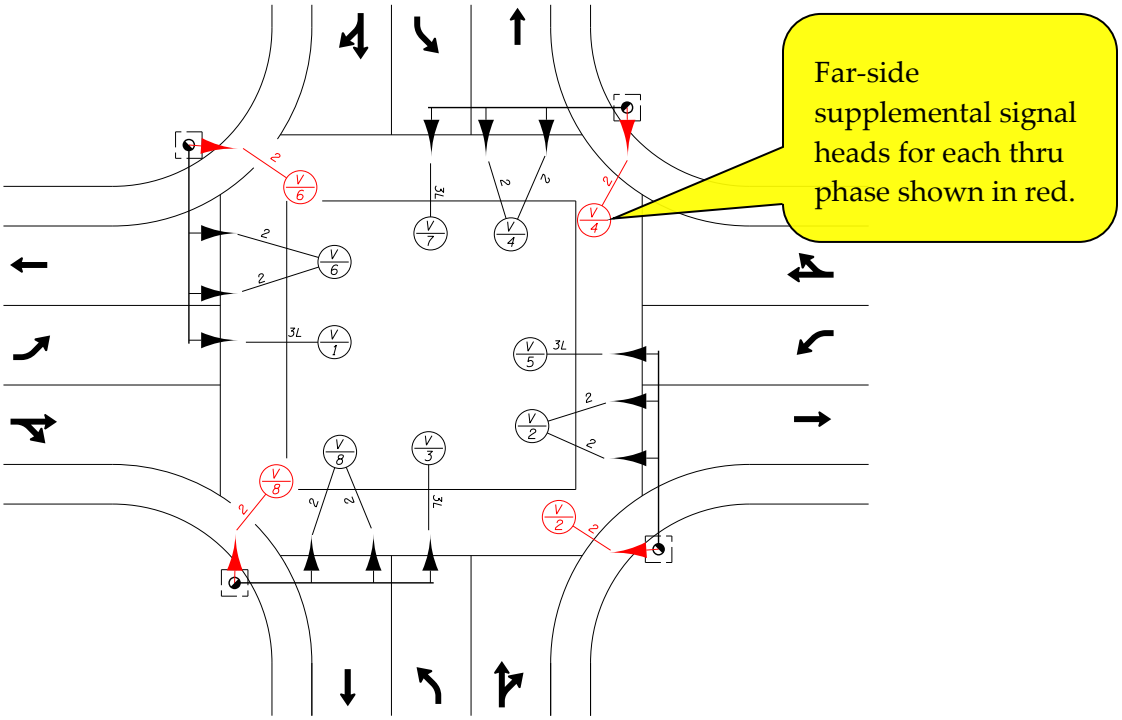
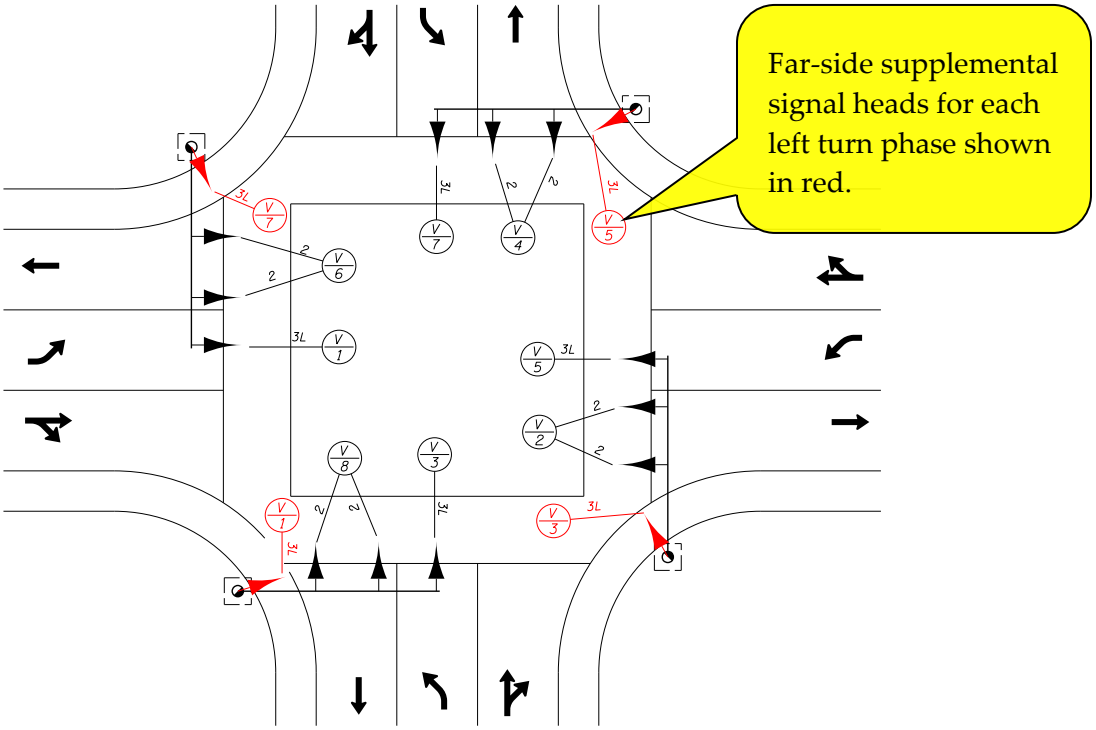


Figure 5-46 | Supplemental Far-Side Signal Heads – Typical Placement for Left Turn Phase



The use and placement of supplemental heads needs to be carefully considered to avoid motorist confusion. Supplemental signal heads can be very beneficial if the signal phasing and geometry allow proper placement. See Figure 5-47. However, there are situations where they should not be installed. For example, near-side supplemental heads should not be used on the right side of the road for the thru movement of an approach that has a right turn only lane with overlap phasing (e.g., the right turn lane is phased differently than the thru phase). See Figure 5-48 which illustrates the potential confusion. Another example where near-side supplemental signal heads are not recommended and can cause confusion is where right turn slip lanes are not controlled by the signal indications (e.g., uncontrolled, yield controlled, or stop controlled) as shown in Figure 5-49. Louvers and cut-off visors can help in some situations (see section 5.2.6).

Figure 5-47 | Supplemental Near-Side Signal Head Placement: Example 1, Recommended

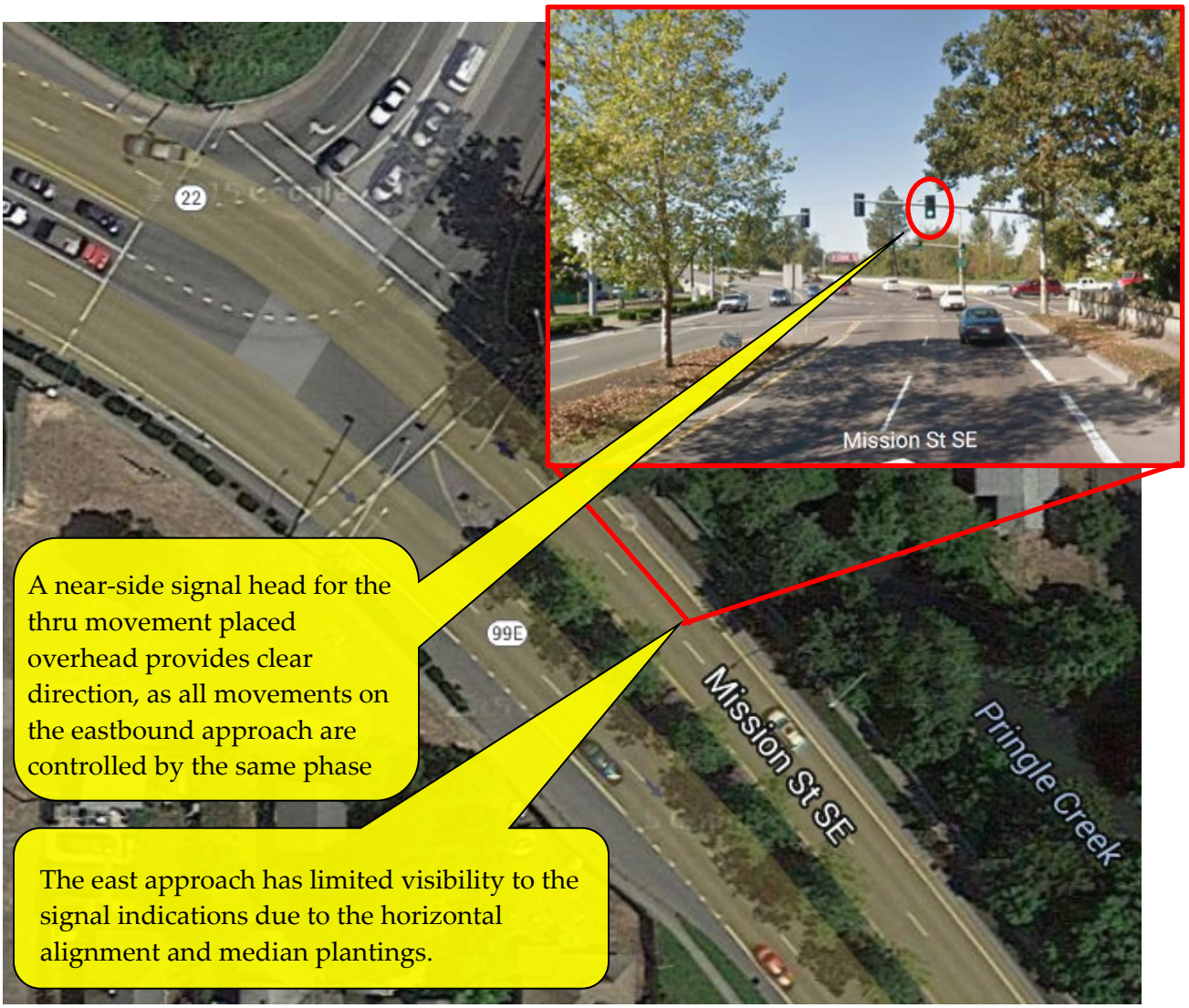


Figure 5-48 | Supplemental Near-Side Signal Head Placement: Example 2, Not Recommended

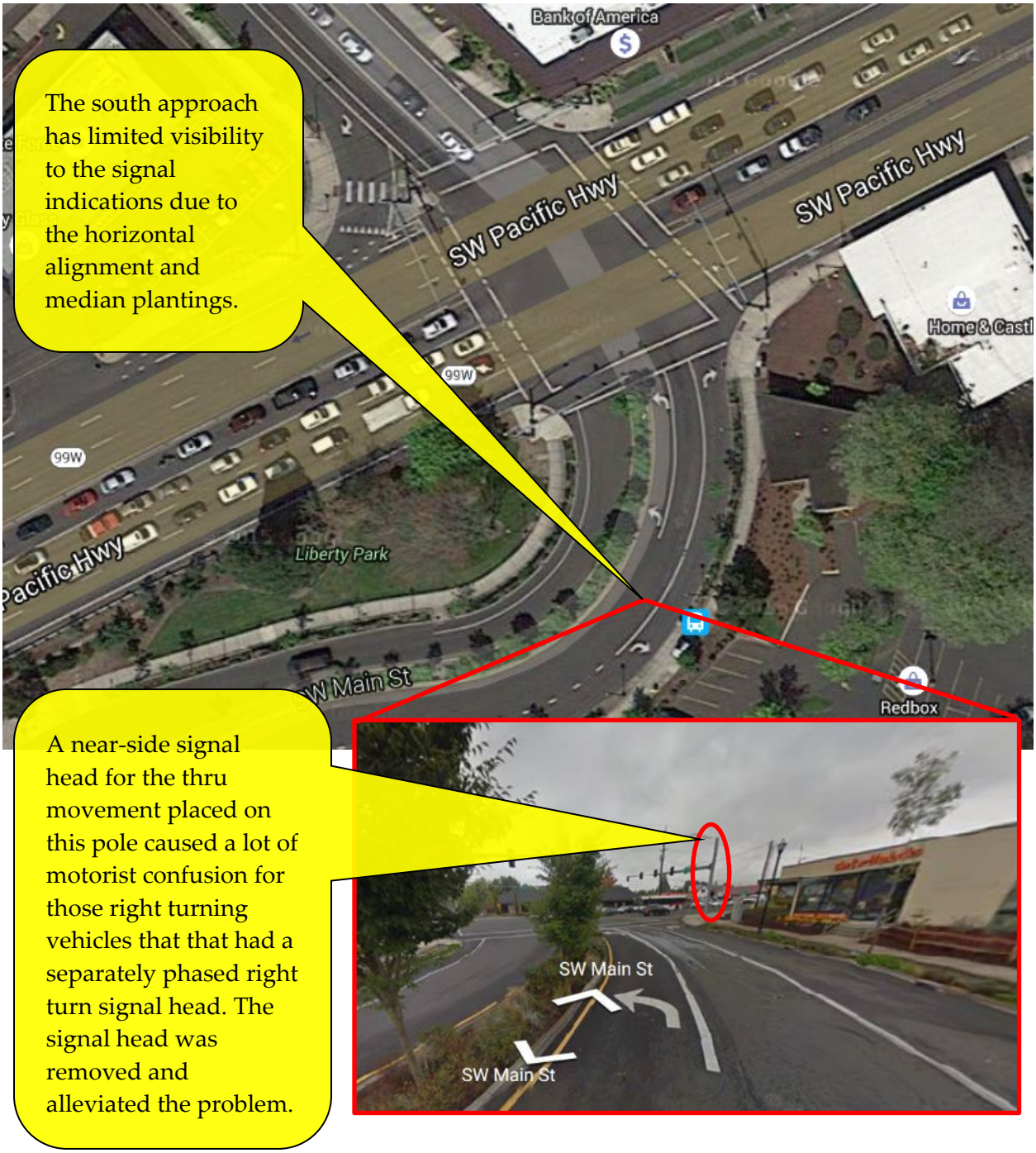
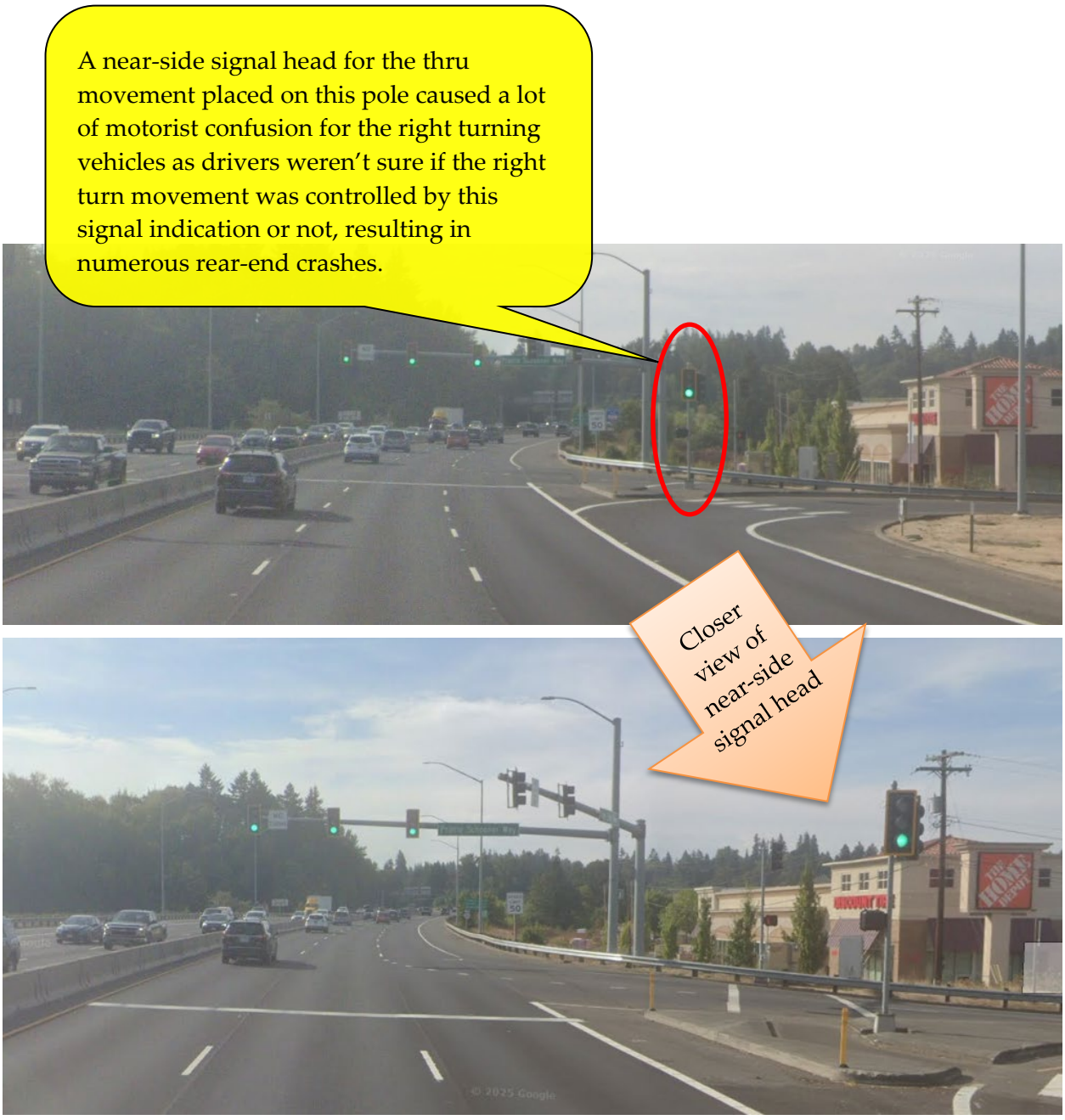
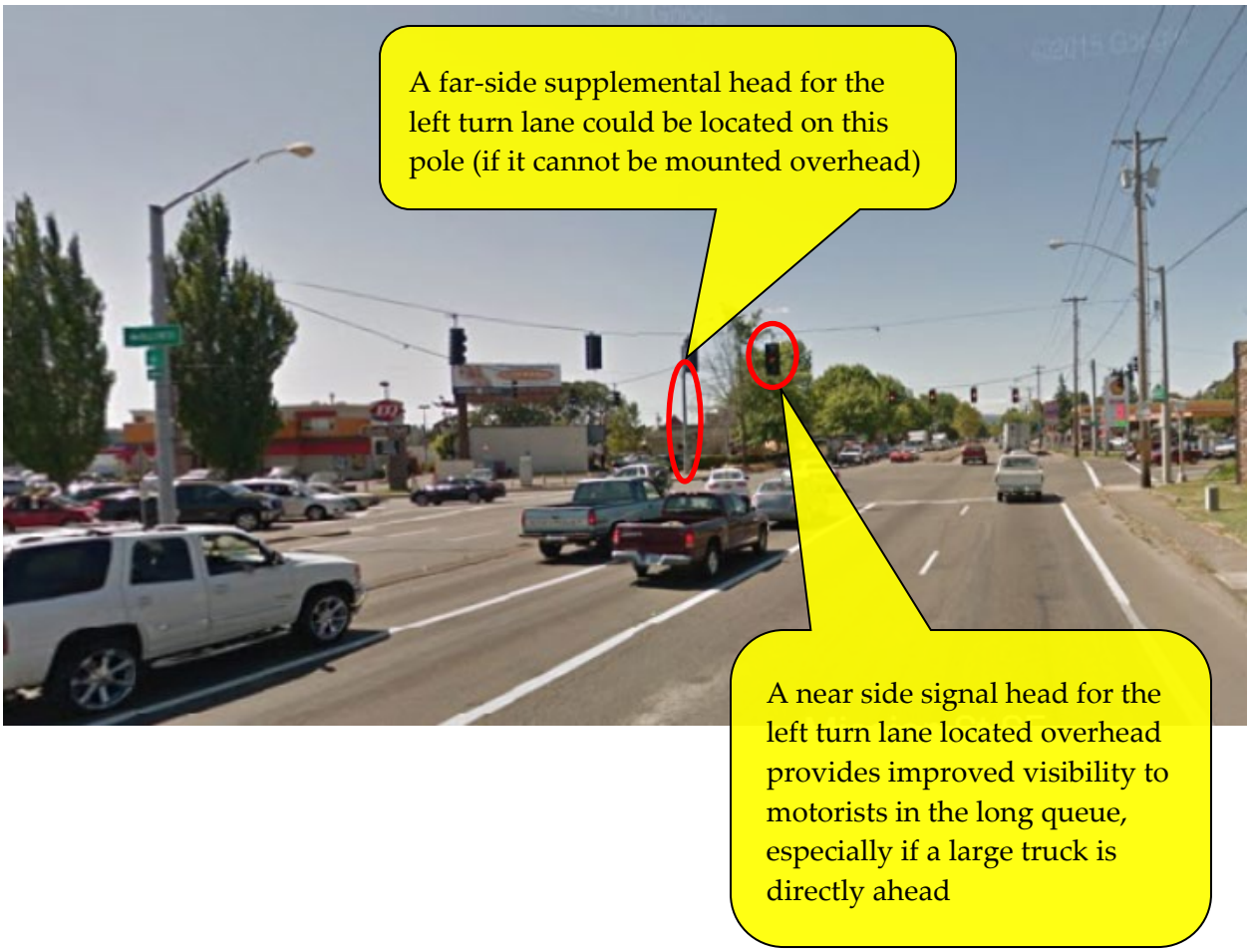


Figure 5-49 | Supplemental Near-Sde Signal Head Placement: Example 3, Not Recommended



Supplemental signal heads can help improve the operation and reduce the likelihood of red light running for minor phases under certain conditions. For example, a left turn phase that has a high volume (the phase typically maxes out rather than gaps out and has long queues) with a high volume of large trucks (cars behind the large truck have an obstructed view of the signal indications the closer you get to the intersection) can benefit from a supplemental left turn signal head located overhead (preferred) or on the far-side pole to the left of the left turn phase. See Figure 5-50.

Figure 5-50 | Supplemental near-side signal head placement: Example 3



Supplemental signal heads can be beneficial for locations with known sun glare issues where the east/west facing signal heads are in direct alignment with the sunrise or sunset during certain times of the year. Sun glare can make it difficult to maintain continuous visual contact with the signal indication while approaching the intersection (temporary blindness) or difficult to determine what signal indications are on or off. While current signal indication standards have helped solve the issue of sun reflection falsely "lighting up" indications that are not actually on (clear lens with only the LEDs providing the color vs. older versions indications where red/yellow/green colored lens were used with white incandescent bulbs), maintaining continuous visual contact remains an issue. A supplemental signal head may be able to provide a better position or angle that helps direct the driver's eye away from the sun. See Figure 5-51.

Figure 5-51 | Supplemental Signal Head Placement – Sun Glare Example



5.2.5 Head Mounting

There are two approved ways to mount signal heads:

- Vehicle signal bracket for attachment to a mast arm or mast arm pole
- Spanwire hanger for attachment to a span wire (note: span wire only applicable to temporary signals)

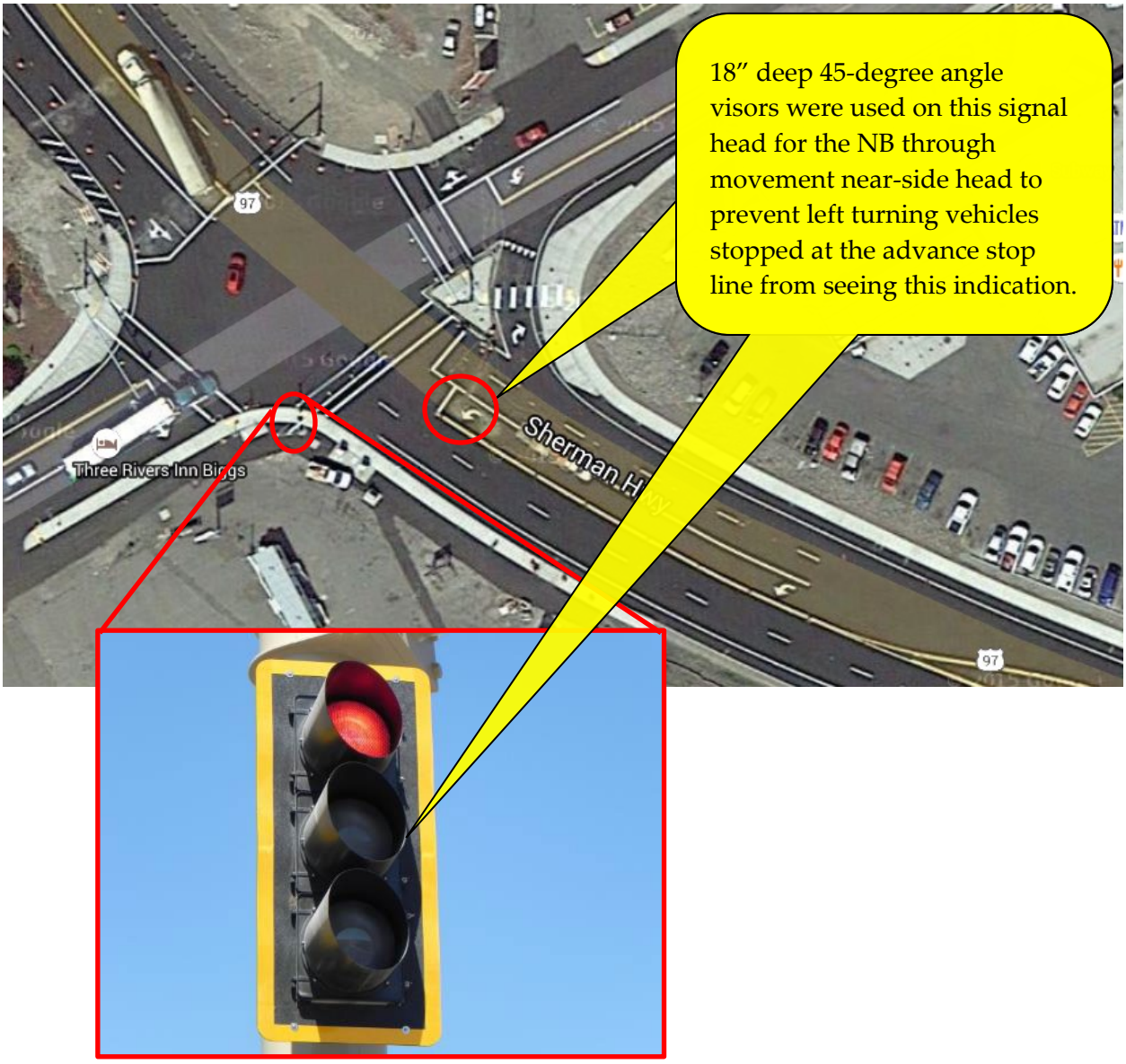
In the past, the use of plumbizers (and elevated plumbizers) to attach signal heads to mast arms was the standard, common practice. This practice required very precise control of vertical constraints, as plumbizers didn't allow much flexibility for installation. Vehicle signal brackets, on the other hand, offer much more flexibility of the control of the vertical elevation.

5.2.6 Signal Head Louvers and Angle Visors

In situations where it is possible to view multiple conflicting phases of traffic signal indications which may lead to motorist confusion, signal louvers and/or 18" deep 45-degree angle visors should be used. See Figure 5-52.

Programmed signal heads were used in the past but are no longer an option.

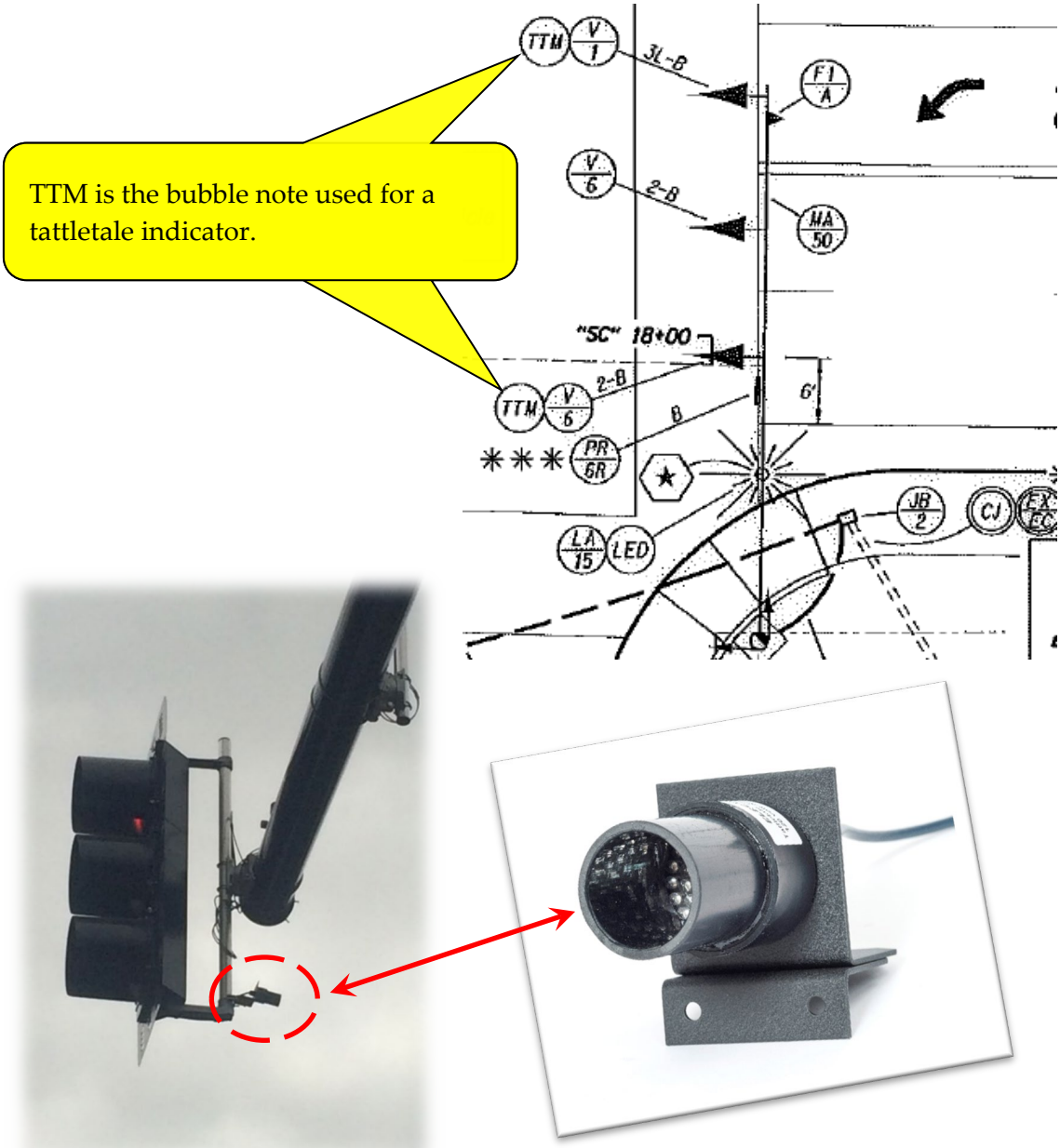
Figure 5-52 | Cut-Off Visor Example



5.2.7 Tattletale Indicators

Tattletale indicators are used at the request of law enforcement to aid in enforcing red light running violations by clearly indicating a red indication is active from certain viewing angles. The tattletale light is directly hardwired to the red indication. Work with region traffic to determine if there is a need for tattletale indicators. Use standard detail DET4400 and coordinate with the law enforcement to determine the best placement for the tattletale, as it is a directional device. See Figure 5-53 for an example.

Figure 5-53 | Tattletale Indicator Example



5.3 Sign Requirements and Layout

Depending on the operation of the intersection and type of signal heads used, certain signs may be required. Other signs may be recommended or optional. The following figures show common signs associated with traffic signal control. Note that positive message signs (e.g., "THROUGH ONLY" sign, which tells the motorist what to do) are preferred over negative message signs (e.g., "NO RIGHT TURN" sign, which tells the motorist what NOT to do).

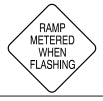
All the signs listed in Figure 5-54 and Figure 5-55 are typically shown and detailed on the signal plan sheet, NOT on the signing plan sheet.

Signs are a common item that have the potential to be detailed on another discipline's plan sheet. Always coordinate with the other discipline's designer to ensure that the design item is only **detailed** in one plan sheet, not both. See chapter 21 for more information on "shown and detailed" vs. "shown and referenced" work and how to properly draft it on plan sheets.

Figure 5-54 | Common Signs Used for Traffic Control

SIGN NUMBERS & SIZE (signs beginning with an "O" are Oregon specific)	SIGN TYPES: Aluminum	SIGN TYPES: Part Time Restriction	RECOMMENDED OR REQUIRED
R6-2L 30"x36" 	AL 1L		Required for one-way streets. One way signs can be installed on the mast arm (R6-2L) OR ground mounted (R6-1L). See MUTCD 2B.40(P10)
R6-2R 30"x36" 	AL 1R		Required for one-way streets. One way signs can be installed on the mast arm (R6-2R) OR ground mounted (R6-1R). See MUTCD 2B.40(P10)
R10-11A 30"x36" 	AL 3		Region Traffic Engineer Operational Approval Required
OR3-12 30"x36" 	AL 3U		StateTraffic-Roadway Engineer Operational Approval Required
R5-2 30"x30" 	AL 3T		StateTraffic-Roadway Engineer Operational Approval Required (typically used in conjuction with U-turn permitted sign)
OR3-5TD 30"x36" 	AL 4		
R3-6L 30"x36" 	AL 4L		
R3-6R 30"x36" 	AL 4R		
OR3-5TT 30"x36" 	AL 4T		
R3-5L 30"x36" 	AL 5L		Required for a trap lane (where a through lane becomes a mandatory turn lane at the intersection) if the trap lane does not have a signal head with arrow indications
R3-5R 30"x36" 	AL 5R		Required for a trap lane (where a through lane becomes a mandatory turn lane at the intersection) if the trap lane does not have a signal head with arrow indications
R3-5A 30"x36" 	AL 5T		
R3-3 36"x36" 	AL 6		Use of appropriate lane use signs is preferred over R3-3

Figure 5-55 | Common Signs Used for Traffic Control (Cont.)

SIGN NUMBERS & SIZE (signs begining with an "O" are oregon specific)	SIGN TYPES: Aluminum	SIGN TYPES: Part Time Restriction	RECOMMENDED OR REQUIRED
R3-2 36"x36" 	AL 6L	PR 6L	Use of appropriate lane use signs is preferred over R3-2. PTR version used for RxR applications
R3-1 36"x36" 	AL 6R	PR 6R	Use of appropriate lane use signs is preferred over R3-1. PTR version used for RxR applications
R5-1 36"x36" 	AL 7		
R10-28 24"x30" 	AL 8		For overhead mounting
OR20-1 24"x12" 	AL 8s		
R10-6 24"x36" 	AL 9		
R10-12 30"x36" 	AL 11		Required with aType 4L signal head. Recommended when a permissive left turn phase has an exclusive left turn lane or a Type 7 signal is used. Optional otherwise.
R10-15a 30"x30" 	AL 12		Required with aType 5 signal head
W3-8 36"x36" 	AL 16		
OR20-5 24"x30" 	AL 17		
W3-4 36"x36" 	AL 18		
W16-13p 24"x18" 	AL 19		
R3-7a 24"x12" 	AL 20		

5.3.1 Layout of Regulatory Signs

Regulatory signs installed on overhead (on a mast arm) should either be located near the signal head that they apply to or centered within the lane that they apply to. For example, the "(right) TURNING VEHICLES STOP FOR PEDS" sign should be placed near the right turn signal head and the "LEFT TURN YIELD ON green ball" sign should be centered within the left turn lane. When placing signs next to signal heads, they will need to be a minimum of 3 feet apart (measured for the center of the signal head to the center of the sign). This accommodates placement of a standard regulatory sign next to all signal indications except for a type 4L (doghouse) head. If placing a sign next to a type 4L head, the sign needs to be a minimum of 4 feet apart.

In the situation where the signal head and the sign should both be centered over the lane (e.g., three through lanes each with a "THROUGH ONLY" sign), the location of the signal head takes precedence (center over lane), and the sign should be located just to the left or right of the signal head. The message on sign will help determine which side of the signal head to place it on. For example, in the left-most through only lane, the "THROUGH ONLY" sign would be more beneficial if placed to the left of the signal head where it is more in the motorist's line of sight if they attempt to make an incorrect left turn. In the right-most through only lane, the "THROUGH ONLY" sign would be more beneficial if placed to the right of signal head for the same reason. In the center through only lane, the placement of the sign to the left or right of signal head would both be equally beneficial.

Occasionally, there are times when two regulatory signs may be desired for one lane. For example, an exclusive right turn lane with a type 5 signal head; The "(right) TURNING VEHICLES STOP FOR PEDS" sign is required and the "RIGHT TURN ONLY" sign may also be appropriate to install. In this case, it is recommended to install one sign to the left of the signal head and one sign to the right of the signal head.

Some signs are applicable to all lanes of traffic, such as the "ONE WAY" signs. In this case, the sign should be placed in the location where the information would be the most critical. For example, on a three-lane approach where a "ONE WAY left arrow" sign is required, the location where this information is most critical is the right-most travel lane (of the three approach lanes, a motorist in the right-most lane is most likely to make wrong-way movement).

For large and/or complex intersections, locating the appropriate signing can sometimes be challenging and ideal spacing and location of signs and signal heads may not always be achievable. In these cases, aligning all necessary equipment becomes a bit of an art, but the final product should broadcast clear, unmistakable information to the approaching motorist.

5.3.2 Street Name Signs and Guide Signs (Custom Designed Signs)

Street name signs and guide signs are custom designed signs (vs. standard MUTCD regulatory signs). Custom designed signs that are mounted to signal poles, mast arms or temporary span wires are detailed on a separate sign plan sheet and only referenced on the signal plan sheet. Custom signs are NOT part of the lump sum traffic signal bid item; they are paid for under the signing bid items (type of sign by the square foot and sign mount type). See chapter 21 for more information on "shown and detailed" vs. "shown and referenced" work and how to properly draft it on plan sheets.

Street name signs are required at each intersection, for each approach leg. The standard location for the street name sign is on the mast arm. If possible, the street name sign should be the sign located closest to the signal pole. All other appurtenances on the mast arm should be located to the left of the street name sign.

Standard signal pole design, as per standard drawing TM650, allows a maximum street name sign area of 21 square feet (mounted on the mast arm) and a maximum guide sign of 60 square feet (mounted on the signal pole). Always verify the size of custom signs to ensure they do not exceed the maximum dimensions. If a sign does exceed the maximum dimensions there are a couple of solutions, listed in order of preference:

1. Contact the sign designer and request a re-design of the sign to fall within maximum dimensions.
2. Ground mount the sign near the signal pole.
3. Contact the traffic structures engineer and request an analysis/recommendation for the oversized sign. A non-standard signal pole (SMX) will likely be required.

5.3.3 Part Time Restriction Signs (PTR)

Part time restriction (PTR) signs are sometimes used depending on the desired operation (see the operational approval). PTR signs are electronic signs that appear black (blank-out) when not in use and display text/symbols when in use. The most common applications for use of a PTR sign includes signals with railroad/light rail preemption. Other unique applications include restricting turning movements by time-of-day/day-of-week or during certain portions of the signal phasing.

5.3.4 Materials and Mounting

The standard material for small signs mounted on signal structures (poles, mast arms, temporary span wires, pedestals) is sheet aluminum. Extruded aluminum is used for larger signs. In the past, interior illuminated signs were used on signal installations due to the poor performance of sign sheeting when signs were mounted overhead. However, with the vast improvement of modern sign sheetings, coupled with the effort to be more energy efficient, interior illumination is no longer necessary or desirable. Modern sign sheetings are extremely effective and visible when mounted overhead and do not have the extra maintenance and power costs that are associated with interior illuminated signs.

There are two approved ways to mount signs that are part of the traffic signal lump sum bid item:

- Sign bracket (Type B) for attachment to a mast arm
- Sign bracket (Type A) for attachment to a span wire using a span wire hanger (note: span wire only applicable to temporary signals)

NOTE: PTR signs are mounted with a vehicle signal bracket due to the wiring.

Mounts for custom designed signs (street name signs and guide signs) which are detailed on the sign plans and paid for under the signing bid items consist of the following:

- Mast arm street name sign mounts for street name signs as per TM679
- Signal pole mounts for guide signs as per TM680

5.4 Pedestrian Signal Equipment Layout

Pedestrian signal equipment location is guided by the current versions of the Manual on Uniform Traffic Control Devices (MUTCD), the Oregon Supplement to the MUTCD, and Public Rights of Way Accessibility Guidelines (PROWAG). It should be determined in conjunction with the curb ramp and crosswalk layout. This is an iterative process, typically requiring adjustments of each feature (e.g., curb ramp, crosswalk, and pedestrian equipment) to achieve the best possible design. This process should coordinated with the roadway designer and be done early in the design process (DAP plans) so that right-of-way needs can be addressed in a timely manner.

If raised medians are present, additional pushbuttons and/or pedestrian signal equipment may be required depending on the configuration of the median and the crosswalk. See Section 5.1.5.

5.4.1 Use of Pedestrian Detection

Pedestrian detection is required for all crosswalks except when the pedestrian phase will be recalled at all times. Pedestrian recalled phases are common in central business districts.

5.4.2 Pushbutton Requirements

Pushbuttons shall meet the following criteria. Note: An ADA curb ramp design exception is required if unable to meet any of these requirements. Contact roadway designer for assistance.

- Horizontal reach to the pushbutton shall be 10 inches maximum (using a side reach, not a forward reach). See Figure 5-56.
    - Pedestal cannot be located behind a curb. See Figure 5-59
- Clear space to access the pushbutton shall be within the 10-inch horizontal reach and unobstructed. The clear space is 30″ x 48″ for a parallel approach or 36″ x 48″ for a head-in/back-in maneuver with a maximum design slope of 1.5%. The clear space shall connect to a pedestrian access route (PAR). See Figure 5-56 and Figure 5-65 thru Figure 5-71.
    - Pedestal foundation shall be installed on a level surface (1.5% max. design slope. See Figure 5-63 and Figure 5-64.
- Turning space is 4.5′ x 5.5′ (signal equipment is a vertical obstruction). See Figure 5-74.
- Vertical reach to the pushbutton is 42″ to 48″ from the adjacent finish grade. See Figure 5-75 and Figure 5-76.

Pushbuttons should meet the following criteria:

- Mounted on a pedestal. Ideally on the same support as their associated pedestrian signal head. See section 5.4.15 for more information.
- 15 feet maximum path of travel length from the pushbutton to curb ramp edge. See Figure 5-77 and Figure 5-78.
- 8-foot minimum separation between buttons (one pushbutton per pedestal). Note this criterion doesn't apply to (see Section 5.4.7):
    - Diagonal curb ramps & single curb ramp serving two crosswalks allowed by ADA curb ramp design exception
    - Two curb ramps that share a single turning space/level area

5.4.3 Deviations from Pushbutton Location Requirements

Meeting all the criteria listed in section 5.4.2 may be impossible at certain locations and compromises in the design will need to be made. The shall criteria are the highest priorities and should be met before attempting to meet any other criteria, as not meeting these criteria requires an ADA curb ramp design exception. The should criteria, while important, are a lower priority and can usually be acceptably mitigated by the deviations discussed in sections 5.4.6, 5.4.7, and 5.4.8.

If unable to meet any of the above listed criteria in section 5.4.2, deviations may be considered. Common deviations are listed below. Any deviations require approval of the state traffic signal engineer during the design approval process.

- Pushbutton mounted on a large pole. See Section 5.4.6.
- Two pushbuttons per pedestal/pole (note: this is the preferred solution for diagonal curb ramps and two curb ramps that share a single turning space). See Section 5.4.7.
- Use of an extension bracket mount. See Section 5.4.8.
- Vertical reach to the pushbutton is less than 42”. See Section 5.4.9.

5.4.4 Incorporating PROWAG Requirements

The 2023 PROWAG is not formally adopted for use by the US DOJ for public right of way, but it is still used as a guide document for best practices. Note: certain other federal agencies have adopted it and it is enforceable under those jurisdictions. The content related to traffic signal design in this manual already takes the PROWAG requirements into account. However, there are a few instances where the PROWAG requirements either differ from MUTCD guidance, can’t be implemented due to technical constraints (e.g., there is no standard product on the market), or simply don’t apply well to real-world application in the built environment. Therefore, the alternative guidance provided in this manual is deemed an acceptable equivalent to the PROWAG requirements. FHWA has also committed to incorporating all the applicable PROWAG requirements into the MUTCD for a future update, therefore Oregon was instructed to not address any PROWAG specific issues in the Oregon Supplement to the MUTCD 11th Edition. Should you have any concerns about discrepancies in this manual vs. PROWAG, contact the state traffic signal engineer. The state traffic signal engineer will review and approve any discrepancies to as part of the design approval process.

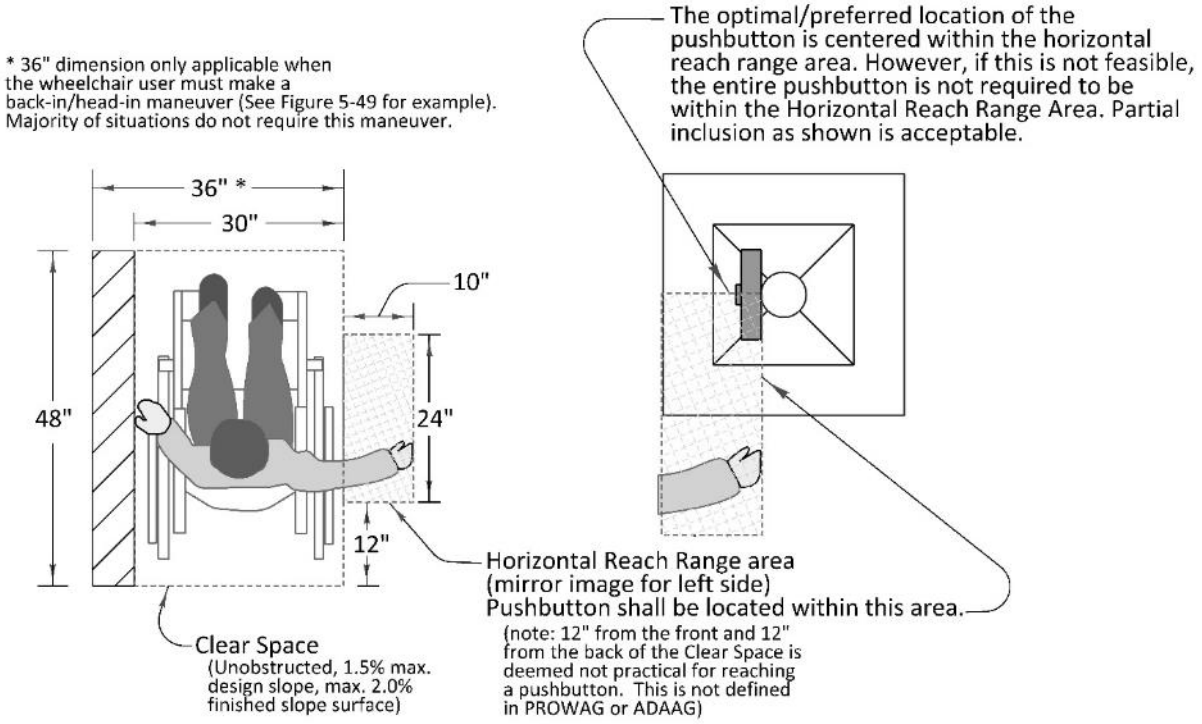
5.4.5 Verifying Pushbutton Requirements

Pushbuttons are mounted with the face of the pushbutton parallel to crosswalk it serves (it should be in-line with the crosswalk striping). It can be mounted on either side of the pedestal as long as all the requirements in section 5.4.2 are met.

During design, the horizontal reach and clear space requirements for the pushbutton should be verified using the design vehicle (wheelchair user) in CADD. See Figure 5-56. The design vehicle should be simulated for each pushbutton in both approach directions. The results of each simulation shall accompany the plan sheets when submitted to the state traffic signal engineer for design approval.

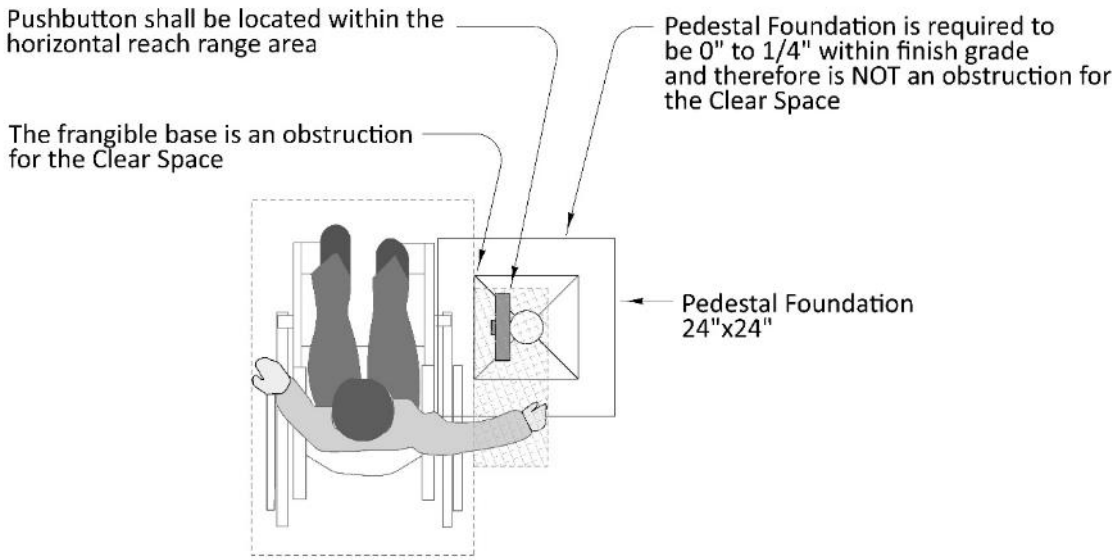
An obstruction to the clear space is defined as any vertical difference that is greater than ¼" or any slope that is designed at greater than 1.5%. When running simulations at each pushbutton, the clear space shall be unobstructed. At intersections with sidewalk and curb ramps, the clear space shall not extend into the vehicular travel way or roadway shoulder. At intersections without sidewalk (rural signals with a pedestrian pad or level landing area on the shoulder), the clear space and connected pedestrian access route shall be free of vehicle encroachment. See section 5.1.8, Figure 5-21, Figure 5-22 for more information on verifying the vehicle swept path.

Figure 5-56 | Design Vehicle (Clear Space with 10" Max Horizontal Reach)



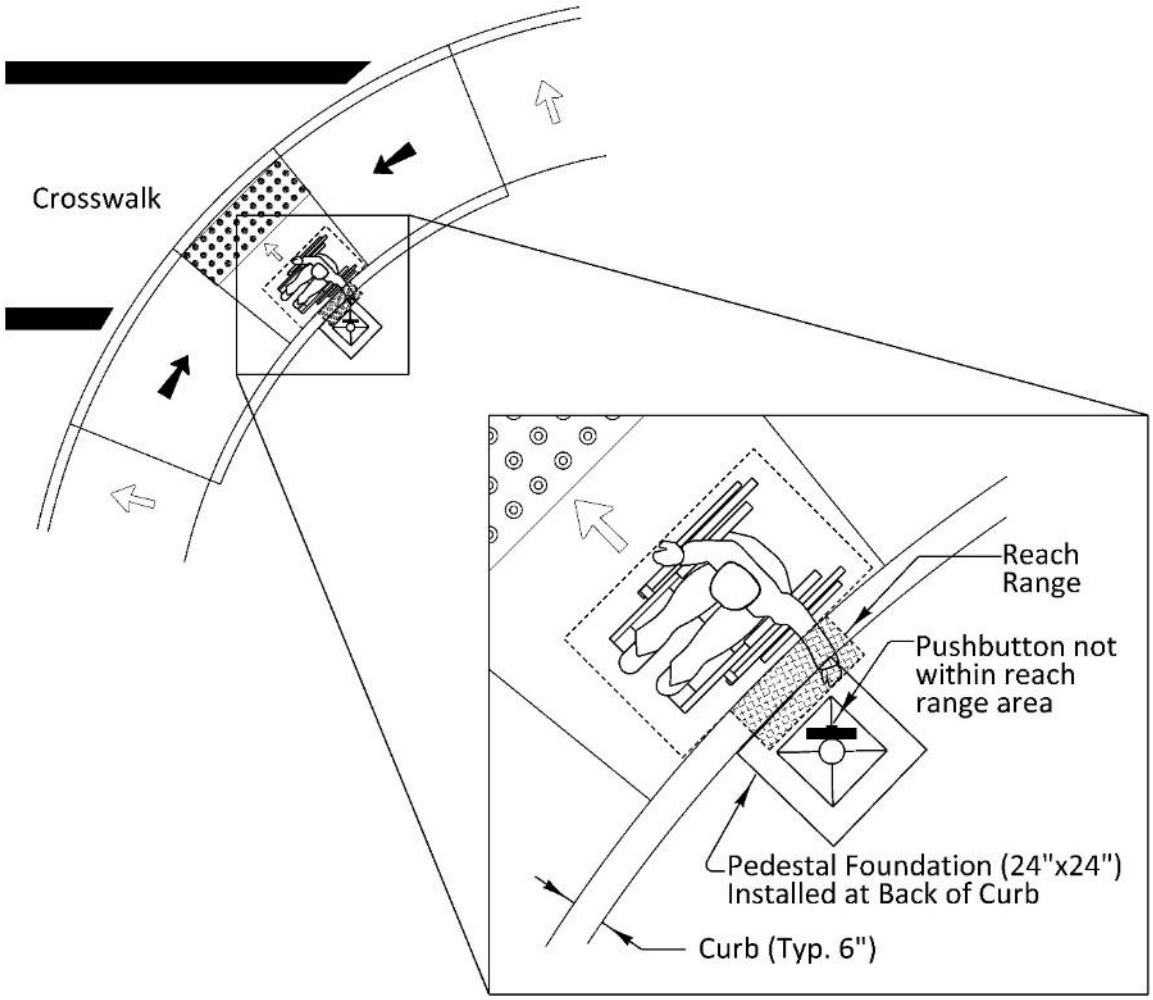
The horizontal reach is measured from the obstruction to the pushbutton. For a pedestal, the obstruction is the edge of the frangible base. The foundation edge is not considered an obstruction as standard drawing TM457 requires the top of foundation to be flush with finish grade (0″ to ¼″ vertical tolerance). See Figure 5-57.

Figure 5-57 | Measuring Horizontal Reach to Pushbutton Mounted on Pedestal



The 10-inch horizontal reach eliminates the placement of the pedestal behind curbs. Curbs are typically 6 inches wide and with a standard construction of the foundation against the back-of-curb, the horizontal reach becomes approximately 13 inches. See Figure 5-58.

Figure 5-58 | Pedestals Located Behind Curbs Do NOT Meet 10 Inch Horizontal Reach Requirement

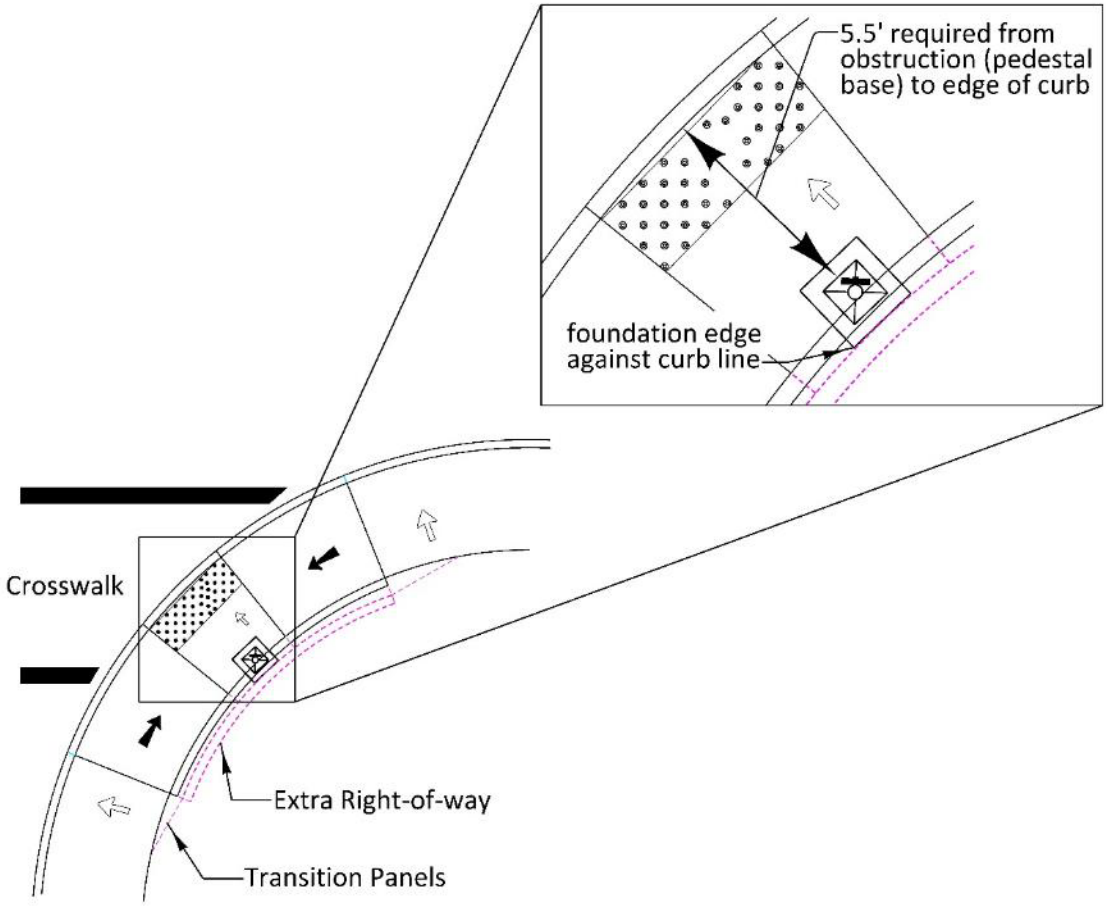


While it may be possible to integrate the pedestal foundation with the curb installation or modify the pedestal foundation to achieve the 10-inch horizontal reach, it is not recommended for two reasons:

- Pedestals located behind a curb makes finding the pushbutton more difficult for low vision pedestrians using a cane (cane sweeps typically don't go over curbs).
- The increased complexity of construction and increased risk of error (requires custom design details and excellent coordination and/or cooperation between subcontractors).

Always place the pedestal in front of the curb. This will likely require transition panels and slightly more right-of-way to achieve the required 5.5 feet between the curb at the crosswalk and the pedestal (obstruction), shown in dashed purple lines in Figure 5-59.

Figure 5-59 | Pedestals Should be Located in Front of Curbs



When placing a pedestal in front of a curb, do not wrap the curb around the pedestal foundation creating tight angles as shown in Figure 5-60. This type of design is more complicated for construction and tends to create maintenance issues (e.g., ponding and trash/debris collection). Install the curb as straight as possible and gently taper/transition to a match point as shown in Figure 5-61. This creates a slightly wider useable path and more room to maneuver a mobility device near the pushbutton. Some additional right-of-way may be required to install a gentle taper/transition for retrofits, but it is highly recommended as this provides a much better installation for the user and for maintenance. See Figure 5-59 and Figure 5-62 for additional examples.

Figure 5-60 | Pedestal with Curb Around Foundation – Avoid Tight Angles

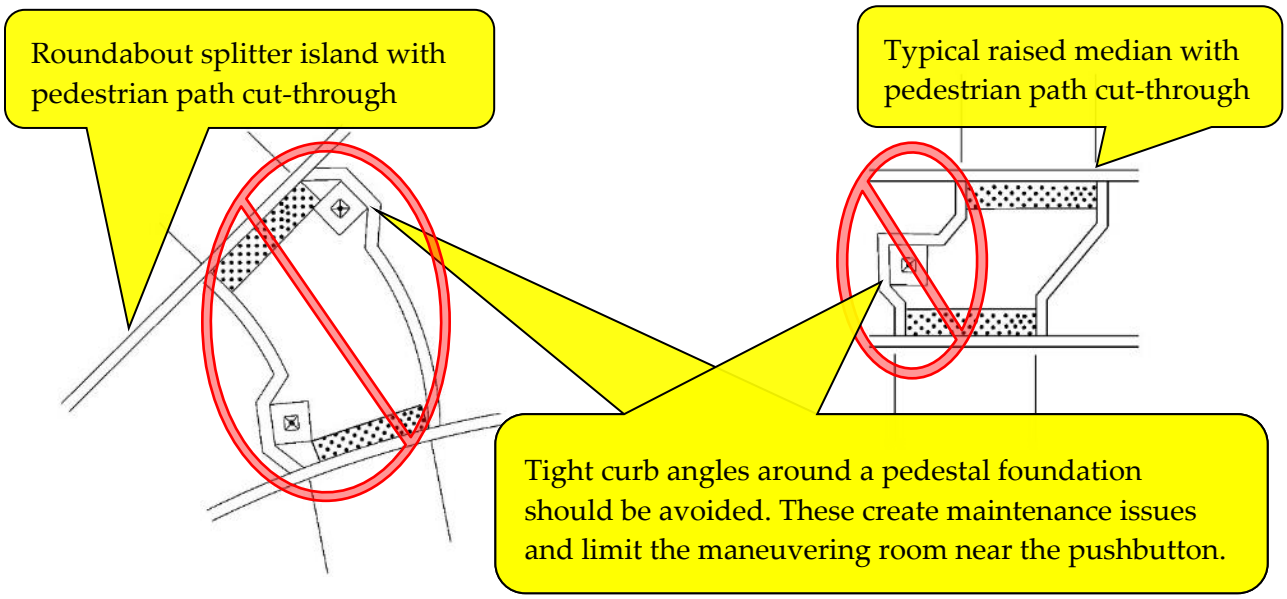


Figure 5-61 | Pedestal with Curb Around Foundation – Use Gentle Tapers

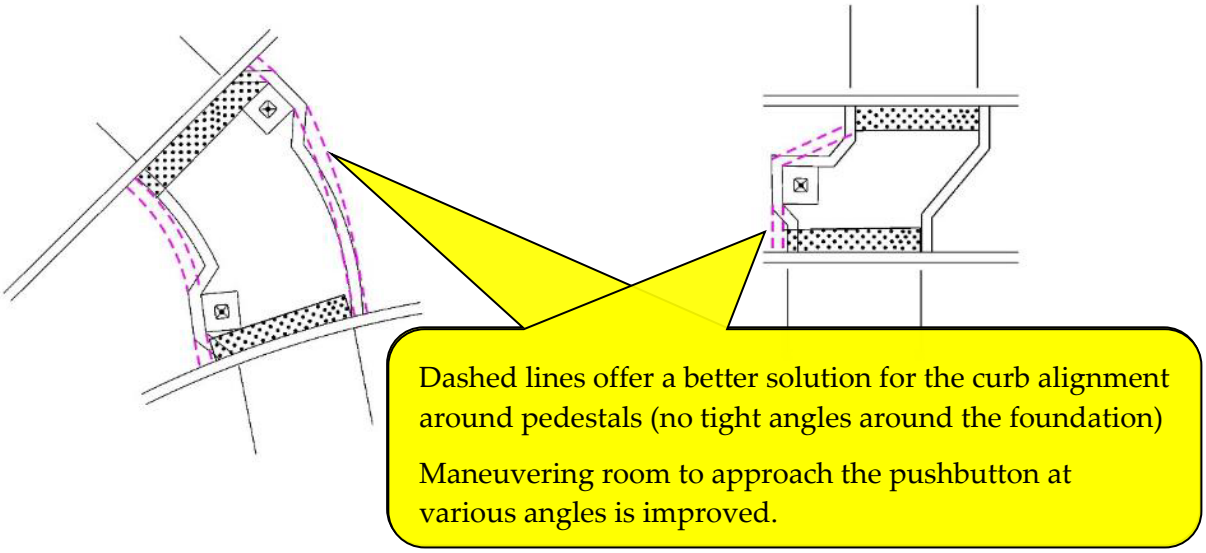
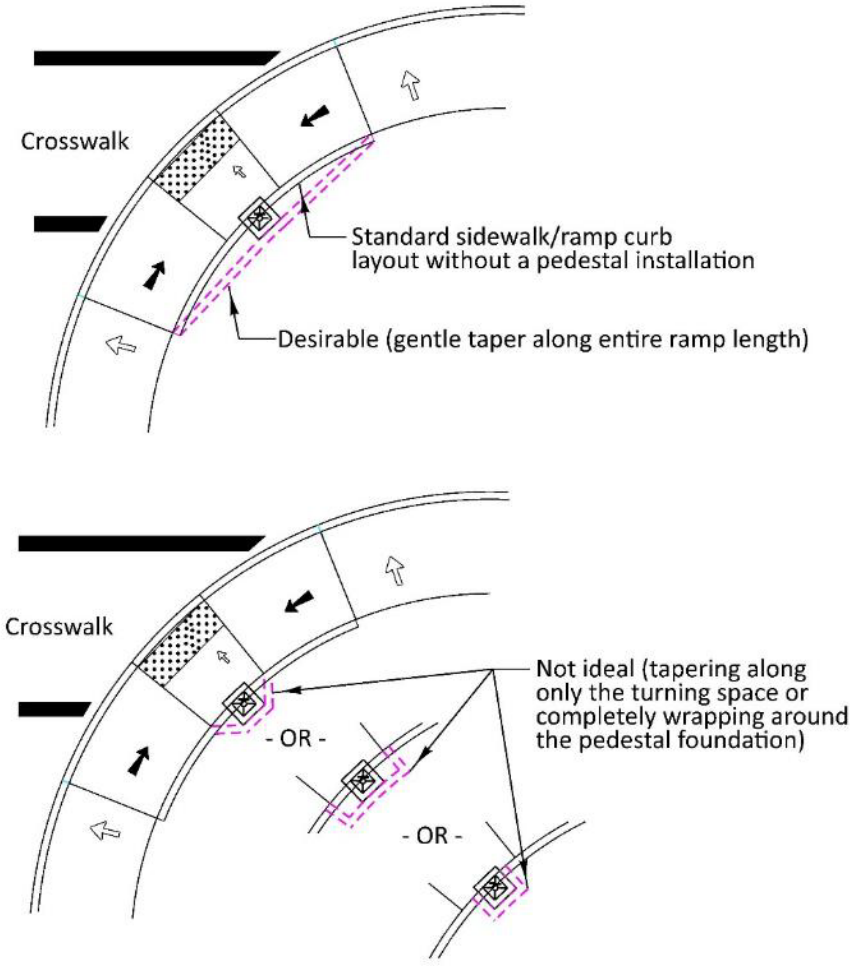


Figure 5-62 | Pedestal with Curb Around Foundation – Examples of Desirable and Not Ideal Curb Layouts





Pedestal foundations must be placed on a level surface (1.5% max. design slope) to meet the requirements for the 10-inch horizontal reach and clear space. See Figure 5-63. Do not place a pedestal foundation across more than one plane (e.g., different concrete panels with different slopes). See Figure 5-64.

Figure 5-63 | Pedestal Foundation Placement – Example 1

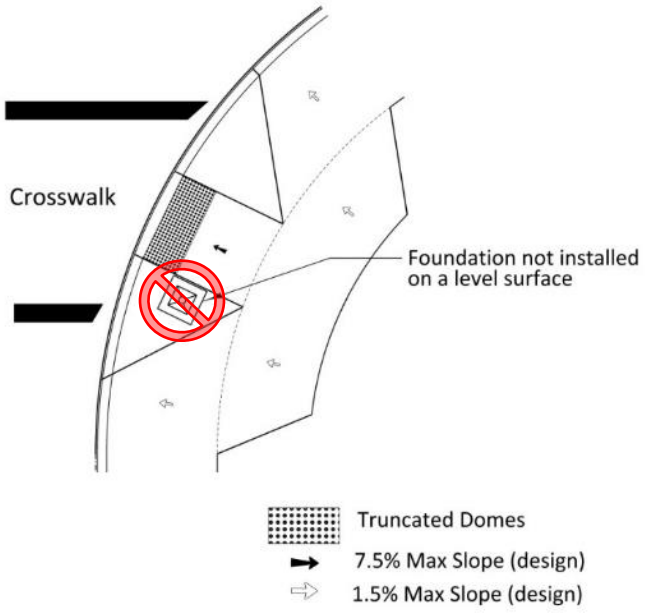
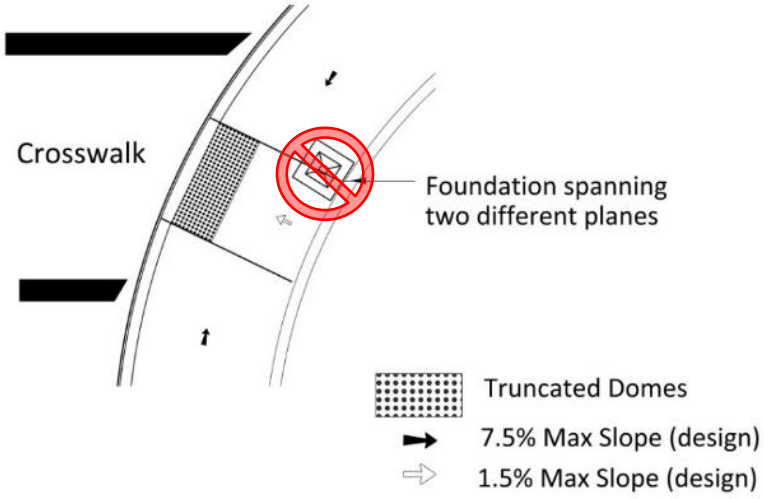


Figure 5-64 | Pedestal Foundation Placement – Example 2



The clear space is the area defined as being level (having a maximum design slope of 1.5%) and is 30”x48” for a typical parallel approach. If the wheelchair user has to back-in/head-in to access the pushbutton, the clear space requirement becomes a little larger: 36”x48”. Typically, the only time a wheelchair user will have to back-in/head-in is when the pushbutton is located on a large pole at perpendicular style curb ramp. See Figure 5-65. Due to the additional effort required for a back-in/head-in maneuver, curb ramp design and pushbutton locations that require this maneuver should be avoided.

The curb ramp turning space (with an obstruction at back-of-walk, such as a pedestal or signal pole) is defined as the 4.5’x 5.5’ unobstructed area located in front of the curb ramp, with the longer dimension towards the curb ramp. The clear space and turning space are independent of each other; they may coincide, overlap, or not touch depending on the curb ramp type and geometrics. **The ideal pushbutton location occurs when the turning space and clear space coincide or have a large overlap for the following reasons:**

- The path the wheelchair user takes to push the button and use the curb ramp is the most direct path
- The pushbutton location is more likely to meet the other ODOT and MUTCD section 4E.08 criteria (e.g. distance from crosswalk: see Figure 5-91, distance from edge of curb ramp: see Figure 5-77, etc.)
- Typically easier to meet the sidewalk and curb ramp slope requirements

Figure 5-65 | Turning and Clear Space – Back-in/Head-in Maneuver Required

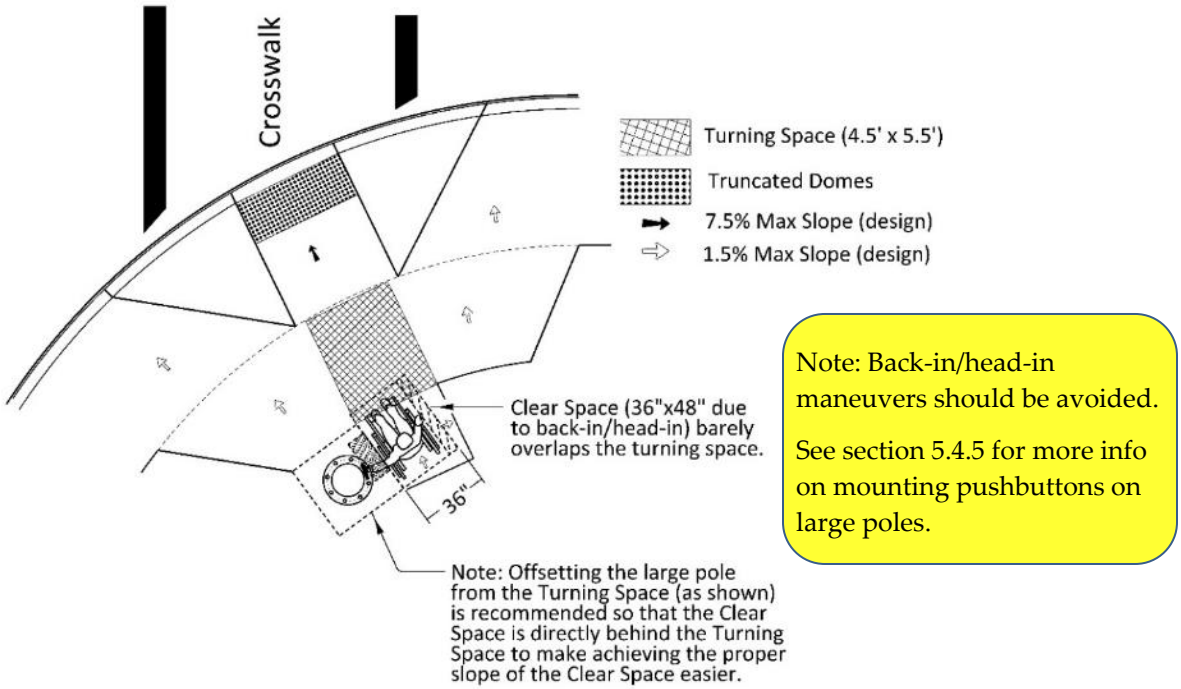


Figure 5-66 through Figure 5-68 show pushbutton placement examples for a parallel approach that meets the shall requirements for horizontal reach and clear space for the three standard types of curb ramps (perpendicular, parallel, and combo), while also showing how the clear space and turning space relate to each other.

Figure 5-66 | Turning and Clear Space – Perpendicular Curb Ramp (Parallel Approach)

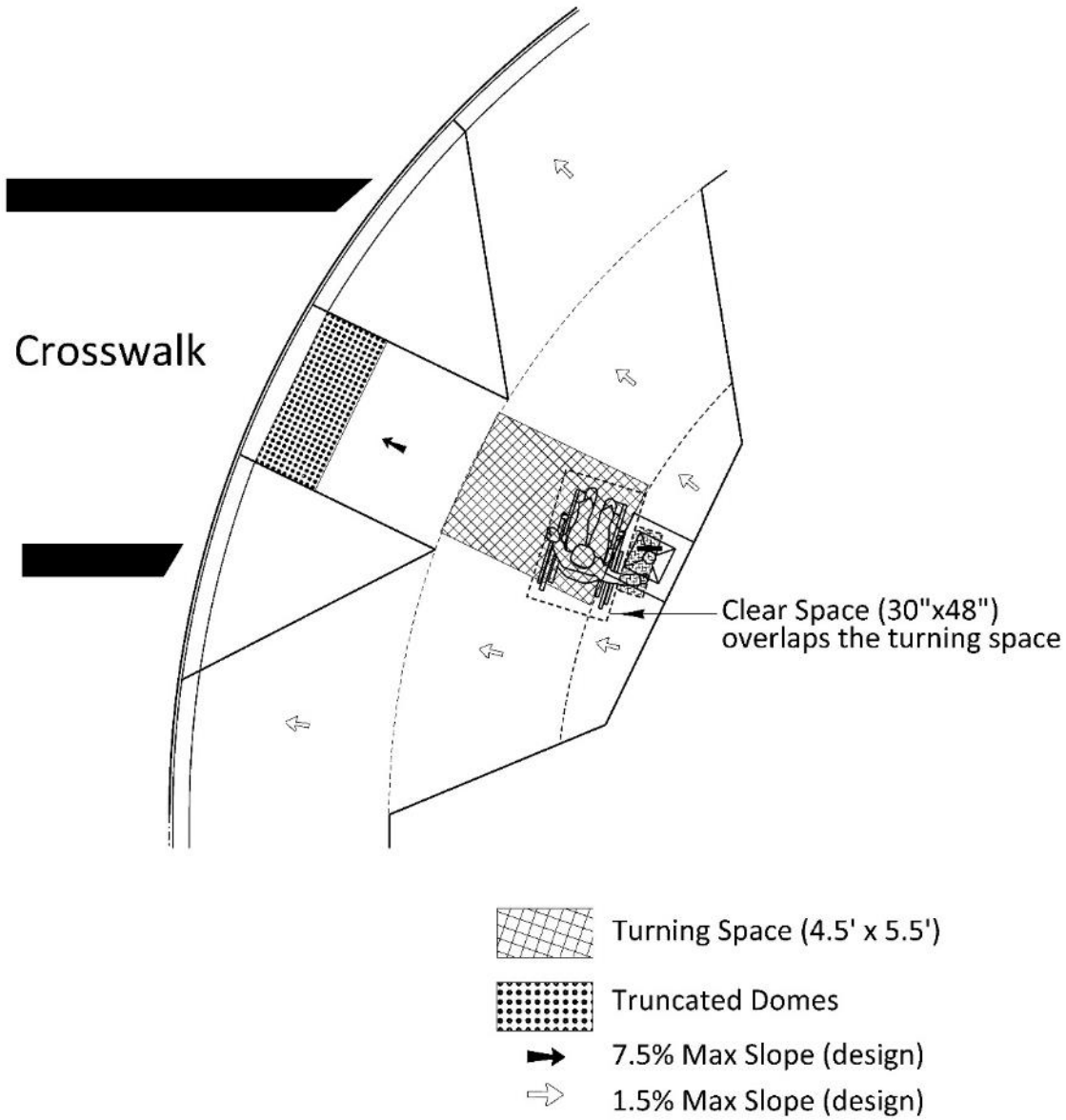


Figure 5-67 | Turning and Clear Space – Parallel Curb Ramp (Parallel Approach)

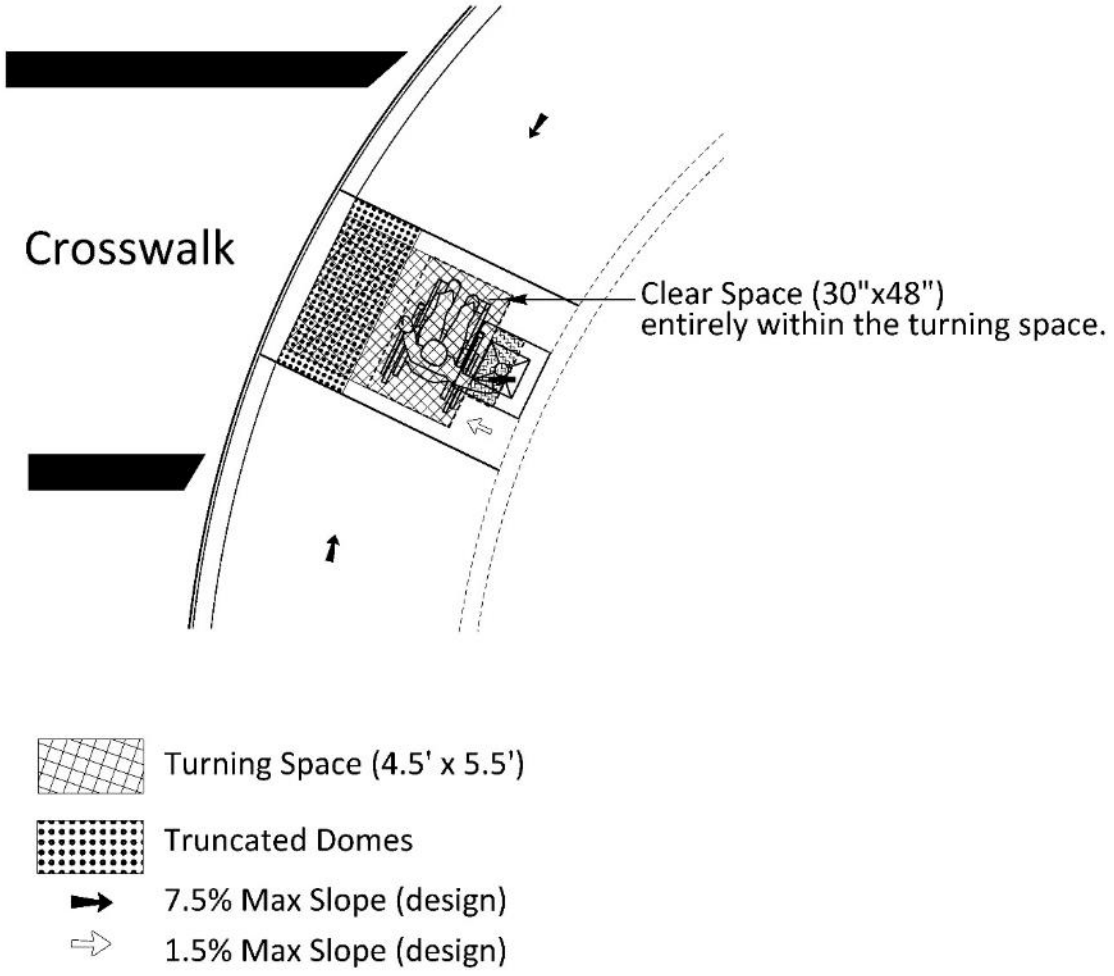
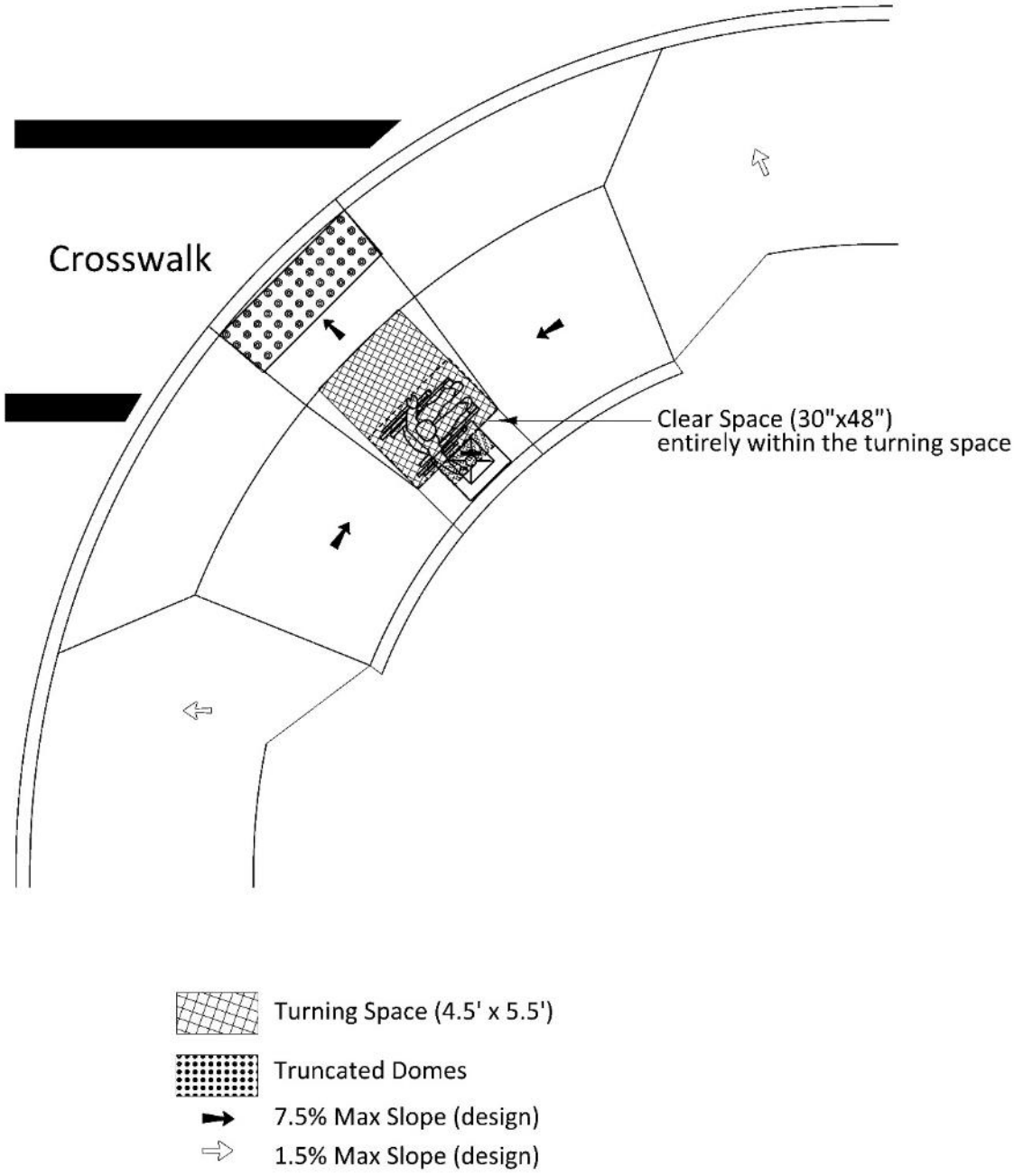


Figure 5-68 | Turning and Clear Space – Combo Curb Ramp (Parallel Approach)



When a wheelchair user is accessing the pushbutton, the clear space (30″x48″ or 36″x48″ as required) cannot be located within any surface that has a designed slope greater than 1.5% (design). See Figure 5-69 through Figure 5-71.

Figure 5-69 | Accessing the Pushbutton – Clear Space within 1.5% Slope (design), Example 1

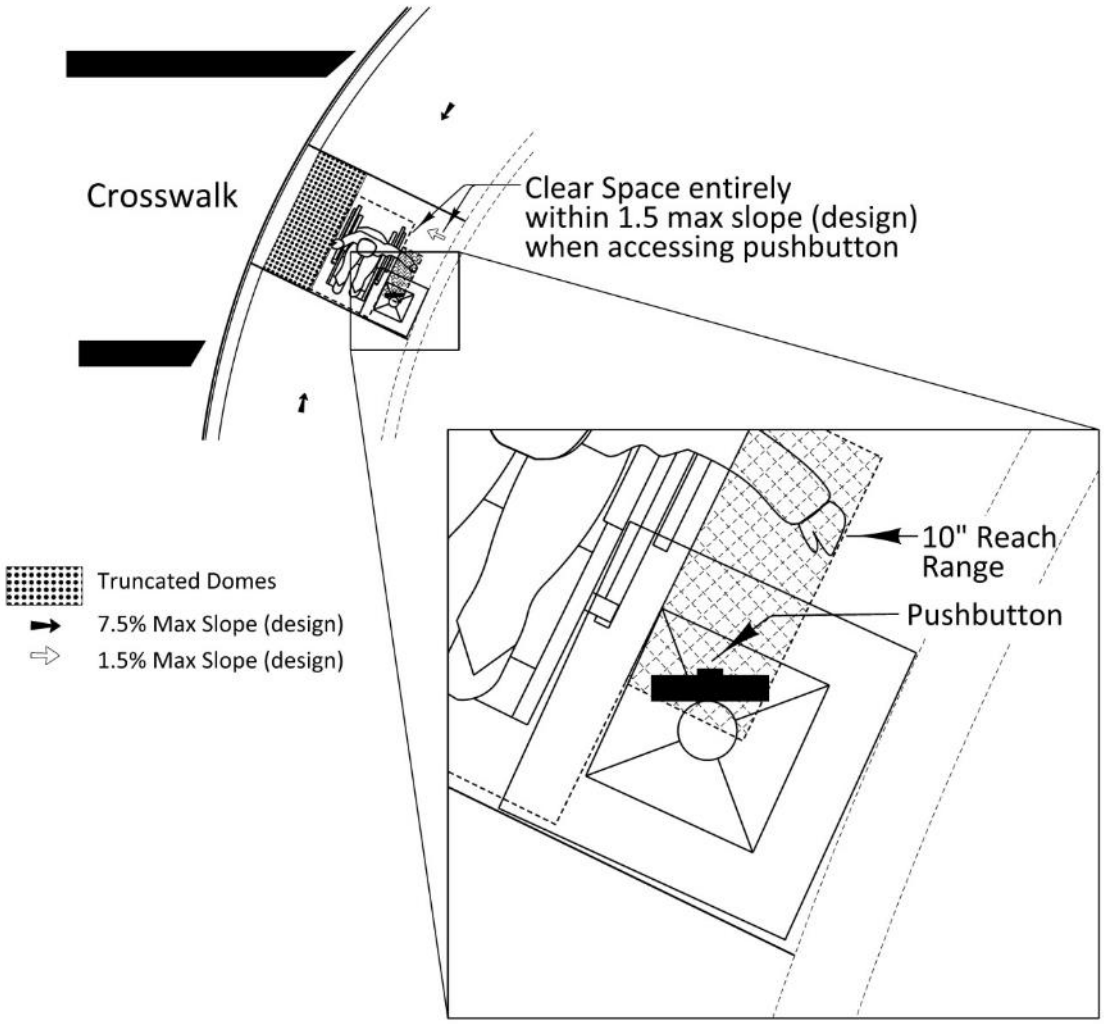


Figure 5-70 | Accessing the Pushbutton – Clear Space within 1.5% Slope (design), Example 2

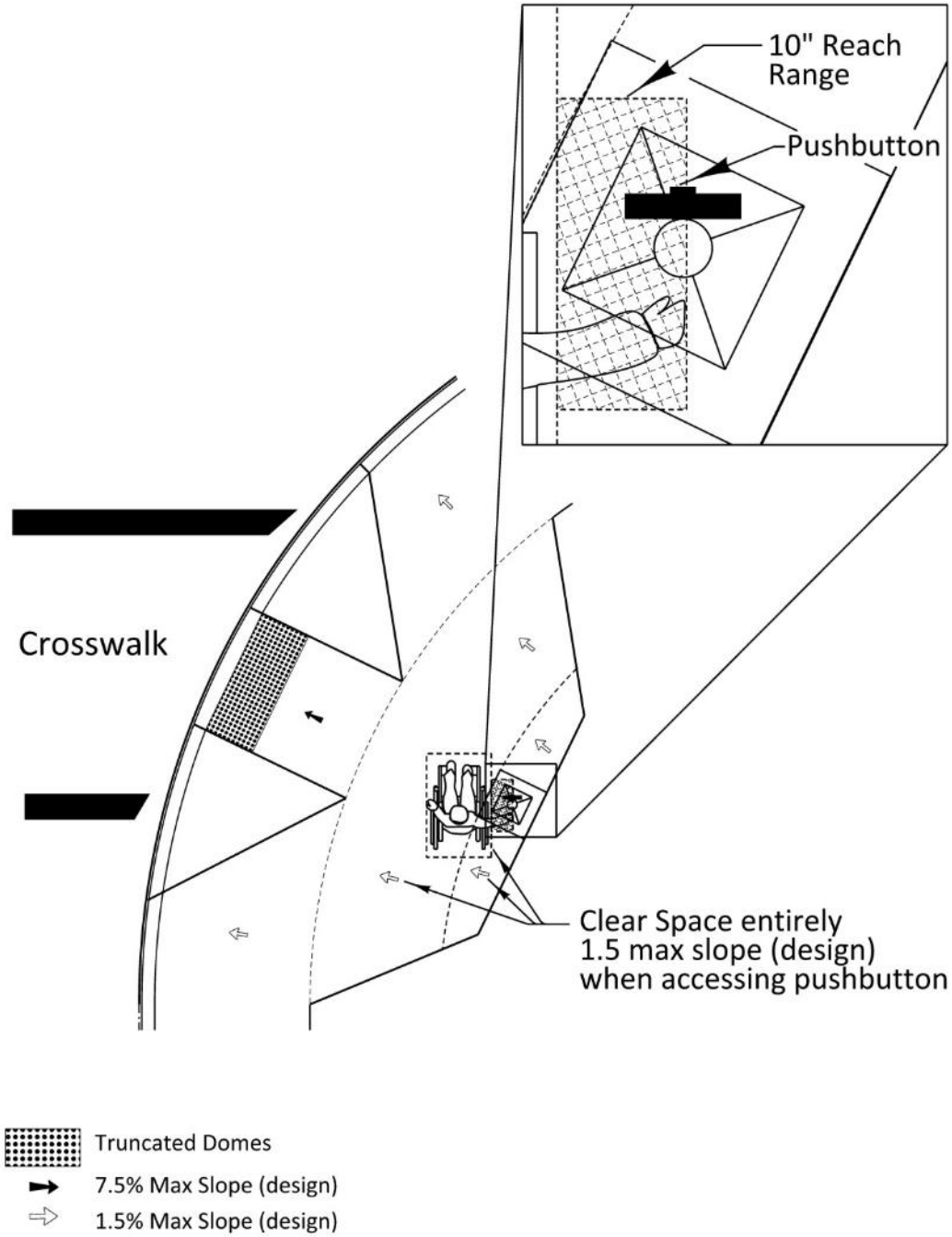
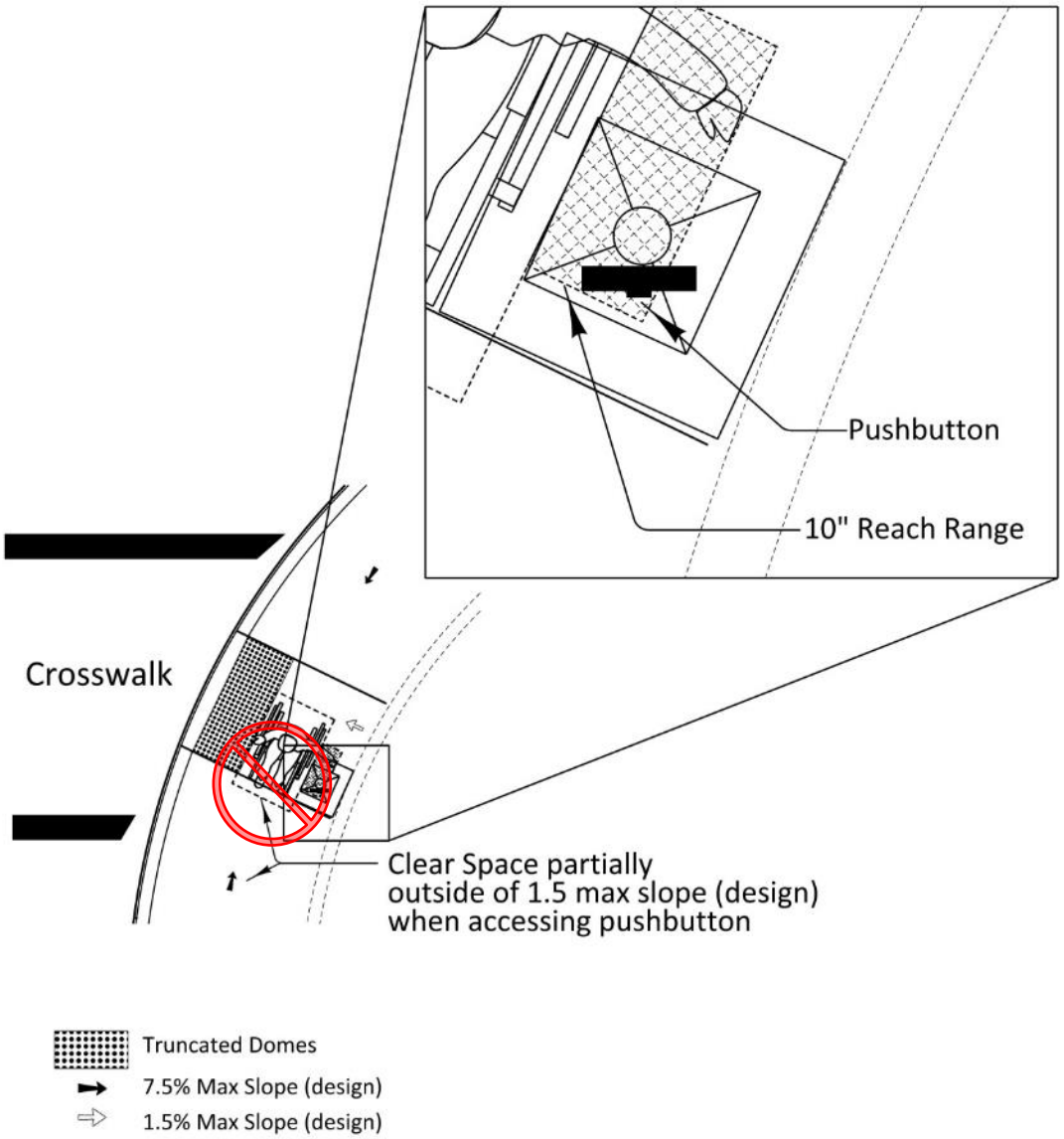


Figure 5-71 | Accessing the Pushbutton – Clear Space NOT within 1.5% Slope (design)



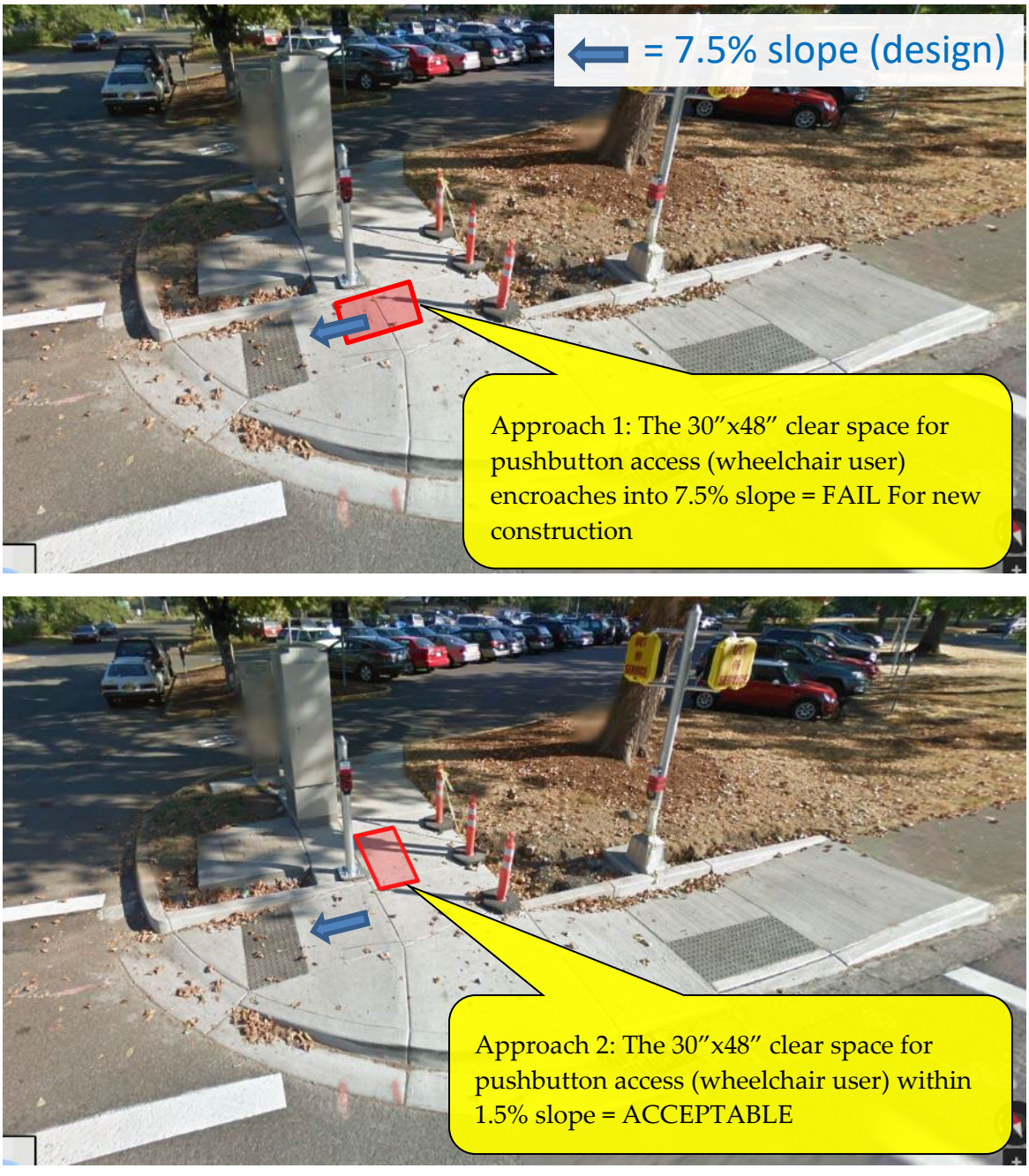
The clear space surface shall be comprised of a material that is solid (e.g., concrete, asphalt). Use of a poorly compacted material (pea gravel, uncompacted aggregate, or soil) will make it difficult or impossible for a wheelchair user to access the pushbutton. This is especially important to consider for temporary signals. See Figure 5-72.

Figure 5-72 | Poorly Compacted Material Example



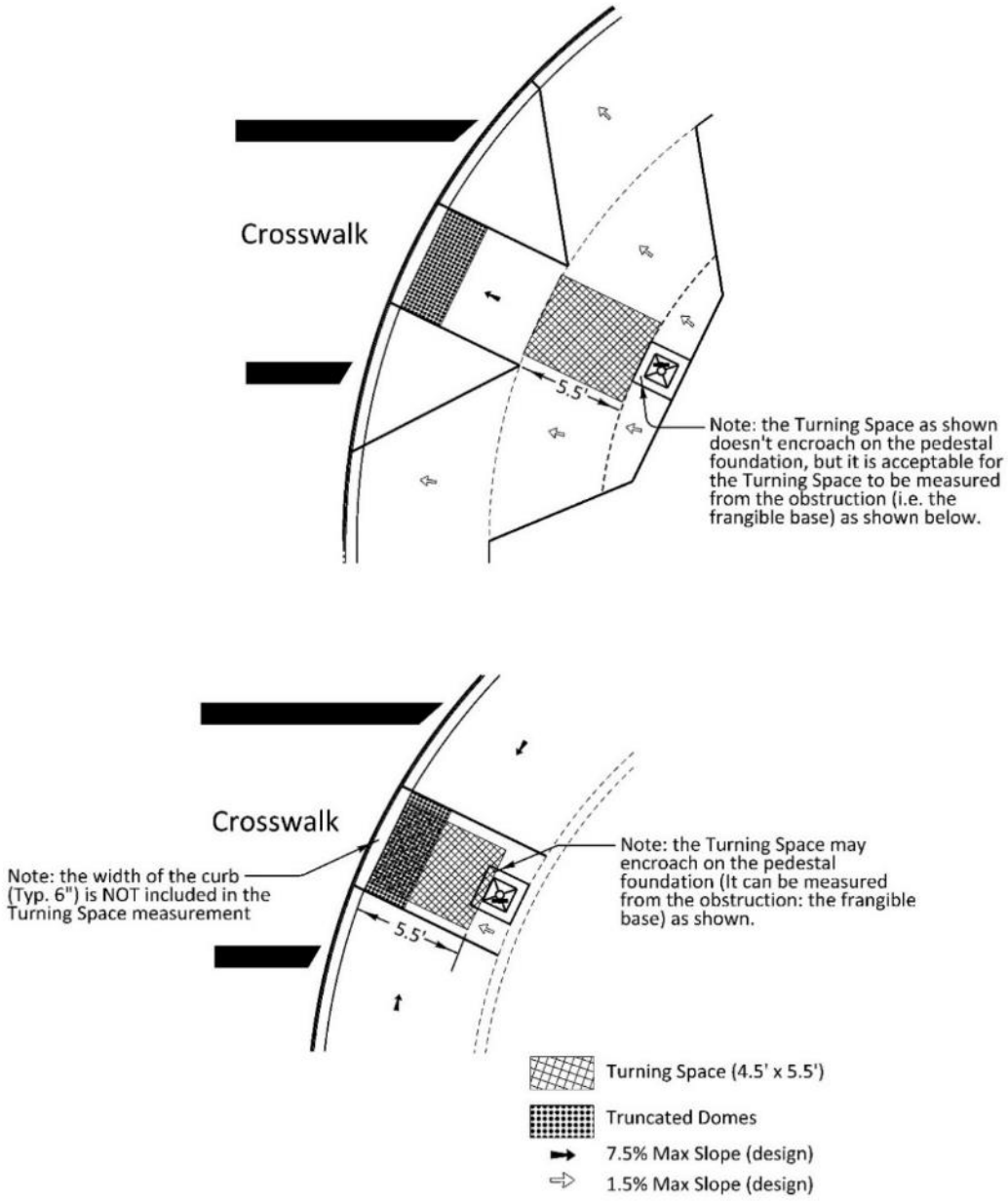
Depending on the curb ramp geometry, there may be multiple ways to parallel approach the pushbutton, which can mean the difference between meeting or failing the clear space slope requirement (1.5% design slope). See Figure 5-73. Be sure to verify the clear space from all possible approaches with the design vehicle in CADD. While only one approach is required to meet the requirements, accessing each approach to the pushbutton can lead to a better overall design that minimizes the amount of maneuvering for the wheelchair user.

Figure 5-73 | Multiple Ways to Parallel Approach the Pushbutton



The turning space for a curb ramp with pedestals or signal poles (obstructions) is required to be 4.5′ x 5.5′ with the 5.5′ dimension measured from the obstruction towards the curb ramp. The width of the curb shall NOT be included in the measurement. An obstruction to the turning space is defined as any vertical difference that is greater than ¼″ or any slope that is designed at greater than 1.5%. See Figure 5-74.

Figure 5-74 | Turning Space Measurement for Curb Ramp with Signal Equipment



The vertical reach requirements for the pushbutton will always be met when using standard traffic signal pedestals, poles, and pushbuttons. Pushbuttons mounted to non-standard equipment, structures, or in unusual locations require verification of the vertical requirements. This includes poles with ornamental bases and poles located behind or above barriers. See examples shown in Figure 5-75 and Figure 5-76.

Figure 5-75 | Verification of Pushbutton Vertical Height Required (Non-Std. Equipment) – Example 1



Figure 5-76 | Verification of Pushbutton Vertical Height Required (Non-Std. Equipment) – Example 2



Pushbuttons should be located no more than 15 feet from the access to the crosswalk (edge of curb ramp). See Figure 5-77. This distance should be measured going through the middle of the turning space to the edge of the curb ramp, which may not always be a straight line. See Figure 5-78. To achieve the most direct measurement (straight line) the clear space and the turning space should coincide or have a large overlap. If two pushbuttons are placed on a single pedestal, make sure to verify this distance for BOTH crosswalks, as it is possible one crosswalk to be within the recommended distance and the other not. See Figure 5-79.

Note that the MUTCD section 4E.08 states that the pushbutton should be 1.5 feet to 6 feet from the edge of curb ramp and allows up to 10 feet when physical constraints make closer placement impractical. While it is desirable to follow the MUTCD guidance and stay within 6 feet, certain curb ramps designed using ODOT standards will not even allow the placement of a pushbutton within 10 feet due to the slope requirements and the 7-inch standard curb exposure. Therefore, ODOT allows up to 15 feet to accommodate the majority of ODOT curb ramp designs. However, use of a combination curb ramp when feasible can help reduce this distance and get closer to meeting the MUTCD guidance. See Highway Design Manual section 815.3.3.

If it is not feasible to place the pushbutton within 15 feet, adjustments to the signal timing walk phase can be made to mitigate the longer distance. Coordinate with the region signal timer if this distance will exceed 15 feet.

Figure 5-77 | Distance from Pushbutton to Crosswalk (Edge of Curb Ramp)

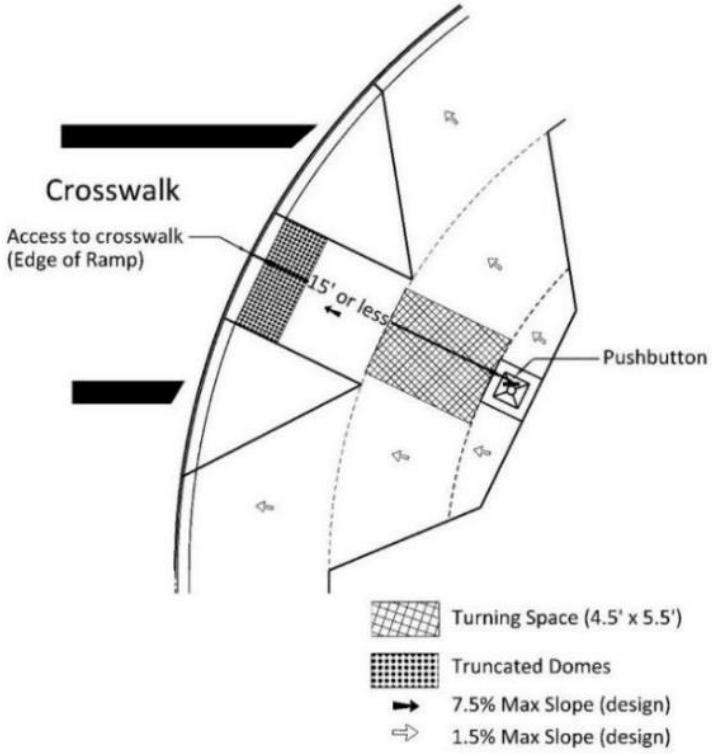


Figure 5-78 | Measuring Distance from Pushbutton to Crosswalk (Edge of Curb Ramp) Example 1

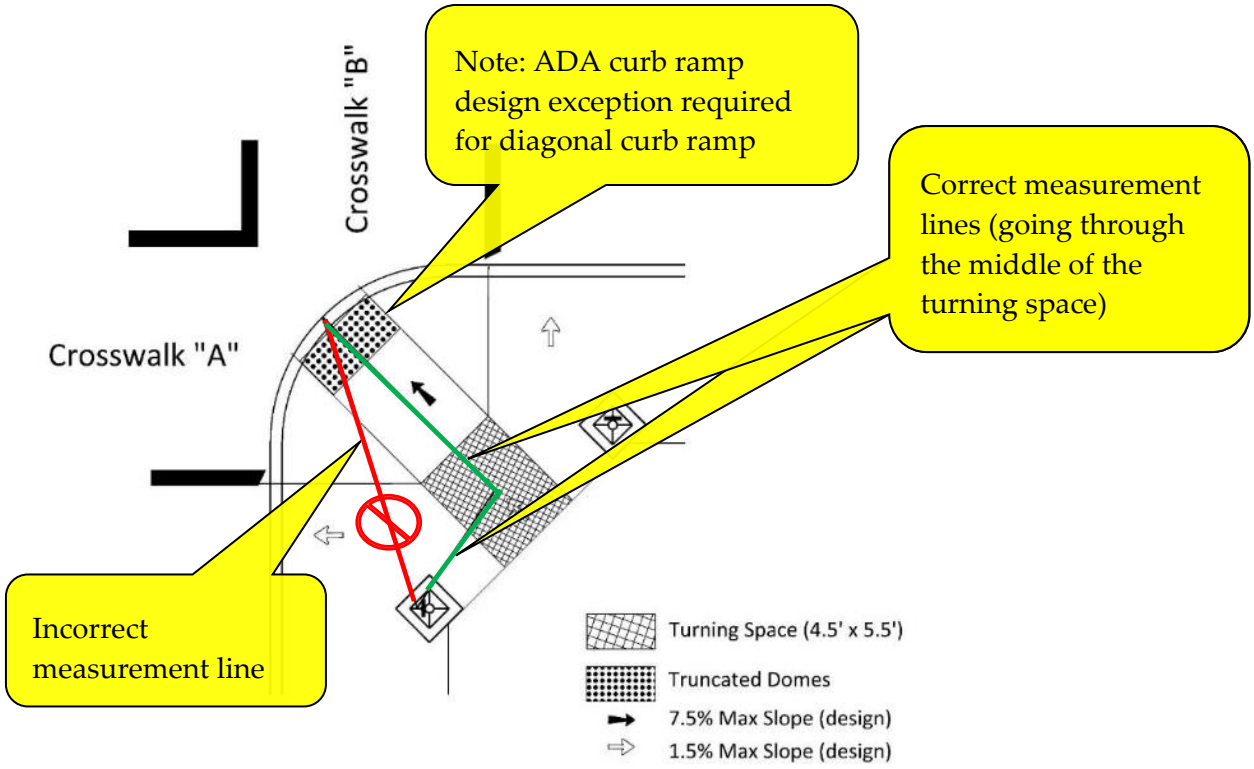
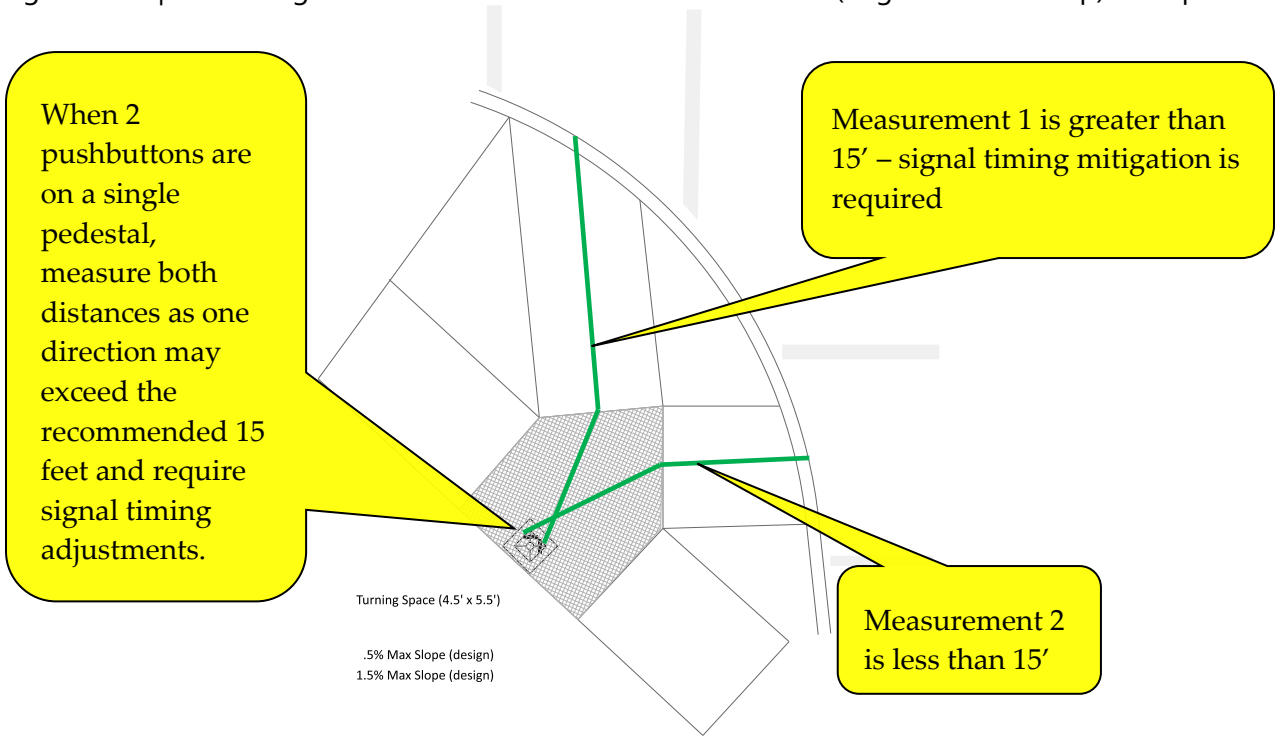


Figure 5-79 | Measuring Distance from Pushbutton to Crosswalk (Edge of Curb Ramp) Example 2

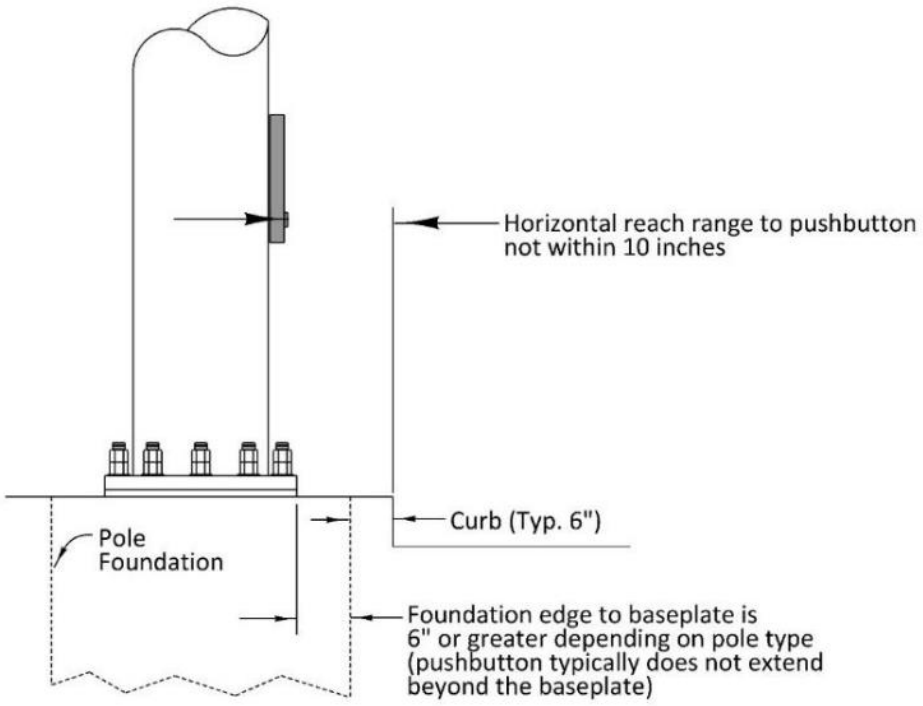


5.4.6 Deviation: Pushbutton Mounted on a Large Pole

Pushbuttons mounted on large poles are discouraged due to the tight tolerances for the 10-inch horizontal reach and high probability of requiring an extension bracket mount. As such, pushbuttons mounted on a large pole should only be considered in rare cases where a pedestal cannot be installed (e.g., areas with limited right-of-way, utility conflicts, etc.).

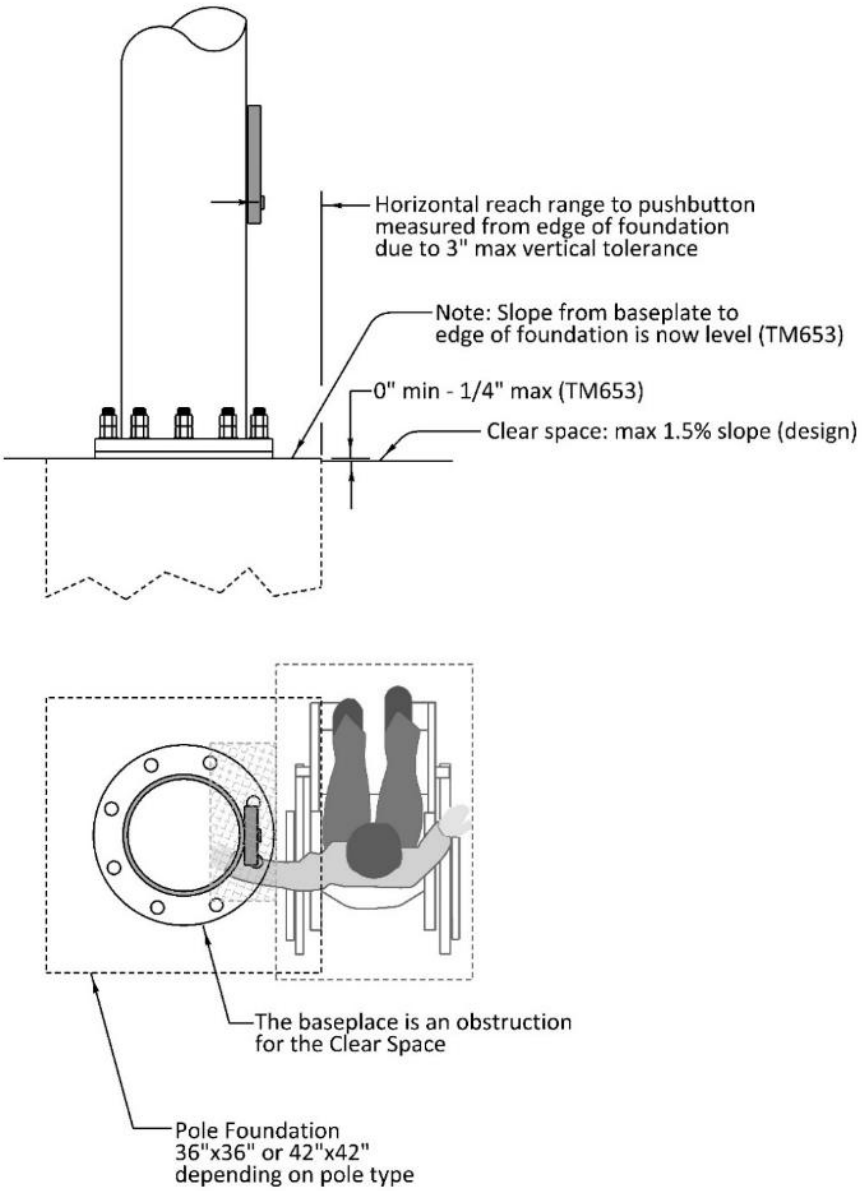
Mounting a pushbutton to a large pole limits the type of curb ramp that may be used. Typically, only a perpendicular curb ramp style will work, with a larger clear space to accommodate the back-in/head-in maneuver. See Figure 5-65. The two other curb ramp styles (parallel and combo) both may include a curb which will not meet the 10-inch horizontal reach if the pole is placed behind the curb. See Figure 5-80. Unlike a pedestal foundation, it is typically not practical to place the large pole foundation in front of the curb if one exists. Integrating the pole foundation with the curb installation, to achieve the 10-inch horizontal reach, is also not recommended due to the increased the complexity of construction (requires custom design details and excellent coordination/cooperation between sub-contractors). If the parallel and combo ramp are able to be designed without the curb at back of ramp, mounting the pushbutton on a large pole becomes a more feasible option when the use of pedestals is restricted.

Figure 5-80 | Poles Located Behind Curbs Do NOT Meet 10-Inch Horizontal Reach Requirement



The foundation of the large pole is no longer an obstruction to the clear space due to recent changes to standard drawing TM653 (the slope from baseplate to edge of foundation is now level and the vertical tolerance of the foundation to the adjacent asphalt or concrete finish grade is now 0" to ¼"). For large poles constructed after January 2020, the baseplate is the obstruction to the clear space. See Figure 5-81.

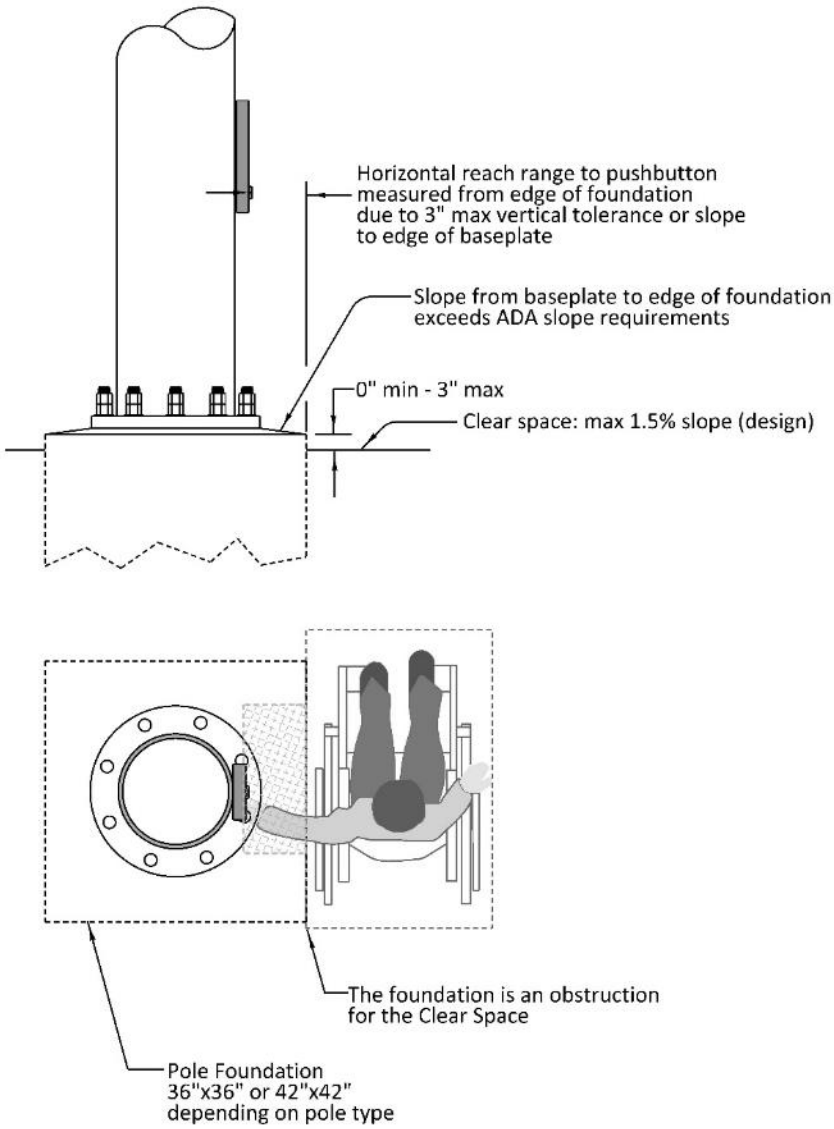
Figure 5-81 | Measuring Horizontal Reach to Pushbutton Mounted on Large Pole (POLES CONSTRUCTED AFTER JANUARY 2020)



For poles constructed before January 2020, the foundation is likely an obstruction to the clear space for two reasons (see Figure 5-82):

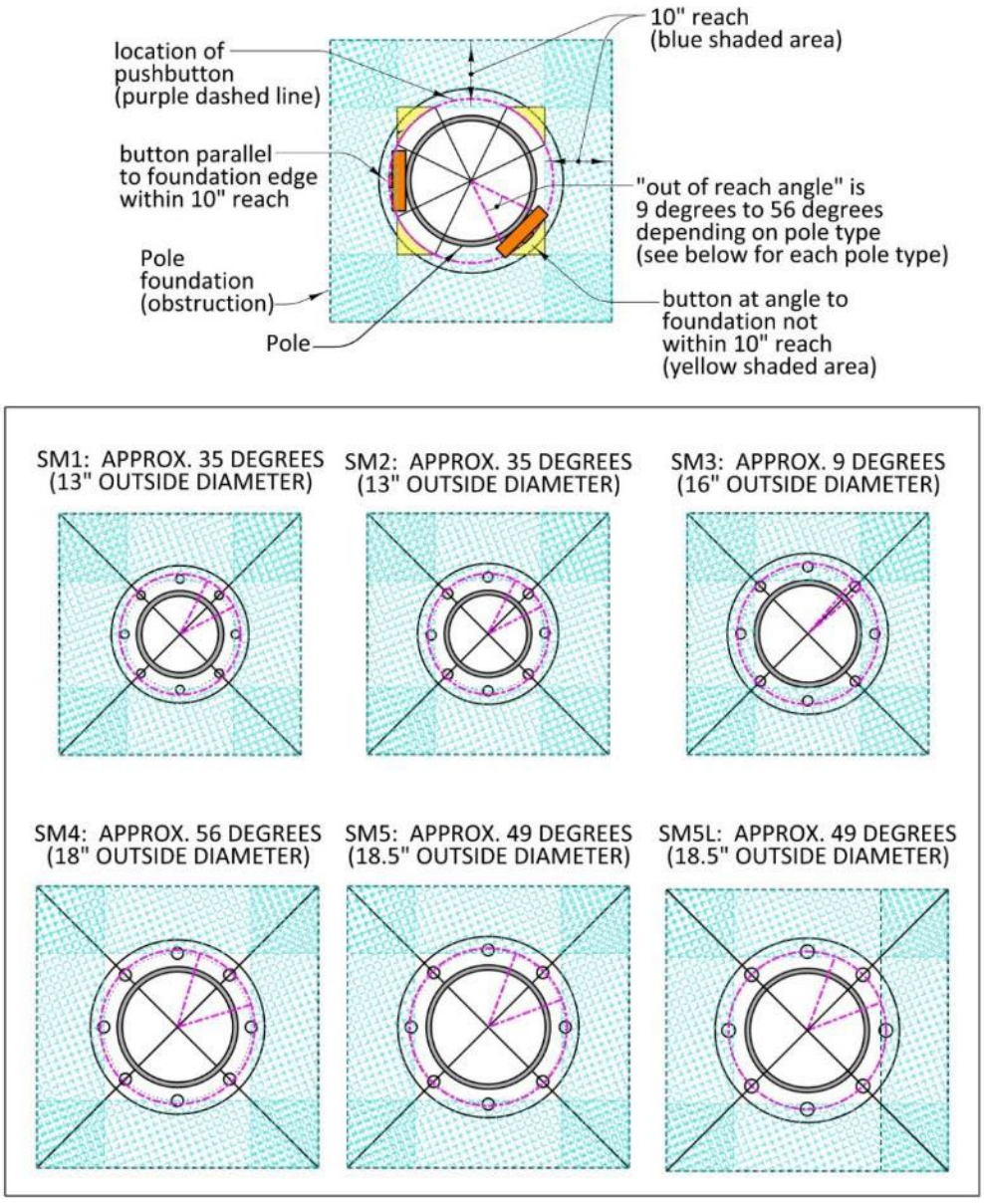
- The 3-inch max vertical tolerance for foundation exposure with respect to the adjacent finish grade, or
- The slope from the foundation control point to the edge of the baseplate exceeds ADA slope requirements.

Figure 5-82 | Measuring Horizontal Reach to Pushbutton Mounted on Large Pole (POLES CONSTRUCTED BEFORE JANUARY 2020)



For poles where the foundation is an obstruction for the clear space (poles constructed before January 2020), the reach distance measured from the edge of the signal pole foundation to the pushbutton will just barely meet the 10-inch horizontal reach for MOST all pole types and pushbuttons listed on the approved blue sheets IF THE PUSHBUTTON IS MOUNTED PARALLEL TO THE EDGE OF THE FOUNDATION. See Figure 5-82. If the pushbutton is installed at an angle to the foundation, there is a point where it will fall outside the 10-inch horizontal reach ("out-of-reach angle"). See Figure 5-83.

Figure 5-83 | Out-of-Reach Angle for Pushbuttons Located on Large Poles (POLES CONSTRUCTED BEFORE JANUARY 2020)



5.4.7 Deviation: Two Pushbuttons Mounted on a Single Pedestal

Two pushbuttons on the same pedestal is the preferred solution for two scenarios:

- For two curb ramps that share a single turning space
- When an ADA curb ramp design exception has been granted for a diagonal curb ramp (one curb ramp that will serve two crosswalks)

Trying to accommodate the 8-foot pushbutton separation for these two scenarios is not recommended due to the following drawbacks:

- The turning space and the clear space would separated by a large distance. This creates a longer (and unnecessary) path for the wheelchair user in certain directions. For example, a parallel style diagonal curb ramp the wheelchair user would have to traverse the 7.5% slope three times if approached from a certain direction. See Figure 5-84
- Unable to meet the MUTCD requirement of 60 inch maximum from the outside edge of the crosswalk striping to the pushbutton in most cases. When pedestrian signal indications are mounted on the same pedestal as the pushbutton, they would likely be blocked from the pedestrian's view by cars stopped at the intersection. See Figure 5-84.
- If the pushbuttons are placed adjacent to the turning space (so that the clear space will coincide with or overlap the turning space), typically only 5 to 6 feet of separation can be achieved. Short separation distances are not desirable as they can create an "obstacle course" on the sidewalk that may be difficult for the sight impaired to navigate. See Figure 5-85.

Note that the MUTCD section 4E.08 states that the pushbuttons should be separated by 10 feet and allows the pushbuttons to be placed closer or on the same pole when it is impractical to achieve the 10-foot separation. While it is desirable to follow the MUTCD guidance and separate the pushbuttons by 10 feet, we have encountered enough locations where pushbutton separation between 8 to 10 feet provides the best access to the pushbuttons within the site constraints. Pushbutton separation of 8 to 10 feet still allows a reasonable amount of separation to avoid creating an "obstacle course" and alternative audible pedestrian messages for buttons less than 10 apart are allowed as per the MUTCD. Therefore, ODOT allows a minimum pushbutton separation of 8 feet. If it is not feasible to separate the pushbutton 8 feet, both pushbuttons should be mounted on a single pedestal.

Figure 5-84 | Drawbacks to the 10-foot Separation of Pushbuttons at Diagonal Curb Ramps

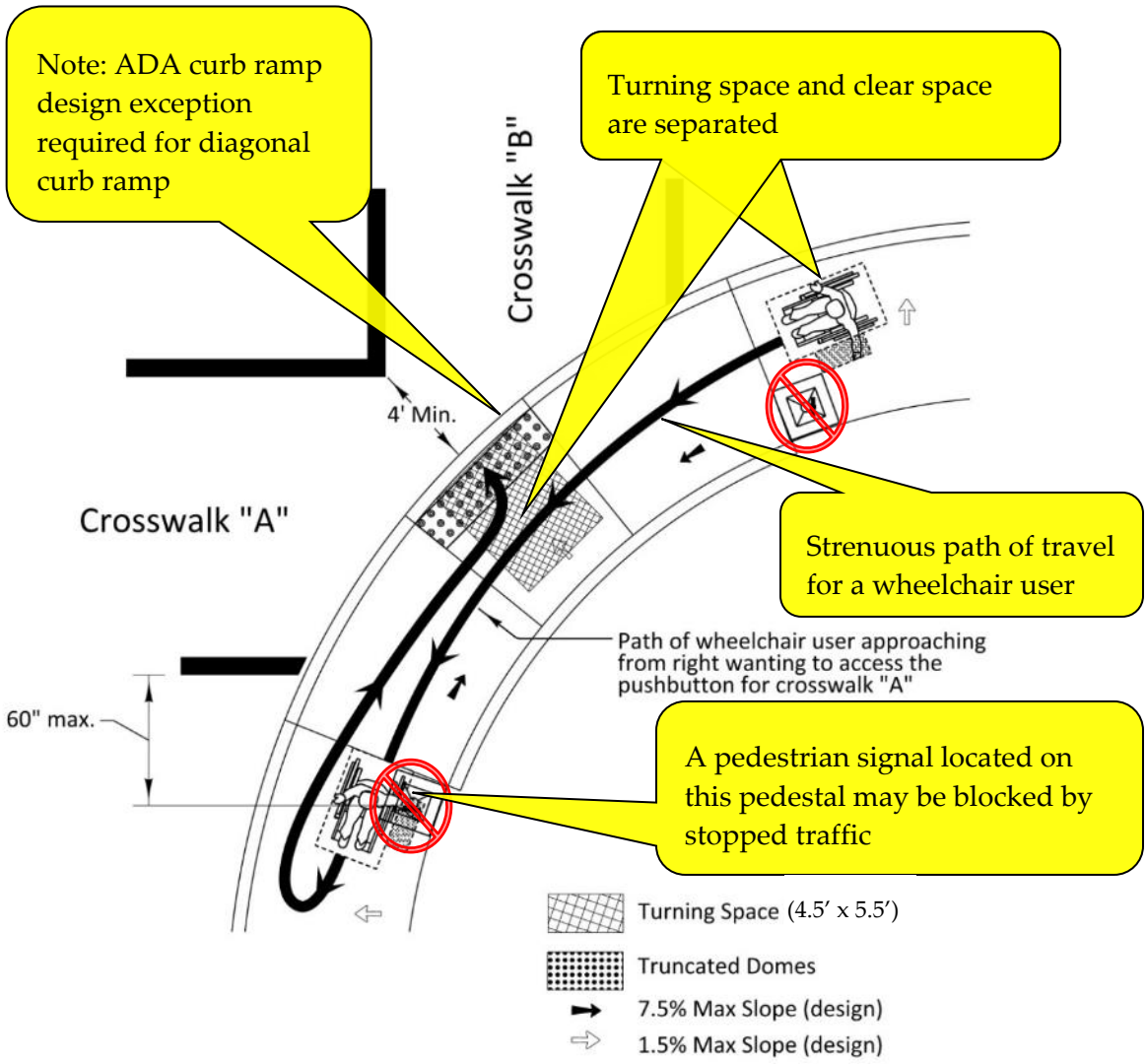
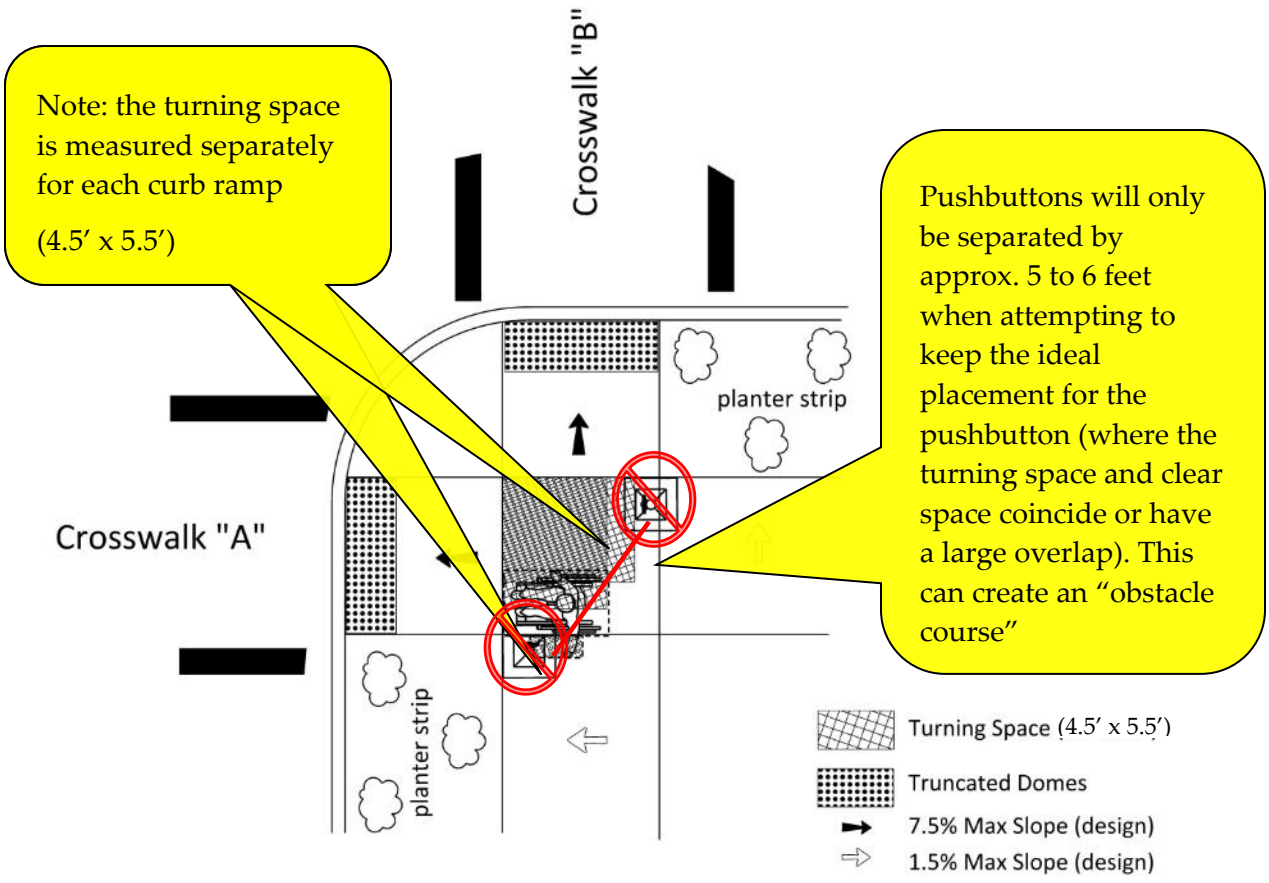


Figure 5-85 | Drawbacks to the 10-foot Separation of Pushbuttons at Two Curb Ramps That Share a Turning Space



See Figure 5-86 for an example of the preferred placement for two curb ramps that share single turning space and Figure 5-87 through Figure 5-90 for the preferred placement for common styles of diagonal curb ramps and combo ramps.

Figure 5-86 | Preferred Pushbutton Placement for Two Curb Ramps That Share a Turning Space (Two Buttons on Pedestal)

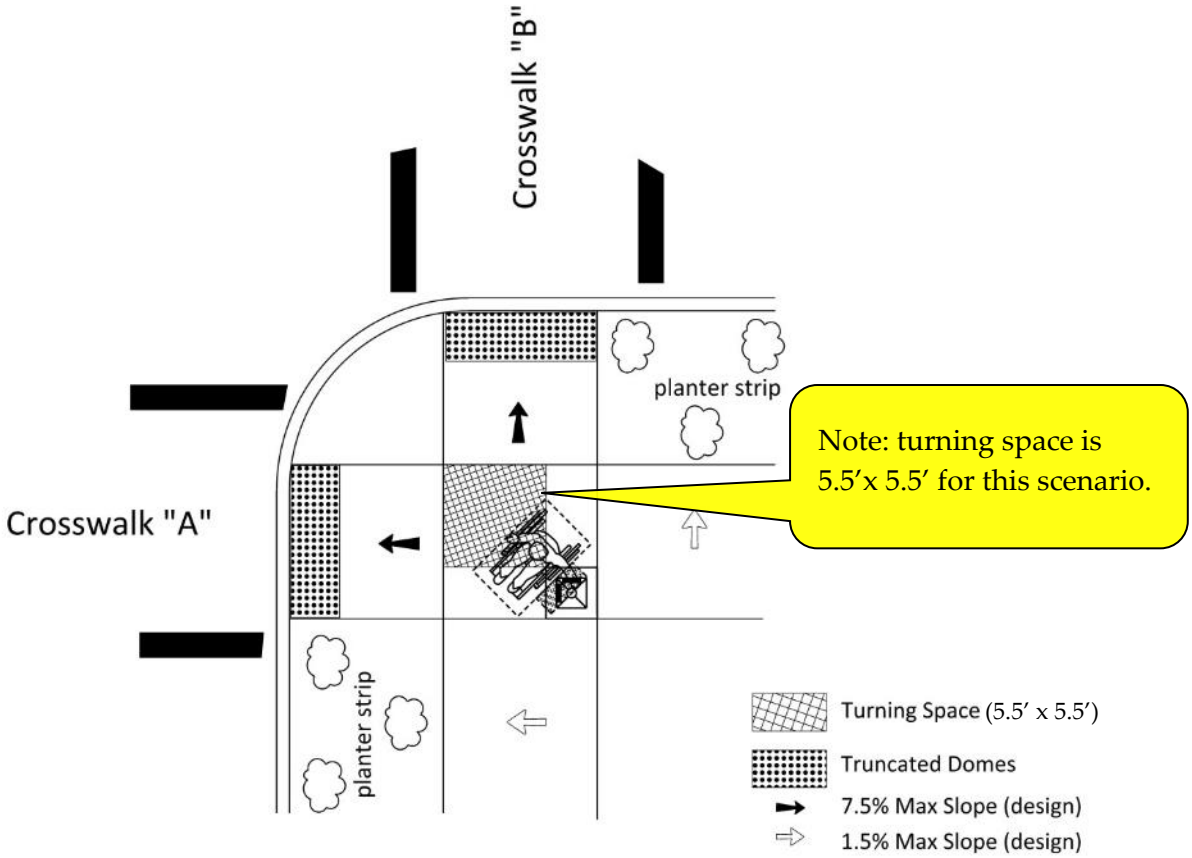


Figure 5-87 | Preferred Pushbutton Placement for Diagonal Perpendicular Style Curb Ramp (Two Buttons on Pedestal)

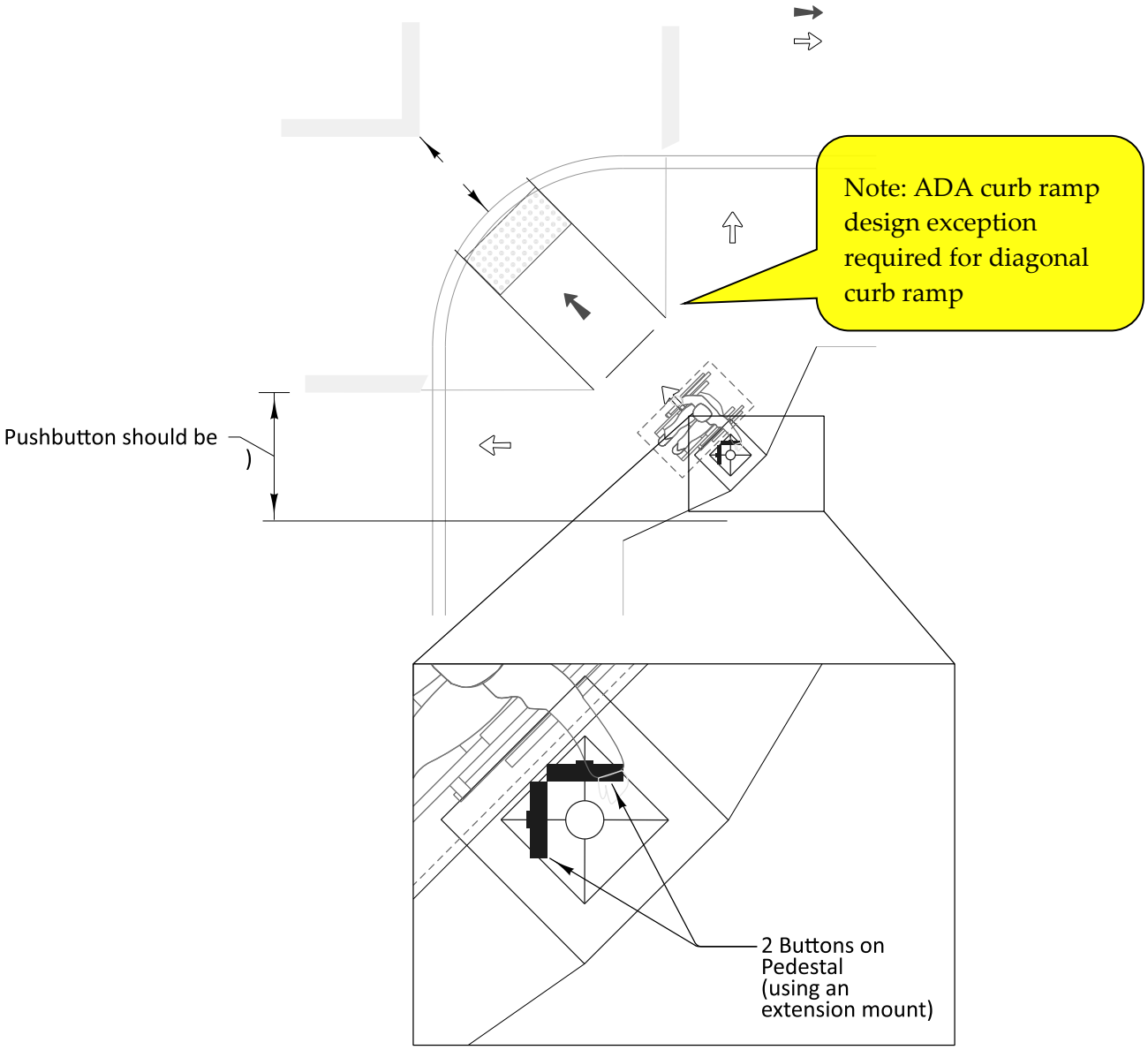


Figure 5-88 | Preferred Pushbutton Placement for Diagonal Parallel Style Curb Ramp (Two Buttons on Pedestal) – Example 1

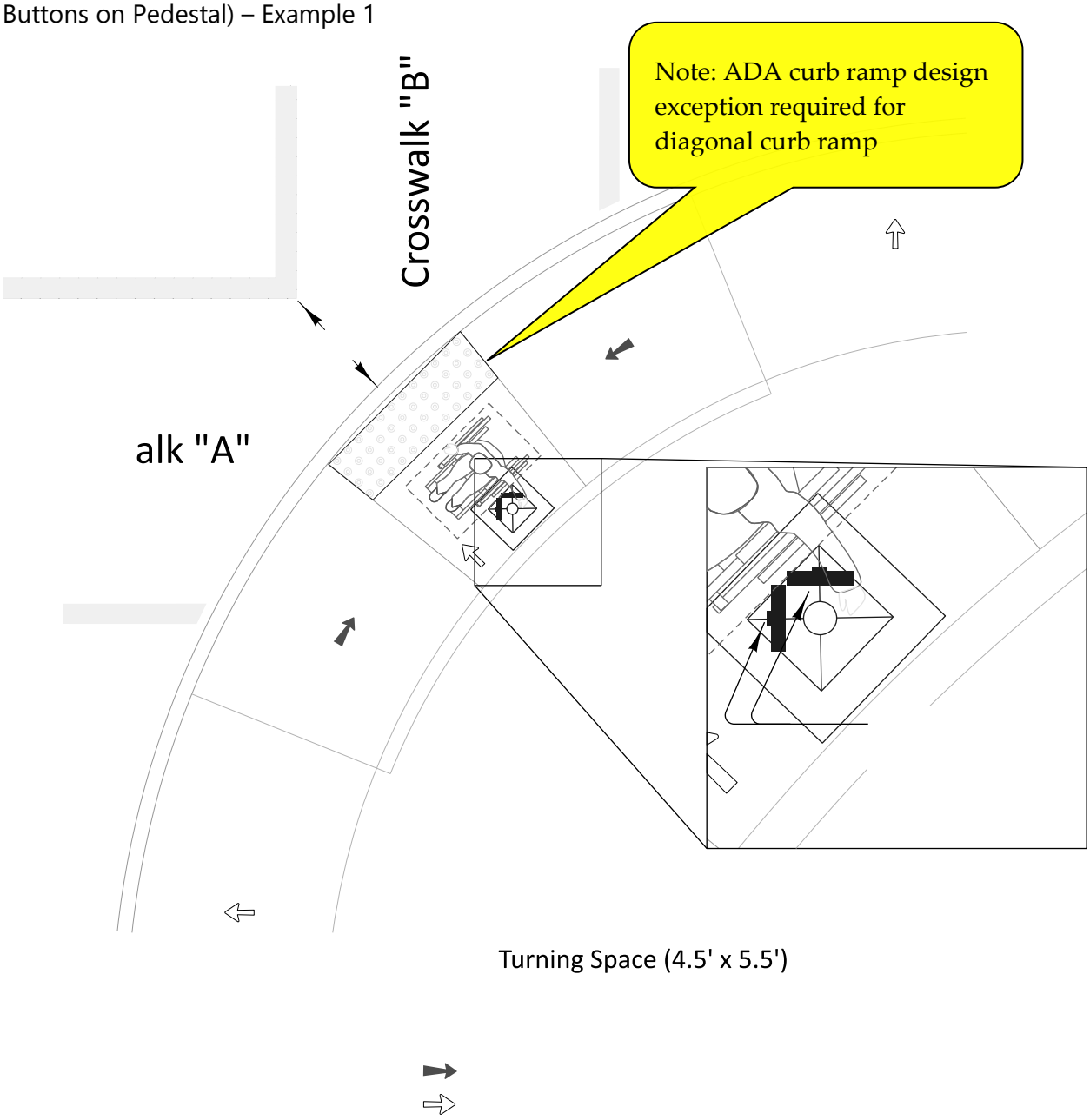


Figure 5-89 | Preferred Pushbutton Placement for Diagonal Parallel Style Curb Ramp (Two Buttons on Pedestal) – Example 2

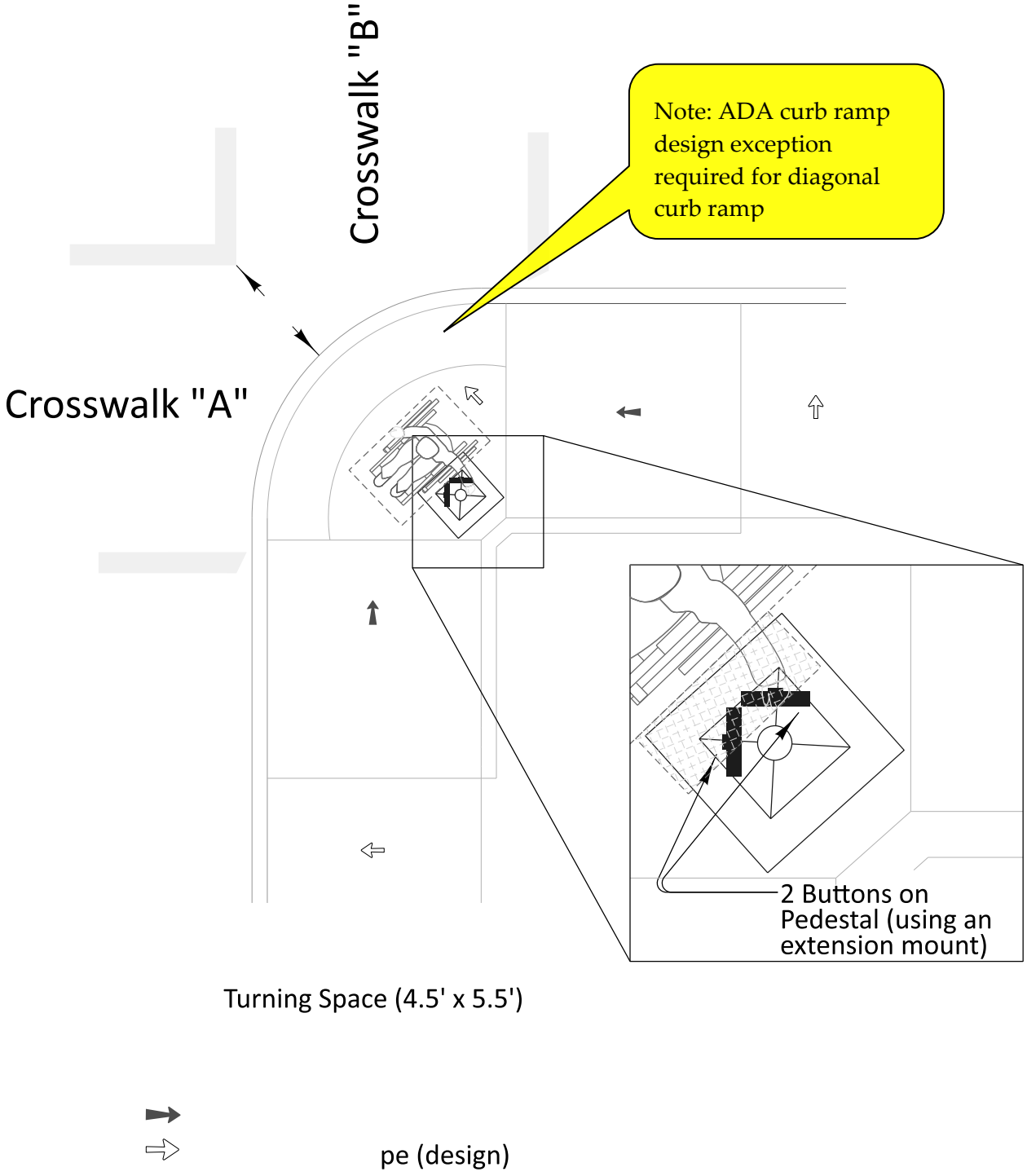
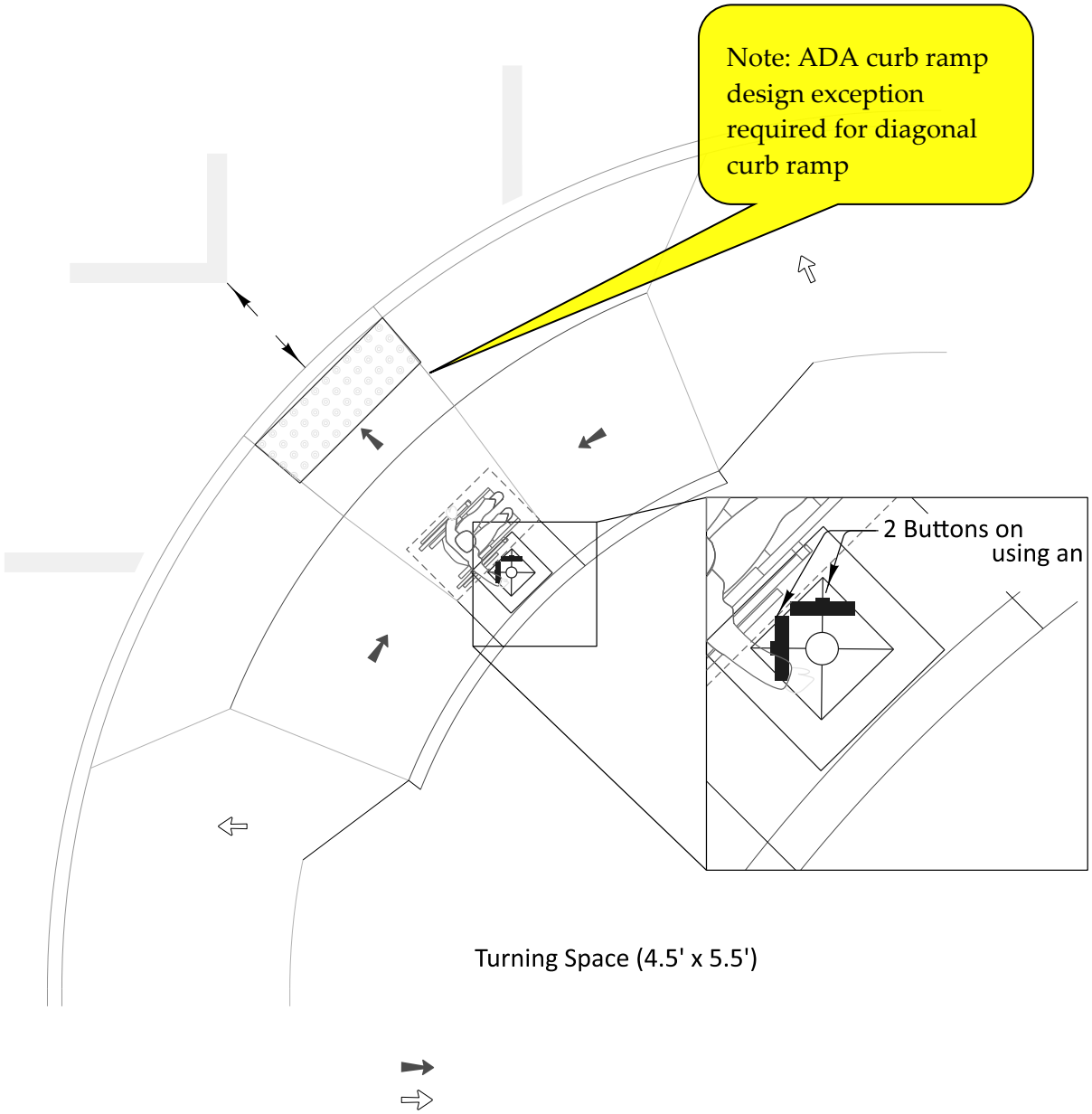


Figure 5-90 | Preferred Pushbutton Placement for Diagonal Combo Style Curb Ramp (Two Buttons on Pedestal)



Several items need extra attention when a diagonal curb ramp serves two crosswalks. Verify the following:

- The pushbutton is located within 60 inches of the outside edge of the crosswalk striping. See Figure 5-91.
- The location of the pedestrian indications will not be blocked by from view by traffic stopped at the stop line. This can be challenging when the radius is small. Advance stop lines may be an appropriate solution to preserve the pedestrian's line of sight to the pedestrian indications.
- There is 4' minimum between the curb ramp and the inside crosswalk striping. This distance provides the wheelchair user a location to maneuver to the desired crosswalk and should be outside of the travel way (including bike lanes). Note that meeting this 4' minimum dimension may not be possible with a small radius. See Figure 5-92.

Figure 5-91 | Pushbutton 60" From Outside Edge of Crosswalk Striping at Diagonal Curb Ramp

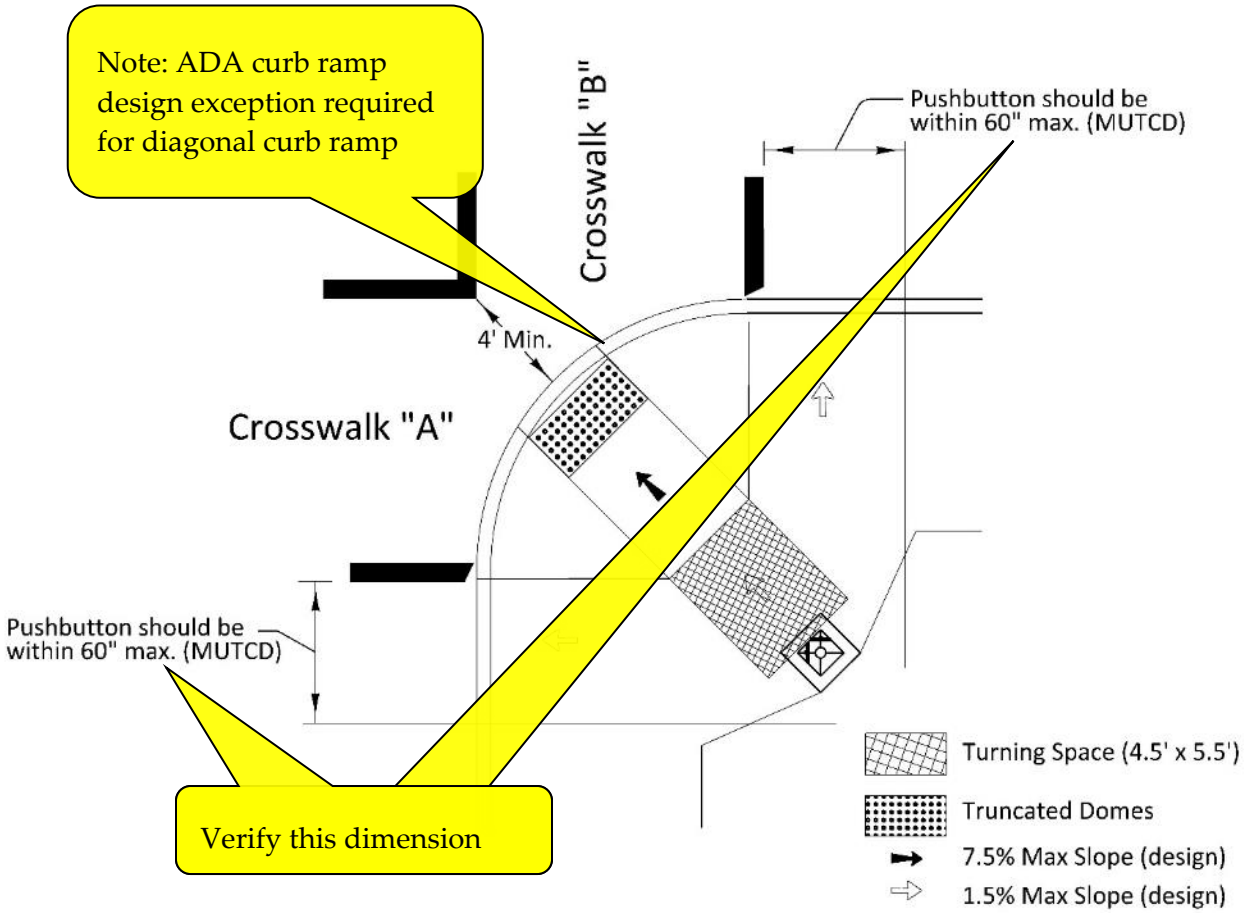
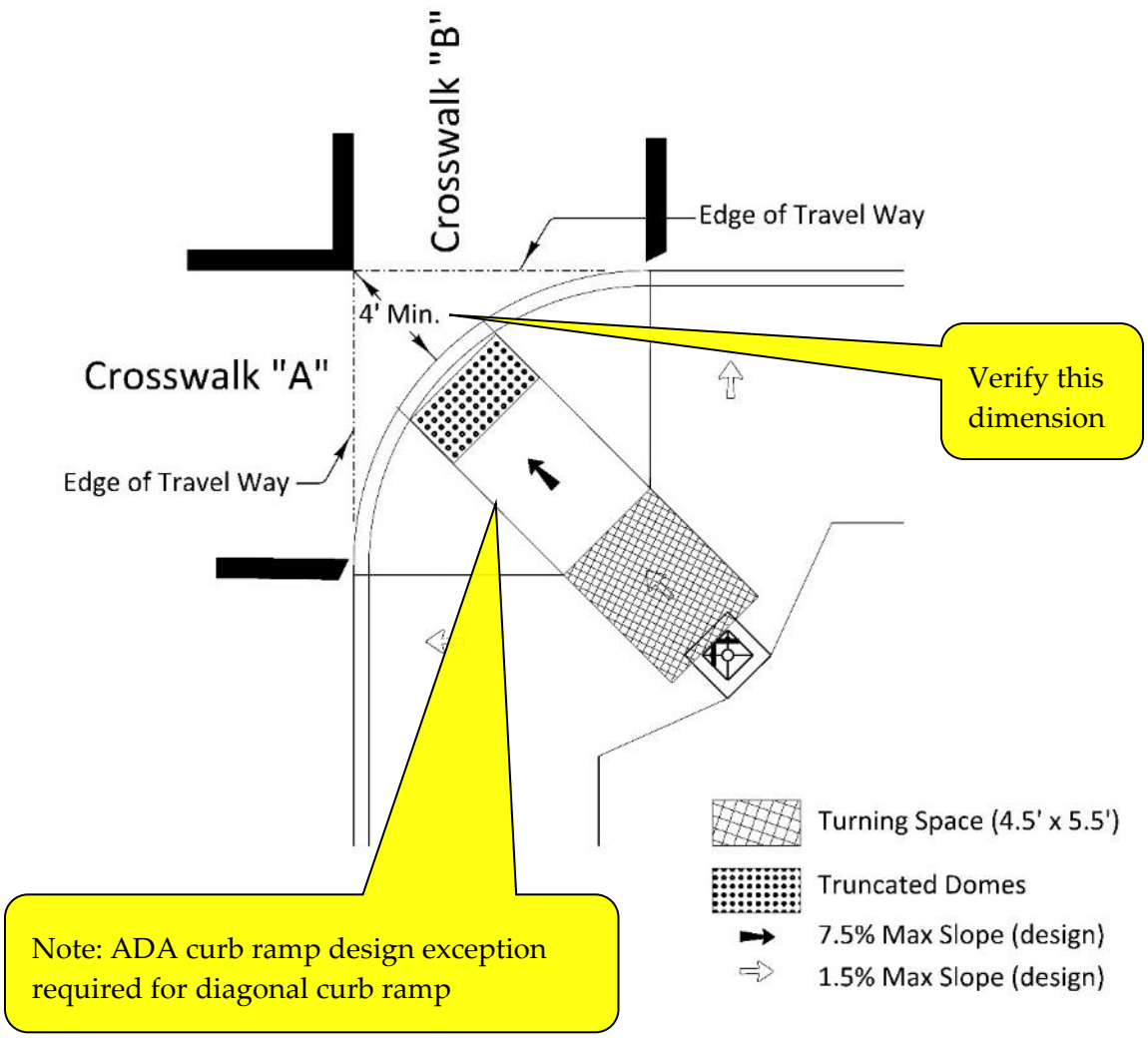


Figure 5-92 | 4′ Minimum Distance Between Curb Ramp and Inside of Crosswalk Striping at Diagonal Ramp



5.4.8 Deviation: Use of an Extension Bracket Mount

Pushbuttons mounted on extensions are discouraged due to the potential for increased maintenance problems and they can also be a potential hazard for pedestrians if they protrude into the clear circulation path. The extension bracket should not be longer than 12 inches to minimize damage caused from improper use (e.g., pedestrian sitting/leaning/pushing/pulling on the extension bracket). Pushbuttons using an extension bracket may not extend more than 4 inches into the clear circulation path (see standard drawing RD720). As such, they should only be used in two specific cases:

- When two pushbuttons must be mounted on 4" diameter pole, as required by TM467. See Figure 5-93.
- Retro-fitting existing installations that do not meet the 10-inch horizontal reach due to a detectable obstacle located on the ground (typically a curb). See Figure 5-94 and Figure 5-95. Do NOT use an extension bracket if reach cannot be obtained due to a slope (as the bracket will protrude more than 4 inches into the circulation path as shown in Figure 5-96).

Figure 5-93 | Extension Bracket Mount for Two Pushbuttons on 4 Inch Diameter Pole



Figure 5-94 | Extension Bracket Mount Example – Standard Button Style



Figure 5-95 | Extension Bracket Mount Example – H-Frame



Figure 5-96 | Extension Bracket Mount Photoshop Example – Extending More Than 4 Inches into the Pedestrian Circulation Path



5.4.9 Deviation: Vertical Reach of Pushbutton

The traffic signal standard drawings state the pushbutton vertical mounting height is 42" to 48". This height should work for most installations. However, the PROWAG requirements allow mounting heights from 15" to 48" to accommodate a wide variety of users and applications. At locations where a request has been made or high volume of children are expected to use the pushbuttons, it may be beneficial to mount the pushbutton slightly lower at 36" rather than the standard location shown on the standard drawings.

While the PROWAG requirements allow placement down to 15", mounting pushbuttons below 36" begins to become less accessible for a large portion of users (requiring them to stoop down to use the pushbutton) and is not recommended. In cases where a mounting height of lower than 36" is necessary to accommodate a user (e.g., access via a wheelchair footrest), consider the following solutions:

- The use of two pushbuttons (one mounted at the standard height and one mounted at the requested height). See Figure 5-97.
- The use of passive pedestrian detection
- The use of recalled pedestrian phases

Work with the state traffic signal engineer when considering a vertical reach deviation to determine the proper site-specific solution. Deviations to mounting height should be shown on the signal plan sheets with a prominent, custom note. Highlighting this deviation to the project manager's office and contractor is also recommended during the pre-construction meeting.

Figure 5-97 | Deviation to Vertical Reach Example



5.4.10 Pushbuttons Located Behind Guardrail

While not ideal, pushbuttons may be located behind guardrail if they meet the criteria specified in section 5.4.2. This can be accomplished by positioning the pedestal between the guardrail posts. Additional coordination between the guardrail installer and the signal installer during construction will be necessary to ensure compliance.

5.4.11 Extended Pushbutton Press Feature

The extended pushbutton press feature provides slower pedestrians an opportunity to request and receive a longer pedestrian clearance time. The region signal operations engineer will determine if this feature is needed. If this feature is used, an additional sign PUSH BUTTON FOR 2 SECONDS FOR EXTRA CROSSING TIME (R10-32P) is required to be mounted adjacent to the pedestrian pushbutton (see Figure 5-98). The Oregon specific sign shown in Figure 5-99 combines the two required federal signs and is preferred over installing the two federal signs.

Figure 5-98 | Extra Crossing Time Sign R10-32P



Figure 5-99 | Extra Crossing Time Sign OR-32



5.4.12 Pedestrian Signal Location

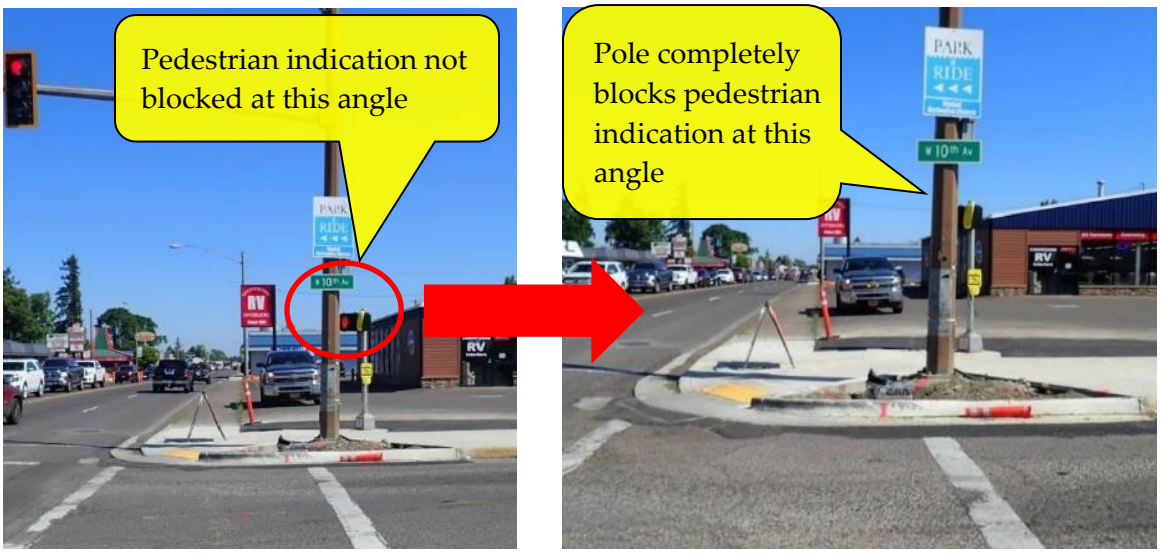
Pedestrian signals are required at all marked crosswalks at a signalized intersection, with the exception of crosswalks marked at channelized right turn lanes that are not controlled by a signal (i.e., right turn movement is either uncontrolled, yield or stop controlled).

All pedestrian signals shall have clear line of sight from within the crosswalk lines from one end of the crosswalk to the pedestrian signal at the other end of the crosswalk. See Figure 5-100. Verify the pedestrian signal will be visible the entire length of the crossing. This is best accomplished by ensuring there are no potential obstructions located in front of the pedestrian signal. See Figure 5-101. Potential obstructions can also include vehicles properly stopped at the crosswalk line.

Figure 5-100 | Good Pedestrian Signal Visibility

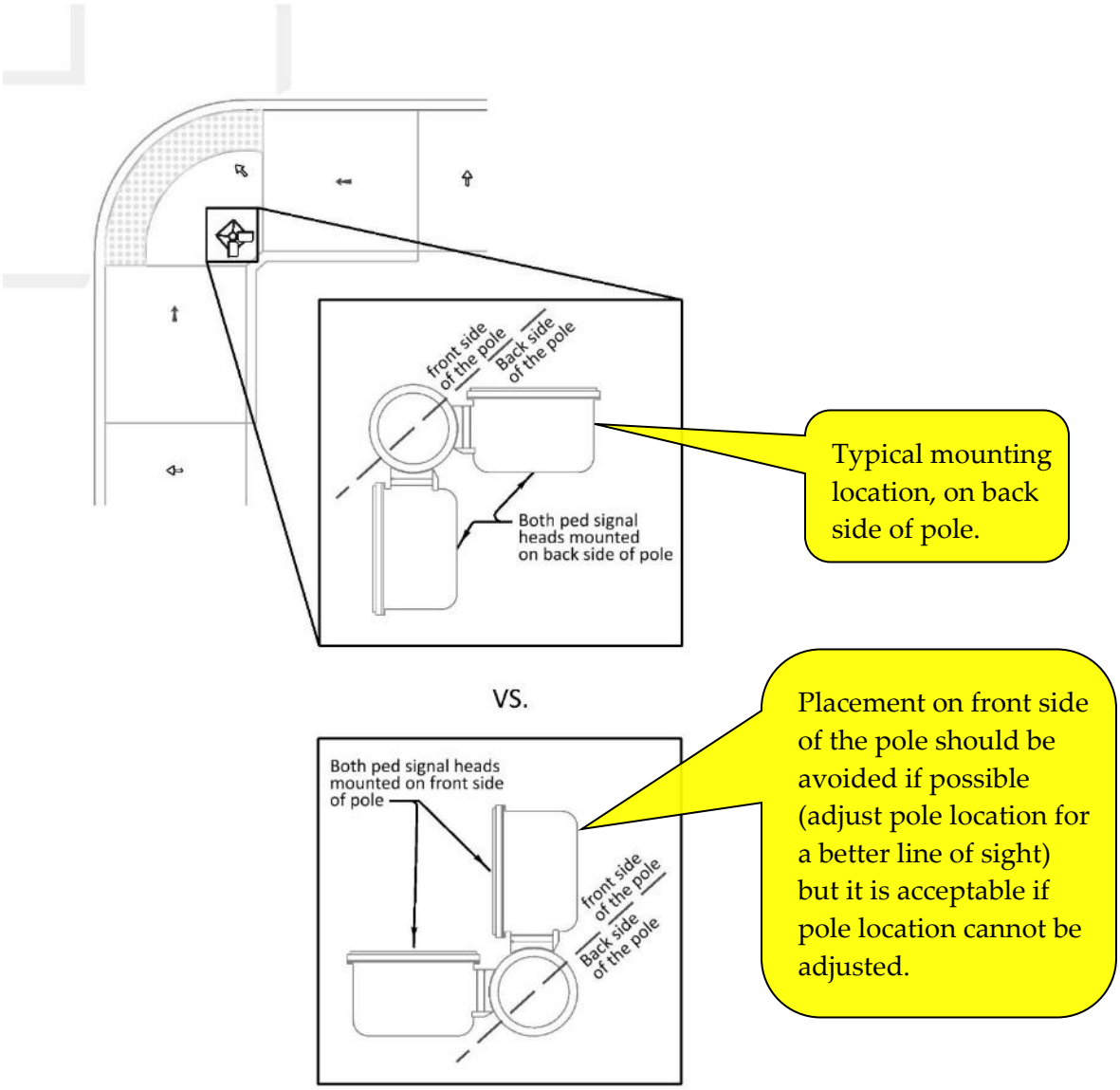


Figure 5-101 | Poor Pedestrian Signal Visibility



Typically, the orientation of the pedestrian signal head is placed on the back side of the pole/pedestal. This results in slightly more room for the swept path of a large truck making a right turn, lowering the risk of the pedestrian signal head getting hit and damaged. However, pedestrian signal heads should be placed on the front side of the pole if it will improve the line of sight to the indication AND the pedestal/pole location cannot be adjusted. See Figure 5-102.

Figure 5-102 | Pedestrian signal orientation (back side vs. front side)

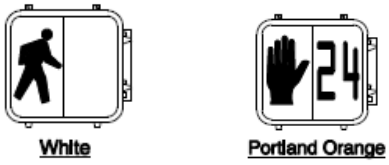


For retro-fit projects where the existing pedestrian signal head is a candidate to remain in place, verify the angle/aim of pedestrian signal head is appropriate for the proposed new ramp and crosswalk alignment. There is a high probability that the existing pedestrian signal head will require adjustment and if that is the case, a new pedestrian head at the correct angle should be installed (vs. re-mounting the existing pedestrian signal head).

5.4.13 Indication Type

All pedestrian signal indications shall be the countdown type. See Figure 5-103. If the scope of the project necessitates the need to install only one new pedestrian signal indication but there are other existing non-countdown pedestrian signal indications at the intersection, all pedestrian signal indications for the entire intersection should be updated.

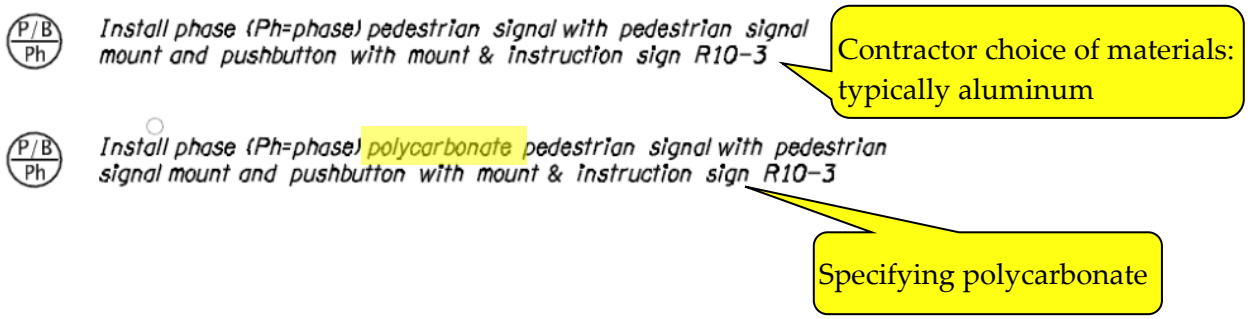
Figure 5-103 | Countdown Pedestrian Signal Indications



5.4.14 Pedestrian Signal Head Materials

The pedestrian signal head material is the choice of the contractor (all items listed on the blue sheets are acceptable) UNLESS the signal designer specifies a particular material in the signal plan via the bubble notes. See Figure 5-104. The material choices are aluminum and polycarbonate. Typically aluminum is the chosen material as it is cost effective and performs well. However, in harsh or windy environments such as the coast and the gorge, heavy duty polycarbonate performs better than aluminum and is recommended. Verify if electrical crew has any material preferences.

Figure 5-104 | Specifying Pedestrian Signal Head Material in the Signal Plan



5.4.15 Audible Pedestrian Signals/Pushbuttons

The operational approval for the traffic signal will state if audible pedestrian signals/pushbuttons are required. Verify with the region traffic engineer. See the ODOT Traffic Signal Policy and Guidelines for additional information.

When audible pedestrian signals/pushbuttons are required, it typically applies to all pushbuttons at the intersection. In rare cases, only certain crosswalks may require audible

devices and this requires the audible devices at both ends of the crosswalk (two total for each crosswalk).

Audible pedestrian signals/pushbuttons typically require the control system located in the pedestrian signal head (to detect the pedestrian signal phase) that is then wired to the pushbutton (to provide the appropriate audible sounds/message based on the pedestrian signal phase). As such, it is ideal to mount the pushbutton and its associated pedestrian signal head on the same support. This makes installation, retro-fits, and maintenance of audible pedestrian signals/pushbuttons much easier.

5.5 Pole Selection and Placement

Mast arm poles are the standard for all new signal and retrofit installations. Span wire installations are no longer allowed for permanent signals. Custom supports (such as bridge or sign structures) should only be considered if standard supports are not feasible.

5.5.1 Right-of-Way

All equipment (including foundations) must be located within right-of-way or permanent easements and shall not overhang private property.

5.5.2 Overhead Structures and Vertical Clearance Standards

Contact the region mobility liaison when any proposed project (new construction, reconstruction, preservation, or maintenance) adds a new or modifies an existing overhead structure (truss sign bridge, monotube cantilever, signal mast arm, and signal strain pole) regardless of meeting the existing minimum vertical clearance standards. In addition, contact the region mobility liaison for any project that reduces the existing vertical clearance regardless of meeting the minimum vertical clearance standards. The region mobility liaison will provide the appropriate coordination with the region, and MCTD. This coordination should address not only project specific mobility requirements, but also any corridor level vertical clearance and mobility needs. Vertical clearance greater than 19’-0” for sign, VMS, and signal support structures are considered non-standard and require a design exception. The signal designer is to follow the procedures outlined in chapter 14 of the ODOT Highway Design Manual. The design exception request process for increasing the vertical clearance greater than the above mentioned 19’-0” will need to consider safety, operations, and impact to other design features to support the approval of the design exception.

5.5.3 Height Restrictions

When working on signals located near airports, there is the possibility of height restrictions which can have an impact on pole selection, especially poles with illumination. Check with the airport regarding flight paths and height restrictions.

5.5.4 Utility Conflicts

Always verify the possibility of overhead and underground utility conflicts when locating poles. Conflicts with overhead and underground utilities will need to be addressed during the design of the signal and resolved before the design is complete.

A minimum of 10 feet from overhead high voltage lines is required as per OAR 437-002-0047. For low voltage lines (e.g., communication, fiber optic, cable, etc.), the following minimum clearances should be provided (see Figure 5-105):

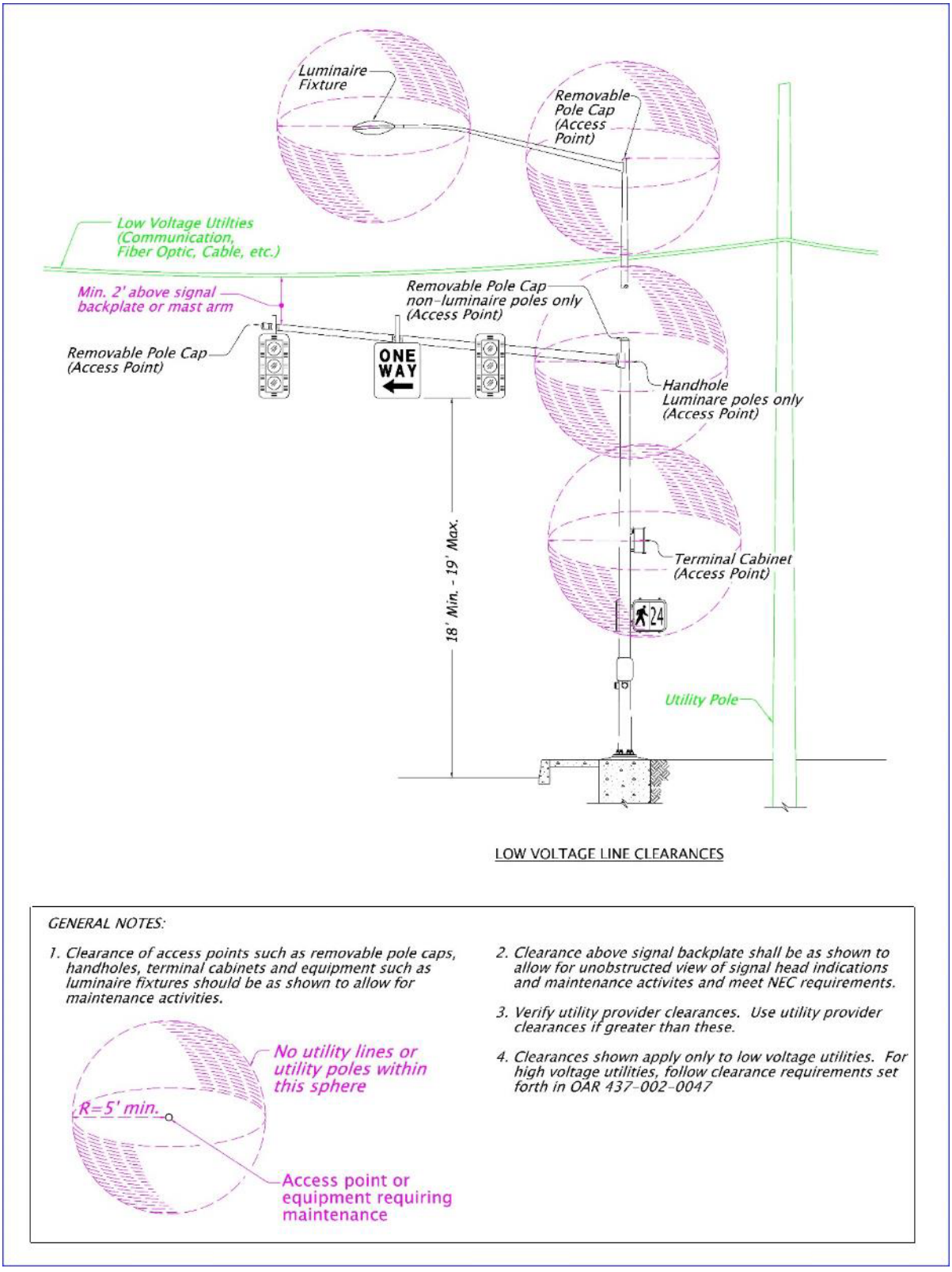
- A minimum of 5 feet from access points (e.g., removable pole caps, handholes, and terminal cabinets) and illumination fixtures
- A minimum of 2 feet from above the mast arm or backplates

The minimums shown in Figure 5-105 meet and exceed the National Electric Safety Code (NESC) requirements for low voltage lines, which typically will have a minimum clearance requirement of 2 foot vertical and 3 foot horizontal. In cases where it is not feasible to obtain the desired clearances shown in Figure 5-105, clearances that meet the minimum requirements of the NESC may be used with agreement from the utility company and the region electrical crew. Note: the NESC typically applies only to utilities (providing power), which is different than the National Electric Code which typically applies to electricians (using the power provided from the utility).

Verify the utility's clearance requirements when placing any signal equipment within 10 feet of a utility pole/cable/cabinet. The region utility specialist will facilitate this communication and provide help if there are any conflicts. See chapter 8 for more detailed information about identifying conflicts and working with the region utility specialist. There are three possible solutions depending on the situation:

1. The signal pole location may need to be adjusted;
2. The utility may need to be relocated; or
3. A combination of number one and two.

Figure 5-105 | Low Voltage Utility Clearances

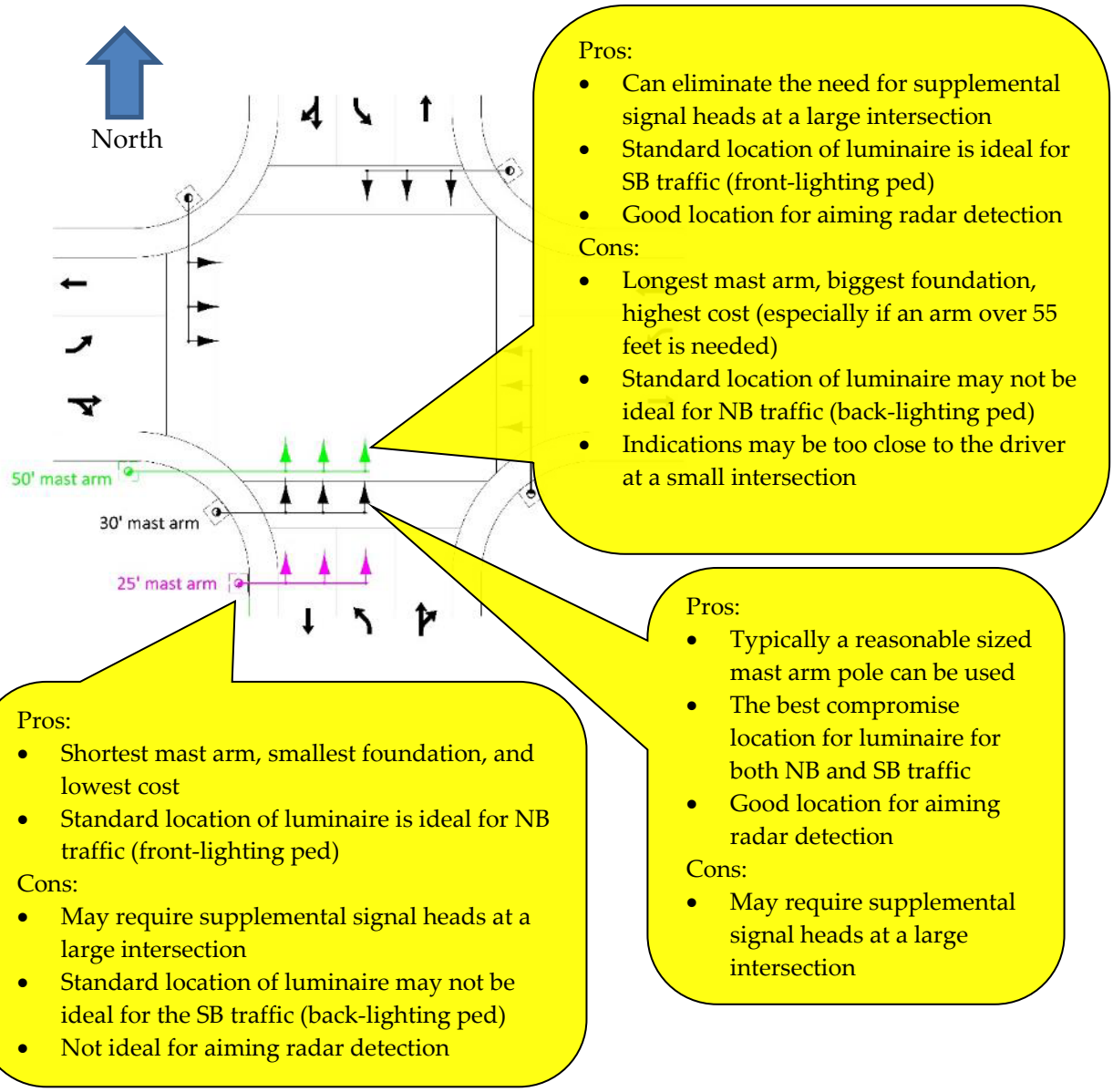


5.5.5 Roadside Placement Requirements

Traffic signal poles shall be located no closer than 5 feet from face of curb to the face of pole or 6 feet from normal edge of pavement when curb is not present. Poles may be located in raised islands if 5 feet clearance can be maintained on all sides of the pole.

Now that pushbuttons, and even pedestrian signals, are typically not installed on the mast arm pole anymore, there is more freedom to locate the mast arm pole anywhere near or along the radius. There are pros and cons for each of the three typical mast arm pole location as shown in Figure 5-106 that should be considered if you have the fortune of being able locate the mast arm pole anywhere near or along the radius.

Figure 5-106 | Typical Mast Arm Pole Locations (Pros and Cons)



5.5.6 Mast Arm Poles

Mast arms come in sizes ranging from 15 feet to 75 feet in 5-foot increments. Mast arms that are 60 feet to 75 feet were added as a standard option in 2019 to replace span wire installations. These longer mast arms have a bigger foundation and are more expensive than mast arms less than 60 feet. As such, the signal designer should strive to use mast arms less than 60 feet whenever possible. Also note that dual mast arms are not an option when using 60 to 75 foot mast arms. Mast arm poles are normally positioned with the mast arm perpendicular to the centerline alignment.

The furthermost piece of equipment on the mast arm (e.g., signal head, sign, or fire preemption detector) shall be located no closer than 6 inches from the tip of the mast arm. This is measured from the centerline of the mount location (which is typically the centerline of the equipment).

Illumination is typically included on all the mast arm poles at an intersection. The orientation of the illumination (location of the illumination relative to the mast arm) is usually located in-line with the mast arm, but it can be located at any degree on a standard mast arm pole as necessary.

When designing a mast arm for permissive left turn phasing operation, the mast arm should be long enough to allow proper placement of a future left turn signal head for protected only or protected/permitted operation.

Pedestrian signals and pushbuttons should not be mounted to a mast arm pole. See section 5.4 for more information about placement of pedestrian signals and pushbuttons.

5.5.7 Strain Poles

Strain poles are no longer allowed for permanent installations. Mast arms that are 60 feet to 75 feet were added as a standard option in 2019 to replace permanent span wire installations. Span wire installations with wood poles are only used for temporary signals. See chapter 11 for more information on span wire/wood pole design and installation.

5.5.8 Vehicle Pedestals – No Longer Used

Vehicle pedestals are no longer used for new construction as per the completely revised standard drawing TM457 effective in December 2022. A frangible base (formally called a pedestrian pedestal) on a pedestal foundation no. 3 (large foundation) is now used to mount vehicle signals (and other higher equipment loading such as RRFBs). See section 5.5.9. If the project work impacts an existing vehicle pedestal, it should be replaced with the new frangible base and pedestal foundation no.3 shown in TM457.

Pedestal mounted vehicle signals shall NOT be used as a substitute for a mast arm for through movement phases. They also should not be used as a substitute for a mast arm for the stem of a T-intersection unless there is no other option (such as height limitations due to a bridge). This is because vehicle signals mounted on pedestals are only 12’ high (from the ground to the bottom of the signal) which makes them not as visible, especially for vehicles in the back of a platoon,

as a standard 18′ – 19′ overhead mounted signal. If used at the stem of a T-intersection, additional supplemental heads may be required to mitigate the loss of visibility.

5.5.9 Pedestals

Pedestals (formally called pedestrian pedestals) consist of a frangible base that can be installed on three different foundations (see TM457):

- Foundation no. 1 – small. This foundation is used only to mount pedestrian pushbuttons
- Foundation no. 2 – medium. This foundation is used only to mount pedestrian signals and pedestrian pushbuttons.
- Foundation no. 3 – large. This foundation is used to mount vehicle signals, signs, detection units, and flashing beacons/RRFBs.

See section 5.4 for more information about mounting pedestrian equipment on pedestals.

5.5.10 Recessed Terminal Cabinet

Recessed terminal cabinets are the standard. Applicable standard drawings in the TM400 and TM600 series should be used.

5.5.11 Pushbutton Posts – No Longer Used

Pushbutton posts are no longer used for new construction as per the completely revised standard drawing TM457 effective Dec. 2022. A frangible base (formally called a pedestrian pedestal) on a pedestal foundation no. 1 (small foundation) is now used to mount only pedestrian pushbuttons. See section 5.5.9.

Foundation no. 1 should only be used if the pushbuttons cannot be located on same support as the pedestrian indications. See section 5.4 for more information about placement of pushbuttons.

5.5.12 Non-Standard Design: Dual Mast Arm Poles, Strain Poles, Sign Bridge, Monotube, Luminaire Poles

A non-standard structure is any structure that does not meet current standard drawing requirements or does not have a current standard drawing associated with it. These types of structures typically include poles for dual mast arms, steel strain poles, or diagonal structures. Note that dual mast arms are not an option when using poles that support mast arms 60 to 75 feet in length. These non-standard structures are custom designed by a structural engineer and require stamped contract plans sheets that contain the specific details for steel fabrication and foundation installation. In the case of sign bridges and monotubes, specially designed mounts for the signal equipment may also be required.

Mounting signal equipment (typically pedestrian equipment) to a stand-alone luminaire pole is discouraged because the use of a standard pedestal is usually feasible. If the use of a standard pedestal is not feasible, a stand-alone luminaire may be used to mount signal equipment only if the luminaire is operating from the same service as the traffic signal.

Contact the traffic structures engineer and see the ODOT Traffic Structures Design Manual for more information on non-standard design.

5.5.13 Reusing or Altering the Loading on Existing Signal Supports

Reusing an existing traffic structure is generally not recommended for a few reasons:

- The age of the structure may make analysis difficult. It will require a lot of assumptions if the necessary information cannot be found. The assumptions must be conservative, which typically leads to the analysis indicating reuse is not an option.
- The structure may be at or near its lifespan or not in great shape.
- Reusing an older pole requires a custom designed foundation (the standard drawings do not apply). This involves more engineering cost and extended review time. An old standard drawing may be used as a starting point for analysis and design when creating a custom foundation detail sheet, but it cannot just be referenced and used without modification. This is because the old standard drawings (and specification references within) have not been maintained and therefore most likely contain out-of-date and erroneous information which must be modified and sealed by an engineer.
- For span wire installations – moving just one pole or installing just one new pole will often require adjustments to the other poles, thus necessitating more than one new pole anyway.
- Reusing a signal pole often results in more cost due to more extensive workzone traffic control. For example, moving an existing mast arm to accommodate a wider radius will require either a temporary signal while the existing mast arm is moved to its new location (the existing signal must remain in operation) or 24-7 flagging (if a temporary signal is not used).

For more info on how to analyze existing mast arm poles and strain poles, and additional information on when it may be appropriate to reuse an existing structure, refer to the ODOT Traffic Structures Design Manual.

Reusing an existing signal support is often less cost effective than installing a new signal support.

5.5.14 Use of Other Agency (Non-ODOT) Approved Poles

This practice is typically not allowed. Contact the traffic structures engineer for guidance and approval if use of non-ODOT poles is desired.

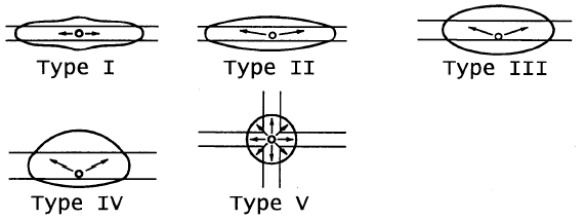
5.6 Illumination

Providing illumination on all traffic signal poles at an intersection is the standard. A separate stand-alone luminaire pole may be used if a mast arm pole is not located in a quadrant. If a stand-alone luminaire pole is used at the intersection, it should be powered from the same service as the traffic signal and designed according to standard drawings TM629 and TM630. The ODOT Lighting Policy and Guidelines and Traffic Lighting Design Manual contain additional information for illumination design requirements.

Standards for illumination design at signalized intersections are:

- 0-degree luminaire arm orientation (in-line with the mast arm)
- 15′ arm length
- 40 feet maximum height. Contact the region electrical crew to verify the maximum height that can be reached by their equipment.
- Light emitting diode (LED) fixtures (see section 5.6.1 for more info). Contact the region electrical crew to verify the wattage of the replacement bulbs they normally stock. Note: high pressure sodium (HPS) fixtures may be used when it is necessary to match the existing illumination system.
- A type 3 light distribution pattern (see Figure 5-107)

Figure 5-107 | Illumination Engineering Society (IES) Light Distribution Patterns



Photometric analysis for signalized intersections is required to verify the default standards provide adequate illumination levels. This is typically performed by the illumination designer. A CADD file of the intersection plan view with signal pole locations is needed to perform the photometric analysis. The illumination designer will provide the following design requirements based on the photometric analysis:

- Luminaire arm orientation
- Length of luminaire arm (as per standard drawing TM629, standard lengths of luminaire arms are 6′, 8′, 10′, 12′, 15′ and 20′)
- Mounting height
- Type and wattage of luminaires
- If any stand-alone luminaire poles are necessary

Intersections that are big and/or complex are more likely to require deviation from the default standards. A copy of the photometric analysis should be saved in the project files (e.g., ProjectWise).

5.6.1 Light Emitting Diode (LED) fixtures

LED fixtures should be used on new projects or on modification projects (that are converting/changing existing fixtures). The specific LED fixtures used on the project shall be approved by the region electrical manager and/or the illumination engineer. See standard specification section 02926.54 and special provision section 00970.15 for LED fixture information. Contact the illumination engineer for any questions on use of LED fixtures.

The general guidance for LED power requirements at standard intersections of two-way, two-lane highways to comply with ODOT illumination standards is as follows:

- 250-275 watt LED (2 locations, far corners on the mainline)
- 130-140 watt LED (4 locations, at each corner of the intersection)

5.6.2 Photo Electric Control Relay

The photo electric control relay is a device used for turning on luminaires based on the ambient lighting conditions. It should be placed on the signal pole that is closest to the base mounted service cabinet (BMCL). The photo electric control relay should be oriented towards the north sky.

5.6.3 Illumination Wiring

The wiring for the illumination that is part of the traffic signal (located on the signal poles) is wired directly from the service cabinet to luminaire and photo electric control relay. Illumination wiring shall not be routed through the signal controller cabinet.

- Three No. 12 AWG THWN wires are needed from the BMCL to the photo electric control relay.
- Two No. 10 AWG XHHW wires are needed from the BMCL to each luminaire (each luminaire must have independent wires directly from the BMCL). Daisy chaining the illumination wiring from luminaire to luminaire is no longer allowed. This wiring will be spliced to the TC cable (see bullet below) via an in-line fuse holder at the pole base.
- TC cable is used from the pole base (splice point using an in-line fuse holder) to the luminaire ballast. This wiring is NOT shown on the plan sheets but is contained in specification 00970.42.
- The ground/bond wire to the signal/illumination pole is a No. 6 AWG THWN. This wiring is NOT shown on the plan sheets but is contained in specification 00960.45(b).

5.7 Fire Preemption

Fire preemption should only be included at a traffic signal if the area/operators have been approved for use. Typically, if fire preemption is present at an existing intersection, it has already been approved and should be replaced if the signal is re-built. The state traffic operations engineer maintains a list of approved fire preemption areas/operators. The signal designer should contact the state traffic operations engineer to verify the approval is documented. If the project scope does not mention fire preemption, verify that fire preemption is not needed or wanted with region traffic. Region traffic will then work with the local operators in the area and submit a request for operation approval to the STE if needed.

If fire preemption used, the detector must be located with a clear line of sight for a minimum distance of 1500 feet. Preferred placement of the detector is on the near side of a mast arm. Remote detectors, multiple barrel devices or alternate locations will be necessary if the roadway curves prior to entering the intersection.

One specialty cable for the fire preemption system is needed from the device mounted in the field back to the signal controller cabinet. No splices are allowed.

All pre-approved (see the green sheets) fire preemption equipment can provide encryption (to assign IDs to those that use the system). However, ODOT does not currently have any jurisdictions using this feature.

5.8 Power Source

Commercial power is used to power all electrical installations (except where solar power has been allowed as an option: e.g., flashing beacons, RRFB, etc.). When installing a new traffic signal, the nearest location to draw power from (the power source) should be used. Power can only be tapped off of a transformer. The Figure 5-108 shows a typical example of a transformer.

Figure 5-108 | Transformer Example



It is critical to work with the region utility specialist to determine what type of power is available and the location of the power source. The traffic signal service requires commercial power of 120V (or 120V/240V if illumination will be provided on the traffic signal). If the existing power source is unacceptable or needs modifications to work, the region utility specialist will handle these issues.

Sometimes the project will necessitate moving the existing power source location to a new location. If this is the case, the signal plan sheets will need to show this.

The wiring from the power source shall enter the service cabinet via a conduit (no aerial connections, except for temporary signals). The design of the conduit and wiring from the power source to the service cabinet is per the requirements of the power company. The plan sheet should just show a reference to the conduit and wiring indicating this. The contractor is responsible for installing the conduit and pull line from the service cabinet to the power source, and the power company is responsible for installing and terminating the wiring from the service cabinet to the power source.

5.9 Battery Back-Up

Battery back-up is no longer supported for use at any traffic signal for several different reasons that are detailed in the history section of this manual. See section 5.15.4 for more information.

5.10 Controller Cabinets

5.10.1 Location

If possible, locate the controller on the right side of a side street approach and try to obtain a power source in that quadrant. There may be limitations that preclude this location such as R/W, power source locations, sidewalk, or businesses located in the quadrant. Contact the region electrical crew for their preference on the location of the controller cabinet.

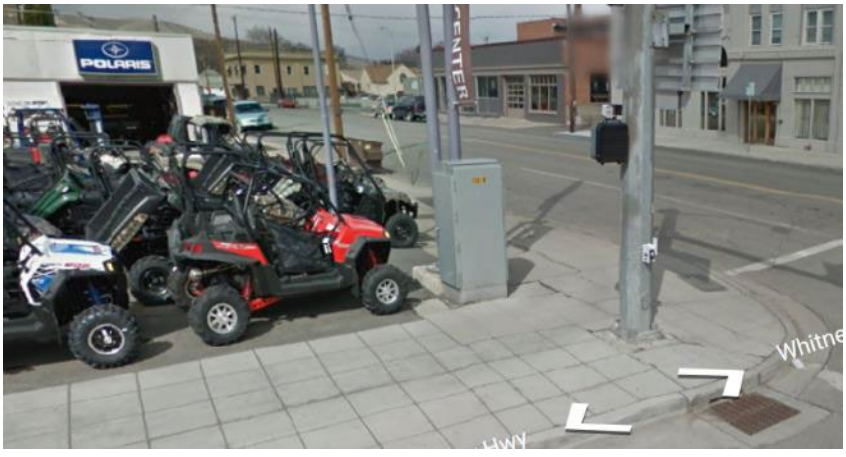
The controller cabinet and the service cabinet should be located together in the same quadrant for ease of maintenance, spaced a minimum of 10 feet apart.

Locate the controller cabinet so that it does not obstruct the view for a side street vehicle turning right-on-red. The controller cabinet has a front louvered door that swings open to the left and a back solid door that swings open to the right. Orient the controller cabinet:

- To have the cabinet doors swing away from traffic, and
- To have the louvered front door positioned to allow a view of a minimum of two traffic signal phases for a person standing in front of and facing the louvered front door (for when electricians or region traffic signal timers are working in the cabinet).

The right-of-way, adjacent properties, and the pedestrian clear circulation path may also have influence on the location and orientation of the controller cabinet. Figure 5-109 shows an example of controller cabinet that is difficult to open and maintain. Make sure that the cabinet door can fully open and does not encroach on private property when fully open. Also maintain the pedestrian clear circulation path (5’ minimum) when the door is open if possible.

Figure 5-109 | Controller Cabinet Front Louvered Door Encroaching on Private Property



The controller cabinet is also required to have a minimum of 3 feet working space all around it to meet applicable codes (NEC, OSHA, and NFPA) for worker safety. This needs to be verified on retro-fit projects. Figure 5-110 shows an example of curb ramp and pedestal retro-fit proposal where the 3 foot minimum working space cannot be met and will require additional design iterations to satisfy this requirement. It is also good practice to verify other project features (such as signing, barriers, etc.) for permanent or temporary installation also meet the 3 foot minimum from the cabinet. See Figure 5-111 for example where a temporary sign blocked access to the controller cabinet.

Figure 5-110 | Controller Cabinet Without the 3 Foot Minimum Working Space

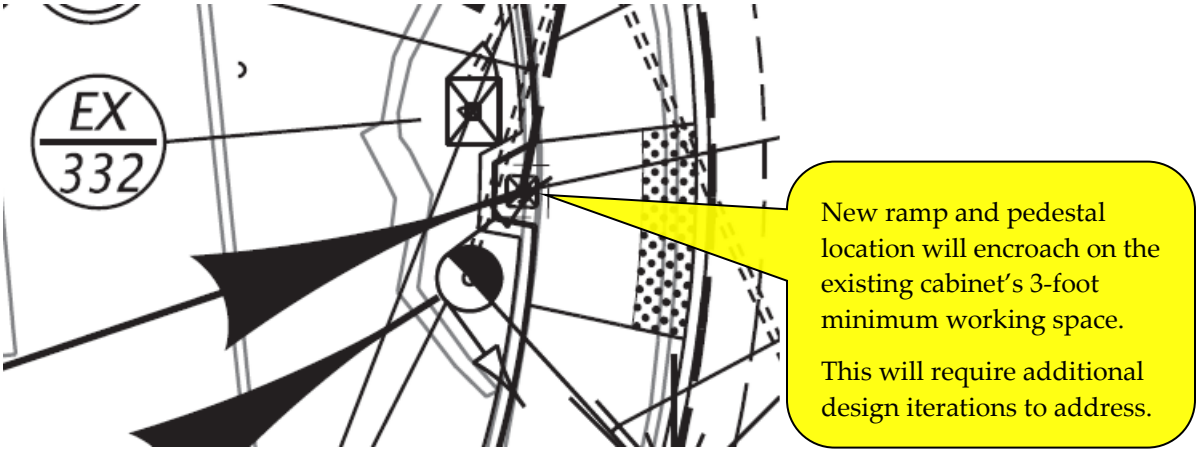
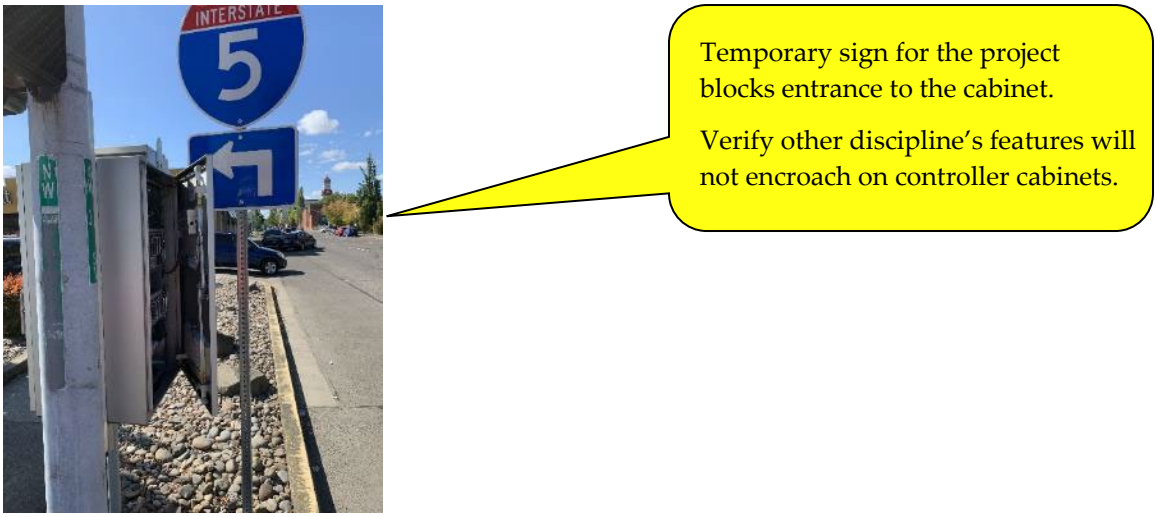


Figure 5-111 | Controller Cabinet Without the 3 Foot Minimum Working Space Due to Other Features Installed on the Project



As per standard drawing TM482, the controller cabinet will have landing pads at the front and back of the cabinet. If there is sidewalk where the controller cabinet is located, it will be placed flush to the back of the sidewalk. If sidewalk is not present where the controller cabinet is

located, a 3-foot-wide concrete walkway for the controller cabinet (and service cabinet) is required. Coordinate with the roadway designer for showing and detailing this concrete walkway on the plan sheets. The landing pads and the walkway are important features that improve the maintainability (and thus service life) of the traffic signal.

5.10.2 332S Controller Cabinet

The 332S controller cabinet is a ground mounted cabinet which is the standard for both permanent and temporary traffic signals. It provides more room and options than the old 332 cabinet.

5.10.3 332 Controller Cabinet

The 332 controller cabinet is a ground mounted cabinet. It is no longer used in new construction.

5.10.4 336 and 336S Controller Cabinet

The 336 and 336S controller cabinets are pole mounted cabinets, smaller than the 332 cabinet. These cabinets are no longer used for permanent or temporary signals.

In the past, these cabinets were commonly used in downtown corridors where the traffic signals operation is simple and pre-timed. However, there are a few reasons why the pole mounted cabinet is no longer used for a permanent or temporary installation:

- They have limited space inside and still take up the same amount of room (width and depth) as a standard 332S cabinet. The only room that is saved is directly underneath the cabinet, which isn't useable.
- They produce challenges for meeting ADA requirements since it creates a protruding object unless it is placed away from a pedestrian walkway.
- A temporary pre-cast foundation that is easy to install and remove for temporary staging is now standard.

5.10.5 Controller Cabinet Power

The controller cabinet is wired to the service cabinet with two No. 6 AWG XHHW wires (shown on the plan sheets) and a ground wire (NOT shown on the plan sheets).

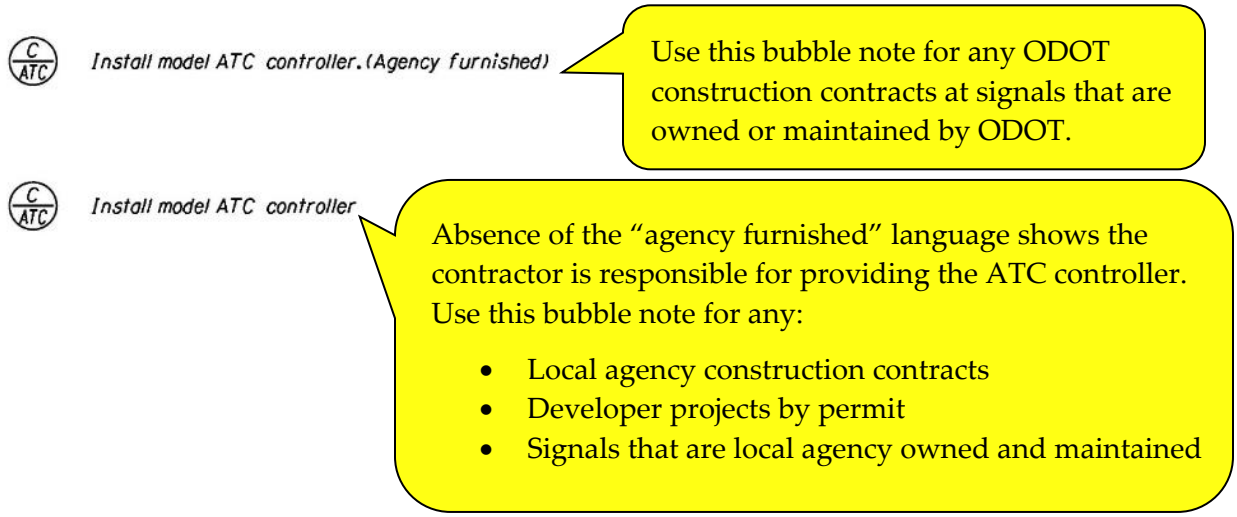
5.10.6 ATC Controller

ODOT has a price agreement contract for the ATC controller which is administered by the ITS unit. Using the price agreement contract on a project will depend on who owns/maintains the signal AND who issues the construction contract. The plan sheets will need to use the correct language in the ATC controller installation bubble note legend as described below and shown in Figure 5-112.

- **On ODOT construction contracts:** For signals ODOT owns (regardless of who maintains) and for local agency owned signals that ODOT maintains, the bubble note legend text shall state the ATC controller is "Agency Furnished". TSSU will provide the ATC controller via the price agreement contract and will charge the contract. The contactor is not responsible for providing the ATC controller or any costs associated with it.
- **On local agency construction contracts:** For any signal, regardless of if it is owned or maintained by ODOT, the bubble note legend text shall show the ATC controller is provided by the contractor. The reason being it is difficult for ODOT to recover the cost of providing the ATC controller via the price agreement contract on a construction contract ODOT didn't issue. The contractor is responsible for providing the ATC controller and costs associated with it. In very rare cases, the local agency administering the contract may elect to furnish the ATC controller (note: they are unable to purchase via the ODOT price agreement contract) and would then use the "Agency Furnished" language in the bubble note legend text.
- **On developer projects by permit:** For any signal, regardless of if it is owned or maintained by ODOT, the bubble note legend text shall show the ATC controller is provided by the contractor. The reason being there isn't a way for ODOT to recover the cost of providing the ATC controller via the price agreement contract. The contractor is responsible for providing the ATC controller and costs associated with it.
- **Local agency owned and maintained signals:** For any local agency owned and maintained signals, regardless of who issues the contract, the bubble note legend text shall show the ATC controller is provided by the contractor. The reason being the price agreement contract is not available to local agencies for local agency owned and maintained signals. ODOT also cannot purchase ATC controllers from the price agreement contract on behalf of the local agency for local agency owned and maintained signals. The contractor is responsible for providing the ATC controller and costs associated with it.

In the rare case where a project requires use of both agency furnished and contractor furnished ATC controllers, contact the state traffic signal engineer for guidance on using custom notes.

Figure 5-112 | ATC Controller Installation Bubble Note Based on Project Specifics



5.10.7 Decorative Controller Cabinet Wraps

The roadway section is currently working on a comprehensive artwork policy/directive for features in the ODOT right-of-way that will include information on decorative materials and the associated process for using them on a traffic signal controller cabinet. Contact the state traffic signal engineer and the senior urban design engineer for more information.

5.11 Service Cabinets

5.11.1 Base Mounted Service Cabinet (BMC)

A base mounted service cabinet (BMC) shown in standard drawing TM485 is the standard service type for traffic signal installations. The BMC should be located in the same quadrant as the controller cabinet. This makes the BMC convenient for maintenance personnel working on the signal. The BMC is required to have a minimum of 3 feet working space all around it to meet applicable codes (NEC, OSHA, and NFPA) for worker safety but the ODOT standard is to locate the BMC at least 10 feet away from any other equipment (e.g., controller, poles, etc.). The BMC should be located on the right side of a side street approach to mitigate mainline exposure and to avoid obstructing the view of side street vehicles making a right turn on red.

5.11.2 Base Mounted Service Cabinet with illumination (BMCL)

Section 5.11.1 still applies; except a base mounted service cabinet with illumination contains extra circuit breakers and a contactor to run a separate circuit for illumination that is part of the traffic signal.

5.11.3 Base Mounted Service Cabinet, Flashing Beacons (BMCF, and BMCFL)

Section 5.11.1 still applies; except a base mounted service cabinet for flashing beacons contains contacts for the flashing indications. The BMCFL can accommodate illumination that is part of the flashing beacon. See chapter 12 for more info on flashing beacons.

5.11.4 Pole Mounted Service Cabinet (SC) and Meter Base (MC)

This type of service is only allowed for temporary signals. See chapter 11 for more information on temporary signals.

5.11.5 Remote Post Mounted Service (RPS)

This style of service is no longer used for new construction.

5.11.6 Wiring

The wiring from the power source to the service cabinet is per the requirements of the power company. See section 5.8 for more information.

The wiring from the service cabinet to the controller cabinet is two No. 6 AWG XHHW wires.

5.12 Junction Boxes

Junction boxes provide a pull point for wires/cables coming from the controller cabinet to the various pieces of equipment in the field. Guidelines for general use are shown on standard drawing TM472.

5.12.1 Junction Box Type and Size

The junction box type/size is determined by the total conduit diameter that is contained within the junction box and the location of where the junction box is located. There are three available sizes as per standard drawing TM472 (JB-1 = small, JB-2 = medium, and JB-3 = large). However, there is default minimum type/size standard. Table 5-5 shows the default minimum standard and Table 5-6 shows how to determine if the default minimum size is adequate or not.

The type of surface that a junction box will be installed in is also an important consideration. This determines whether a concrete apron around the junction box is needed or not as per TM702. Junction boxes located in the sidewalk do not require a concrete apron. Junction boxes located in unsurfaced areas (e.g., gravel shoulders, behind guard rail, in landscaped areas, etc.) require a 12-inch-wide concrete apron surrounding the box. The concrete apron provides support to the sides of the box.

Table 5-5 | Default Minimum Junction Box Type/Size

Type/Size	Location/use
JB-3T: Two (Tandem) 30″x17″x12″ boxes	The same quadrant as the signal controller: first access point for all signal, detector, and interconnect wires/cables.
JB-2: Single 22″x12″x12″ box	All quadrants without the signal controller: secondary access point for signal, detector, and/or interconnect wires/cables.

Table 5-6 | Sizing for Junction Box Type/Size

Type	Size	Total Conduit Diameters Allowed (Inches)	Remarks	Material
JB-1	17″x10″x12″	12	Non-traffic areas only	Concrete/Concrete Polymer
JB-2	22″x12″x12″	18		
JB-3	30″x17″x12″	34		

5.12.2 Junction Box Placement

Junction boxes should be spaced a maximum of 300 feet between junction boxes on a conduit run. Note that handholes used for ITS applications (fiber communication) may be spaced a maximum of 1000 feet as per TM702.

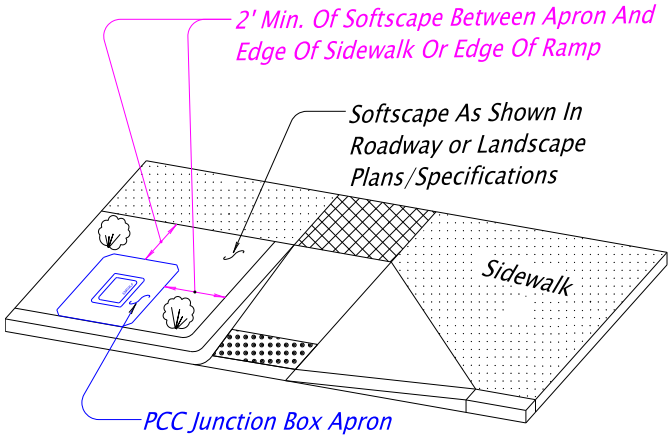
Junction boxes should be located within 50 feet of the nearest signal pole, pedestal, or controller cabinet.

Junction boxes may be located in the sidewalk, raised islands, or in unsurfaced areas with incidental traffic (e.g., gravel shoulders, behind guard rail, in landscaped areas, etc.). The junction box should be placed in a flat area that can be easily and safely accessed by region electrical crews.

Consideration should be given to water flow and drainage to avoid placing a box in a low spot that will collect a significant amount of water.

When boxes are located in unsurfaced areas near sidewalk or curb ramps, care needs to be taken to ensure that the appropriate ADA requirements for softscaping (rock, bark, grass, etc.) are met. A minimum of 2 feet from the edge of the PCC junction box apron to the edge of the sidewalk or curb is required. See Figure 5-113. The intent of the softscaping is to provide tactile information to a visually impaired pedestrian about the path they should or should not follow. Concrete aprons for junction boxes located too closely to a curb, curb ramp, or sidewalk are hard to distinguish from the concrete of the sidewalk/curb ramp and could mislead a visually impaired pedestrian off the appropriate path. If the 2-foot minimum cannot be obtained or there are site-specific questions about the need for softscaping, it is best to work with the roadway designer and traffic engineering section early to determine the best solution (which may require an ADA curb ramp design exception or other mitigation).

Figure 5-113 | ADA Softscaping Requirements for Junction Box PCC Apron



Do not place a junction box in the following areas:

- Within a travel lane
- Driveway or access where it may be exposed to traffic
- In the slope or landing area of a curb ramp

If it is important to have the junction box at very specific location, make sure to note that on the plans with appropriate detail (station/offset/elevation) otherwise, standard drawing TM702 allows the contractor some flexibility to place junction boxes at the approximate location shown.

5.12.3 Use of Existing Junction Boxes

Use of existing junction boxes is allowed if all of the following statements are true:

- The junction box is relatively new, in good condition, and in a good location,
- The junction box is the appropriate size,
- The junction box itself will not have to be adjusted due to the adjacent construction work, and
- The junction box will not have any new conduit installed within.

Junction boxes are a very low-cost item and it is more cost effective to remove an old junction box and install a new one if any of the above statements are false. A common construction change order on preservation projects is additional payment for the contractor to adjust or install new junction boxes as a result of the work done on the roadway shoulder. Change orders should be avoided as they are generally more expensive than having the contractor bid the same work. Therefore, if there is a good chance that an existing junction box will be damaged, need adjustment, or is just a maintenance headache, you should remove it and install a new one. If, during construction, the contractor is able to use the existing junction box they can submit a cost reduction proposal (as per specification 00140.70) that can be considered (which should result in a credit to the contract if the existing boxes can indeed be used).

5.12.4 Elevation Adjustments & Considerations for Existing Junction Boxes

Retro-fit projects often change the existing finish grade elevations which requires attention to how existing junction boxes (and the conduit and wiring inside) will be impacted. The standard junction box depth is 12 inches (see TM472) with conduit exposed 2 to 3 inches above of the bottom of the junction box (see TM471). See Figure 5-114 and Figure 5-115 for examples of the impacts resulting from elevation changes.

Figure 5-114 | Impacts from Lowering Elevation Without Adjusting Conduit in Junction Box

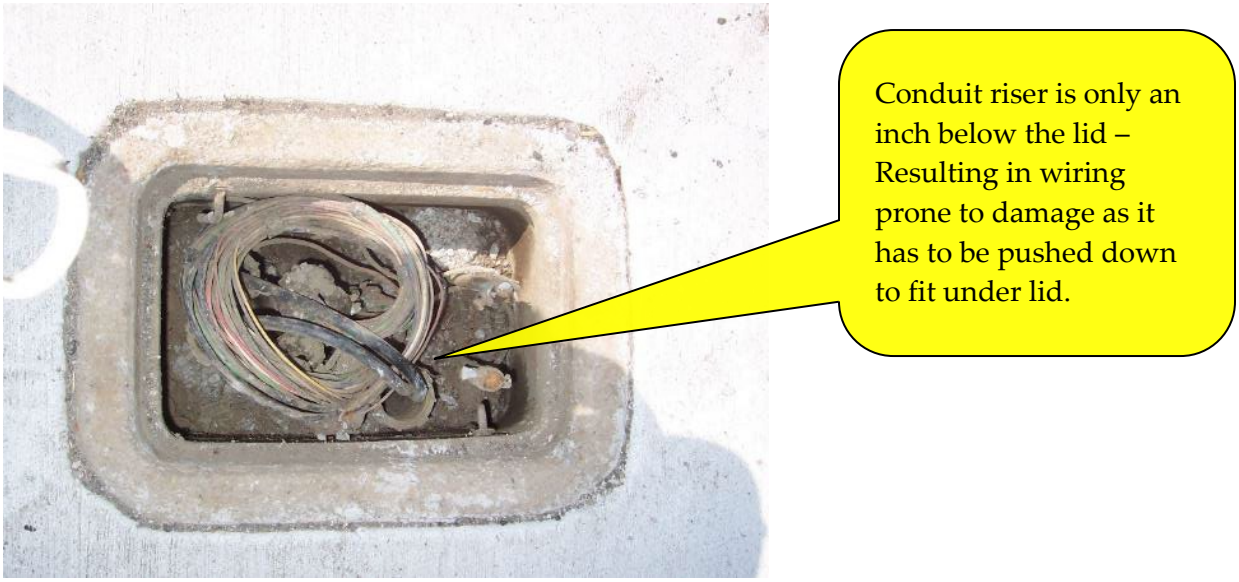


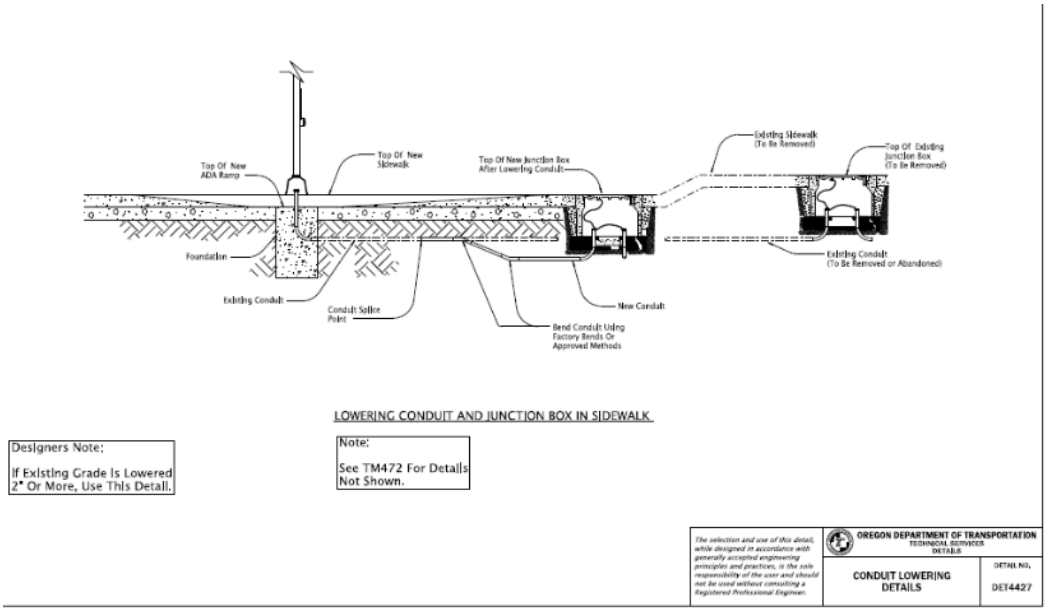
Figure 5-115 | Impacts from Raising Elevation Without Adjusting Junction Box



If the finish grade elevation increases, the junction box will need to be raised so that it is flush to the new surface. This requires the foundation of the junction box to be raised which is likely to require the conduit risers to also be replaced to maintain proper clearance above the bottom of the box and to allow good compaction of the crushed rock foundation. Replacing the conduit risers then requires removing the existing wiring to the nearest junction box while the conduit riser is replaced and then re-installing the existing wiring into the new conduit riser. See note below in yellow box for more additional info about re-installing existing wiring.

If the finish grade elevation decreases, the junction box will need to be lowered so that it is flush to the new surface. If the existing junction box elevation changes more than an inch, use DET4427 which shows how to adjust the conduit elevation in the lowered junction box. See Figure 5-116. This detail requires removing the existing wiring to the nearest junction box while the conduit is adjusted and then re-installing existing wiring into the new lowered conduit. Note that replacing an existing junction box with a handhole (without finish grade elevation changes) will also require using this conduit lowering detail due to the additional 12 to 24 inches of box depth.

Figure 5-116 | DET4427 – Conduit Lowering Details



Conduits are not allowed to enter the side of standard traffic signal junction boxes; they must enter from the bottom of the box as per TM471.

If adjustment of any existing junction boxes will require replacing/splicing existing conduit (which requires re-installing wiring), verify with region electrical crew if the existing wiring can be re-installed or if all new wire should be installed. If the traffic signal condition rating is low or the signal is over 20 years old, re-installing existing wire is not recommended.

5.12.5 Deviations From Junction Box Placement Standards

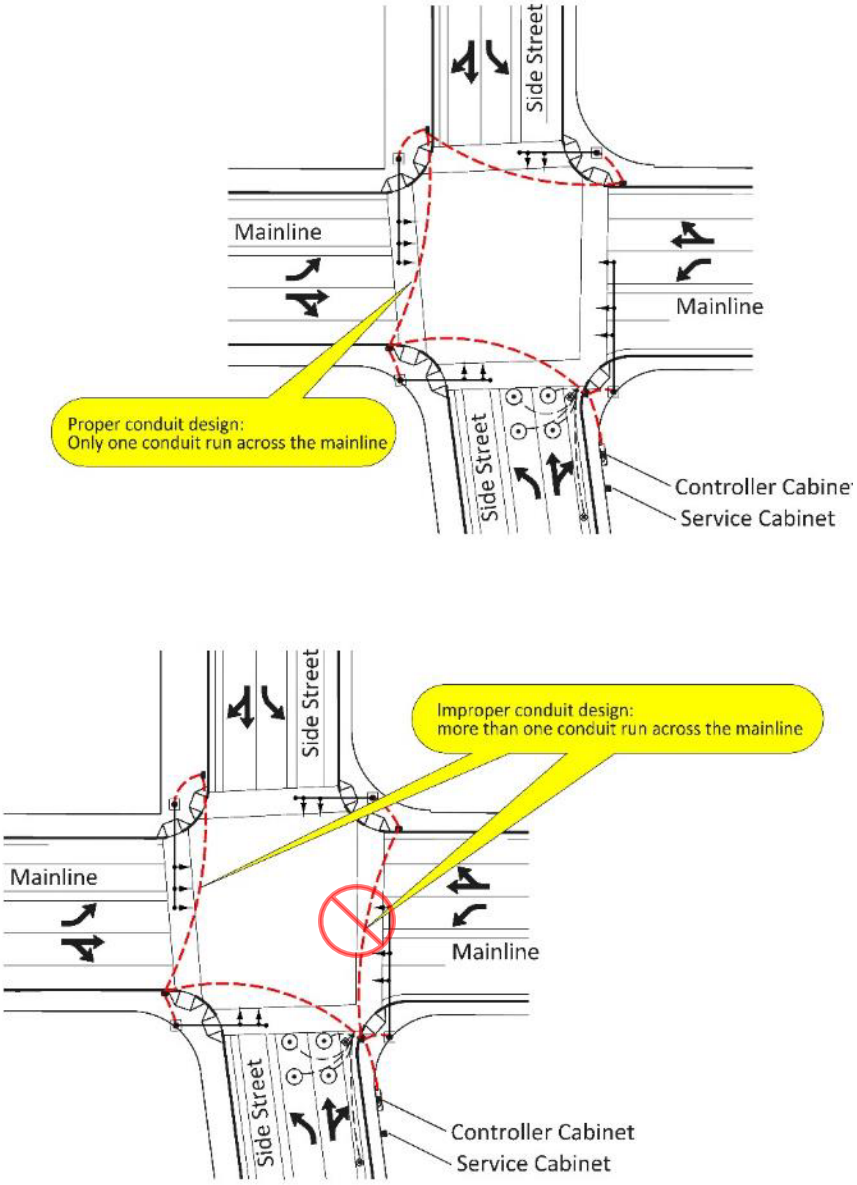
Meeting all of the criteria listed in section 5.12 may be impossible at certain locations where the project scope and budget is very limited (e.g., curb ramp replacement projects, ARTS projects, etc.). If unable to meet any of the criteria in section 5.12, deviations may be considered. The most common deviations are listed below. Any deviations require approval of the state traffic signal engineer during the design approval process.

- **Junction box placement in the slope or landing area of a curb ramp.** When curb ramps are redesigned the existing junction boxes often end up being located in the slope or landing area of the new curb ramp. When possible, the preferred solution is to relocate the junction box to new location as per the placement standards in section 5.12.2 by splicing new conduit to the existing conduit. However, depending on the age of the traffic signal system and project scope, splicing the existing conduit system to relocate the junction box might be too risky. In these cases, replacing the junction box in-place might be the best solution. The junction box has to be installed flush, so it cannot span two different plans. If the junction box is installed on a slope, additional support of the box with a modified concrete apron and foundation is likely necessary to ensure the box remains flush to the sloped surface over time. Custom details with appropriate information (station/offset/elevation) should be shown in the plans.
- **Using a non-standard junction box depth or a modified foundation for the junction box.** If the finish grade elevation changes require raising an existing junction box, installing a deeper than standard depth junction box, handhole, or modifying the junction box foundation (e.g., extra concrete at the edge of the new box to raise it up) may be appropriate solutions depending on the project scope and age of the traffic signal system (to avoid risky conduit and re-wiring work). Custom details with appropriate information (station/offset/elevation) should be shown in the plans.

5.13 Conduit

Once the junction box placement is complete, conduits routes can be determined to connect all equipment to the controller cabinet. Standard practice is to cross the mainline only one time. See Figure 5-117. Conduit that goes across an existing roadway (mainline or side-street) should be installed by horizontally directional drilling (HDD) to avoid the temporary traffic control and potential pavement damage associated with open trenching.

Figure 5-117 | General Conduit Layout



5.13.1 Conduit Size

To determine the proper size of conduit, two criteria need to be considered: ODOT requirements and the wire fill calculation. The larger of the two criteria governs. See section 5.14 for information on wiring.

ODOT Requirements:

- Conduit crossing mainline or side street shall be 2-inch diameter minimum
- One spare 2-inch diameter conduit from the controller cabinet to the nearest junction box shall be installed for future use, shall contain a poly pull line and be capped at each end
- 1½-inch diameter minimum size conduit
- 3-inch diameter maximum size conduit
- If loop detection is approved by the state traffic signal engineer on the project as per chapter 6, one spare 2-inch diameter conduit from the signal pole to the nearest junction box shall be installed for future installation of non-invasive detection. The spare conduit shall contain a poly pull line and be capped at each end. This spare conduit shall be omitted when non-invasive detection (the default standard) is installed.

Regions may have a minimum value that is larger than the statewide minimum standards listed above. Verify with region traffic or region electrical crews. Additional spare conduits may also be installed if anticipated future conditions deem them necessary. Larger conduit and spare conduits can be helpful in the future when a traffic signal requires a retro-fit to meet the ever changing design standards and technology requirements. However, increasing conduit size and/or adding additional spare conduits can come with some downsides that should be considered:

- Larger junction boxes and/or deeper conduit trenches may be required.
- Conduit larger than 2-inches and/or more than 4 conduits installed in a mast arm pole foundation greatly increases the difficulty in installing them properly around the rebar/anchor rods. Verification of clearances to the foundation rebar/anchor rods is necessary and custom installation details may be required on the plan sheets.
- Conduit installed for future purposes is very risky unless the future project has well defined design parameters and dedicated funding. There have been projects in the past where future design and/or funding were not pinned down which resulted in either the spare conduits not being installed in the right location for the future design (and couldn't be used) or the age of spare conduits had resulted in enough deterioration that they were no longer usable on a future project.

The ODOT minimum design standard for new construction allows a maximum wire fill of 70 percent of the NEC maximum allowed wire fill. This allows ample room for additional wires if needed in the future. For existing signals where new wire is being installed into existing conduit, the NEC maximum allowed wire fill is acceptable to use. To calculate wire fill, use Table 5-7 through Table 5-9. See Figure 5-118 and Figure 5-119 for example calculations.

Table 5-7 | Wire Area

Cable *AWG*	Cable Area (in^2) THWN	XHHW	Cable Type	Cable Area (in^2)
18	n/a	n/a	**FPC**	0.0784
16	n/a	n/a	**LF**	0.0908
14	0.0097	0.0139	**LF 18awg**	0.0616
12	0.0133	0.0181	**6/P**	0.3117
10	0.0211	0.0243	**12/P**	0.4902
8	0.0366	0.0437	**CC 4/14**	0.1257
6	0.0507	0.0590	**CC 5/14**	0.1452
4	0.0824	0.0814	**CC 6/14**	0.1698
3	0.0973	0.0962	**CC 7/14**	0.1735
2	0.1158	0.1146	**CC 10/14**	0.2922
1	0.1562	0.1399	**CC 12/14**	0.3117
1/0	0.1855	0.1825	**CC 15/14**	0.3632
2/0	0.2223	0.2190	**Video Cable**	0.2866
3/0	0.2679	0.2642	**Radar Cable**	0.1320
4/0	0.3237	0.3197	**Cat 6 Cable**	0.0881
			Fiber Optics	Variable: contact ITS for correct size
			Piezo Cable (ATR)	0.187

Table 5-8 | Conduit Fill Table (NEC & ODOT Max Fill: PVC Schedule 40 and HDPE Conduit, Article 344 in NEC Chapter 9, table 4)

Conduit size Inch	*Internal Dia Inch*	NEC % Max Fill (in^2) 1 wire 53%	2 wires 31%	3+ wires 40%	ODOT % Max Fill (in^2) 1 wire 53%	2 wires 31%	3+ wires 40%
1/2	0.602	0.151	0.088	0.114	0.106	0.062	0.080
3/4	0.804	0.269	0.157	0.203	0.188	0.110	0.142
1	1.029	0.441	0.258	0.333	0.309	0.180	0.233
1 1/4	1.360	0.77	0.45	0.581	0.539	0.315	0.407
1 1/2	1.590	1.052	0.616	0.794	0.737	0.431	0.556
2	2.047	1.744	1.02	1.316	1.221	0.714	0.921
2 1/2	2.445	2.488	1.455	1.878	1.742	1.019	1.315
3	3.042	3.852	2.253	2.907	2.696	1.577	2.035
3 1/2	3.521	5.161	3.018	3.895	3.612	2.113	2.726
4	3.998	6.654	3.892	5.022	4.657	2.724	3.515

Table 5-9 | Wire Fill Requirements

Wire Fill Requirements	
Existing conduit:	Sum of Cable Area (in^2) within conduit < NEC % Max Fill (in^2)
New conduit:	Sum of Cable Area (in^2) within conduit < ODOT % Max Fill (in^2)

Figure 5-118 | Conduit Sizing Example 1

Conduit Sizing Example No. 1

Given: How large of a new conduit is needed if the conduit has to carry the following cables?

1.) Thirteen No. 14 AWG THWN
2.) Two Loop Feeder Cables*
3.) One 6/P (interconnect cable)*
4.) One No. 8 AWG THWN (signal system common)
5.) One No. 6 AWG THWN (Ground/Bond wire. Not shown on) plans, but required by specification)

*Note - loop feeder cables and interconnect cable are normally installed in separate conduits from the signal system.

Step 1: Determine Total cable area using Cable Area Chart:

13*(0.0097) =	0.1261	1*(0.0366)=	0.0366
2*(0.0908) =	0.1816	1*(0.0507)=	0.0507
1*(0.3117) =	0.3117		

Total Sum = (0.1261+0.1816+0.3117+0.0366+0.0507) = **0.7067**

Step 2: Use the ODOT % Max Fill Chart to compare calculated total sum to max. allowable fill (use column for 3+ wires - since the total # of wires in this conduit is 18)

0.7067 > 0.556, therefore, a 1.5" conduit is too small

0.7067 < 0.921 , therefore a 2" conduit is OK**

**check to make sure that a 2" conduit will meet the other ODOT requirements for conduit size

Figure 5-119 | Conduit Sizing Example 2

Conduit Sizing Example No. 2

Given: An existing 2" conduit has the following existing cables, can 4 additional Loop Feeder cables be installed?

1.) Thirteen AWG No. 14 THWN
2.) Two Loop Feeder Cables*
3.) One 6/P (interconnect cable)*
4.) One No. 8 AWG THWN (signal system common)
5.) One No. 6 AWG THWN (Ground/Bond wire. Not shown on) plans, but required by specification)

*Note - loop feeder cables and interconnect cable are normally installed in separate conduits from the signal system.

Step 1: Determine Total cable area using Cable Area Chart:

13*(0.0097) =	0.1261	1*(0.0366)=	0.0366
2*(0.0908) =	0.1816	1*(0.0507)=	0.0507
1*(0.3117) =	0.3117		
4*(0.0908) =	0.3632 } New Cables		

Total Sum =(0.1261+0.1816+0.3117+0.3632+0.0366+0.0507+0.3632) =1.0699

Step 2: Use the NEC % Max Fill Chart to compare calculated total sum to max. allowable fill (use column for 3+ wires - since the total # of wires in this conduit is 22)

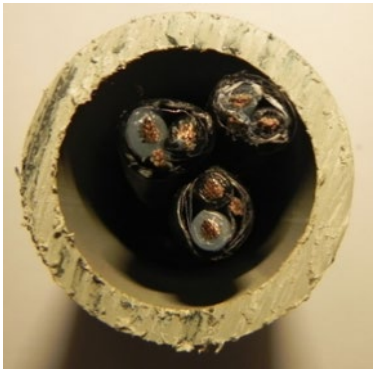
1.0699 < 1.316 , therefore the existing 2" conduit is big enough to allow the new cables**

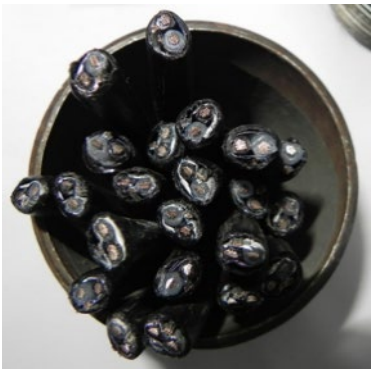
** note that for a new conduit installation, a 2.5" conduit would be required based on ODOT's Max Fill Chart

Wire fill rates can be visually deceiving if you are not accustomed to working with conduit and wire. Table 5-10 should be helpful in providing some perspective (note: the conduit bushing has not been installed for better photo clarity).

For new wire installations in existing conduit, the signal designer MUST check the existing conduit size, wire count, and condition in the field to make sure the proposed new wires will not exceed the NEC maximum allowed wire fill. The signal designer should coordinate with the electrical crew to determine if it is feasible to add new wiring to any existing conduit. Failure to verify this is a fatal flaw.

Table 5-10 | Visual Wire Fill Requirements

 1″ conduit w/5 loop feeder cables Exceeds NEC max fill Exceeds ODOT max fill	 1″ conduit w/4 loop feeder cables Exceeds NEC max fill Exceeds ODOT max fill
 1″ conduit w/3 loop feeder cables Does NOT exceed NEC max fill Exceeds ODOT max fill	 1″ conduit w/2 loop feeder cables Does NOT exceed NEC max fill Exceeds ODOT max fill (just barely)

 1½″ conduit w/control cables Does NOT exceed NEC max fill Exceeds ODOT max fill	 2″ conduit w/control cables Does NOT exceed NEC max fill Does NOT exceed ODOT max fill
 1½″ conduit w/9 loop feeder cables Exceeds NEC max fill Exceeds ODOT max fill	 1½″ conduit w/9 loop feeder cables +1 video cable Exceeds NEC max fill Exceeds ODOT max fill
 2½″ conduit w/22 loop feeder cables Exceeds NEC max fill Exceeds ODOT max fill	 3″ conduit w/22 loop feeder cables Does NOT exceed NEC max fill Does NOT exceed ODOT max fill

5.13.2 Conduit Materials

There are several different types of conduit materials that can be used for traffic signal installations. The conduit material is NOT specified on the plan sheets as this information is contained within the standard drawing TM471 (contractor shall install non-metallic conduit unless otherwise shown). The following information is some basics on conduit materials. Refer to standard drawing TM471 for detailed info.

- **Rigid Metallic Conduit**
  - Typically not used for permanent traffic signals. Rigid galvanized metallic conduit is a good choice where there is the potential for damage, such as conduit located above ground (on poles or structures). However, fiberglass is also a good choice for conduit installed on structures and should be considered first.
  - For conduit located under railroad tracks, there is a requirement to place the conduit holding wires within a rigid metallic conduit "sleeve" as per the special provision boiler plates.
- **Rigid Non-Metallic Conduit**
  - Fiberglass (schedule 40) – used for elbows and in foundations as per standard drawing TM471. Fiberglass can also be used instead of rigid metallic conduit in above ground locations.
  - PVC (schedule 40) – used for risers in junction boxes as per standard drawing TM471. This is the most common type of rigid non-metallic conduit used for other applications in traffic signal installations due to cost and availability.
  - High density polyethylene (HDPE) – typically used when installing conduit by horizontal directional drilling.
  - Liquid Tight Flexible – Only used for mounting conduit on temporary wood poles as per the standard drawings.

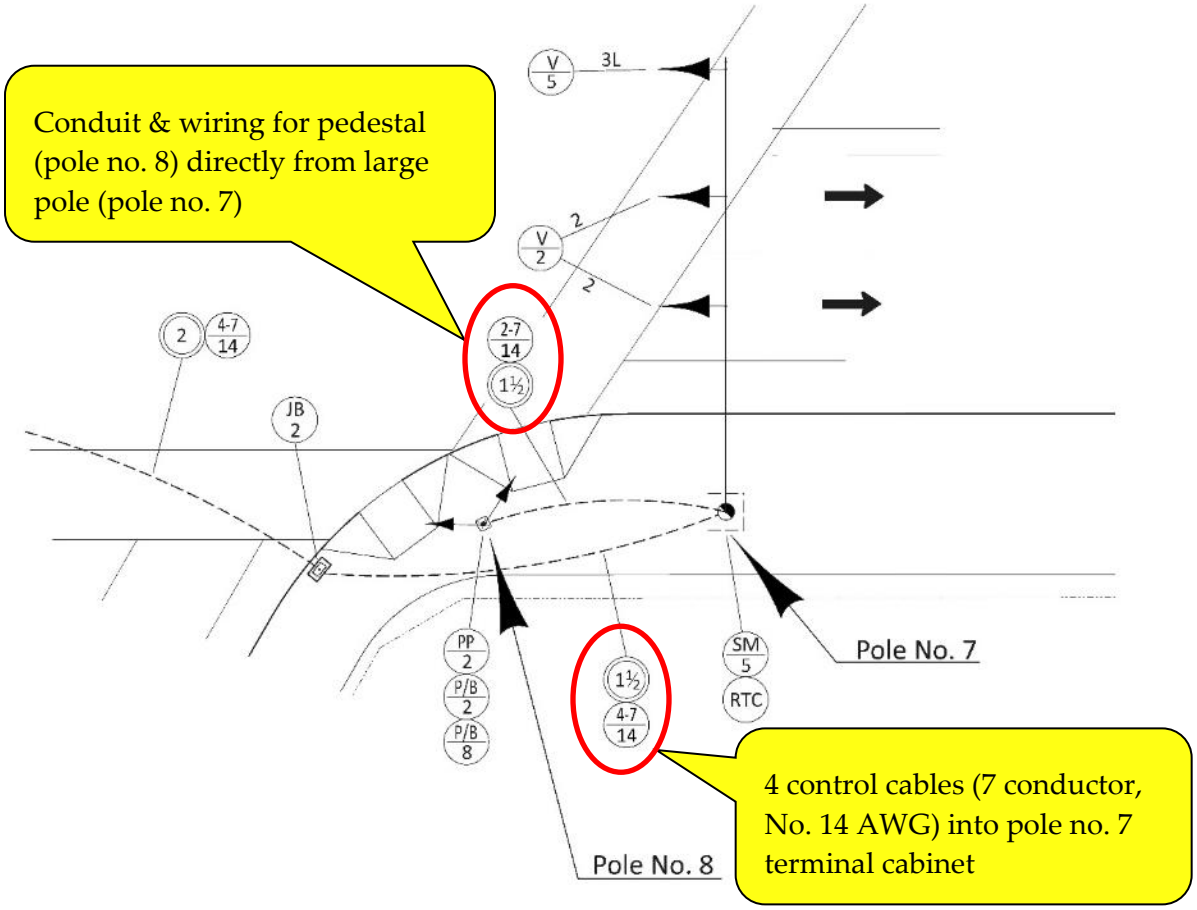
5.13.3 Expansion Fittings

Whenever traffic signal conduit must be placed on or in a structure, conduit expansion fittings are required. The structure will experience expansion/contraction depending on the stresses subjected to it, and so the conduit must also allow for movement too. Therefore, expansion fittings are used on the conduit run at all structure expansion joints as per the special provision boiler plates. Because the special provisions state this requirement, it is not necessary to show this detail on the plan sheets.

5.13.4 Routing Conduit to Pedestals

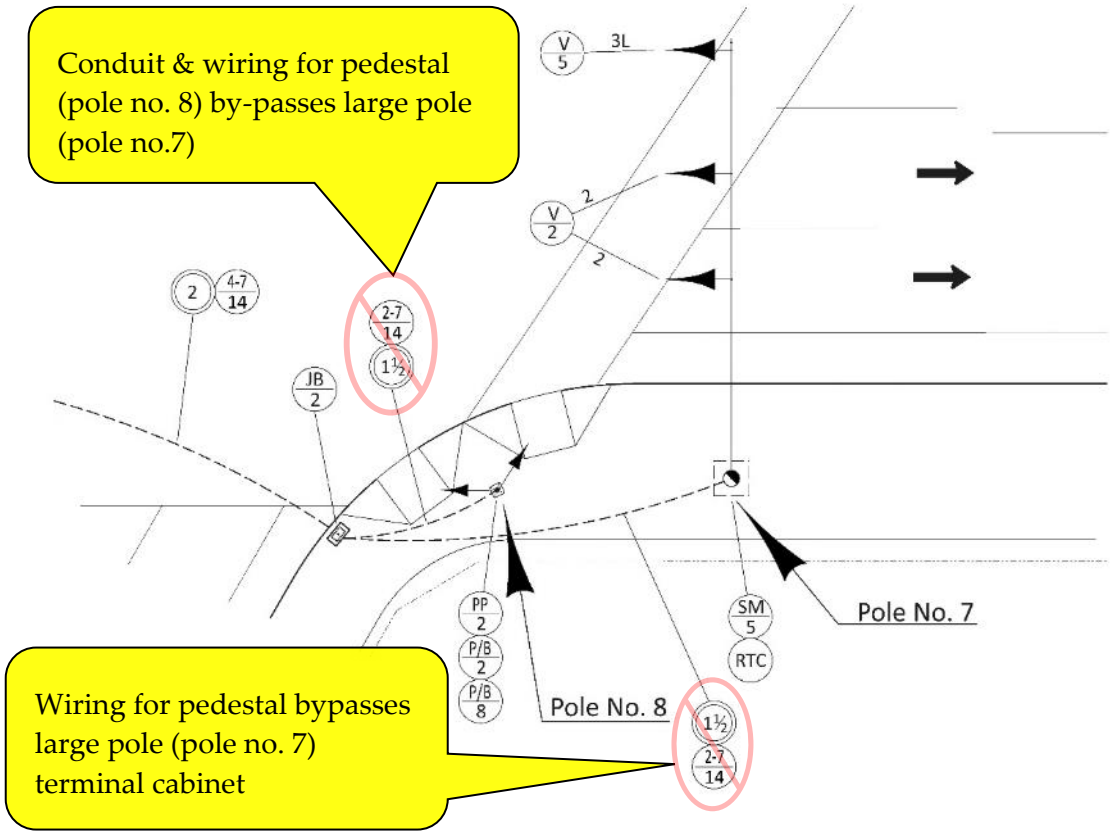
When a large pole is located in the same quadrant as pedestals, route the conduit from the junction box in the same quadrant to the large pole, then from the large pole to the pedestal(s). The wiring for the pedestal will be spliced in the terminal cabinet of the large pole. Routing the conduit and wiring this way allows for easy replacement of the pedestal and wiring to the pedestal in the event of a pedestal knock-down (all pedestals are designed to break-away) due to the splice point in the large pole terminal cabinet. See Figure 5-120.

Figure 5-120 | Conduit Routing to Pedestal with Large Pole in Same Quadrant – Preferred Method



Do NOT route conduit from the junction box in the same quadrant directly to the pedestal(s) when a large pole is located in the same quadrant. See Figure 5-121. However, for retro-fit projects (e.g., adding pedestals to an existing signal due to curb ramp reconstruction), this is likely the only feasible option, as installing a new conduit in an existing pole foundation should be avoided when possible.

Figure 5-121 | Conduit Routing to Pedestal with Large Pole in Same Quadrant – Avoid This Method



When a large pole is NOT located in the same quadrant as the pedestal (e.g., T-intersection), the conduit should route from a junction box in that quadrant to the pedestal, as shown in Figure 5-122. Do NOT route conduit directly to the pedestal. See Figure 5-123.

Figure 5-122 | Conduit Routing to Pedestal Not Located in Same Quadrant as Large Pole – Preferred Method

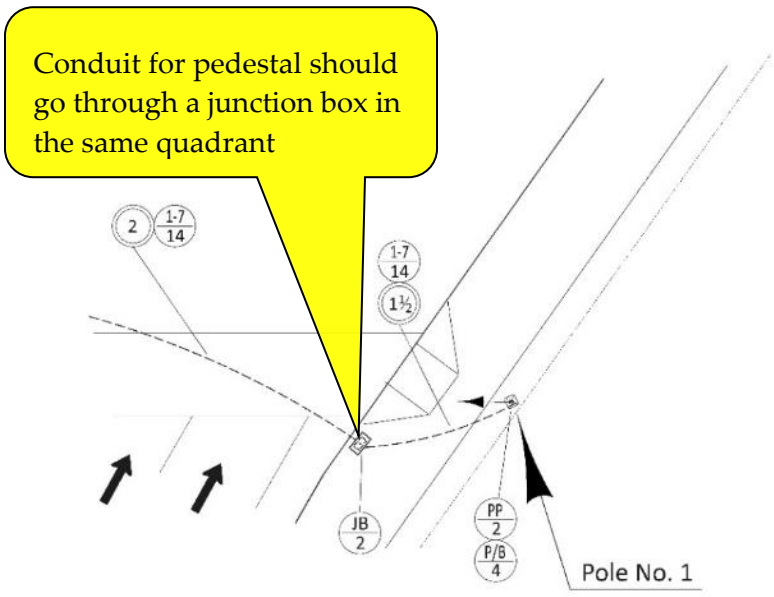
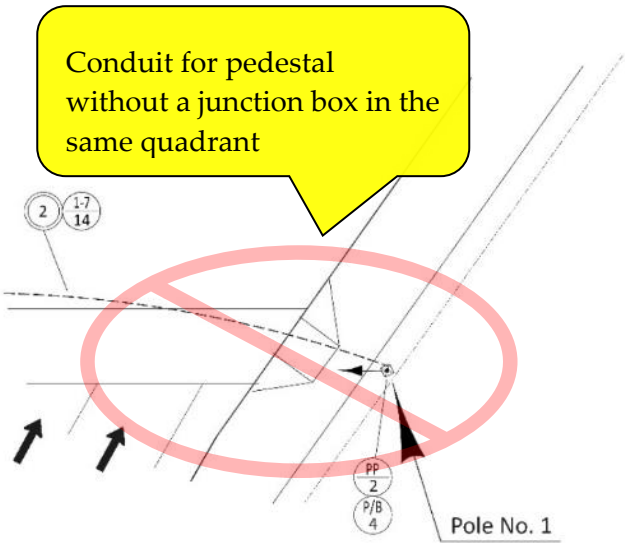


Figure 5-123 | Conduit Routing to Pedestal Not Located in Same Quadrant as Large Pole – Avoid This Method



5.13.5 Conduit Trenching Depths & Underground Conflicts

Retro-fit projects often change the existing finish grade elevations which requires attention to how existing conduits will be impacted. ODOT standard conduit cover is shown on TM471 and ranges from 18 inches to 30 inches (or as per the permit if the permit requires depths that are greater) depending on where the conduit is located. If the finish grade elevations are lowered, the existing conduit may need to be reinstalled at the correct depth. Also note that existing conduits may not have been installed at or adjusted to the current required depths on past projects.

Information on conduit depth during the design phase is typically not available, forcing solutions to be explored during the construction phase as they are discovered. However, the region electricians are good sources of info for site-specific issues (based on past inspections or problems they have encountered over the years) and should be consulted to verify any known issues during the design phase.

If the finish elevation grade is being lowered significantly, there is known issues with shallow conduit, or construction activities discover a shallow conduit, the impacted conduits should be replaced by new conduit installed at the current depth requirements. If this is not possible, either due to the scope of work, budget, or construction timelines, other solutions may be considered such as following the NEC minimum cover standard of 6 inches with conduit encased in concrete. Contact the state traffic signal engineer for approval of using this option and for additional site-specific design requirements.

Underground utilities can also cause conflicts when installing conduits. Conduits that will cross any existing utilities or that will be installed close to an existing utility should be identified. Depending on the situation, the utility or the conduit may need to be relocated, a different installation method may be desirable (horizontal directional drilling vs. open trench) or custom instructions may be needed on the plan sheets. See chapter 8 for more details about identifying utility conflicts and working with the region utility specialist to mitigate any anticipated issues.

Adjustment of any existing conduit may require replacing/splicing existing conduit (which requires re-installing wiring). Verify with region electrical crew if the existing wiring can be re-installed or if all new wire should be installed. If the traffic signal condition rating is low or the signal is over 20 years old, re-installing existing wire is not recommended.

5.14 Wiring

Traffic signals have three distinct systems for wiring based on the voltage used:

- 120V AC for all signal indications (includes both vehicle and pedestrian indications)
- 240V AC for illumination that is part of the traffic signal
- 24V DC for pedestrian pushbuttons and vehicle detection system

When wiring a traffic signal, NO SPLICING IS ALLOWED!

5.14.1 Wire Types

Control Cable (multi-conductor cable)

Control cables are multi-conductor cable with assorted stranded copper wires of a particular gauge (No. 14 AWG, No. 12 AWG, etc.). The standard material (wire and insulation) is defined by IMSA (International Municipal Signal Association). The 7-conductor control cable as shown in standard drawing TM470 is used to provide electricity from the controller cabinet to:

- Signal heads
- Pedestrian signal heads
- Pushbuttons

The control cables within a mast arm (from the terminal cabinet to the signal heads) are not shown on the plans but are instead detailed in the standard drawings.

The 7-conductor control cable was chosen as the standard to simplify installation (only one type of cable to bring to the job site), simplify design (one cable for each phase directly from the controller cabinet to the pole terminal cabinet/device), and simplify inspection (one type of cable without extensive color code requirements, easier plan reading). This simplification does have a few downsides such as, larger or more conduit required, higher wiring quantity required, and more spare wires. However, the benefits stated above outweighed these costs.

Single Conductor Wire THWN

Single conductor wire THWN is used to provide electricity from the controller cabinet to:

- Photo control electronic relay
- Flashing beacons
- PTR signs

Single conductor wire THWN is no longer used in new construction for signal heads, pedestrian signal heads or pushbuttons, but it may still be used for retro-fit projects when the use of control cables is not feasible due to inadequate existing conduit size.

Note there are two exceptions for single conductor wire THWN in new construction as per TM470: wiring in the large signal pole for pedestrian signals and pushbuttons mounted on the large signal pole (see Figure 5-121) and wiring in the ramp meter assemblies for type 8 signal heads (see Figure 5-119).

The color code for single conductor wire is shown in the standard details.

THWN stands for:

- T: Thermoplastic insulation
- H: High temperature (usually 75 °C when dry or damp)
- W: Moisture resistant (usually 60 °C when wet)
- N: Nylon jacket

Single Conductor Wire XHHW

Single conductor wire XHHW is used to provide electricity from the service cabinet to:

- The in-line fuse holder (located in the pole base) for illumination on the signal pole
- The controller cabinet

XHHW stands for:

- X: Cross-linked synthetic polymer insulation
- HH: Higher temperature (usually 90 °C when dry or damp)
- W: Moisture resistant (usually 60 °C when wet)

TC Cable

This cable contains three conductors with XHHW insulation with an overall PVC jacket. It is used to provide electricity from the in-line fuse holder (located in the pole base) to:

- The illumination fixture

The TC cable within the pole is not shown on the plans but is instead detailed in the standard specifications.

5.14.2 Wire Gauge

The American wire gauge (AWG) is a standardized wire gauge system for the diameters of round, solid conductors. The cross-sectional area of each gauge is an important factor for determining its current carrying capacity. Increasing gauge numbers give decreasing wire diameters.

The standard wire gauges used by ODOT for traffic signal installations are shown below:

- No. 6 AWG is used for:
  - Power from the service cabinet to the controller cabinet
  - Ground/bond wire
- No. 10 AWG is used for illumination
- No. 12 AWG is used for:
  - Power from service cabinet to the photo control electronic relay
  - PTR signs
- No. 14 AWG is used for powering:
  - Signal heads (vehicle/bike)
  - Pedestrian signal heads
  - Pushbuttons
  - System common/system neutral (inclusive in the control cable for the above listed equipment)
  - Flashing beacons

5.14.3 Voltage Drop

In certain circumstances, such as a temporary one-lane, two-way traffic signal where the distance between the controller cabinet and the signal equipment is excessive, a larger gauge wire (than the standard) may be needed to power the equipment due to the voltage drop that occurs over the distance of the wire. Voltage drop should not exceed three percent. However, with the use of LED signal heads (which do not require as many watts as an incandescent signal head) the need to use larger gauge wire is now rarely a necessity, even with temporary one-lane, two-way traffic signals.

5.14.4 Bonding/Grounding Requirements

All ground rods, metal conduit, metal poles, grounding wire, metallic junction boxes, metallic junction box covers, and cabinets shall be mechanically and electrically secure to form a continuous, effectively grounded and bonded system. Typically, a No. 6 AWG stranded copper wire is used for grounding/bonding.

The standard drawings, section 00960.45 of the Oregon Standard Specifications for Construction, and National Electric Code contain all the requirements for bonding and grounding. Because of this, the signal plan sheets typically do NOT show or detail any grounding/bonding requirements. It is recommended that the signal designer consult these sources or contact the region electrical crew for additional information on grounding/bonding.

5.14.5 Common/Neutral (Shared) Wire

A neutral/common wire is needed for each signal system to complete the circuit. There are three separate wiring systems used in traffic signals.

1. 120V AC for signal indications – includes both pedestrian & vehicle indications
2. 24V DC for pedestrian pushbuttons
3. 240V AC for illumination on signal poles (two hot 120V wires, No. 10 AWG XHHW wire, therefore no common/neutral required)

Control cable is used for the first two systems in which the common/neutral is inclusive. If single conductor wiring is used for the first two systems due to a retro-fit project where the existing conduit cannot accommodate control cable, see the January 2020 version of the Traffic Signal Design Manual for information on common/neutral wiring.

5.14.6 Wiring Signal Heads (From Head to Terminal Cabinet)

Each signal indication in a signal head requires a "hot" wire and a "common/neutral" wire in order to complete the circuit. Refer to Figure 5-125 when reading the bulleted text below for a description of the wiring diagram that is used in Figure 5-125 through Figure 5-132 for each signal head type:

- The type 2 signal head shows the hot wiring for each indication (red, yellow, green) entering the signal indication from right side and the common/neutral wiring entering from the left side. This wiring is contained within the signal head itself and NOT shown or detailed on the plan sheets.
- The wiring from the terminal block within the signal head connects to the terminal cabinet located on the signal pole. This wiring is accomplished with a 7-conductor control cable; one for each signal head regardless of type (see Figure 5-124). It is located within the mast arm (or along the span wire for a temporary signal). Note that use of a 7-conductor control cable results in one to three spare wires depending on the type of signal head that is used. This wiring is NOT shown or detailed on the plan sheets for mast arm installations as standard drawing TM470 details this information, but it is shown and detailed on the temporary signal plan sheets for span wire installations.
- From the terminal cabinet on the signal pole one 7-control cable is routed back to the signal controller cabinet (in conduit) to power each signal phase. Note that use of a 7-conductor cable in conduit will have between two and six spare wires depending on the number of phases and indication configuration of the signal head. See 5.14.8 for more info. This wiring is shown and detailed in the plan sheets.

Figure 5-124 | 7-Conductor Control Cable Wiring for Signal Heads (TM470)

7 CONDUCTOR CONTROL CABLE			SIGNAL HEAD TYPES			
CONDUCTOR NUMBER	BASE COLOR	FIRST TRACER	6L* or 3LBF*	4L*, 5* or 7	1R, 1Y 2, 2B, 2BM, 3L, 3LCF, 3R 4 or 9	10*
1	WHITE	—	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL
2	BLACK	—	YELLOW	YELLOW	YELLOW	YELLOW
3	RED	—	RED	RED	RED	RED 1
4	ORANGE	—	FLASHING YELLOW	TURN YELLOW	SPARE	RED 2
5	GREEN	—	GREEN	GREEN	GREEN	GREEN
6	BLUE	—	SPARE	TURN GREEN	SPARE	SPARE
7	WHITE	BLACK	SPARE	SPARE	SPARE	SPARE

* Signal heads in standard detail DET4401

Figure 5-125 shows the wiring required for a type 2, 2B, 2BM, 3L, 3R, or 3LCF signal head. These signal head types contain one phase and three functions (red, yellow, and green). The 3LCF signal head yellow indication performs two functions (flashing arrow and solid arrow) via software programming. One "hot" wire for each function (exception is the type 3LCF) and one common/neutral wire is required, resulting in 3 spare wires.

Figure 5-125 | Wiring for Type 2, 2B, 2BM, 3L, 3R, and 3LCF Signal Heads

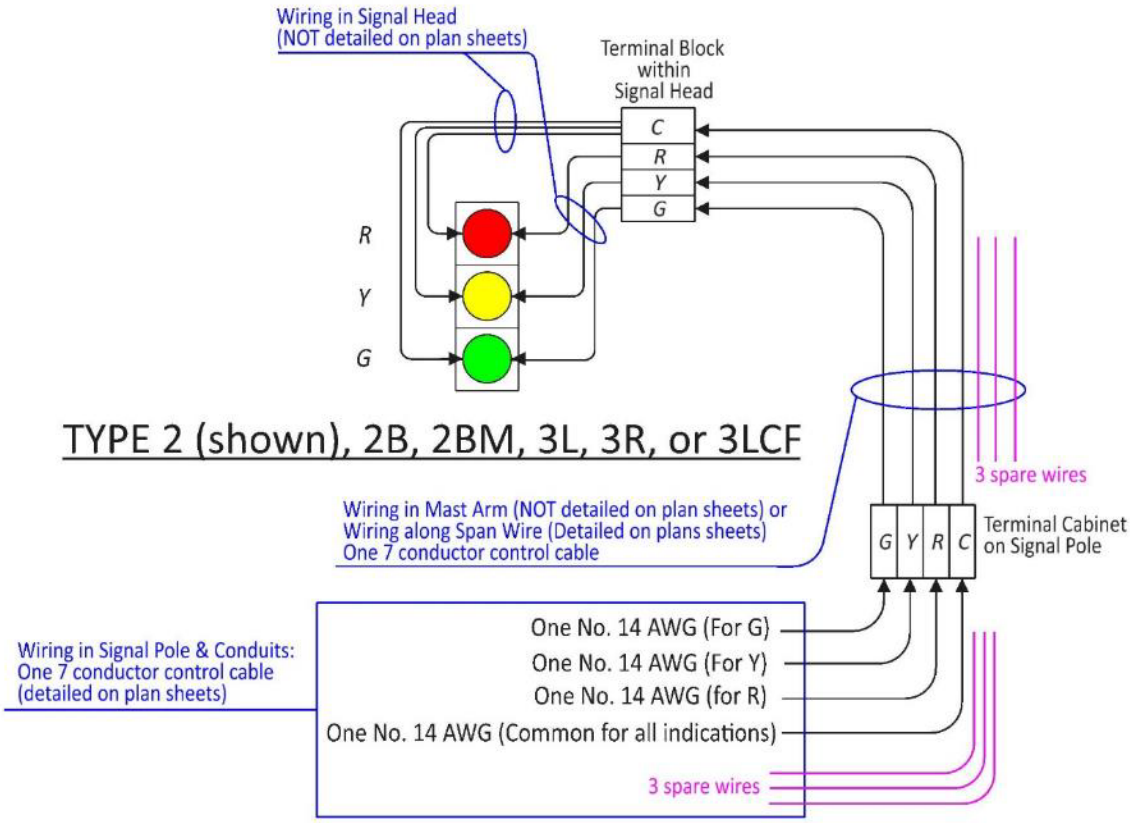


Figure 5-126 shows the wiring required for a type 3LBF signal head. This signal head type contains one phase and four functions (red, yellow, flashing yellow and green). All of the solid arrow indications are wired to the protected left turn phase (typically 1, 3, 5, or 7) and the flashing yellow arrow is wired to an unused overlap phase green (OLA for ph.1 FYA, OLB for ph. 3 FYA, OLC for ph. 5 FYA, and OLD for phase 7 FYA) which via software is linked to the opposing through movement. One "hot" wire for each function and one common/neutral is required, resulting in 2 spare wires.

Figure 5-126 | Wiring for Type 3LBF Signal Head

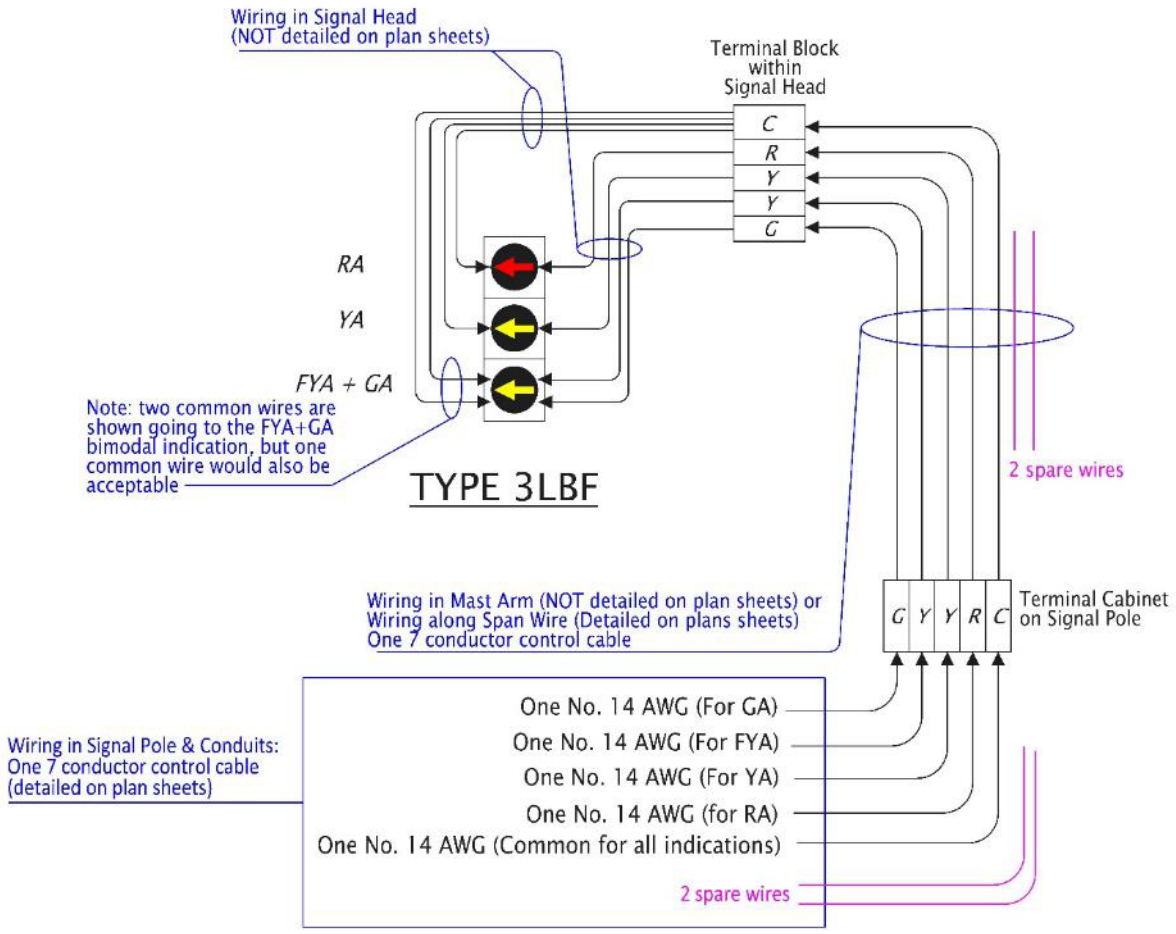


Figure 5-127 shows the wiring required for a type 4 or type 9 signal head. These signal head types contain one phase and three functions (red, yellow, and green). The two green indications always operate together on the same phase. Because of this, the wiring shown and detailed on the plan sheets looks no different than for a type 2 signal head; One "hot" wire for each function and one common/neutral wire is required, resulting in 3 spare wires. The additional wires needed to power each green indication occur within the signal head, which is not shown or detailed on the plan sheets.

Figure 5-127 | Wiring for Type 4 & 9 Signal Heads

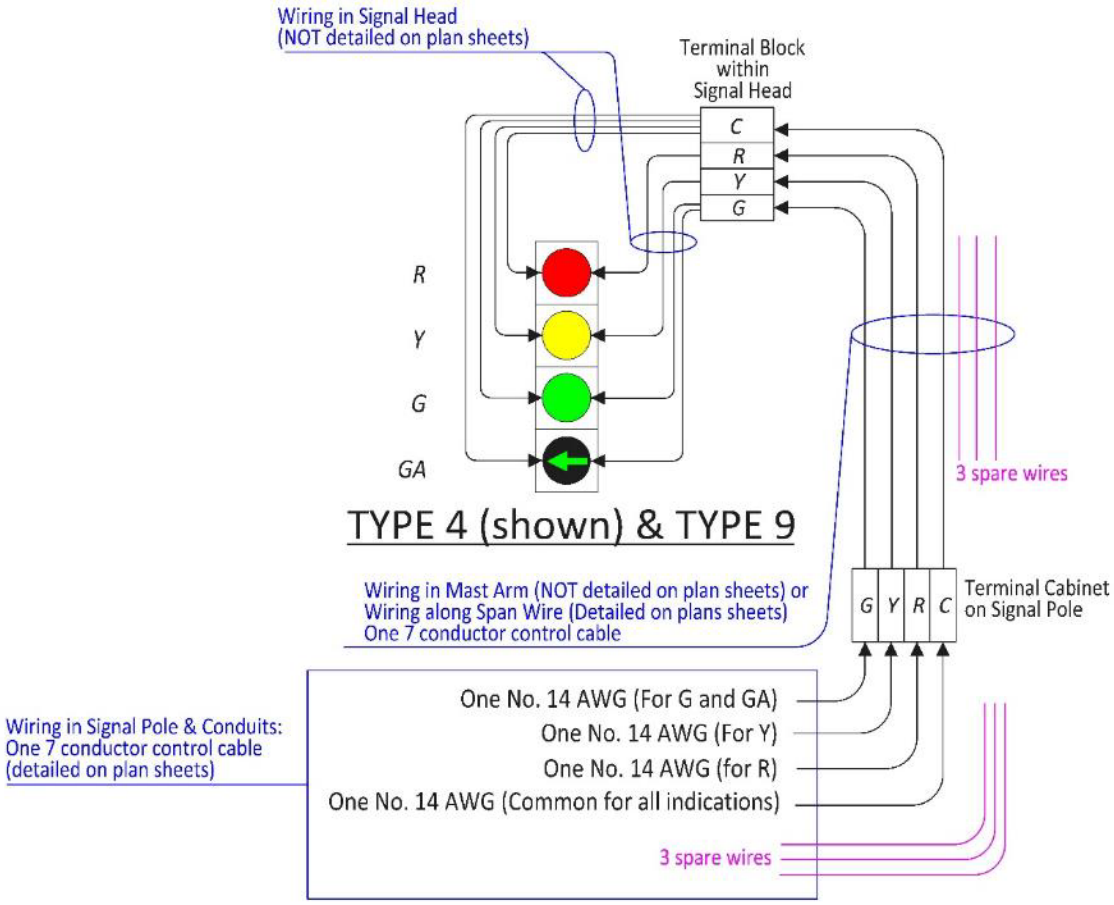


Figure 5-128 shows the wiring required for a type 4L or type 5 signal head. These signal head types contain two separate phases (the arrow indications are for the protected turn phase and the ball indications are for the through phase/permissive turn) and five functions total (red, yellow, and green for one phase and yellow and green arrows for the second phase). All of the ball indications are wired to the through movement phase (typically 2, 4, 6, or 8) and the two arrow indications are wired to the appropriate protected left turn phase (typically 1, 3, 5, or 7). One "hot" wire for each function and one common/neutral wire is required, resulting in 1 spare wire for the control cable in the mast arm. Two conductor cables are required in the conduit (one for each phase) which results in 3 spare wires for one phase, and 5 spare wires for the second phase. Note that the neutral/common is provided by only one of the two required conductor cables in the conduit and it doesn't matter which control cable provides the neutral/common.

Figure 5-128 | Wiring for Type 4L & 5 Signal Heads

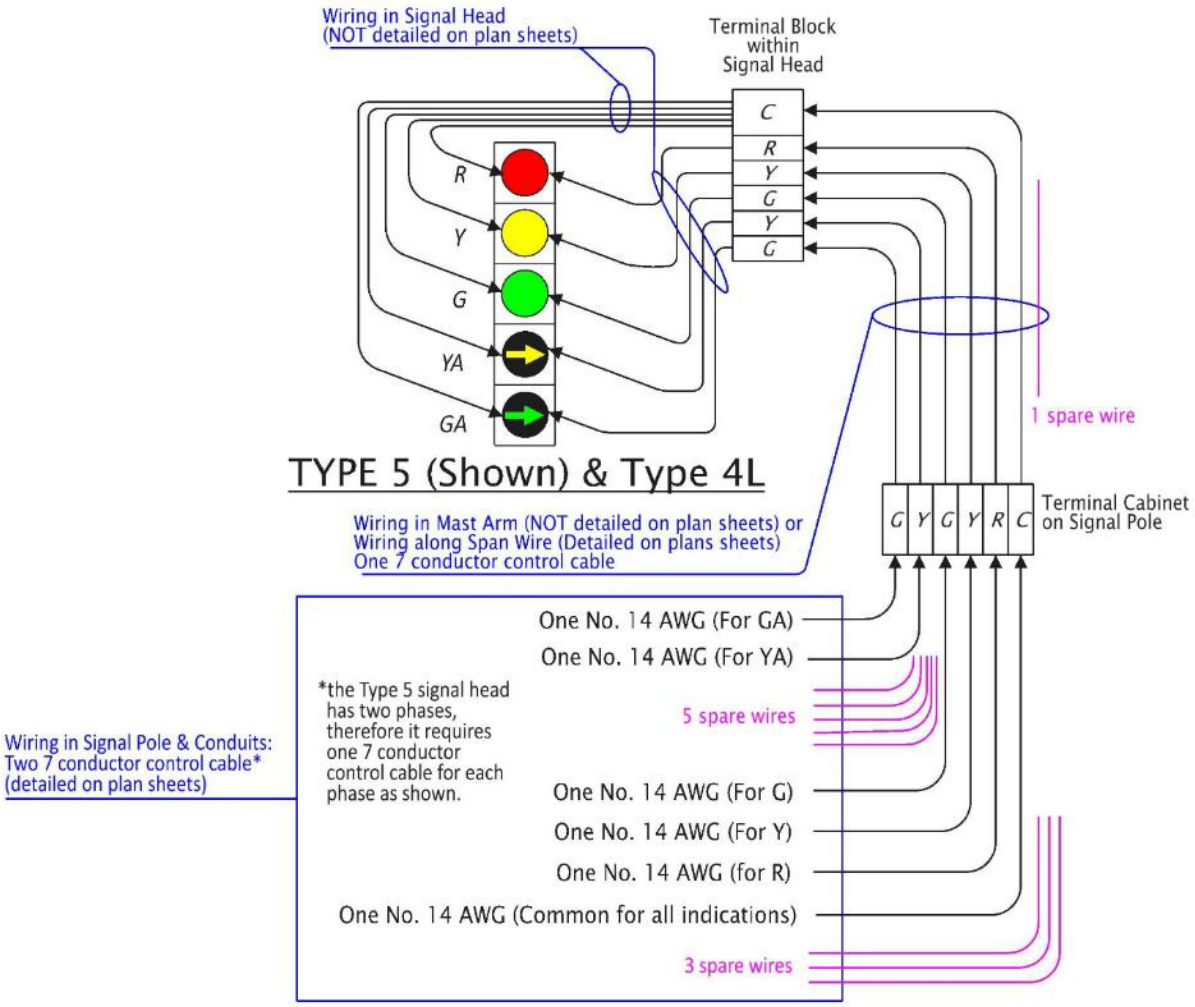


Figure 5-129 shows the wiring required for a type 6L signal head. This signal head type contains one phase (the left turn) and four functions (red, yellow, flashing yellow, and green). All of the solid arrow indications are wired to the protected left turn phase (typically 1, 3, 5, or 7) and the flashing yellow arrow is wired to an overlap phase green (OLA for ph.1 FYA, OLB for ph. 3 FYA, OLC for ph. 5 FYA, and OLD for phase 7 FYA) which via software is linked to the opposing through movement. One "hot" wire for each function and one common/neutral wire is required, resulting in 2 spare wires.

Figure 5-129 | Wiring for Type 6L Signal Head

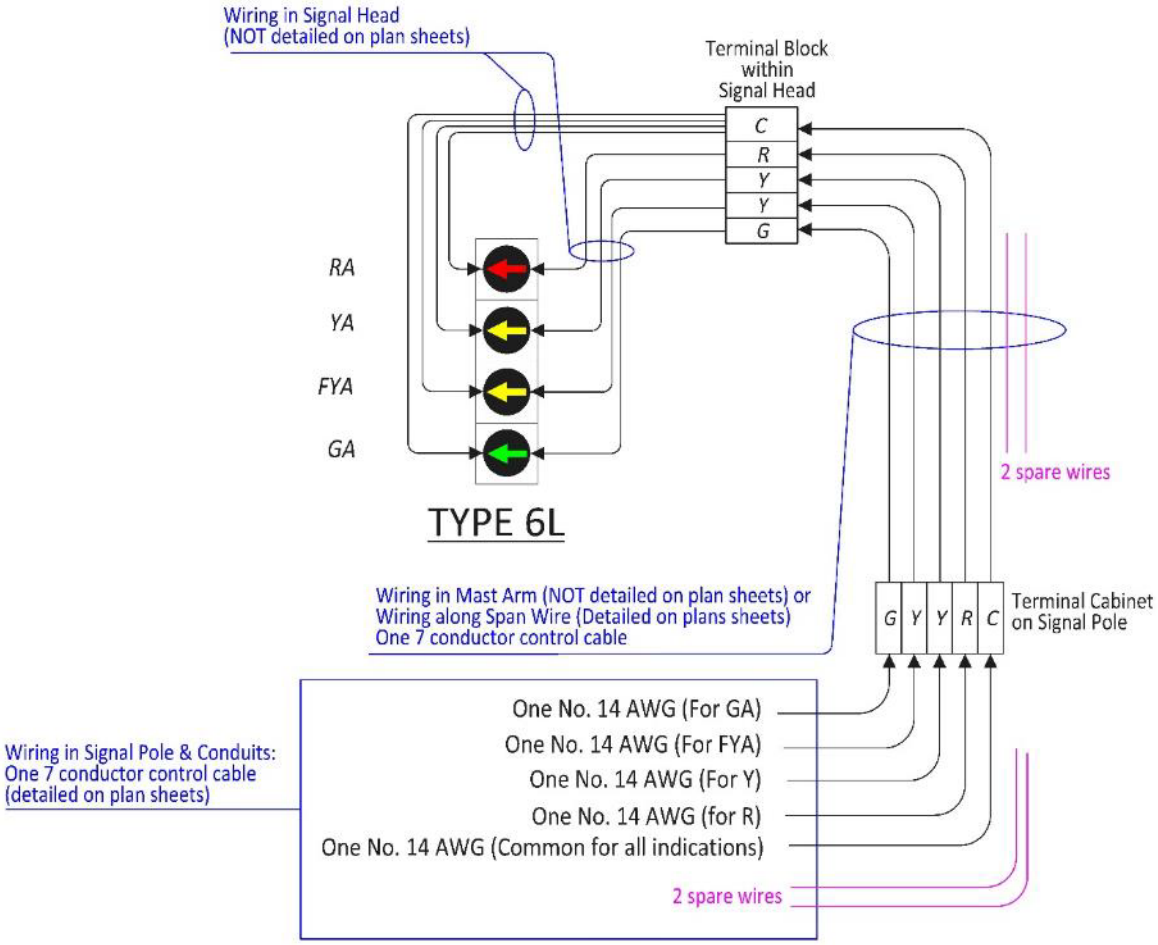


Figure 5-130 shows the wiring requirements for a type 7 signal head. This signal head type contains two separate phases and a total of four functions (red, yellow, and green for one phase and green arrow for the second phase). Unlike the type 4 signal head, the green arrow and green ball operate on the different phases. All of the ball indications are wired to the through movement phase (typically 2, 4, 6, or 8) and the green arrow indication is wired to the adjacent protected left turn phase (typically 1, 3, 5, or 7). This enables the green arrow to only be displayed during railroad preemption and remain dark during normal phase rotation. One "hot" wire for each function and one common/neutral wire is required, resulting in 2 spare wires for the control cable in the mast arm. Two conductor cables are required in the conduit (one for each phase) which results in 3 spare wires for one phase, and 6 spare wires for the second phase. Note that the neutral/common is provided by only one of the two required conductor cables in the conduit and it doesn't matter which control cable provides the neutral/common.

Figure 5-130 | Wiring for Type 7 Signal Head

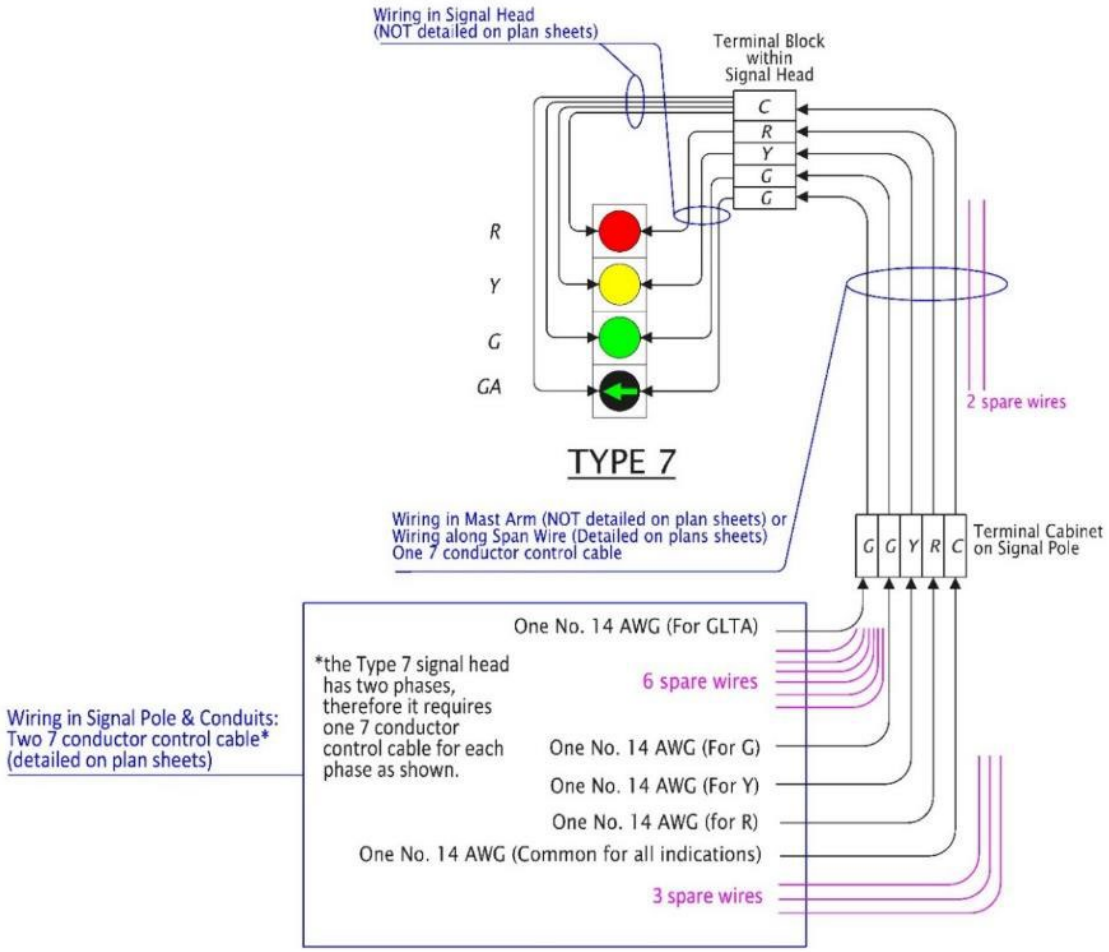


Figure 5-131 show the wiring requirements for a type 8 signal head. This signal head type contains one phase and two functions (red and green). This signal head type is for a ramp meter and is always mounted on a pedestal with a type 2 signal head above it as per standard drawing TM492. Standard drawing TM470 requires the type 8 signal head to be wired from the above mounted type 2 signal head terminal block with No. 14 AWG THWN single conductor wires because there is no terminal cabinet for a pedestal. One "hot" wire for each function and one common/neutral wire is required. Wiring in the conduit contains one 7 conductor cable that is terminated in the type 2 signal head terminal block.

Figure 5-131 | Wiring for Type 8 Signal Head

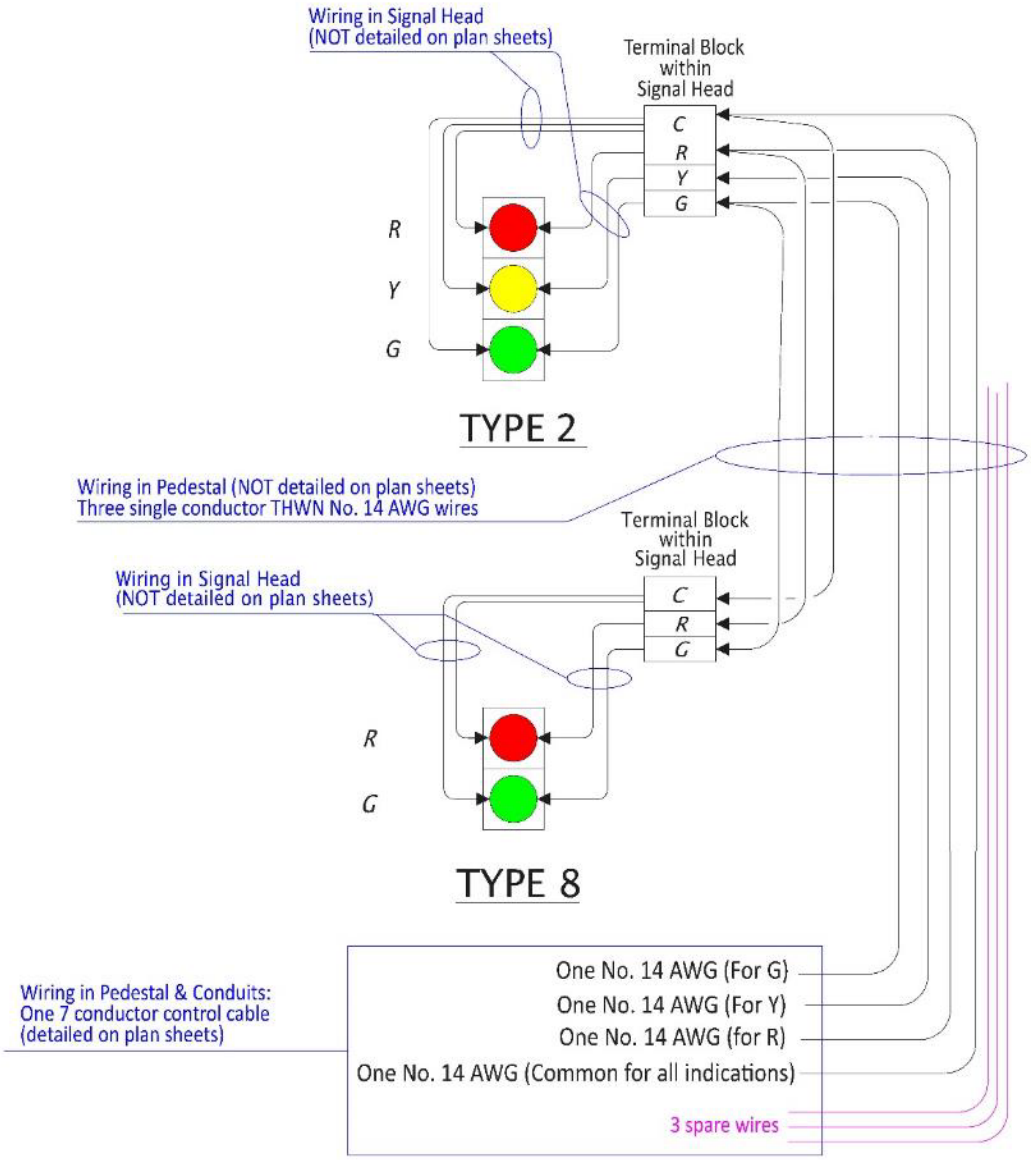
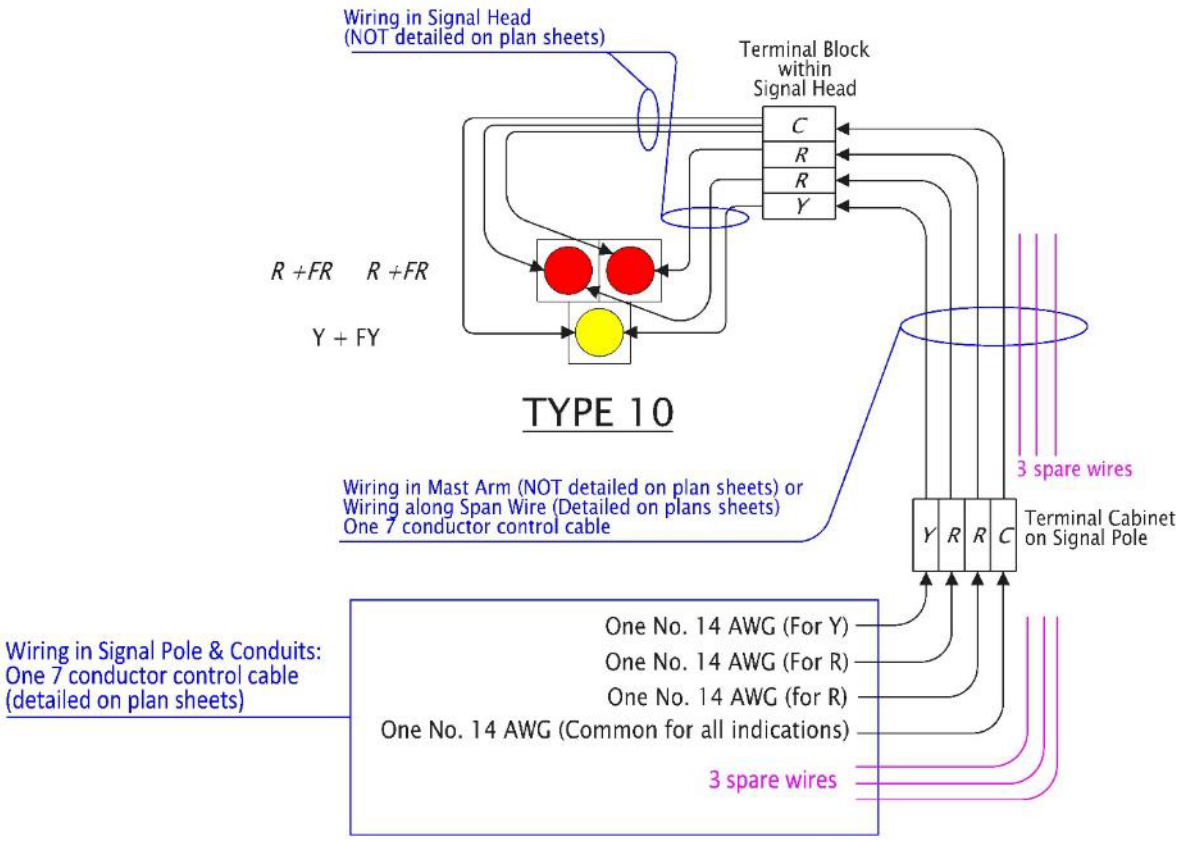


Figure 5-132 shows the wiring requirements for a type 10 signal head. This signal head type contains one phase and two functions (red and yellow). However, the red function is comprised of two indications that must operate in a "wig-wag" pattern (one off, one on and visa-versa) and therefore requires a separate wire for each indication. This results in a total of three "hot" wires, one common/neutral, and 3 spare wires.

Figure 5-132 | Wiring for Type 10 Signal Head



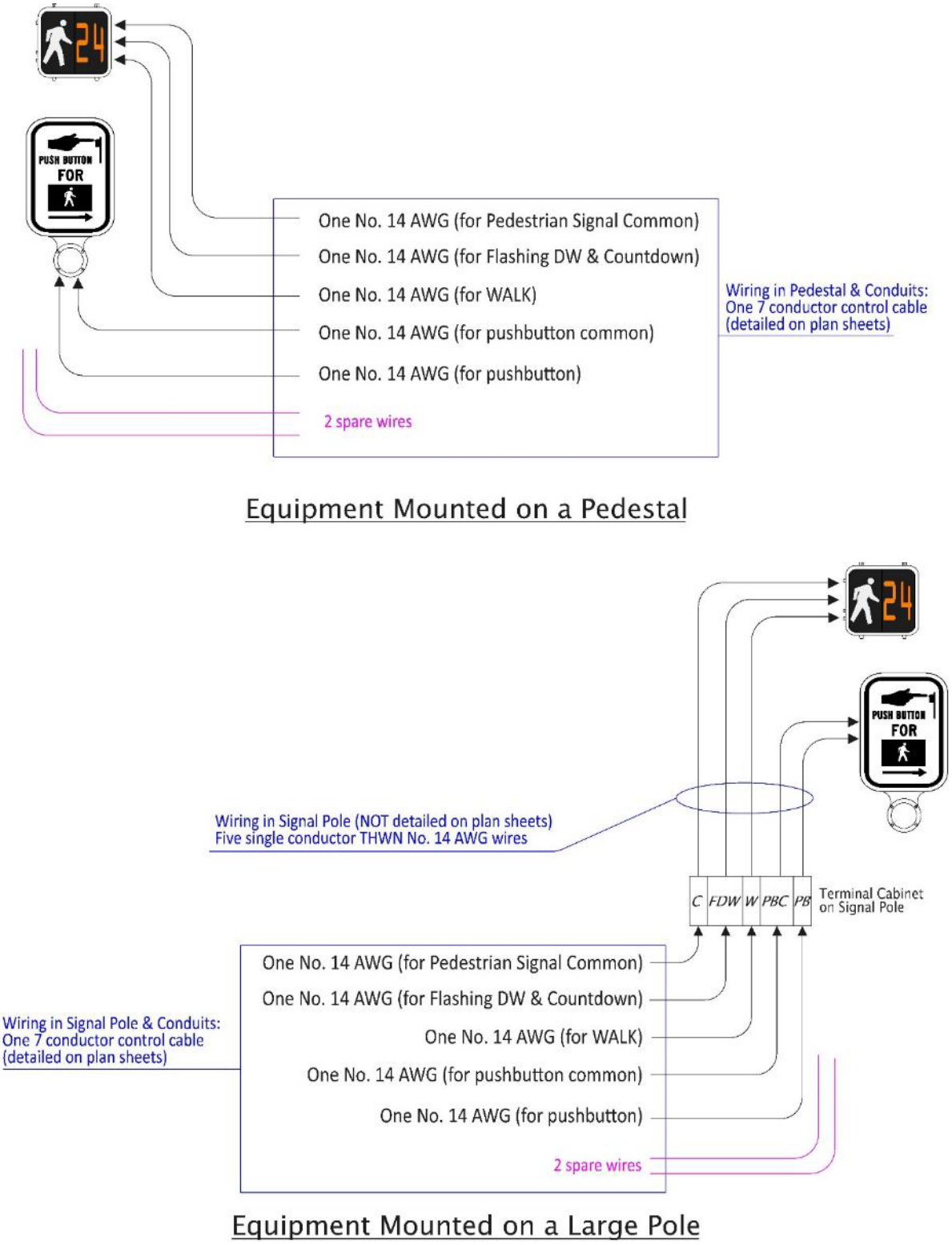
5.14.7 Wiring Pedestrian Signals and Pushbuttons

Figure 5-133 shows the requirements for a pedestrian signal and pushbutton mounted on a pedestal and mounted on a larger signal pole (typically both the pedestrian signal and pushbutton for the same phase are mounted on the same support and therefore require one 7 conductor control cable as shown). Standard drawing TM470 requires the pedestrian signals and pushbuttons mounted on signal poles to be wired from the signal pole terminal cabinet to the equipment with No. 14 AWG THWN single conductor wires as shown.

Pedestrian signal heads contain one phase and two functions (walk and flashing don't walk). The countdown indication is inclusive to the flashing don't walk wiring. Pedestrian pushbuttons contain one phase and one function (contact closure of the pushbutton to provide one input to the controller). One "hot" wire for each function and one common/neutral wire is required for the pedestrian signal (total of 3 wires) and for the pushbutton (total of 2 wires), resulting in 2 spare wires. A separate common/neutral wire is required for the pedestrian signal and the pushbutton. This is because the pedestrian signal and pushbutton operate on two different voltage systems (pedestrian signal on a 120V AC system and the pushbutton on a 24V DC system).

If the pedestrian signal head and pushbutton for the same phase are mounted on different supports, one 7 conductor cable would be used for each piece of equipment. This results in 5 spare wires for a pushbutton and 4 spare wires for a pedestrian signal.

Figure 5-133 | Pedestrian Indication and Pushbutton Wiring

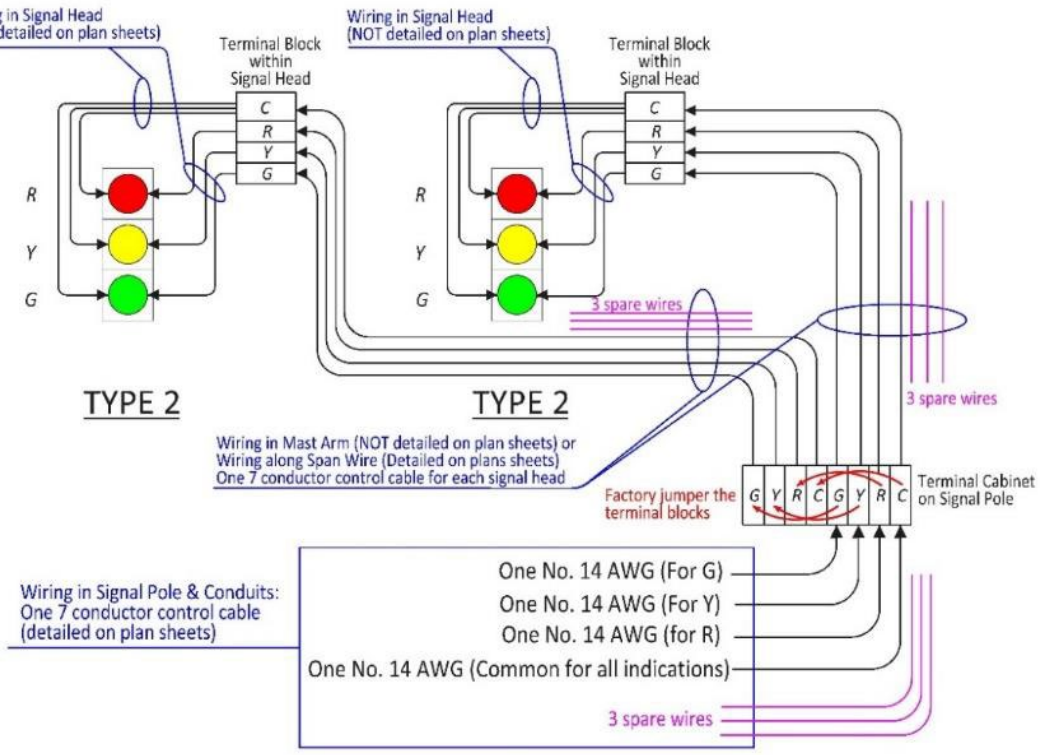


5.14.8 Wiring Signal Phases (from Terminal Cabinet to Controller)

The previous sections detailed how each signal head needs to be wired, while this section focuses on how each signal ***phase*** is wired (wiring from the terminal cabinet on the signal pole to the controller).

Multiple signal heads (located on the same pole) are often needed for one phase. Figure 5-134 shows one of the most common applications; two signal heads for one through movement phase (typically phases 2, 4, 6, or 8). Only one 7-conductor cable is needed for each phase, regardless of the number of signal heads that that phase has. Figure 5-134 shows three "hot" wires, one common/neutral, and 3 spare wires of the control cable from the controller cabinet to the terminal cabinet on signal pole. "Factory jumpers" are used on the terminal block within the terminal cabinet on the signal pole to provide power to the additional signal head. If a third signal head was added to the same phase, the same "hot" wires and one common/neutral of the control cable would be used from the controller cabinet to the terminal block on the signal pole, but an additional set of jumpers in the terminal cabinet on the signal pole would be used to power the third signal head. This principle of using jumpers in the terminal cabinet on the signal pole applies to any number of signal heads that are intended to operate on the same phase (on the same pole).

Figure 5-134 | Wiring Multiple Signal Heads for the Same Phase on the Same Pole

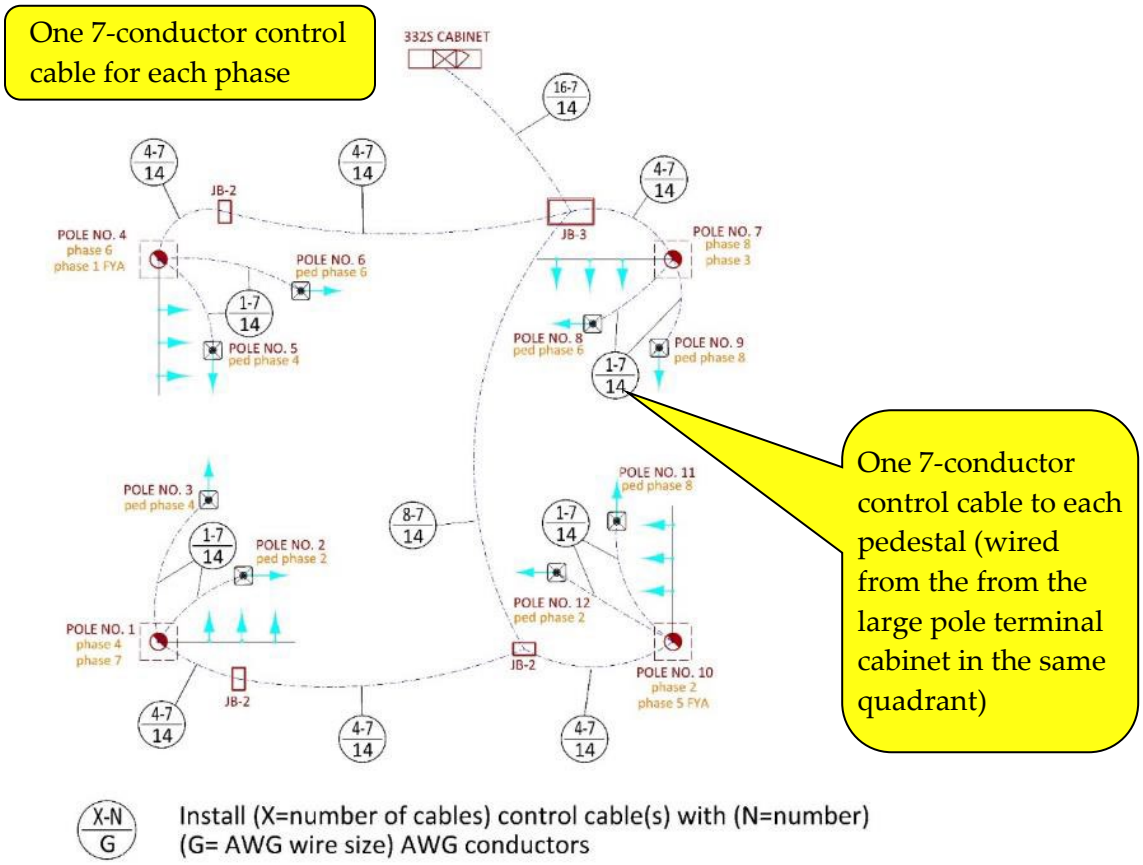


Using 7-conductor control cables is the default standard for wiring phases from the controller cabinet to terminal cabinet (in conduits). One 7-conductor control cable is required per phase (vehicle and pedestrian) from the controller cabinet to the pole terminal cabinet. See Figure 5-135 and Figure 5-136 for examples.

Figure 5-135 | 7-Conductor Control Cable Wiring For Signal Phases (TM470)

			PEDESTRIAN PHASES	VEHICLE PHASES
7 CONDUCTOR CONTROL CABLE			1 PEDESTRIAN PHASE	1 VEHICLE PHASE
CONDUCTOR NUMBER	BASE COLOR	FIRST TRACER		
1	WHITE	—	NEUTRAL	NEUTRAL
2	BLACK	—	WALK	YELLOW
3	RED	—	DONT WALK	RED
4	ORANGE	—	P.B. COMMON	SPARE
5	GREEN	—	PUSHBUTTON	GREEN
6	BLUE	—	SPARE	SPARE
7	WHITE	BLACK	SPARE	SPARE

Figure 5-136 | Wiring Phases with Control Cables



5.14.9 Wire Fill at the Terminal Cabinet Entrance and Mast Arm Connection

There are two critical locations on the mast arm pole that limit the amount of control cables that can be used within the pole and should be verified:

- **The external terminal cabinet entrance (only applicable for retro-fit projects with existing signal poles that have external terminal cabinets):** The terminal cabinet entrance dimension is through a 2 ½ inch diameter factory installed hub. This can accommodate a maximum of 16, 7-conductor control cables with No. 14 AWG conductors, using a 60% max fill rate as per the NEC for conduit and tubing nipples that do not exceed 24 inches in length. As per current wiring standards, the external terminal cabinet entrance will contain control cables going into the terminal cabinet (from the signal controller cabinet) and control cables going out of the terminal cabinet (to the equipment mounted on the pole and mast arm). See Figure 5-137.
- **The mast arm connection:** The mast arm connection dimension is a 2-inch diameter pipe sleeve. This can accommodate a maximum of 11, 7-conductor control cables with No. 14 AWG conductors, using a 60% max fill rate as per the NEC for conduit and tubing nipples that do not exceed 24 inches in length. The mast arm connection will contain all control cables from the terminal cabinet to the equipment located on the mast arm. See Figure 5-137 (existing external terminal cabinet only) and Figure 5-138 (recessed terminal cabinet).

Figure 5-137 | Verify Wire Fill at Terminal Cabinet and Mast Arm Connection (External Terminal Cabinet. Retro-Fits Only)

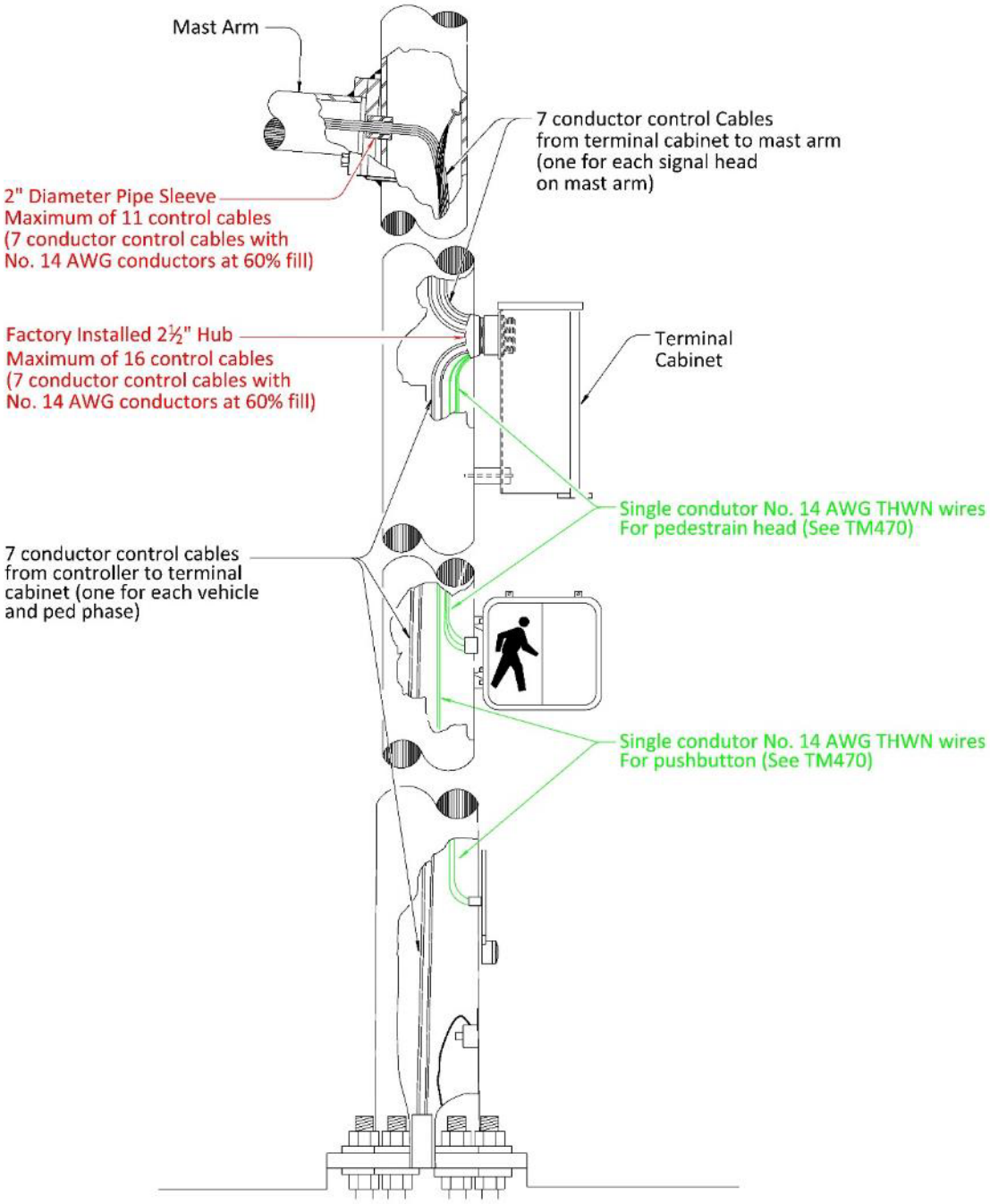
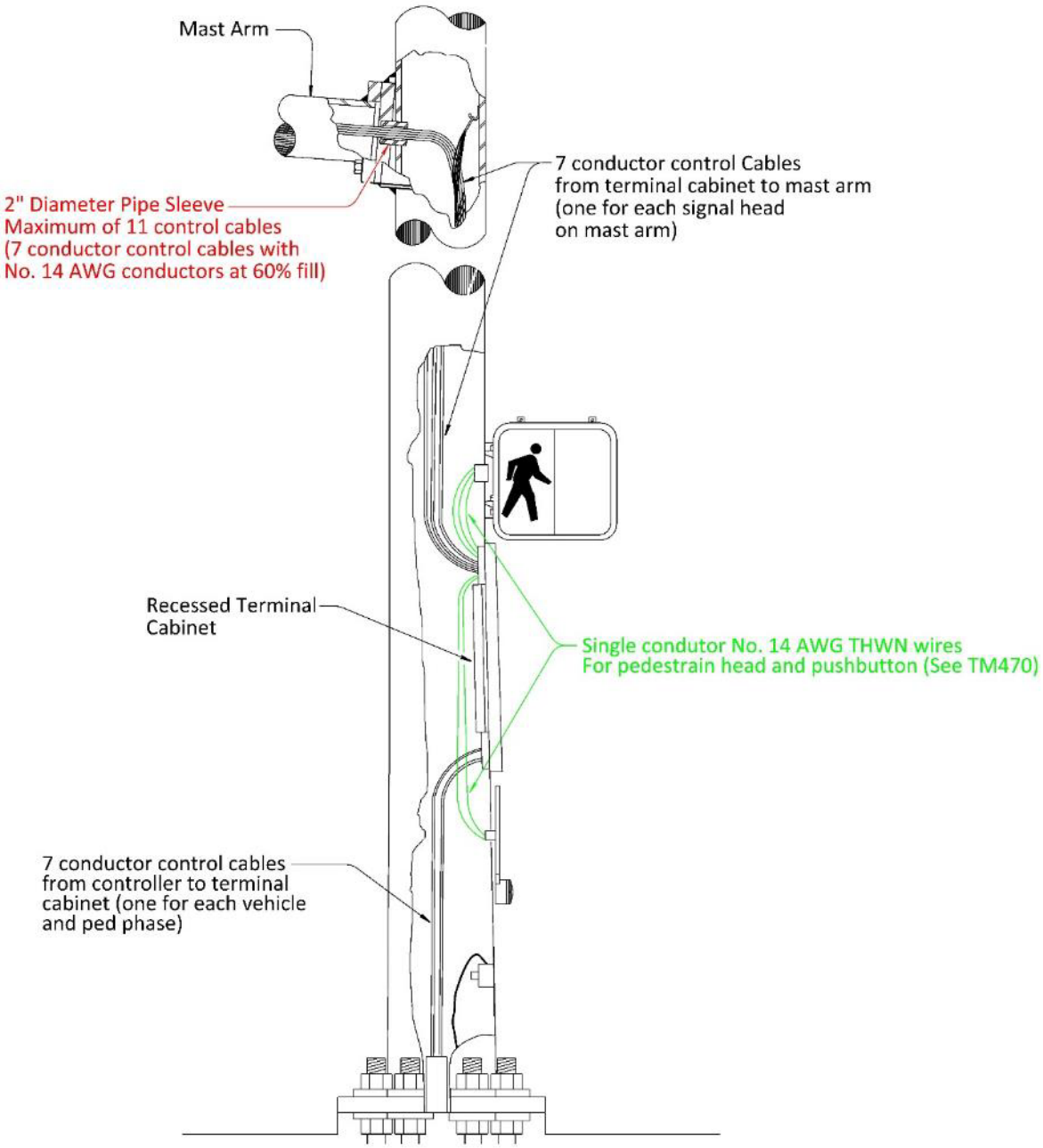


Figure 5-138 | Verify Wire Fill at Mast Arm Connection (Recessed Terminal Cabinet)



5.14.10 Wiring Part Time Restriction (PTR) signs

The only function of the part time restriction (PTR) sign is on or off. Therefore, only two THWN No. 12 AWG wires are required for it to function; one "hot" wire for the PTR sign and one wire for the common/neutral to complete the circuit. If using a control cable, a No. 12 AWG two conductor control cable is used. Using a No. 12 AWG wire helps easily identify the PTR wiring at a glance in the field.

5.15 Background/Reference Information

This section contains more in-depth information to aid in understanding guidance presented in this chapter.

5.15.1 Wiring History

This section has been provided for information and documentation purposes only.

Control cable with a variety of conductors (e.g., four, five, six, ten, twelve, and fifteen conductor control cables) have been used in the past for certain signal heads and certain combinations of phases to be more efficient (result in less cost and less spare wires). The decision to use 7-conductor control cables for all signal wiring was made for the following reasons:

- The cost savings between a four, five and six conductor control cable (for signal heads) verses a seven conductor control is not significant (less than a dollar/foot difference)
- The additional spare wires are beneficial for potential future uses (no need to pull more wire)
- Consistency
- Ease of construction (only need to buy and use one type of control cable for all signal heads)
- Large quantity unit pricing (instead of needing several different sizes of control cable for the various types of signal heads, seven conductor control cable can be purchased in a larger quantity for all signal heads)

5.15.2 Type 3LCF Signal Heads for Flashing Yellow Arrow

On August 12th, 2014, FHWA issued Interim Approval for the optional use of three section flashing yellow arrow signal faces (IA-17):
https://mutcd.fhwa.dot.gov/resources/interim_approval/ia17/ia17.pdf

On December 11th 2014 ODOT received approval from FHWA to install three section center flashing arrows as part of IA-17:
https://www.oregon.gov/ODOT/Engineering/Documents_TrafficStandards/FHWA-IA-17_Oregon-Use.pdf

The following list contains the reasons why three section center flashing arrows were pursued as the ODOT standard:

1. Physical characteristic of the 3 section center flashing arrow signal head
    a. Structural loading between 3 section protected only and 3 section center flash are the same.
        i. This is not the case when using a four section FYA signal head which is 14 inches taller.
    b. Vertical clearance between 3 section protected only and 3 section center flash are the same.
        i. This is not the case when using a four section FYA signal head which is 14 inches taller.
    c. Maintenance is allowed to standardize parts since the 3 section head can be used for protected only, PPLT, and permissive only operation.
        i. This is not the case when using the four section head.
    d. Maintenance is allowed to standardize LED modules. They only need six LED modules to allow any operation: Red/Yellow/Green balls and Red/Yellow/Green arrows.
        i. This is not the case when using bimodal green/yellow arrow LED modules.
            1. Note: The bimodal green/yellow arrow LED modules are not supported by the ITE specification for LED modules.
    e. Outputs from the controller cabinet remain the same to run protected only or center flash PPLT: Three wires.
        i. This is not the case when using the four section head: Requires four wires.
        ii. This is not the case when using the bimodal LED module: Requires four wires.
    f. Three section center flash is an easy conversion from 3 section protected only. Requires cabinet modifications only.
        i. This is not the case when using the four section head: Requires a head change out and adding one wire from the cabinet
        ii. This is not the case when using the three section bimodal green/yellow LED module: Requires the change out of one LED module and adding one wire from the cabinet.
2. Safety and operational characteristic of the 3 section center flashing arrow signal head
    a. Research completed on the 3 section center flash as noted in IA-17: http://apps.trb.org/cmsfeed/trbnetprojectdisplay.asp?projectid=2763
    b. Quote from IA-17 “The research results demonstrated that a three-section FYA signal face in which the middle yellow arrow signal indication is used to display both the steady change interval and the flashing yellow permissive interval provides a safe and effective operation for road users”
3. Currently there are three options for flashing yellow arrow head types: Three section center flash, three section bottom bimodal green/yellow, and four section. All three are

acceptable options and are considered equals for operations and safety. But when considering physical characteristics and ease of maintenance for the 1,500 traffic signals and numerous personnel that work on them on the state highways the three section center flash is the best option.

5.15.3 Sign History

Figure 5-139 below shows a list of signs that are no longer used. It is by no means all inclusive, but is included in this manual for historical purposes.

Figure 5-139 | Signs No Longer Used

SIGNS NO LONGER USED	
OR10-10L 30"x36" 	"LEFT TURN SIGNAL" sign
OR10-10R 30"x36" 	"RIGHT TURN SIGNAL" sign
OR17-1 30"x36" 	"LEFT TURN YIELD TO ONCOMING TRAFFIC" sign replaced by R10-12
OR22-14 30"x36" 	"RIGHT TURN YIELD TO PEDS ON GREEN ball symbol" sign replaced by OR10-15

5.15.4 Battery Back-up History

ODOT's history, recent discussions, and position on using battery back-up for traffic signals is documented below.

ODOT has used battery back-up at traffic signals for two main reasons:

- Reduce congestion at locations with high mainline volumes between the time the power outage occurs to the time that a maintenance crew can respond on-site to the event.
- The MUTCD (section 4D.27p11 in 2009 version and section 4F.19p08 in 11th edition version) states that traffic signals interconnected to a railroad crossing should be provided with a back-up power supply.

However, ODOT's experience with battery back-up used traffic signals over the years has not proven to be beneficial. Therefore, we no longer support installing battery back-up at any traffic signals for the following reasons:

- **The battery back-up has not met our expectations for performance.**
    - The transfer of power from commercial to battery back-up is not always seamless. We have had several instances where the signal goes into flash mode which then has to be manually reset.
    - The UPS system tends to lock out and the battery doesn't last long in cold temperatures. For example, in region 5 the battery back-up in traffic signal cabinet ID 13025 has approximately a 900W capacity according to the controller readout. The typical cabinet load peaks around 450W. The battery back-up at this location seems to run fine in warmer temps but around 30F it would not stay running for more than a minute (and the batteries were not drained). This was only discovered after a citizen complaint and then significant time and effort observing and troubleshooting.
    - Multiple locations and instances of the battery back-up status and history log being incorrect leading to suspicion of the batter back-up system not performing as expected (either dates/times were incorrect or there was no log at all of known power outages).
- **Commercial power is very reliable in Oregon.** We are fortunate to have reliable power. When outages occur, they are usually resolved very quickly as highway corridors typically have a high priority. Battery back-up is not expected to operate longer than 1 hour, so extended power outages require different solutions than battery back-up.
- **All-way stop operation is a safe and effective short-term temporary solution at traffic signals until issues can be troubleshot and corrected or until the power resumes.** When a traffic signal loses power, the public is trained to treat the intersection like an all-way stop. Drivers are always required to not stop on the tracks per law and signs are also always posted as a reminder at rail interconnected traffic signals. While queues will

build up when the traffic signal loses power in a high traffic volume area, the all-way stop will allow traffic to "continuously" advance off the tracks as the queues for all approaches take equal turns getting through the intersection.

- **Trains are required to stop at crossings or proceed at a lowered speed only with flaggers when commercial power outages occur.** Power outages will typically affect both the railroad crossing equipment and the traffic signal equipment as the commercial power for each is often from the same transformer. The rail owner will receive notification of commercial power loss which initiates the additional safety protocols for train operation until the power resumes. Battery back-up for the interconnected traffic signal doesn't provide any safety benefit when the additional safety protocols for train operation are in effect.
- **Battery back-up requires resources that exceed our current staffing levels and budget.** We have found that a significant amount of maintenance and monitoring is necessary to ensure the battery back-up is and will be ready to perform when needed.
- **Need to focus our limited resources on the highest priority traffic signal needs.** The traffic signal asset management program has identified many high benefit cost ratio needs that should be addressed first before considering battery back-up, such as:
    - Replacing signal installations that have a condition rating less than 70%. 2024 data show that approx. 12% of traffic signals rate poor and approx. 5% rate very poor statewide (out of a statewide total of 1456 traffic signal assets).
    - Upgrading outdated signal heads: adding backplates, 12" lens, and/or reflectorized backplates
    - Installing type 7 signal heads at railroad interconnected signals
    - Upgrading pedestrian signal indications to countdown style
    - Replacing cabinets with a PDA1 power supply
    - Installing or upgrading network communication equipment
    - Upgrading controllers
    - Upgrading existing loop detection to non-invasive detection

CCD rail safety is in concurrence and will revise all crossing orders that specify the requirement for battery back-up in the traffic signals. The list below is known crossing orders that specify this requirement:

- Order No. 51324: Contains several ODOT rail interconnected traffic signals in region 5
- Order No. 51389: Traffic signal at Tualatin Valley Highway and Cornelius Pass Road

6 Detector Plan

This chapter will discuss all the design elements that are needed for a detection system, in order of the recommended process for designing a new traffic signal. Design of the detection system typically begins after the signal design.

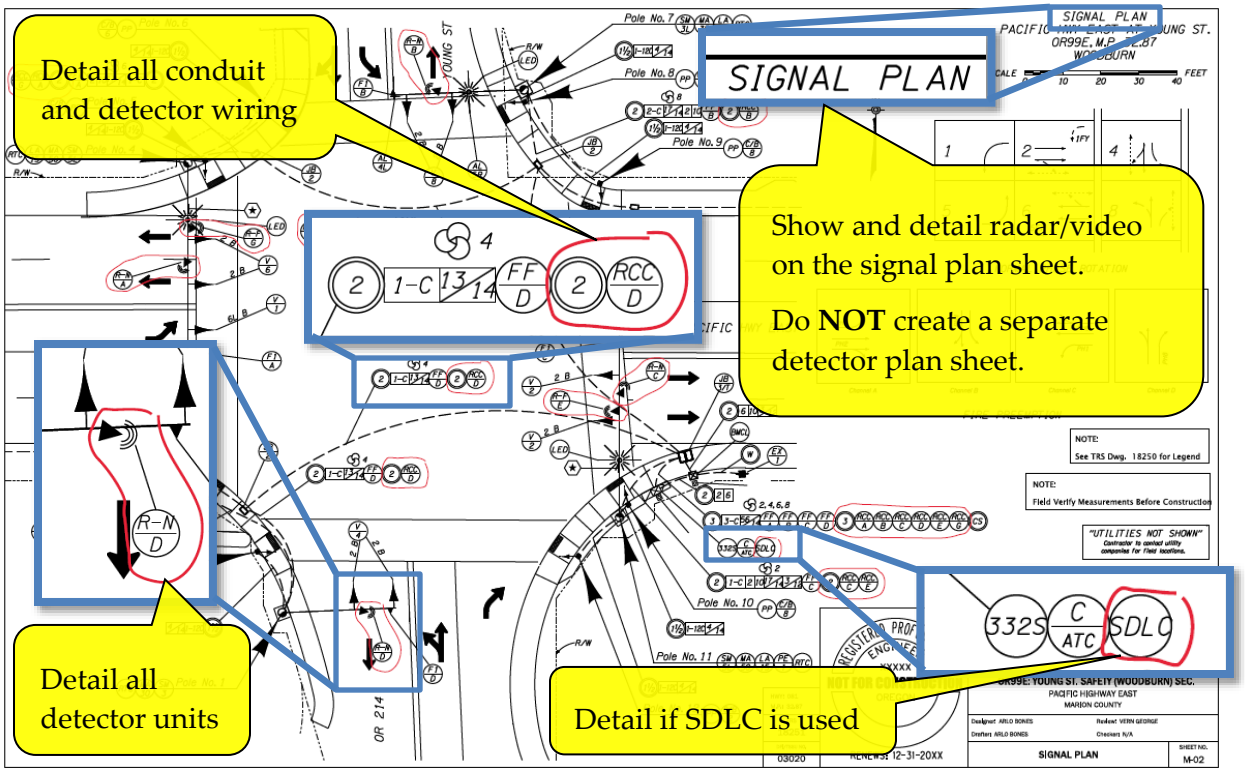
Detection is required for all vehicle phases to enable the use of automated traffic signal performance measures (ATSPM), regardless of any vehicle phases that are recalled.

A separate detection plan sheet is no longer required for radar/video detection. It is still required if loops are approved for use (see Section 6.1.)

Show radar/video equipment on the signal plan sheet **only** (show the detector unit, detector conduit, and detector wiring.) See Figure 6-1.

Radar/video detection zones and coverage areas are shown on the **cabinet print only, at the signal timer's request**. The region signal timer will configure the zone set up. Provide the cabinet print at DAP for the signal timer to review and provide a preliminary configuration. See chapter 20 for more information on coordinating with the signal timer and the process for creating the cabinet print.

Figure 6-1 | Signal Plan Sheet – Show and Detail All Radar Equipment



6.1 Detection Type

ODOT's default standard detection type is radar (includes bike detection). Video detection may also be used with concurrence from the region signal operations engineer (section 6.9 contains specific information for video detection that is in addition to or differs from the information contained in this chapter that is for radar.) ODOT has selected these non-invasive forms of detection as the standard for the following reasons:

- Ease of moving detection zones (future paving projects and temporary lane configurations can be accommodated).
- Cost effective for providing automatic traffic signal performance measures (ATSPM) which can require significantly more detection than traditional detection layouts.
- Ability to easily maintain detection zones (repairing damaged inductive loops requires a contractor. Historically, ODOT has not been successful in repairing damaged loops in a reasonable timeframe due to limited maintenance funding).
- Simplifies the controller cabinet hardware and improves troubleshooting ability (when using the standard SDLC connection).
- Ability to accommodate dynamic entry speeds to the intersection for improved dilemma zone protection (e.g., red/green extension).

No form of detection is without drawbacks and non-invasive forms can have issues with occlusion, less accurate counting, weather, etc. While non-invasive forms of detection may not be the perfect solution in every case, the drawbacks are tolerated to achieve the higher-level benefits listed in the bullet points above.

Non-invasive forms of detection are typically mounted on the mast arm, luminaire arm or vertical signal pole and should work well in the majority of locations. However, there are situations where additional detection devices or unique mounting locations may be necessary (e.g., stand-alone pedestals):

- Roadway/intersection geometry that limits the line of sight for the detection device
- Low illumination levels
- Occlusion
- Existing conduit condition/fill rate will not allow adding new wiring

Non-invasive detection devices used on the project must be listed on the approved traffic signal product lists (green sheets). Devices not listed on the green sheets require approval from the state traffic signal engineer.

Other forms of detection, such as inductive loops and preformed inductive loops may be used only if an investigation finds that non-invasive detection is not feasible. For example:

- Retro-fit situations where conduit condition/fill rate limits installation of additional cables *and* installing stand-alone pedestals to mount the devices is not an option.
- Controller cabinet space limitation *and* replacing the controller cabinet is not an option.

This investigation should be done as early as possible in the design process, ideally before DAP. In these cases, the region traffic engineer should concur with the investigation to use loops and send justification to the state traffic signal engineer for approval via email.

When a project impacts ANY existing loop detection, it should be replaced with non-invasive detection.

Installing loops should be avoided.

6.1.1 Inductive Loop Detection

Loop detection is no longer the ODOT standard as advances in controller cabinet hardware and software are making it less desirable from an efficiency, cost effectiveness and maintenance standpoint. Loop detection is also not compatible with an SDLC connection in the 332s controller cabinet and limits the ability to implement automatic traffic signal performance measures (which is a high priority for the agency).

If the state traffic signal engineer approves the use of loops on your project, information for how to detail and show loops on a detector plan sheet will be provided. See the 2017 version of this manual (available on the traffic signals website) and the standard details for more information on loop detection design/installation.

6.1.2 Multiple Detection Technologies at a Single Intersection

The preference is to keep detection design, installation, and maintenance as standard and simple as possible. This is best achieved with one detection technology. Use of multiple detection technologies at a single intersection is discouraged as it can be challenging to configure the hardware in the controller cabinet, resulting in non-standard arrangements that are more difficult to maintain and troubleshoot. However, there may be times where it is acceptable to have multiple technologies (e.g., using a new technology for bike and pedestrian detection). The state traffic signal engineer will approve use of multiple detection technologies on a case-by-case basis.

6.2 Detection Basics

Detection allows the signal controller to service signal phases and provide variable amounts of green time based on the demand. Detection needs are determined by the desired signal operation; therefore, it is important to have a basic understanding of the signal operation standards that dictate the standards for vehicle detection design.

Each signalized intersection is the result of side street (typically city or county road) intersecting with a mainline (state highway). In the case where a state highway intersects with another state highway, one route must be designated the mainline and the other route will be the side street. This is usually easy to determine based on traffic volumes, posted speeds and the presence of stop/yield control at the intersection prior to signalization. There cannot be two mainlines or two side streets, there must be one of each designated for each intersection. This fundamental principle results in signal operations that will meet driver expectation; drivers **do not** expect to stop on a mainline roadway and **do** expect to stop on a side street. This designation is shown in the operational approval based on how the phases are labeled (phases 2 and 6 are mainline through phases and phases 4 and 8 are side street through phases).

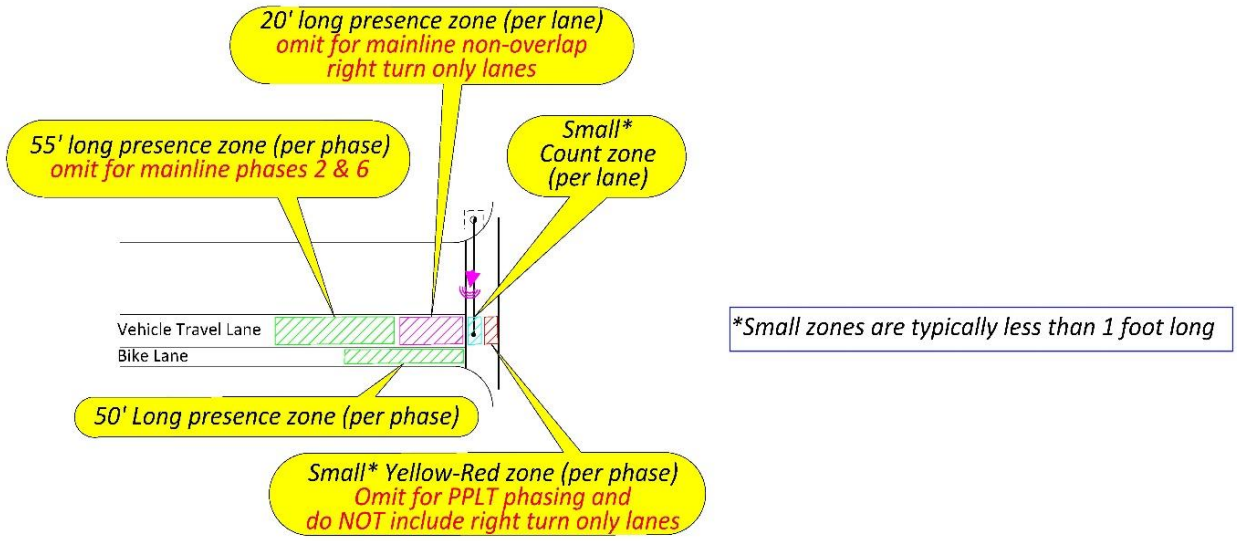
6.2.1 Presence Detection

Presence detection is used for each vehicle lane (except mainline right turn only lanes that do not have an overlap phase) and each bicycle lane. The length of the presence detection and its use varies slightly depending on the lane use and phasing (see Figure 6-2 for the standard presence zone layout):

- When used on side streets (phases 3, 4, 7, and 8) and mainline left turn phases (phases 1 and 5), it is placed at the stop bar, and covers a total of approximately 75 feet. It is designed to place a call into the signal controller when a vehicle approaches on a red indication and to extend the green time based on vehicle demand of queued vehicles proceeding on a green indication. Side street phases and left turn phases are **not** recalled like the mainline through phases, and therefore will not turn green unless there is vehicle demand.
- When used for mainline through phases (phases 2 and 6), it is placed at the stop bar, covers approximately 20 feet and is designed to provide additional data needed for automated traffic signal performance measures.
- When used for a bicycle lane, it is placed at the stop bar, covering approximately 50 feet. It is designed to place a call into the signal controller when a bike approaches on a red indication (for bike lanes on the side street) and extend the green time based on the slower traveling speed of a cyclist approaching on a green indication (for bike lanes on the side street and mainline).

Count zones and yellow-red zones (data needed for automated traffic signal performance measures) as shown in Figure 6-2 are also provided by the near range detector unit.

Figure 6-2 | Detection Basics – Presence Detection For all Vehicle and Bike Lanes (Including Count and Yellow-Red Detection) Standard Layout



STANDARD PRESENCE DETECTION (Near-Range Unit)

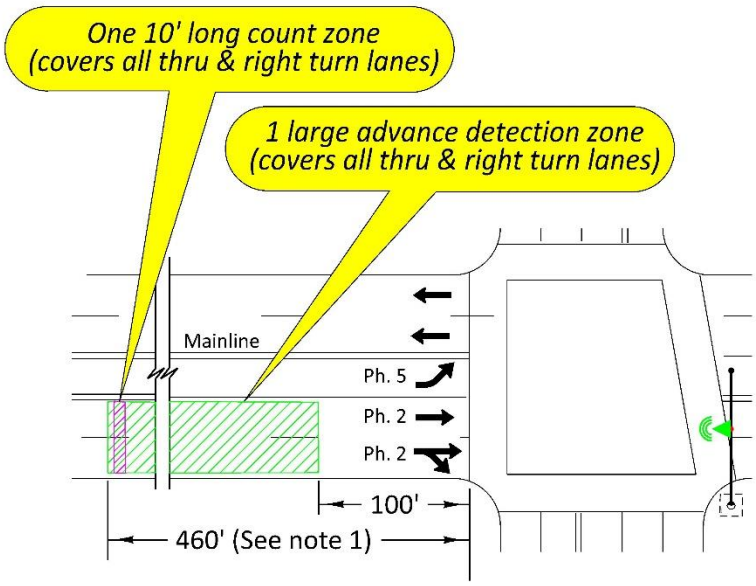
6.2.2 Advance Detection (or Volume Density Detection)

Advance detection is used for the mainline through phases (phases 2 and 6) and interchange off-ramps. See Figure 6-3 for the standard advance detection zone layout. It can detect vehicles approximately 900 feet away from the stop bar. Only 460 feet from stop bar is required to adequately detect vehicles up to 55 mph. However, detecting vehicles approximately 900 feet from the stop bar may be desirable for approaches with high speed or high truck volumes. Advance count zones as shown in Figure 6-3 are also provided by the far range detector unit. See section 6.8 for more information.

Advanced detection is designed to extend green time and reduce the occurrence of the dilemma zone for a vehicle approaching the intersection. The dilemma zone occurs where a vehicle is too close to the intersection to comfortably stop when the yellow indication starts and also too far away to get completely through the intersection before the yellow indication terminates. Each vehicle actuation during the mainline green phase will extend the green time such that the vehicle may continue through the intersection without stopping. Radar detection provides great flexibility for detecting vehicles within the range/view of the device and is also capable of using algorithms to better protect the dilemma zone, even for vehicles that are accelerating or decelerating when approaching the traffic signal.

While advance detection can put a call into the controller when the vehicle approaches on a red indication, the call function is fulfilled primarily by presence detection instead. Additionally, the ODOT standard for signal timing is to recall the mainline through phases, which makes the call feature unnecessary for these phases (e.g., a vehicle actuation is **not** required to service the mainline through phases). When only the mainline phases are recalled, the signal will "rest" in green on the mainline when there are no vehicle actuations.

Figure 6-3 | Detection Basics – Advance Detection Standard Layout



STANDARD ADVANCE DETECTION (Far-Range Unit)

Notes:

1. Detection that starts 100' from the stop bar and extends a minimum of 460' from the stop bar is acceptable for posted speeds of 55 mph and lower. However, the far-range unit on the green sheets is capable of reaching 900'.

2. If MaxAdapt is used (Verify with Region Traffic), add a Near-Range Unit to provide advance Count Detection Zones as shown in Figure 6-5.

6.2.3 Signal Timing Functions That May Be Used with Detection

The following functions are used by the signal timer to make the traffic signal operate efficiently and collect data:

- **Extend/carryover/stretch** – This function is only active during the green phase of the associated signal phase. It allows the green time to be extended based on the parameters within the signal timing. It also allows the input of a detector to remain "on" for a pre-defined amount of time after the actual vehicle actuation has turned off, effectively elongating the size of the detection zone.
- **Call** – This function is only active during the red phase of the associated signal phase. It allows the signal controller to service the associated signal phase within the parameters of the normal phase rotation; signal phases other than the mainline through phase are only serviced if there is demand.
- **Delay** – This function is only active during the red phase of the associated signal phase. It allows the input of a detector to remain "off" for a pre-defined amount of time during the actual vehicle actuation, reducing the chance of unnecessarily serving a phase from unintended actuations (e.g., vehicles turning right on red.)
- **Count** – This function simply counts the number of actuations. The ability to count actuations provides critical volume data to the signal timer developing the appropriate signal timing parameters throughout the life of the traffic signal. Count detection is also needed for certain automatic traffic signal performance measures.

6.3 Beyond Basic Detection

Depending on the location, desired signal operation and other unique circumstances at the intersection, you many need to consider additional detection beyond the basics.

6.3.1 Interchange Ramps

For interchange ramps, use presence detection as shown for a side street phase (see section 6.2.1) plus advance detection. Advance detection helps address the higher prevailing speed of a vehicle that has just exited the freeway (see section 6.2.2).

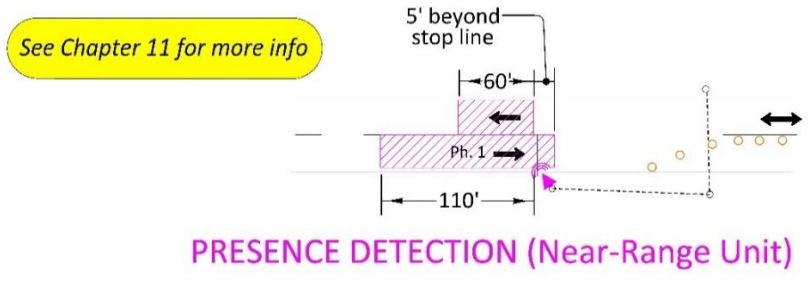
In addition to standard presence and advance detection, "dump" detection may also be desired. Dump detection may be necessary for an interchange ramp to prevent ramp queues from backing up onto the freeway by allowing the signal controller to give priority and extended green time to the ramp phase if the queue reaches a certain point for a certain period of time. Dump detection may be used if engineering judgment determines a need. Verify dump detection needs with the region signal operations engineer.

It is always preferable to have the ramp alignment be designed to accommodate the calculated design life 95 percentile queue length, which would eliminate the need for dump detection. However, this is not always feasible. An operational analysis is always required to determine if dump detection is needed and to determine the optimal placement of the detection. This will likely require a stand-alone near-range detector unit mounted on a pedestal within 20 feet of the where the detection zones are needed.

6.3.2 Temporary Bridge Signals (One-Lane, Two-Direction)

Temporary bridge signals are used to allow travel in both directions in one lane. Presence detection is used as shown in Figure 6-4.

Figure 6-4 | Temporary Bridge Signal Presence Detection



6.3.3 Bicycle Detection

Bicycle detection should be installed where bike lanes are present. See section 6.2.1. If no bike lanes are present, but there is a high volume of bike riders, bike detection may be used on the shoulder or other locations if engineering judgment determines a need.

Bicycle detection should also be used in bike boxes when the signal phases are not recalled.

Note that properly detecting bicycles is challenging for most forms of detection due to bike material composition (problematic for loops), detecting the difference between vehicles and bikes (problematic for radar), appropriate location to be user friendly without being an obstacle or frequently hit (problematic for pushbuttons), and paths that cyclists choose to take (problematic for all forms of detection).

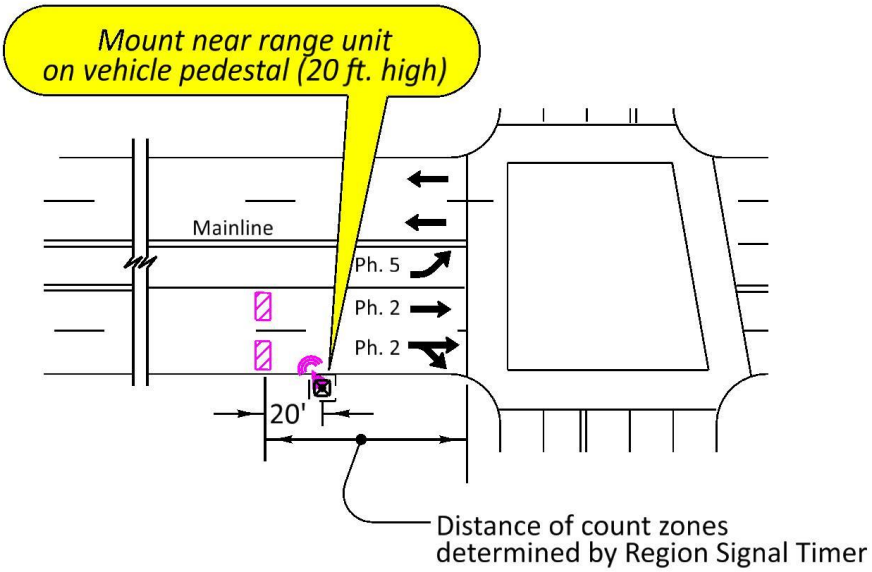
Fortunately, non-invasive detection technology is improving rapidly and is getting much better at distinguishing bikes from other vehicles (even traveling in the same lane). Therefore, pushbuttons for bike detection are strongly discouraged (note: the one exception is for a specific temporary application discussed in chapter 11). Verify bike detection needs with the region signal operations engineer and available technologies with the state traffic signal engineer.

6.3.4 Adaptive Signal Timing Detection

Adaptive signal timing detection works much differently than the standard detection discussed in section 6.2. Typically, more detection is needed for adaptive to work properly, as the adaptive software collects more data to use in determining how to operate the signal. When designing a detection system that will be using adaptive signal timing, it is important to follow the software manufacturer's recommendations for detection placement.

In addition to the standard advance detection shown in Figure 6-3, count detection placed beyond the anticipated queue (in free-flow traffic) as shown in Figure 6-5 may be recommended for optimal performance when using MaxAdapt adaptive signal timing. Work with region traffic to determine the site-specific detection needs.

Figure 6-5 | MaxAdapt Advance Count Zone Layout for Radar Detection



Region traffic engineer approval is required for use of adaptive signal timing.

6.3.5 Railroad Detection

Depending on the location of the railroad crossing, the intended signal operation and rail crossing order requirements, additional vehicle detection zones may be necessary for proper detection. See chapter 16 for more information on railroad related signal design.

6.3.6 Automated Traffic Signal Performance Measures (ATSPM)

ODOT has committed to implementing ATSPMs as part of FHWA's Everyday Counts 4 Initiative. Certain detection zones are included solely for ATSPM data collection which can be used to track performance measures at signalized intersections and assess impacts of timing and operation decisions in real time. The presence detection and advance detection standard shown in Figure 6-2 and Figure 6-3 will be able to capture the following ATSPM (See ODOT Traffic Signal Management Plan for more information):

- Red light running (safety)
- Split failure (safety and operations)
- Purdue coordination (operations)
- Arrival on red/green (safety and operations)

6.4 Detection Zone Layout Considerations

Standard detection zone layout is shown in Figure 6-2 and Figure 6-3. These zones should be used as an initial starting point when deciding where to mount the detector units, but keep in mind that site specifics may require the signal timer to make some adjustments to the zones, device mounting location, or signal timing parameters in order to operate the signal as intended. Examples of these adjustments are detailed in the following subsections. Discuss any site-specific considerations with the region signal timing staff to ensure the concern can be properly addressed. Keep in mind that the frequency of the concern occurring may be low enough to not warrant any signal timing or detection modifications.

6.4.1 Advance Stop Bars

If a crosswalk is present, the near side of the crosswalk bar functions as the stop line for vehicles. Separate advance stop bars prior to a crosswalk are only used when the geometry of the intersection cannot accommodate the design vehicle's turning path without them. Advance stop bars also require region traffic engineer approval. However, advance stop bars should not be used in lieu of proper geometric design; the roadway should be designed to accommodate the design vehicle without use of advance stop bars whenever feasible. If an advance stop bar is used, detection is not typically needed between the advance stop bar and the crosswalk marking, but it can be used if engineering judgement determines a need.

6.4.2 Bridge Decks

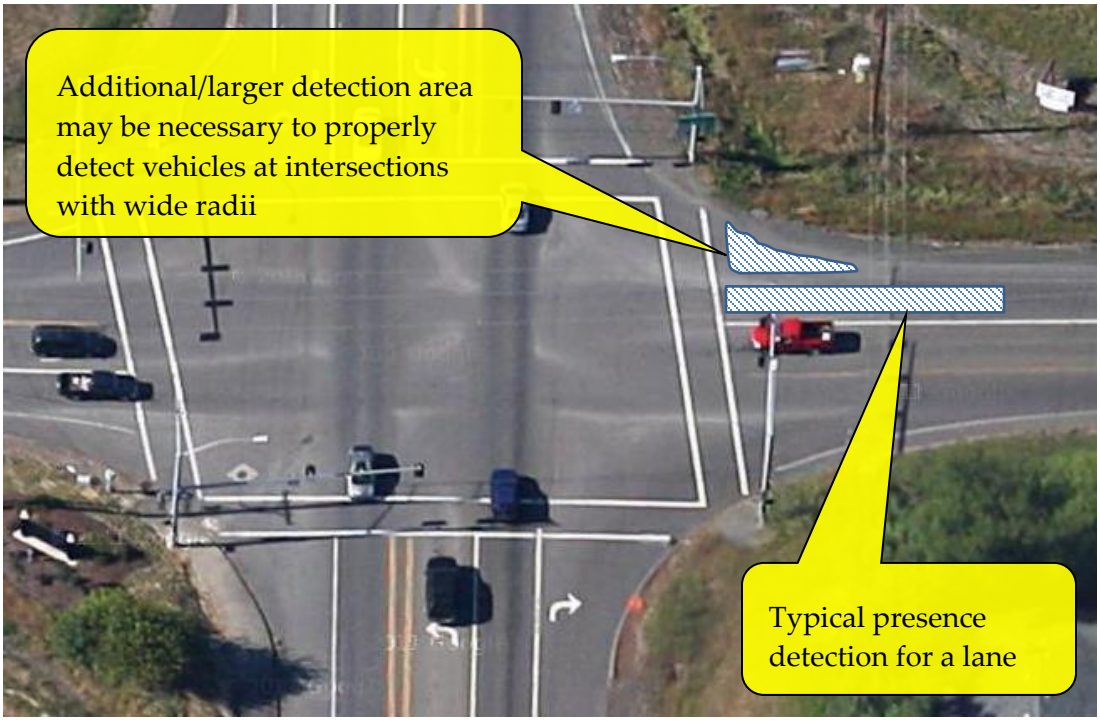
There are only two types of detection that can be used on a bridge deck:

- Non-invasive is the default standard. This type of detection is the only viable solution for existing bridge decks.
- Preformed loops, which are installed on top of the bridge rebar prior to the deck pour. This type of detection should be avoided if possible. If used, the signal designer will need to coordinate with the bridge designer. See standard detail DET 4435.

6.4.3 Wide Corner Radius

An intersection with wide radii (typically rural locations that do not have a bike lane), may need a larger detection coverage area to properly accommodate vehicles and bikes. For non-invasive detection, this is very easy to implement if the device is mounted and aimed to cover the radius.

Figure 6-6 | Detection Placement Considerations: Wide Radius



6.4.4 Accesses: Driveways, Streets, and Alleys

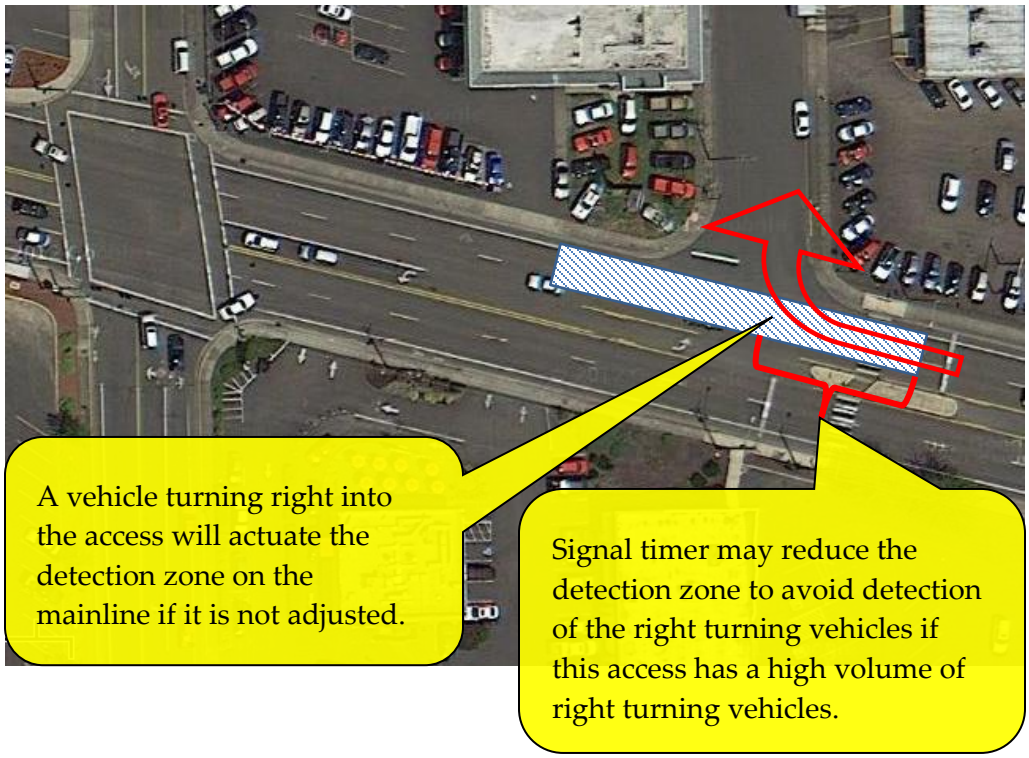
Vehicles accessing driveways, streets or alleys near signal detection may result in unintentional actuations that adversely affect the efficiency of the signal operation. This can lead to motorist frustration, longer queue lengths and more traffic congestion. One of the best solutions to improve signal operations and overall safety is to remove or restrict certain movements of any

access that is within the influence area of the signalized intersection. Coordinate with the appropriate region traffic and access management staff to discuss the possibility of removal or restriction of movements. If this is not feasible, adjustment of the detection zones may be necessary. For example in Figure 6-7, shortening the mainline advance detection zone to avoid the travel path of vehicles turning right into the access could avoid unintended actuations that will unnecessarily extend the green time on the mainline.

Note: Unintentional actuations are less of a problem for non-invasive forms detection as the detection zones can be configured for a specific direction of traffic (e.g., they will not activate if a vehicle drives over the zone the wrong way).

Loop detection cannot distinguish direction of travel and therefore has more potential for unintentional actuations.

Figure 6-7 | Detection Placement Considerations: Right Turns Impacting Mainline Detection



6.4.5 Short Minor Street/Driveway Signalized Approaches

The standard placement for presence detection covers approximately 75 feet. However, if the minor phase approach is short in distance (e.g., to a driveway) or the pavement doesn't extend very far past the radius, the signal timer may shorten the actual detection zone to a reasonable distance based on site conditions. See Figure 6-8. If the signalized driveway approach is for a private residence (e.g., the general public will not use it), pushbutton detection should be used as it is more predictable, reliable, and cost effective. See Figure 6-9 for example.

Figure 6-8 | Detection Placement Considerations: Short Minor Street/Driveway Signalized Approaches

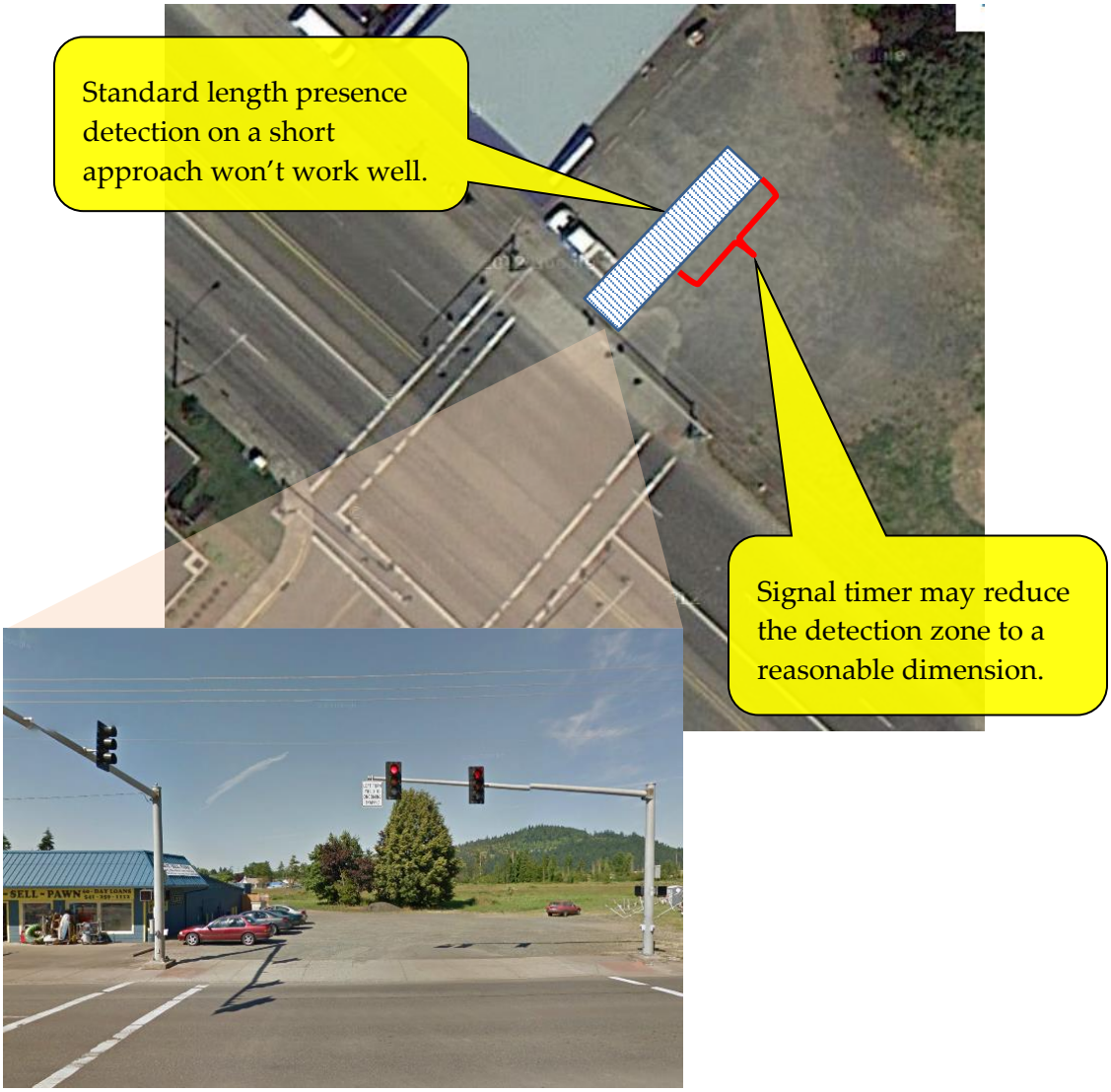


Figure 6-9 | Detection Placement Considerations: Private Driveway Signalized Approaches



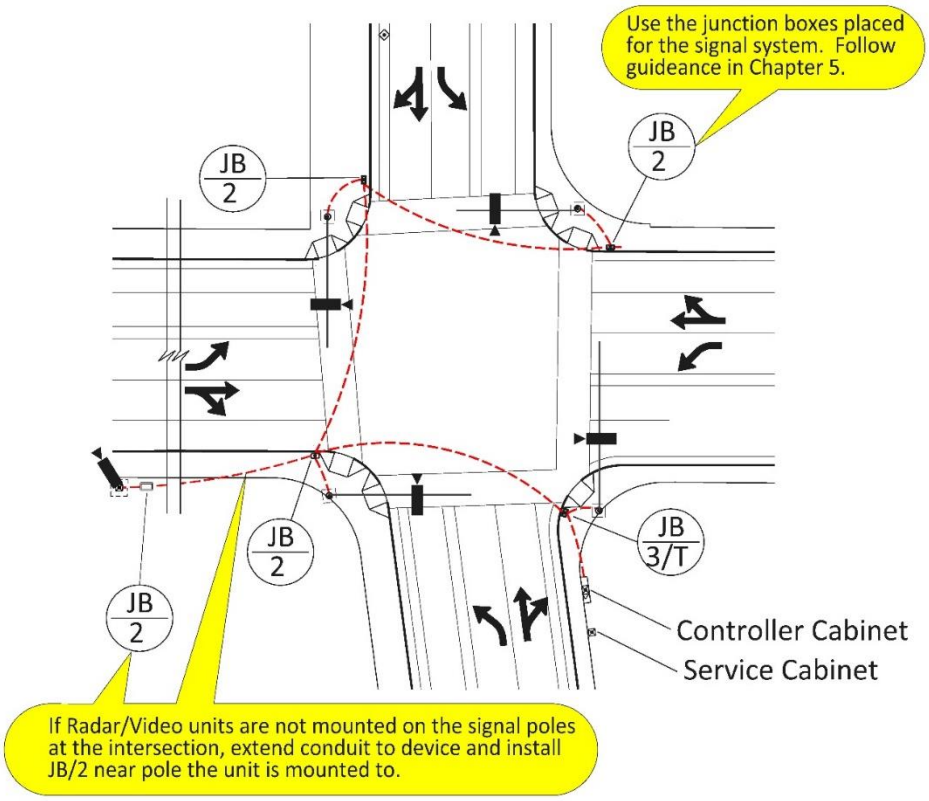
6.5 Conduit and Junction Box System

Detection equipment wiring should be placed in a conduit exclusively used for detection. The conduit system for detection equipment is separate from the signal conduit system, but it follows the same route (in the same trench) and size requirements as the signal system conduit to each pole where detector units are mounted. The junction boxes placed in each quadrant for signal system conduits should be used for the detection system conduit. See Figure 6-10 and chapter 5 for additional information on conduit and junction boxes.

If detector units are mounted at locations other than the signal poles, extend conduit and place a JB/2 size junction box next to the pole/pedestal it is mounted on. See Figure 6-10.

In retro-fit situations, the radar/video detection wiring may be contained within the same conduit as the signal system if the maximum wire fill rate (See chapter 5) is not exceeded.

Figure 6-10 | Radar/Video Detection Conduit and Junction Box System



6.6 Synchronous Data Link Control (SDLC) – Bypassing the Detection Input File

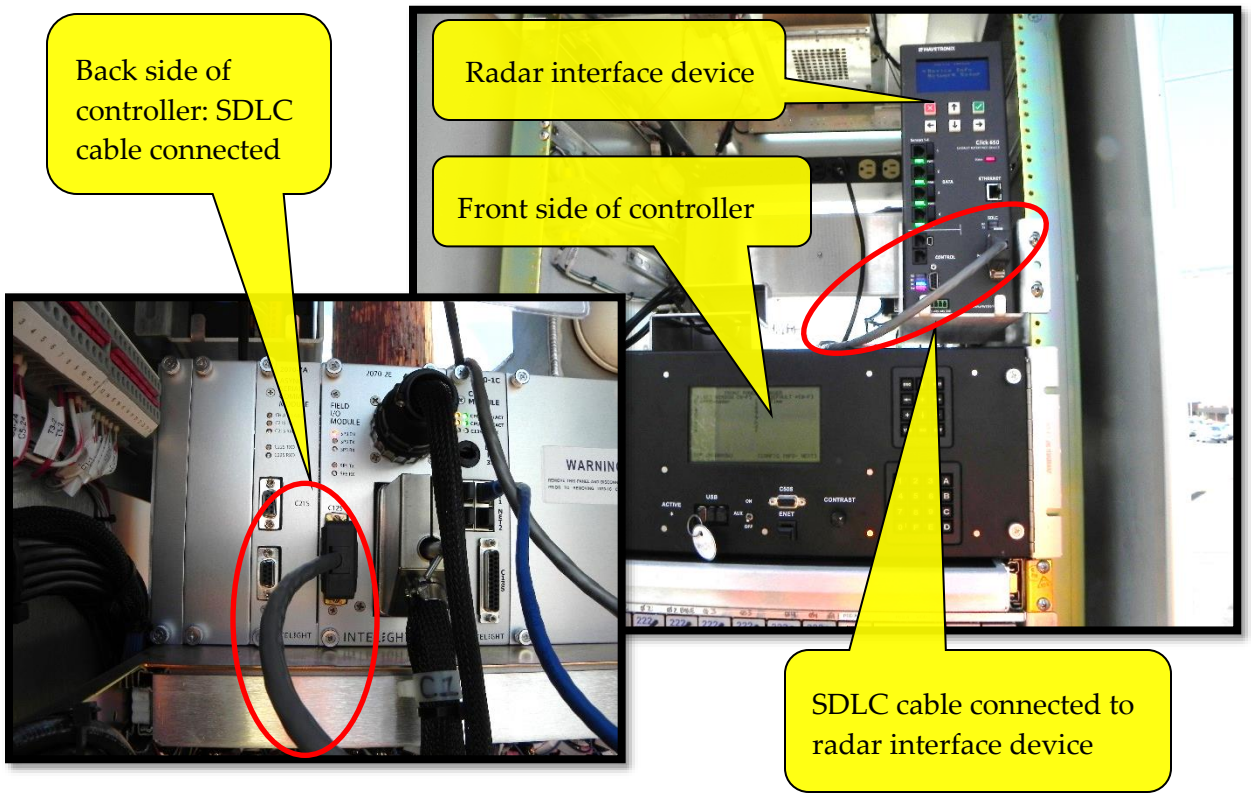
SDLC is a serial communications standard for transmitting data and is the new standard for wiring radar and video hardware in the controller cabinet. It is used to pass information directly between the controller and radar/video interface devices. An SDLC cable plugs into the controller and into the radar/video interface device. This communication bypasses the input file and the C1 and C11S controller connectors. See Figure 6-11.

SLDC cannot be used with the 2070 and Voyage as the software is unfinished for SDLC communication.

SDLC cannot be used for loop detection.

Existing controller cabinets should update the controller cabinet equipment (An ATC controller and radar/video interface devices) to accommodate the SDLC connection if possible.

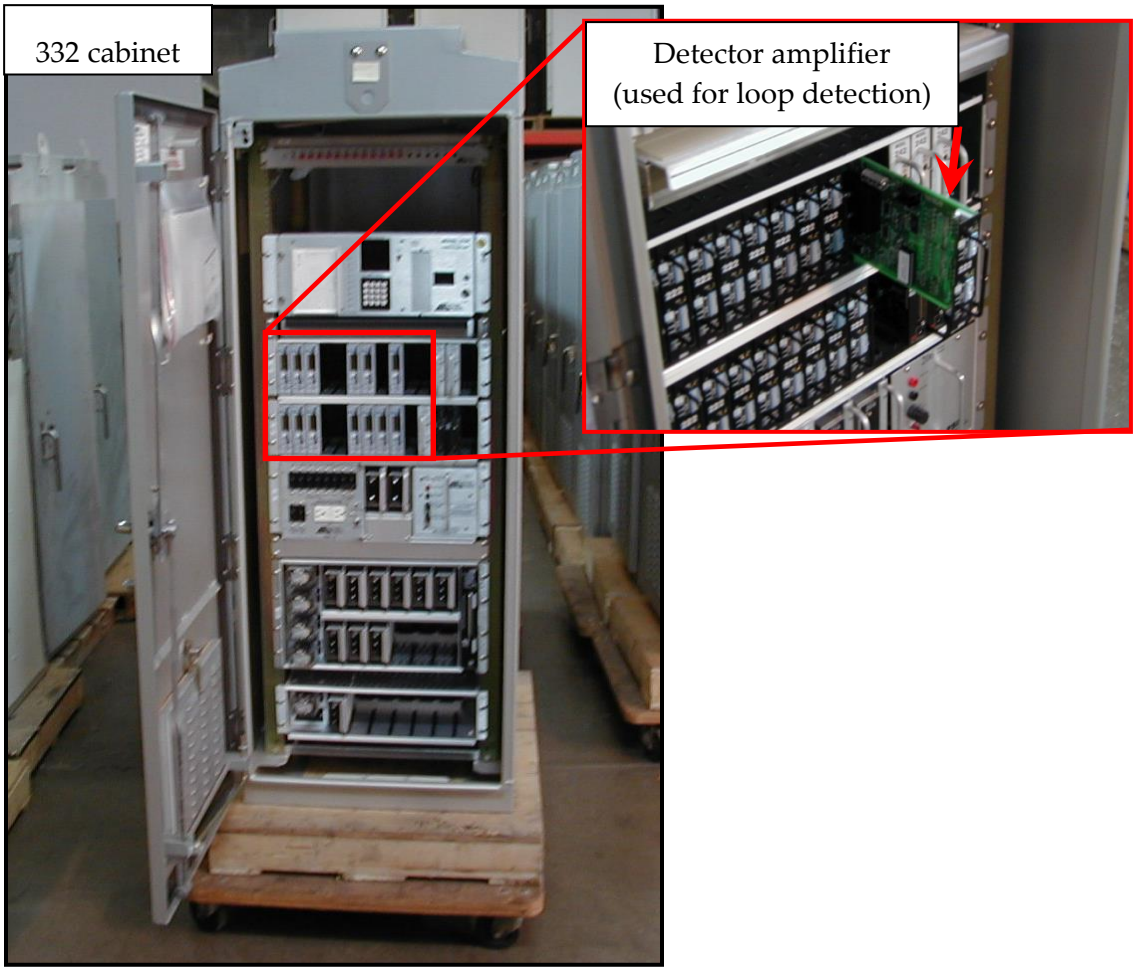
Figure 6-11 | Signal Controller Cabinet Detection with SDLC



6.7 Detection Input File

The signal timer is responsible for configuring the detection input file (see Figure 6-12) and this information is now only shown in the cabinet prints. Detector input files and information associated with input file terminations are no longer shown on the contract plan sheets. See chapter 20 for more information about coordinating with the signal timer and creating the cabinet print.

Figure 6-12 | 332 Signal Controller Cabinet Detection Input File Location



6.8 Radar Detector Unit Placement and Labeling

The type of radar unit and the detection zone area will determine the best mounting location for the unit. A field visit is highly recommended to confirm that the intended placement of the detector unit will not have any obstacles in the way that may cause dead spots in the detection zones (e.g., vegetation, trees, other signal heads, etc.).

The type of pole that the radar detector unit is mounted to is important as it determines the correct radar cable splicing detail to include in the contract plans:

- Poles with a recessed terminal cabinet: Standard drawing TM466 is used and shows the radar cables are spliced in the recessed terminal cabinet.
- Poles without a recessed terminal cabinet (old poles with an externally mounted terminal cabinet and temporary wood poles): Standard detail DET4420 is used to show the radar cable splice details. Follow the instructions on the standard detail for use. Note there are two options and it is important to verify the electrical crew's preference for which option to use.

The region signal timer's review and concurrence of the detector unit placement is critical for proper set up of the desired detection zones. This should be done at the DAP stage in the project via the cabinet print process described in chapter 20, sections 20.2 and 20.3.

A few general rules of thumb for the three different types of radar units:

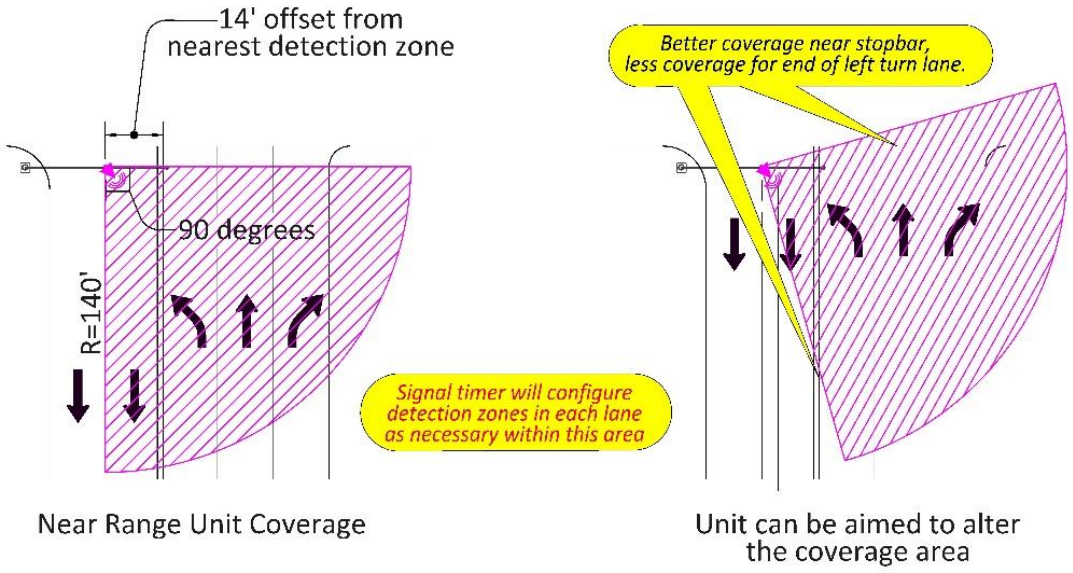
- **Near-range radar units**

  Near-range radar units are typically used for presence detection; it has an arc shaped detection area that extends 140' from the device. This can provide detection inputs for multiple phases and can separate detection inputs for adjacent lanes/phases. Make sure that this arc shaped detection covers the basic zones of detection shown in Figure 6-2.

  Near-range radar units are recommended for counting at low speeds (less than 35 mph); it is not as accurate at higher speeds, but still performs adequately with an accuracy around 95%. The backside of the mast arm with at least a 14-foot offset from the nearest detection zone is the recommended location, but other locations may be acceptable as per the manufacturer. See Figure 6-13.

  For large intersections with high traffic volumes, bike lanes or other vehicle lanes may be occluded by large vehicles in adjacent lanes. Detection is critical on the side street, left turn phases, or when a bike phase is provided (e.g., any phase that does not operate as a recalled phase needs detection to bring up a green indication). In these cases, consider an additional near-range unit to provide adequate detection of all lanes. Verify detection needs with the signal timer.

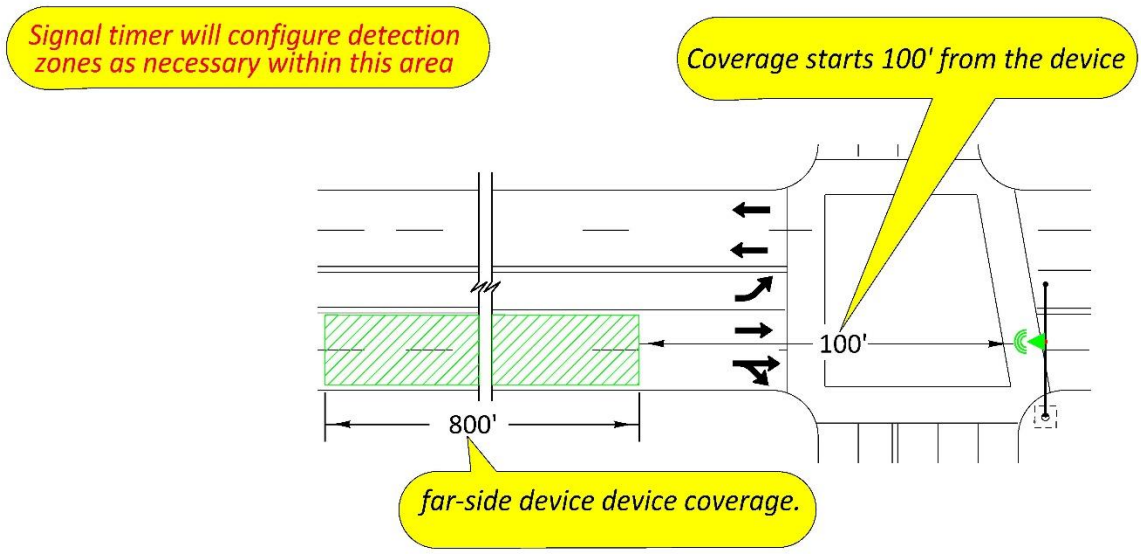
Figure 6-13 | Near Range Unit Coverage Area



- **Far-range radar units**

  Far-range radar units are typically only used for the mainline, recalled through phase. It has a long, somewhat narrow shaped detection area that extends out to 900 feet. Each unit can only be used for a single phase and it cannot provide separate detection inputs for adjacent lanes (e.g., one big zone configuration will cover *all* lanes for phase 2). The detector units track vehicle speed and can calculate an estimated time of arrival to reduce the occurrence of vehicles in the dilemma zone. The units can also be set up to include advanced count zones in pulse mode at between 350 feet and 600 feet to collect arrival-on-green data. The advanced count zone should be placed as far back as possible to avoid queues degrading the data quality. The far side mast arm is the preferred mounting location for these units because the sensor cannot detect vehicles in the first 100 feet. The unit may also be mounted in several different locations, as per the manufacturer. See Figure 6-14.

Figure 6-14 | Far Range Unit Coverage Area



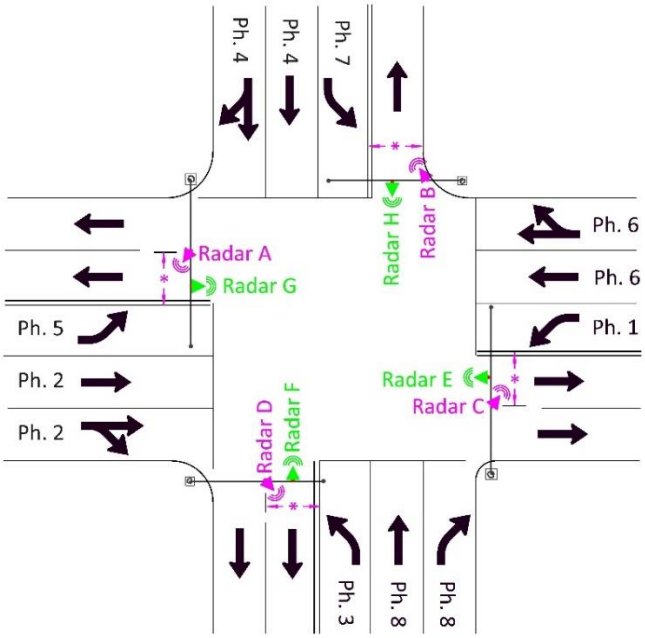
Far Range Unit Coverage Area

- **Side-fire radar units**

  Side-fir radar units are typically only used for ramp meter mainline count detection (see chapter 13 for more info). They should not be used for signalized intersections as the near-side and far-side units adequately address the detection needs. Also, these units require additional equipment in the traffic signal controller cabinet that doesn't integrate well. As such, they shall only be used if approved by the state traffic signal engineer. The unit is aimed perpendicular to traffic with the detection zone spanning the entire approach. This device is accurate at counting all vehicles, even at high speeds. This unit should be mounted according to the manufacturer's recommendations for the offset/height requirements.

The radar units should be placed and labeled by phase as shown in Figure 6-15. If the standard placement of radar devices on the mast arm pole/mast arm is not feasible (e.g., retro-fit with conduit fill issues, will not provide the desired detection zone coverage, or there are concerns about occultation), detector units should be installed on stand-alone pedestals. Supplemental detector units, in addition to the detector units on the mast arm pole/mast arm, may also be considered to get the proper detection zone coverage. Work with the region signal timer during the DAP review of the detector zones on the cabinet print (see chapter 20) to determine the proper placement and number of detector units needed.

Figure 6-15 | Standard Radar Labeling & Typical Placement



Radar Label	Phase	Radar Type
A*	2 & 5	Near/Matrix
B*	4 & 7	Near/Matrix
C*	6 & 1	Near/Matrix
D*	8 & 3	Near/Matrix
E	2	Far/Advanced
F***	4	Far/Advanced
G	6	Far/Advanced
H***	8	Far/Advanced
I Thru Z**	Misc.	Misc.

*12' device offset from lane that will have a detection zone

** If a detector does not fall into the standard label/phase shown above, then assign it a letter alphabetically between I and Z

*** Not typically installed for the side street. Verify with Region Signal Operations Engineer.

6.9 Video Detection Camera Placement and Labeling

On the mainline, one camera is used for the detection zones within 200 feet of the stop line (typically mounted on the mast arm for presence detection) and another camera is used for detection zones located more than 200 feet from the stop line (typically mounted on the luminaire arm for advance detection).

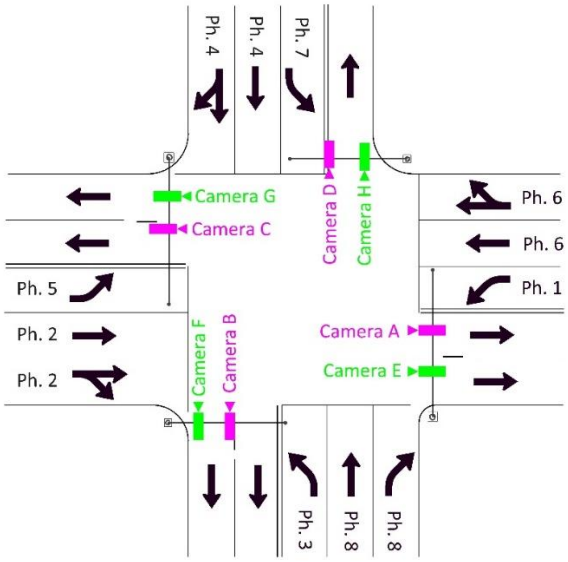
On the side street, one camera is typically used per approach (usually only presence detection is needed on the side street).

Cameras should be mounted on as stable a fixture as possible. Cameras should be able to view 450 feet if mounted at 45 feet. Typical mounting is on a luminaire arm or mast arm. Accurate vehicle detection is optimized by placing the camera directly over the lane(s) it will be monitoring. Otherwise, occlusion may cause false or missed calls. Each detection zone (see sections 6.2 and 6.3 for standard detection zone layout) should be adequately illuminated for detection at night.

The cameras should be placed and labeled by phase as shown in Figure 6-16.

The region signal timer's review and concurrence of the detector unit placement is critical for proper set up of the desired detection zones. This should be done at the DAP stage in the project via the cabinet print process described in chapter 20, sections 20.2 and 20.3.

Figure 6-16 | Standard Camera Labeling & Typical Placement



Camera Label	Phase	Typ. Mount Location
A	2 & 5	mast arm
B	4 & 7	Luminaire arm or mast arm
C	6 & 1	mast arm
D	8 & 3	Luminaire arm or mast arm
E	2	Luminaire Arm
F***	4	Luminaire Arm
G	6	Luminaire Arm
H***	8	Luminaire Arm
I Thru Z**	Misc.	Misc.

** If a detector does not fall into the standard label/phase shown above, then assign it a letter alphabetically between I and Z

*** Not typically installed for the side street. Verify with Region Signal Operations Engineer.

7 Interconnect & ITS communication Plan

This chapter will discuss the design elements that are shown on an interconnect plan sheet. Information regarding the intelligent transportation systems (ITS) communication plan sheet will also be included for reference only, as these plan sheets are produced by the ITS unit.

7.1 When is Communication Needed?

There are two main types of communication used for traffic signals:

- **Central communication** is required for all traffic signals. This allows remote access for manipulation of the signal timing and ability to implement automated traffic signal performance measures (ATSPM). Central communication is achieved through an interconnect system that connects the one (or more) controller cabinets to a network server.
- **Local communication** may be required for signals located in an urban corridor. This allows multiple signals to operate in coordination to help provide an uninterrupted flow of traffic along that route. Local communication is achieved through an interconnect system that connects one controller cabinet to another controller cabinet. Always contact region traffic to discuss the need for local communication if other signals are located less than ½ mile away. Often, the operational approval will indicate if this is a requirement.

7.2 Background and Design Responsibilities

Traffic signal communications have been rapidly changing in the last several years. Migration from the 170E/HC11 controller to the 2070L controller to the current advanced transportation controller (ATC) has resulted in advanced methods of communication between the devices in the field and also communication from the field back to a central control. The 170 controller used twisted pair copper interconnect for communication between signals with dial up telephone service for remote communication. The ATC is capable of being connected to a network and uses MaxView central software to remotely monitor and manage traffic signal timing performance.

At the present time, region traffic and the traffic engineering section do not have the staff and expertise to design networking and communication systems for traffic signals. Until the traffic engineering section is able to provide this expertise, the ITS unit is responsible for determining the form of communication to be used on the project (see section 7.3). The ITS unit will design certain portions of the work, with the traffic signal designer responsible for other portions of the work. ITS unit is also responsible for ordering the network and radio equipment and coordinating the installation and turn-on of the network circuits with the information services branch staff (ISB).

7.3 Forms of Communication

The ITS unit, in conjunction with traffic engineering section, will determine the proper form of communication based on region traffic's needs. Fiber optic is the preferred form. If fiber optic is not feasible, other acceptable options include 4.9GHz radio (back to a nearby ODOT facility), cellular broadband, and leased dedicated ethernet.

Twisted pair copper (VDSL) is no longer allowed for new installations. **Existing signals with twisted pair copper will need to be replaced with fiber optic or one of the other acceptable options.** This is due to VDSL switches being discontinued by Siemens/RuggedCom due to low customer demand and copper systems being problematic for ODOT networking staff to support. Note that Siemens/RuggedCom will continue supporting products only if they are still under warranty.

7.4 Scoping the Traffic Signal Communication System

Scoping the traffic signal communication system can be simple or very complex depending on the methods and equipment used. It is critical to contact the traffic engineering section and the ITS unit at the scoping phase of the project. The traffic engineering section and ITS unit will work with region staff and the signal designer to determine the best option for the communications needed. Once the form of communication is determined, the staff responsible for design will be determined.

As an example, if fiber optic local communications is scoped for the project, the signal designer will be responsible for the interconnect plan sheet & standard specifications which will include junction box/hand hole locations, conduit, and type of wire/cable in the conduit. The ITS unit will be responsible for the ITS communication plan sheet details which include the splice diagrams, fiber optic specifications, anticipated items, LPIF, etc.

The ITS unit, in conjunction with the traffic engineering section, will determine the proper form of communication to use on the project. Contact us early in the design phase.

7.5 Use of Communication Equipment Based on Project Type/Location

7.5.1 Maintained and Operated by ODOT (Projects by Local Agency or Permit)

The ITS unit should be contacted early during scoping for involvement with the project requirements and the development of the intergovernmental agreement (IGA). The security of the network is extremely important to the operation of the traffic signals and needs to be described within the IGA.

The design must use ODOT approved communications equipment. If possible, this will be ODOT supplied and the cost reimbursed.

7.5.2 Maintained and Operated by Local Agencies on State Highways

These locations must use industrial hardened communications equipment approved by the traffic engineering section. If possible, this will be ODOT supplied and the cost reimbursed.

Local agency central communication is acceptable (only center to center communication). There shall be no direct connection from the traffic signals to the ODOT Network.

7.5.3 Locations off the State Highway

These locations cannot use the ODOT communications price agreement contract to purchase equipment.

7.6 Long Term Communication Planning

Efforts are underway in several regions between the ITS unit and the region traffic offices in creating long term communication plans for traffic signal projects. These plans will help identify high level communication options and identifying the costs to develop traffic signal projects.

7.7 Design Considerations

7.7.1 Controller

The standard ATC controller can accommodate all forms of communication. Older controller models have limitations and should be replaced with an ATC controller.

7.7.2 Junction Boxes and Conduit Location and Sizes

Fiber optic installations use a "hand hole" instead of a junction box. See standard drawing TM702 for a general depiction. Hand holes may be spaced at a maximum of 1000 feet. There are 3 different handhole sizes shown on the standard drawing. Contact the ITS unit to determine the appropriate size.

For non-fiber optic installations, the interconnect system uses the same junction boxes that have been placed for the traffic signal system. Beyond the traffic signal system junction boxes, the interconnect system requires junction boxes spaced a maximum of 300 feet apart. See section 5.12.1 for more information on junction boxes.

7.7.3 Conduit

A separate, minimum two-inch diameter conduit is used for the interconnect system. See section 5.13 for more information on conduit requirements.

The signal designer should consider controller locations, signal/detector conduit design, and physical features of the roadway when deciding where to route the interconnect conduit between controller cabinets. By using detector and signal conduit trenches, you can greatly reduce the quantity of trenching needed for the interconnect conduits.

Aerial installation using existing utility poles is not recommended as this requires more maintenance and reoccurring fees for using the poles that belong to others. It is more economical in the long run to install the interconnect system underground. However, aerial installation may be considered if the initial cost of going underground is prohibitive and approval from the utility is received.

7.7.4 Fiber Optic Wiring

The number of fiber optic strands needed for interconnection is determined by the ITS unit. This is shown on the interconnect plan created by the signal designer. See Figure 7-1. Fiber optics are spliced as necessary in the hand holes as determined by the ITS unit. This is shown on the fiber optic cable splice diagram created by the ITS unit. See Figure 7-2.

Figure 7-1 | Fiber Optic Installation – Example of Interconnect Plan Created by the Signal Designer

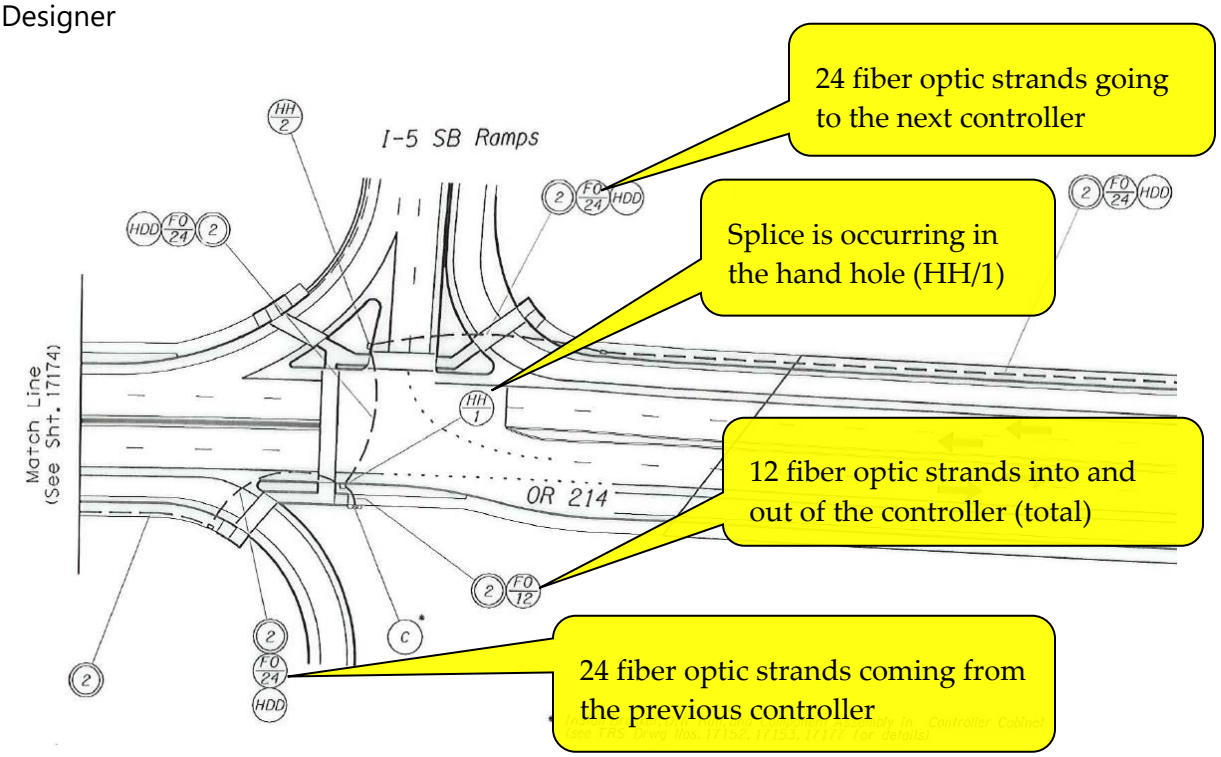
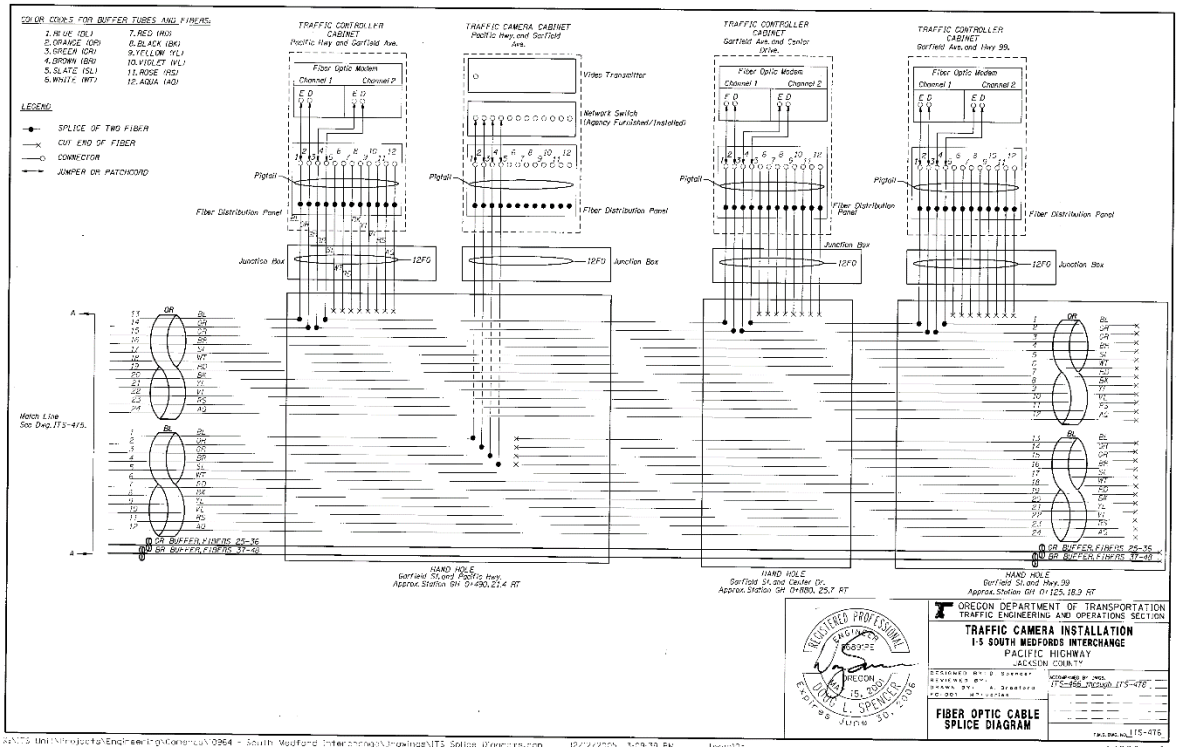


Figure 7-2 | Fiber Optic Installation – Example of Fiber Optic Cable Splice Diagram Created by the ITS Unit



8 Existing Utilities plan

8.1 General

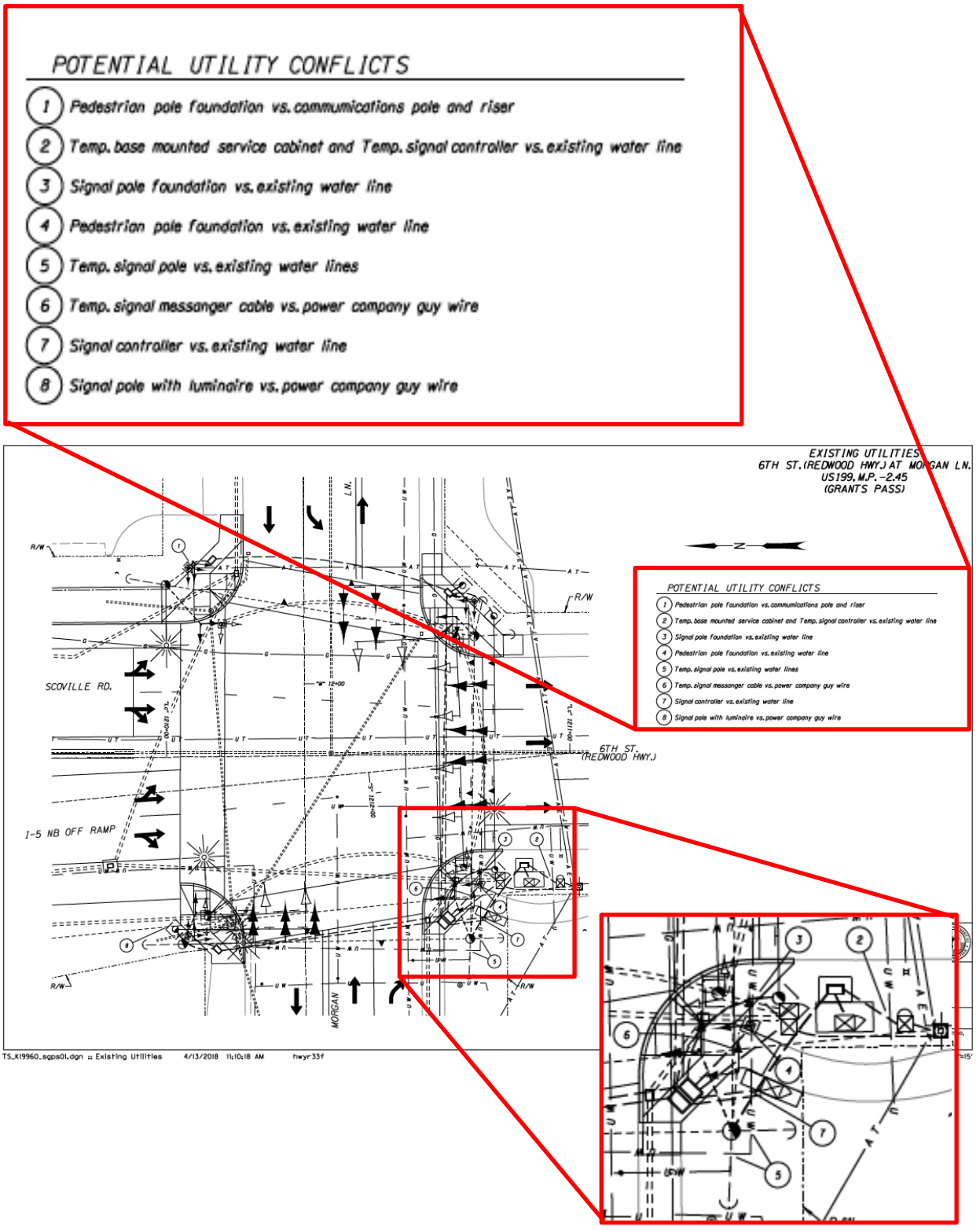
The existing utilities plan sheet should show the location of utilities with respect to the major signal work at the intersection. It has two main purposes:

- Providing the contractor enough information for bidding the work. The bid price needs to reflect the risks they will face during construction for signal drilled shafts, horizontal direction drilling, pole foundations, trenching and other underground work associated with a signal project.
- Providing a consistent reference point for any utility issues/discussions/decisions that occur during construction. The information shown can help all parties (EOR, construction office, and contractor) with quickly evaluating options from a high level if a utility conflict arises. It also helps in objectively evaluating claims for cost and schedule impacts that occur in construction. Without this plan sheet, the contractor and construction office will both be coming from a different perspective, making it difficult to efficiently evaluate and resolve disputes and claims in a fair and equitable manner.

The inclusion of this plan sheet in the contract plans does NOT remove the requirement of the contractor to "call before you dig". The signal designer is also still responsible for working with the region utility specialist to resolve all known utility conflicts prior to letting the project. The existing utilities plan sheet layout is a great tool to use during the design phase to communicate with the region utility specialist by highlighting potential conflicts that will require resolution before the project is let (either by relocating the existing utility or by moving the signal equipment). See Figure 8-1 for example of using the plan sheet during the design phase.

Utility conflicts should be identified early in the design process and resolved through the region utility specialist PRIOR to letting the project.

Figure 8-1 | Existing Utility Plan Sheet Used During Design Phase – For Region Utility Specialist



8.2 When is this Plan Sheet Needed?

An existing utilities plan sheet is required for each intersection on the project if the work entails installing any poles, pedestals, cabinets, or conduit. These items can have a substantial impact to existing utilities due to their required foundation depth and/or height. In addition, these items generally need to be installed in very specific locations with tight placement tolerances, so addressing a utility conflict during construction can be very costly in either material costs and/or timelines.

An existing utilities plan sheet is not required for:

- Signal work contained within the existing signal appurtenances or the roadway (e.g., signal head replacement, loop replacement, etc.).
- Interconnect/communication work that extends beyond the scale of the plan sheet used to show the intersection (this work spans a long distance and typically contains less critical design aspects with respect to utility conflicts).

However, an existing utilities plan sheet is recommended for each intersection for all other types of signal work if survey information for the utilities is available.

9 Details Plan

9.1 General

The details plan sheet is used to show any design information that cannot be shown on the standard designated plan sheets. This is typically due to a drafting space issue; for example, the pole entrance chart is contained on a separate details plan sheet because there is not enough room on the signal plan sheet to show all the pertinent signal design information. Other common design information shown on detail sheets includes customized diagrams created from standard details.

This chapter will cover the two basic types of information routinely contained on the details plan sheet; the pole entrance chart and custom details created from standard details.

9.2 Pole Entrance Chart - General

The pole entrance chart lists the micro details related to the signal pole and all mounted signal equipment. Some of the information listed in the pole entrance chart is redundant (e.g., the mast arm length is listed on the signal plans AND in the pole entrance chart), but this chart aids in reviewing signal pole submittals and also serves as a quick glance summary for how many and what type of poles are needed for the project.

There are two default types of pole entrance charts; one for mast arms (see section 9.3) and one for temporary span wires (see section 9.4).

9.2.1 When is a Pole Entrance Chart Needed?

A pole entrance chart is required for any work that involves installing a new pedestal or signal pole. If the project involves a combination of mast arms and temporary span wires, both charts will need to be included.

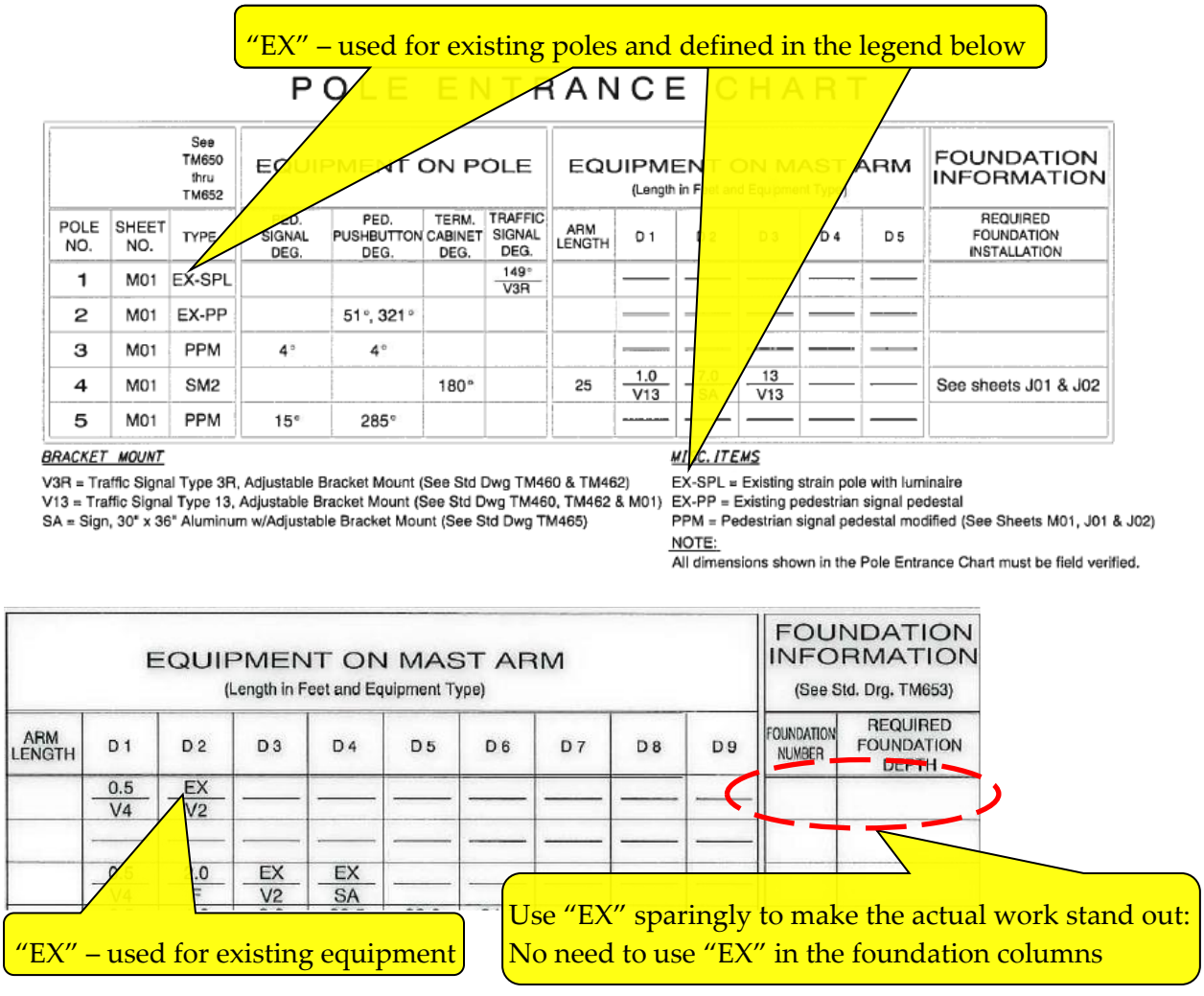
A pole entrance chart is recommended for any work that modifies the equipment located on an existing mast arm, span wire, or signal pole. The exception to this recommendation is for minor modifications where all the necessary information (contained in the pole entrance chart) can be very clearly shown on the signal plan sheet. For example:

- If the scope of work is only replacing existing pushbuttons on existing poles/pedestals in the same mounting orientation, a custom note on the signal plans would be adequate. If the mounting orientation is different, the new mounting degree could be shown on the signal plan sheet rather than in a separate pole entrance chart.
- If the scope of work was just adding a new signal head to an existing mast arm, the mounting distance can be shown on the signal plan sheet measured from the nearest piece of existing equipment rather than in a separate pole entrance chart.

9.2.2 Detailing Existing Signal Poles/Pedestals on the Pole Entrance Chart

The project scope may require a mix of new and existing signal poles/pedestals. Existing poles/pedestals shall be numbered if there is work on them (e.g., replacing signal heads or pedestrian pushbuttons). "EX" should be used to define the existing pole type. When there is work being done on the pole/pedestal, use EX as necessary for equipment (but sparingly to make the actual work stand out) to denote the existing features that are to be retained and protected. If no work is being done at the pole/pedestal AND it has been numbered, all other columns in the pole entrance chart should be blank. See Figure 9-1 for examples.

Figure 9-1 | Existing Poles/Pedestals in the Pole Entrance Chart



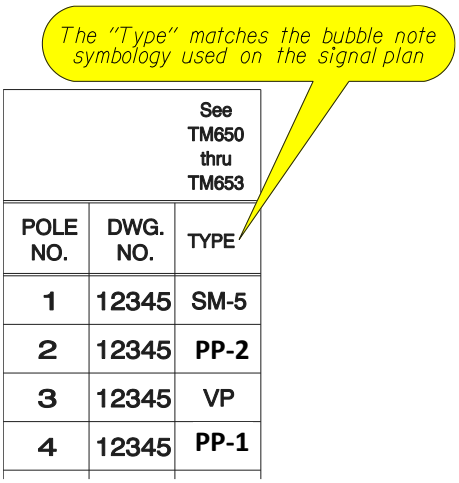
9.3 Pole Entrance Chart – Mast Arm

The following section discusses how to fill out the mast arm pole entrance chart properly. If any of the columns do not apply to the pole that is being detailed, leave those columns blank.

9.3.1 First 3 Columns

The first 3 columns list the basic pole identifiers: the unique pole number, the signal plan sheet the pole is located on, and the type of pole it is (signal pole type as per standard drawing TM650 or pedestal type as per standard drawing TM457). See Figure 9-2.

Figure 9-2 | Basic Pole Information

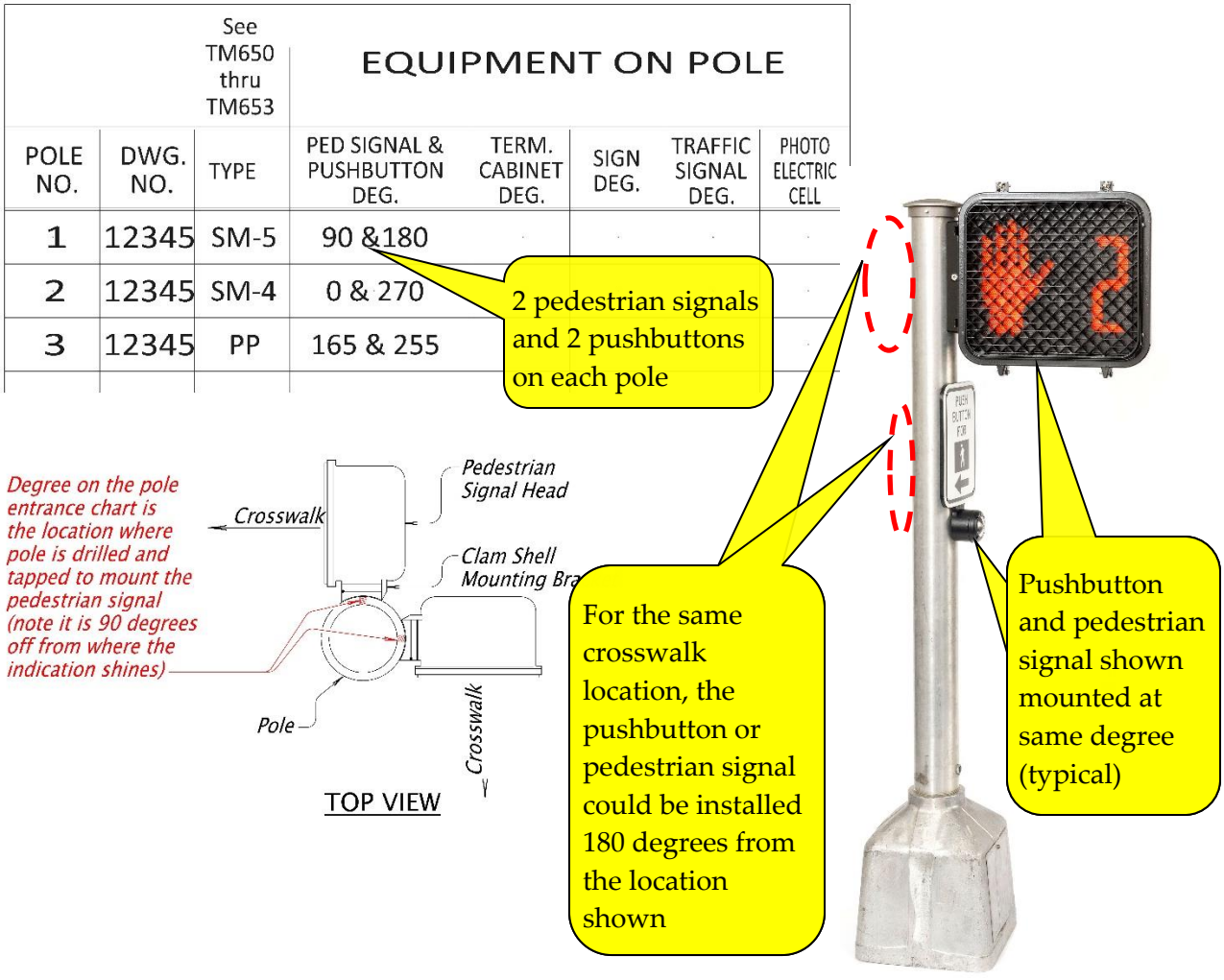


9.3.2 Equipment on the Pole

The next five columns detail all the equipment that is mounted on the vertical pole. All equipment that is mounted on the vertical pole is measured by degrees to ensure the correct orientation of the equipment. The degrees are shown to the nearest 5-degree increment.

The pedestrian signal and pushbutton degrees column shows the location of the where the pole is drilled and tapped to attach the mount for the pedestrian signal (which is 90 degrees from the face of the signal indication) and the mount for the pushbutton. The pushbutton degrees are also included in this column as the pushbutton mount is typically at the same orientation as the pedestrian signal mount. In the case where the pushbutton needs to be at a different orientation than the pedestrian signal indication (180-degree difference), add a column to separate the two pieces of equipment. If more than one pedestrian signal indication/pushbutton is mounted to a pole an "&" symbol is used between the two locations. See Figure 9-3.

Figure 9-3 | Pedestrian Signal Degrees



For a mast arm pole, the degrees are measured clockwise from the centerline of the mast arm. Pedestrian signals should be mounted at or near 90 degrees and 180 degrees on a mast arm pole (located on the "back-side" of the mast arm pole). See Figure 9-4. They may be mounted on the "front side" of the mast arm pole (at or near 0 degrees and 270 degrees) if that location provides a better line of sight within the crosswalk, but keep in mind that pedestrian indications located on the front side of the pole are more vulnerable to being damaged by large trucks making a right turn at the intersection. See Figure 9-5. Note that the degrees for mast arm poles are measured differently than degrees for pedestals; pedestal degrees are measured from the north arrow. See Figure 9-6.

Figure 9-4 | Pedestrian Signal Degrees – Pole 1 Example

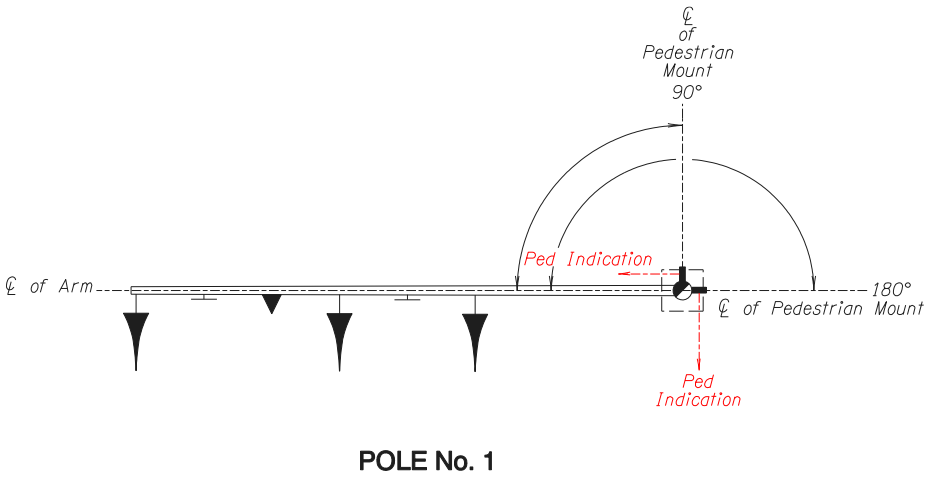


Figure 9-5 | Pedestrian Signal Degrees – Pole 2 Example

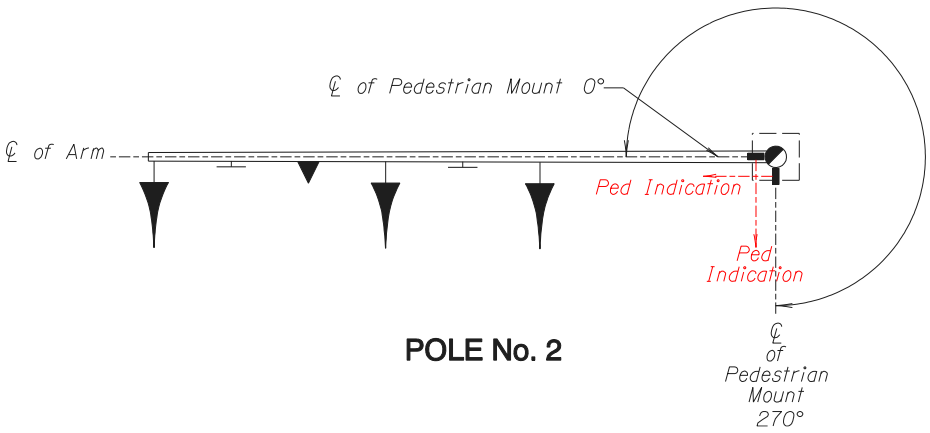
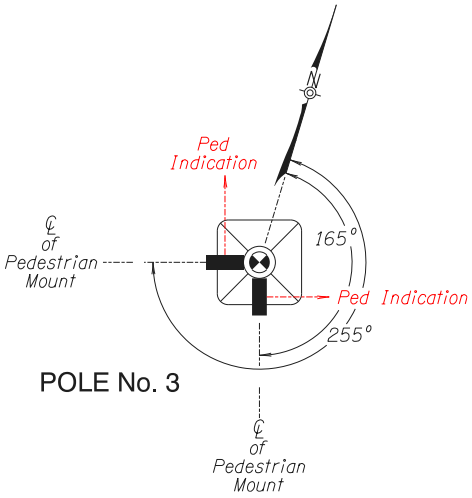


Figure 9-6 | Pedestrian Signal Degrees – Pole 3 Example

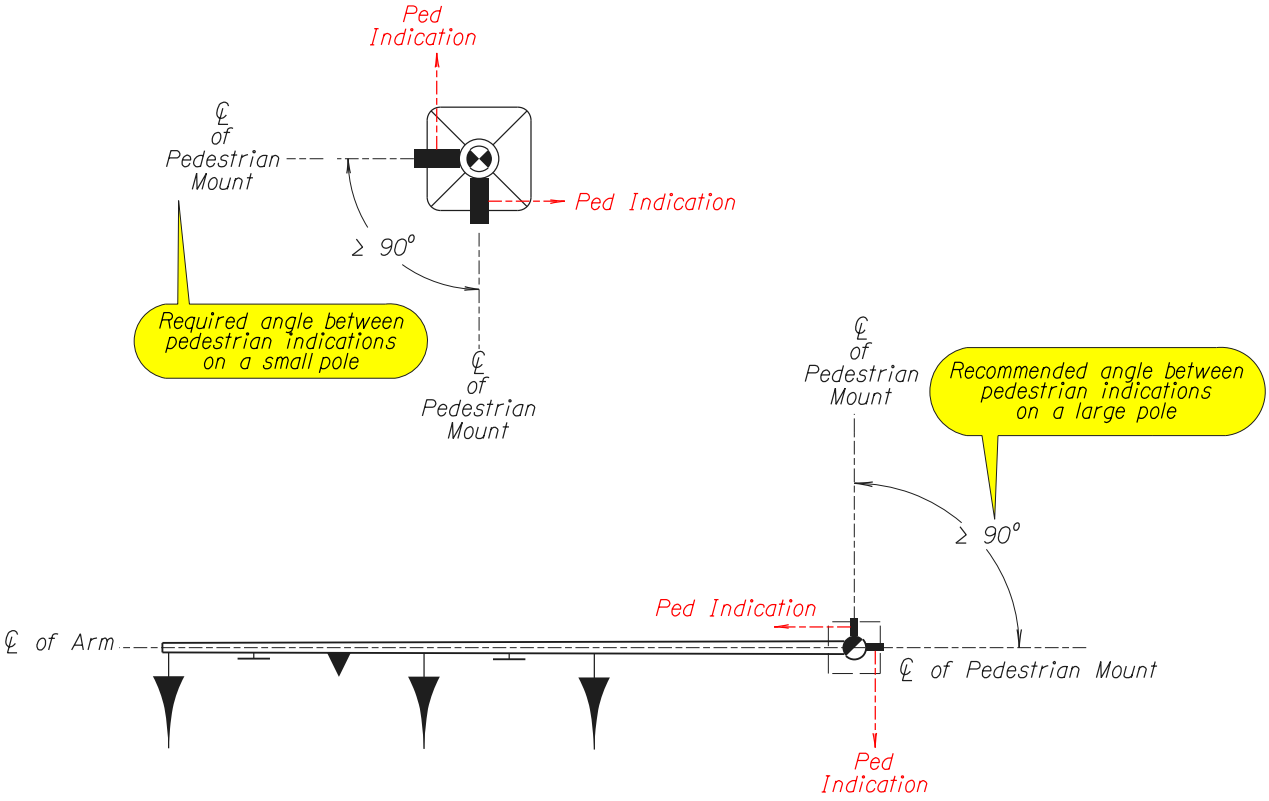


The origin for measuring degrees is NOT the same for mast arm poles (clockwise from the arm) and pedestals (clockwise from the north arrow).

When two pedestrian indications are mounted to the same pole, the acute angle between the two pedestrian heads should be 90 degrees or greater on a large diameter pole (mast arm pole and temporary wood pole) and shall be 90 degrees or greater on a small diameter pole (pedestal). See Figure 9-7. When the indications are placed closer than 90 degrees several things may occur:

- The indications can be occluded
- The clamshell mounting brackets cannot be installed (the hardware for each indication would overlap)
- It may be difficult to fully open the clamshell and/or the pedestrian indication for maintenance

Figure 9-7 | Pedestrian Signal Degrees – Angle Between Two Pedestrian Indications



The terminal cabinet degrees shows the location where the pole manufacture needs to install the recessed terminal cabinet. See standard drawings in TM400 series and TM600 series for additional details. See Figure 9-8. Pedestals do NOT have a terminal cabinet. For mast arm poles, the terminal cabinet degrees should be located at 180 degrees unless there is some obstruction which would make accessing the terminal cabinet difficult at 180 degrees. See Figure 9-9. The region electrical crew will provide direction on the best location to mount the terminal cabinet in these situations. See Figure 9-10 for examples of some solutions to make the terminal cabinet accessible.

Figure 9-8 | Terminal Cabinet Degrees

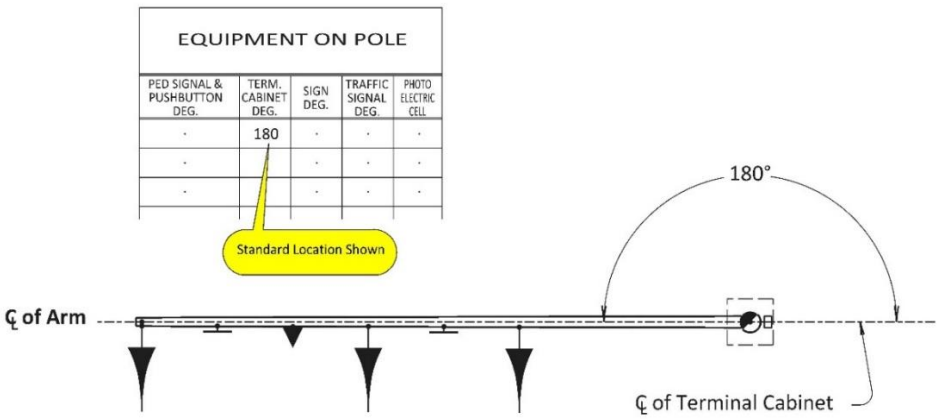


Figure 9-9 | Terminal Cabinet Degrees: Access Obstruction Examples

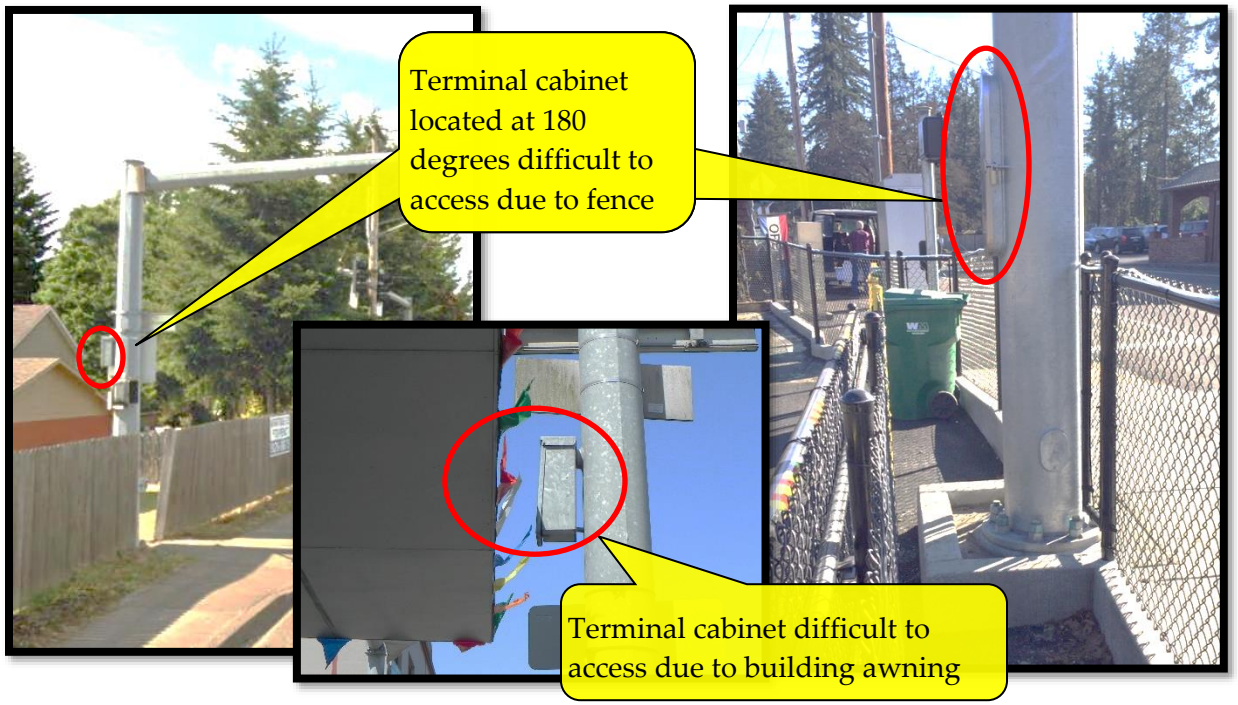
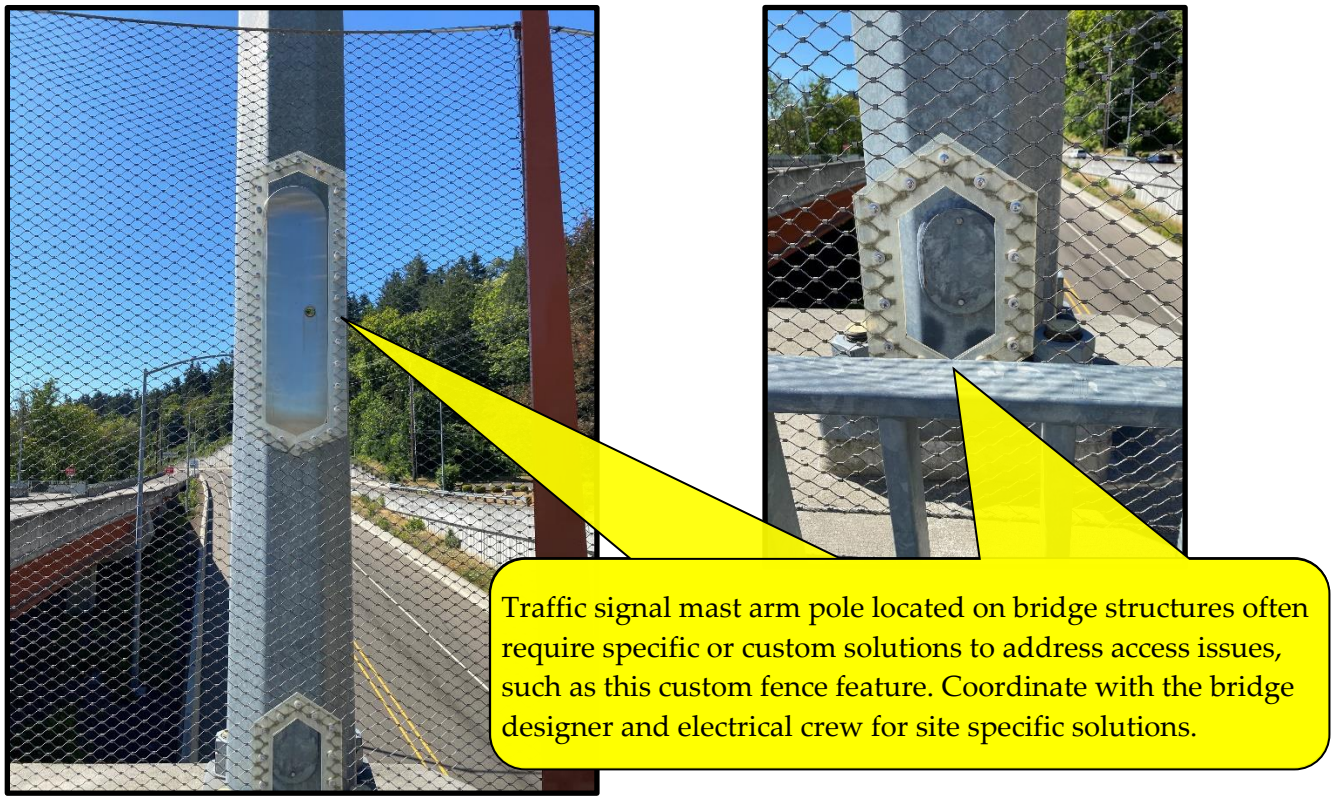
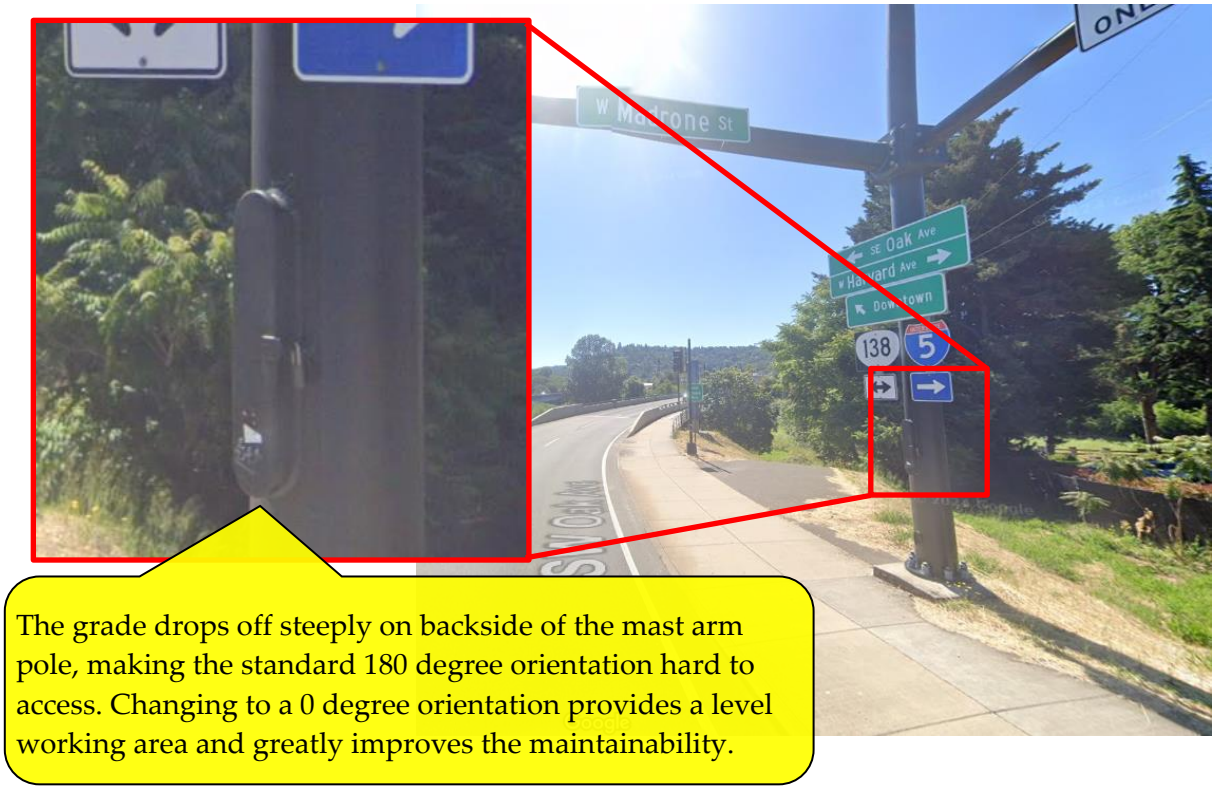


Figure 9-10 | Terminal Cabinet Degrees: Examples of Solutions to Access Issues

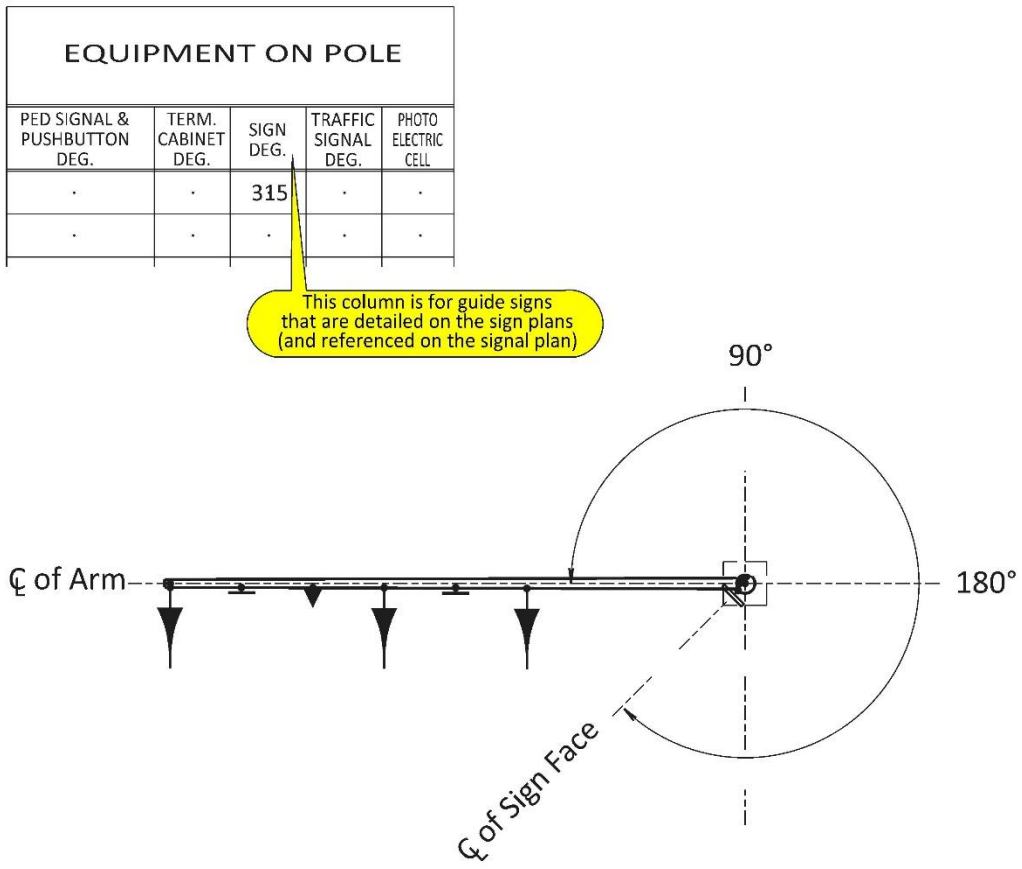




The sign degree column shows the location of the face of the sign mounted on the signal pole, typically a guide sign. See Figure 9-11. The other details for the guide sign fabrication and mounting will be shown on the signing plans and will be paid for as a sign bid item (not under the lump sum traffic signal bid item). Guide signs mounted to signal poles must meet the requirements shown in standard drawings TM650 and TM680 (such as a maximum area of 60 square feet, maximum height of 7 feet and maximum width of 12 feet). If at all possible, the guide sign should be designed to fit within these parameters. If the sign cannot be meet these requirements and cannot be mounted in a different location, then a standard signal pole cannot be used and a custom designed pole must be used.

If a sign other than a guide sign is mounted to the pole (e.g., a NO TURN ON RED sign), this column is used to detail the orientation. In the case where multiple signs are mounted to the same pole (e.g., guide sign AND a regulatory sign) it is recommended to add a column to the "equipment on pole" to distinguish between the two signs. See Figure 9-15. Multiple signs on the same pole must be evaluated to ensure that a standard pole will accommodate the loading as per TM660 and TM680.

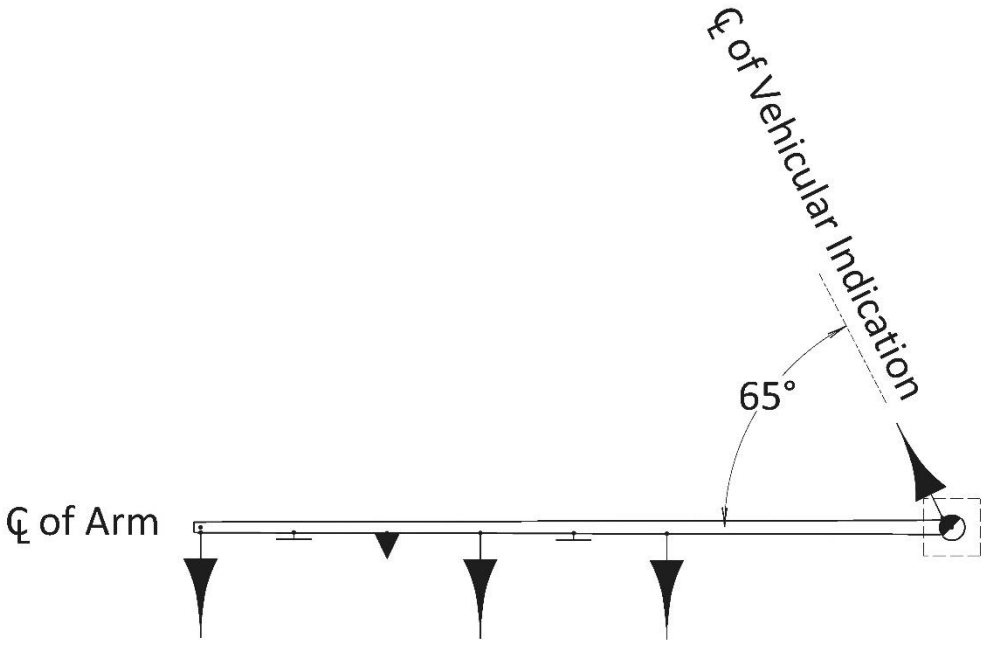
Figure 9-11 | Sign Degrees (Typically for a Guide Sign)



The traffic signal degree column shows the location of the face of the vehicle signal indication mounted on the pole. See Figure 9-12. Vehicle signal indications are not typically mounted to signal poles unless there is need for a supplemental signal indication or the intersection geometry/phasing requires unique placement of the signal indication.

Figure 9-12 | Traffic Signal Degrees

EQUIPMENT ON POLE				
PED SIGNAL & PUSHBUTTON DEG.	TERM. CABINET DEG.	SIGN DEG.	TRAFFIC SIGNAL DEG.	PHOTO ELECTRIC CELL
.	.	.	65	.
.	.	.	.	.



The origin for measuring the degrees is NOT the same for mast arm poles and pedestals.

The photo-electric cell column shows the location of the mount used for the photo electric cell. See Figure 9-13. The photo-electric cell's sensor must be oriented to the north to operate most effectively, so when mounting the photo electric cell to the pole, ensure that photo electric cell's sensor will NOT be pointed directly at the signal pole. See Figure 9-14.

Figure 9-13 | Photo Electric Cell

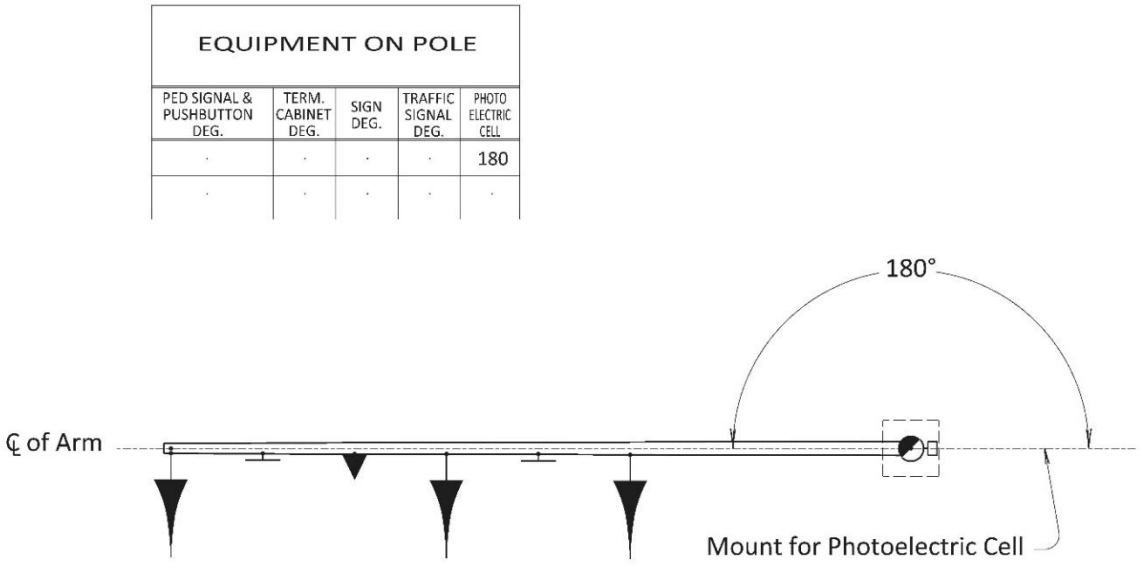
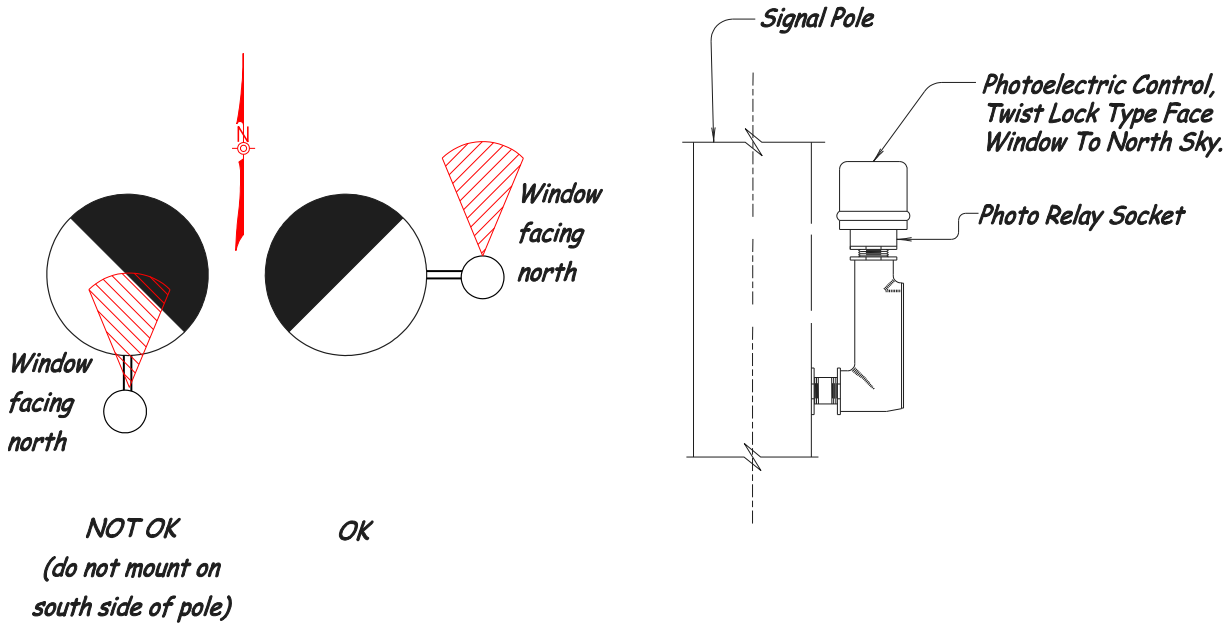
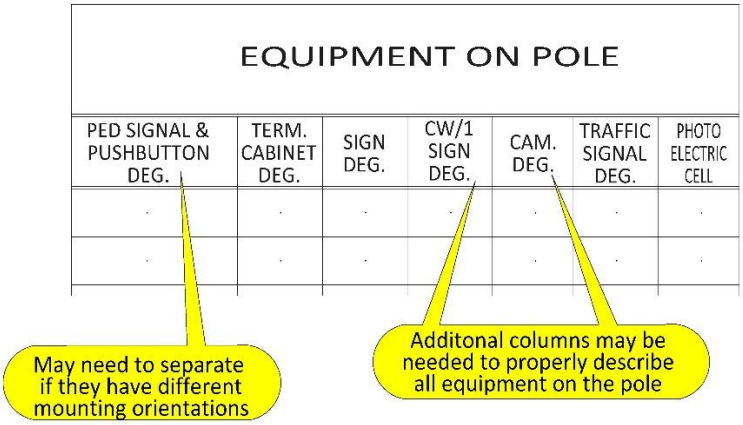


Figure 9-14 | Photo Electric Cell Orientation



There may be cases where additional columns may need to be added to the "equipment on pole" section. Typical examples include a column for the "crosswalk closed" sign if it needs to be mounted to the signal pole, a "Cam. Deg." column if a video detector/ITS camera is mounted to the pole, or a column for pushbuttons if they have a separate the mounting orientation from the pedestrian signal head. See Figure 9-15.

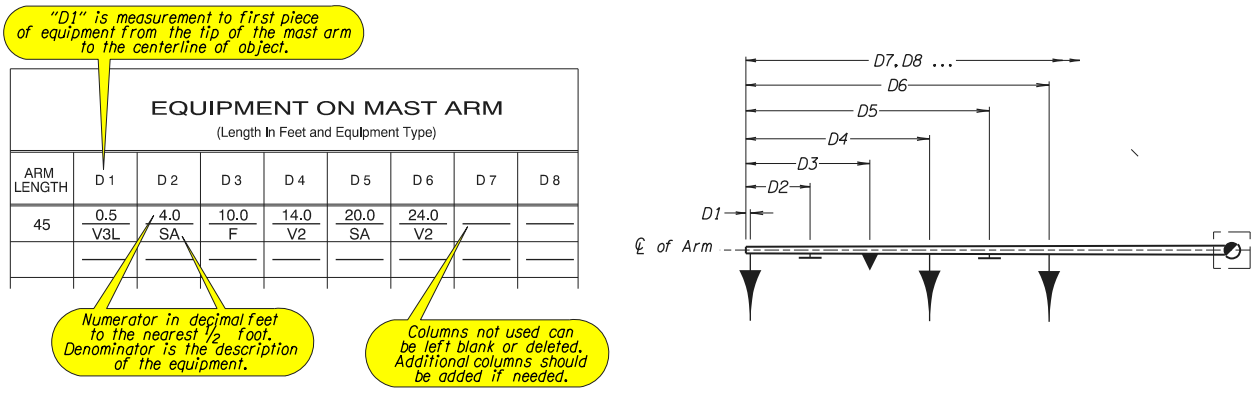
Figure 9-15 | Adding Columns



9.3.3 Equipment on the Mast Arm

The next columns show all the equipment located on the mast arm. See Figure 9-16. The first column shows the mast arm length. The following columns list each piece of equipment that is located on the mast arm, starting from the tip of the mast arm and going towards the signal pole. For each piece of equipment, the distance in feet from the tip of the mast arm (numerator) AND a description of the type of equipment (denominator) is included. The description is a standard abbreviation that is defined in the legend below the pole entrance chart. The distance is shown in decimal format, with measurements rounded to the nearest half foot.

Figure 9-16 | Mast Arm Equipment



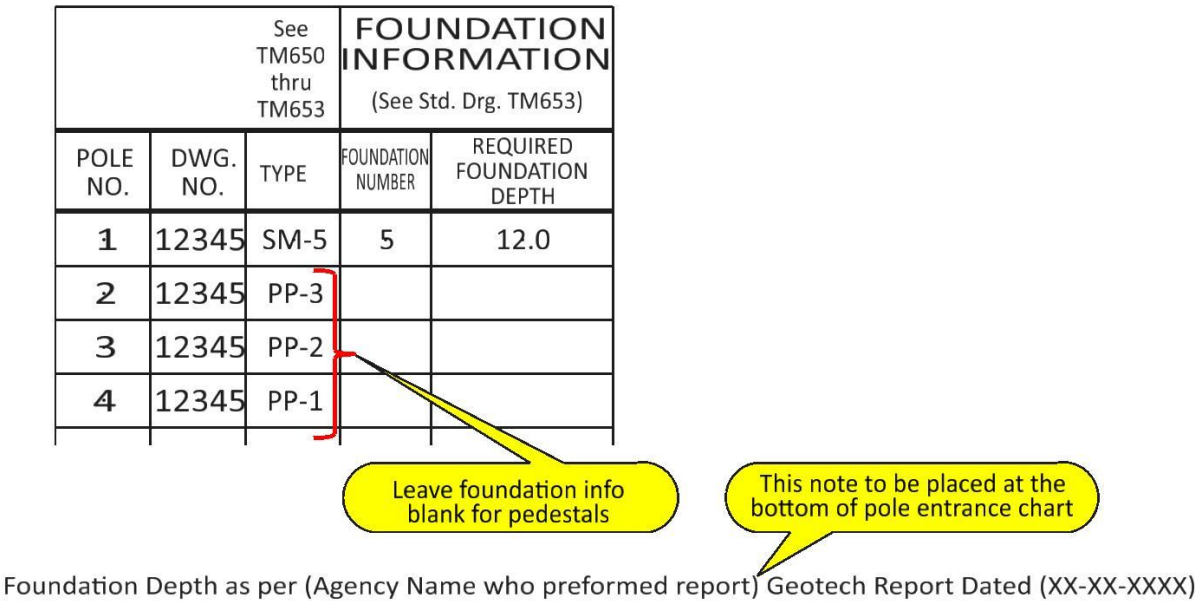
9.3.4 Foundation Information

The foundation information columns show the foundation number and the foundation depth for each signal pole. See Figure 9-17. The foundation number is specific to the type of mast arm pole type used and is found on standard drawing TM653 in the "standard foundations" chart. The foundation depth is determined using site specific information documented in a geotechnical report according to the ODOT Traffic Structures Design Manual. This report is produced by the geotechnical engineer once the location of the signal poles has been determined. The foundation depth is shown in decimal format to the tenth of a foot. The geotech report is also referenced on the plan sheet just below the pole entrance chart with the name of the agency/firm that produced the report and the date of the report.

Do NOT include any foundation information for pedestals as the three standard foundations are installed according to standard drawing TM457. Leave these columns blank.

If a custom foundation is used, use "See Dwg. No. XXXXX" in either the "foundation number" and/or "required foundation depth" columns to reference the custom details.

Figure 9-17 | Foundation Information

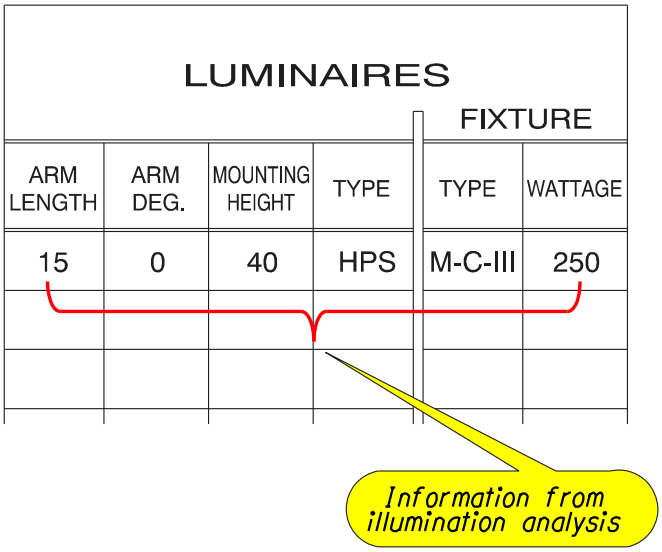


9.3.5 Luminaires

The illumination columns show the details for the luminaires mounted on signal poles. See Figure 9-18. The information comes from the illumination analysis. The following are typical values for illumination:

- 15-foot arm length
- 0 arm degrees (in-line with the mast arm)
- 35 to 40 foot mounting height
- Standard luminaire type is LED
- Standard fixture type for LED is type 3.
- Standard wattage is from 130 to 275, depending on design.

Figure 9-18 | Luminaire Information



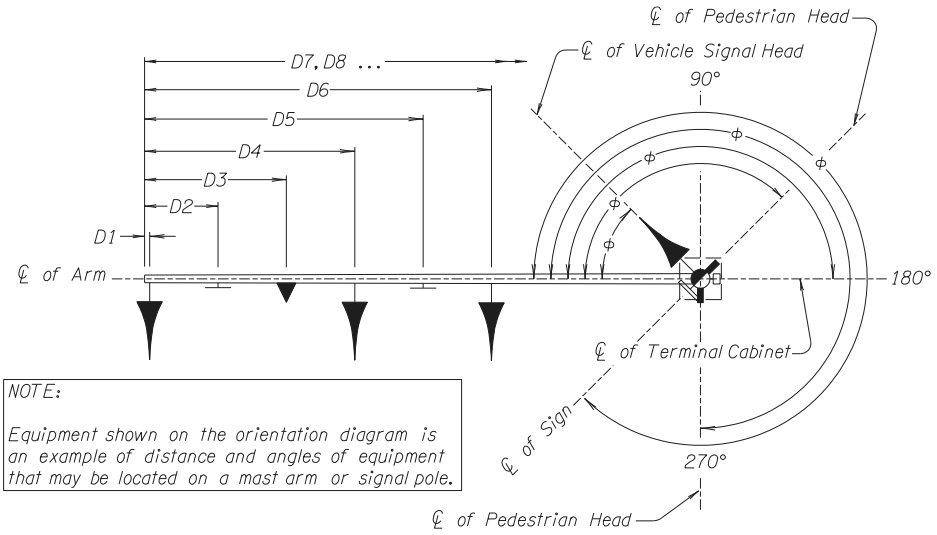
9.3.6 Orientation Diagrams

The orientation diagrams provide a legend for how to read the information provided by the pole entrance chart.

There are two standard orientation diagrams that are included with the pole entrance chart:

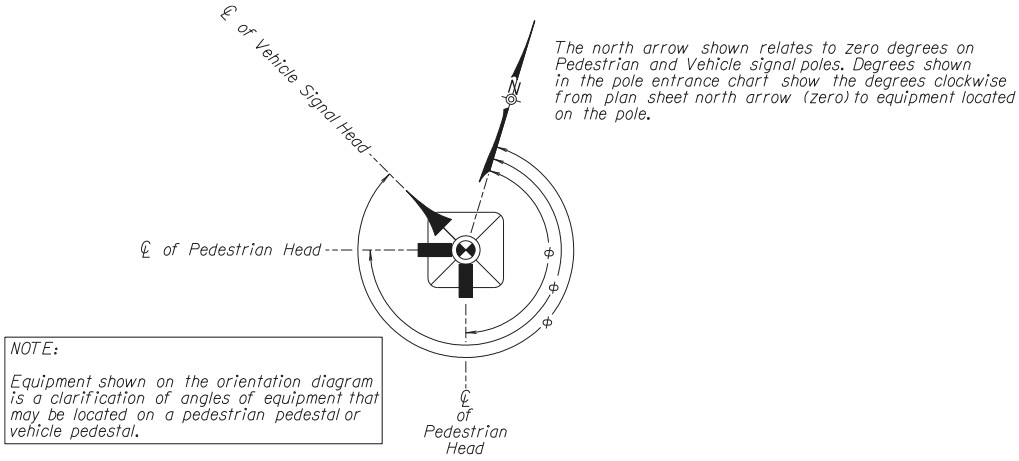
- The mast arm orientation diagram. See Figure 9-19.
- The pedestal orientation diagram, included only if a pedestal is used on the project. See Figure 9-20.

Figure 9-19 | Mast Arm Orientation Diagram



MAST ARM POLE ORIENTATION DIAGRAM

Figure 9-20 | Pedestal Orientation Diagram



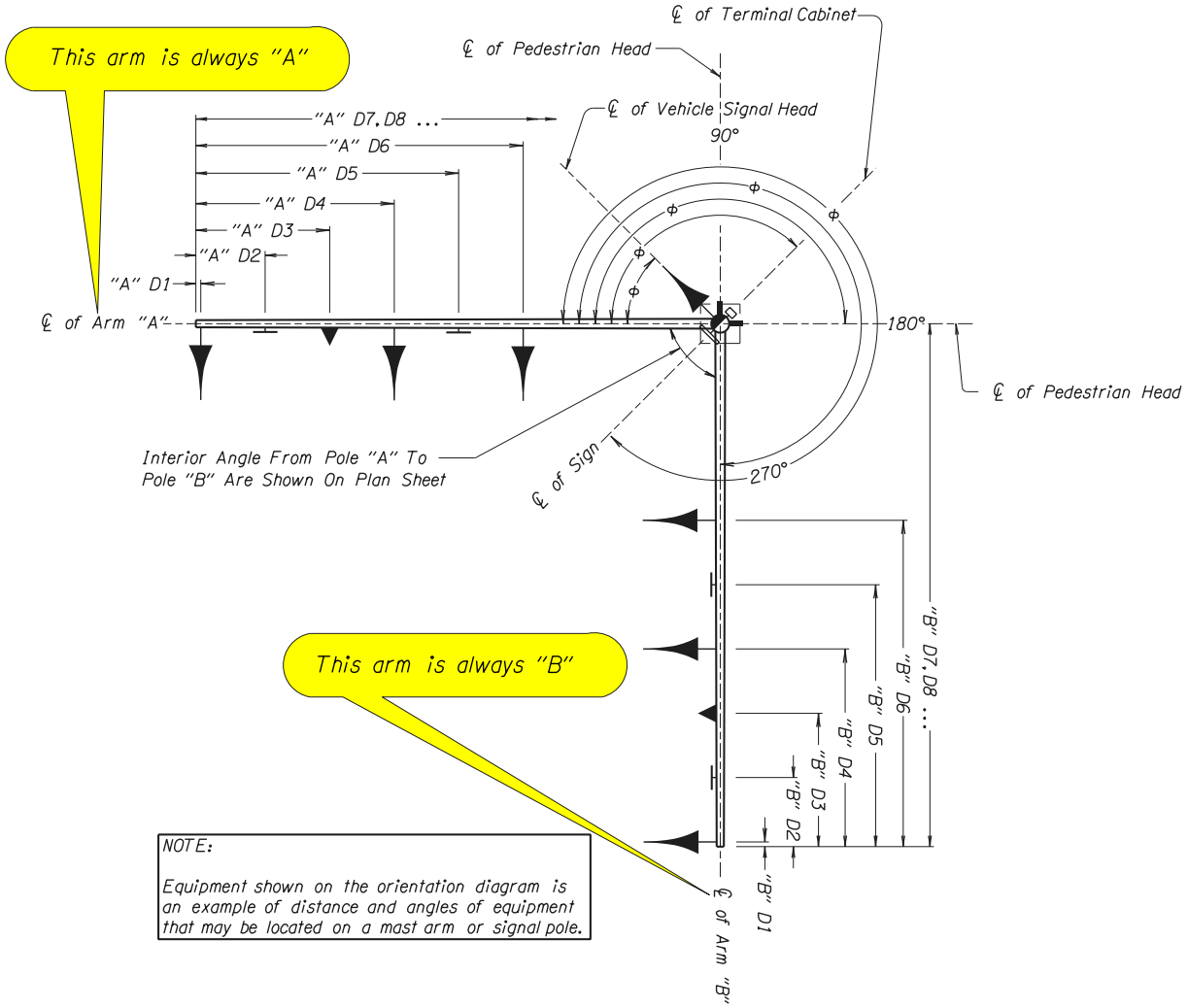
PEDESTRIAN PEDESTAL / VEHICLE PEDESTAL ORIENTATION DIAGRAM

9.3.7 Detailing Dual Mast Arm Pole in the Pole Entrance Chart

A dual mast arm pole is a custom designed pole and requires a few more pieces of information in the mast arm pole entrance chart (and signal plan sheet) than a standard mast arm pole. In addition, there is a specific pole orientation diagram that must be used for dual mast arm poles.

A dual mast arm pole has one mast arm labeled "A" and one labeled "B" as per the orientation diagram. This clearly designates which arm is being detailed in chart. See Figure 9-21. If possible (e.g., there is only one dual mast arm on the project or each dual mast is oriented in the same way), rotate the dual mast arm in the orientation diagram to match the orientation in the signal plan sheet. See Figure 9-22.

Figure 9-21 | Twin Mast Arm Pole Orientation Diagram



TWIN MAST ARM POLE ORIENTATION DIAGRAM

Figure 9-22 | Twin Mast Arm Pole Orientation Diagram – Rotated

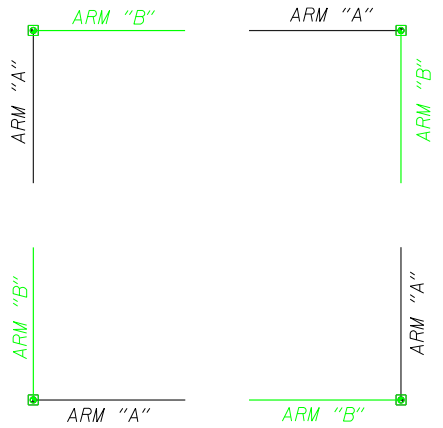


Figure 9-23 through Figure 9-27 show the additional information that is necessary to properly detail a dual mast arm pole in the pole entrance chart.

Figure 9-23 | Twin Mast Arm Pole – Pole Entrance Chart

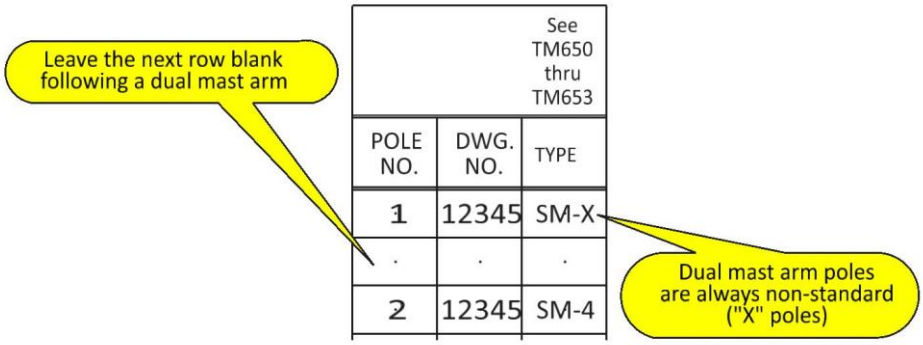


Figure 9-24 | Twin Mast Arm Pole – Equipment on Pole

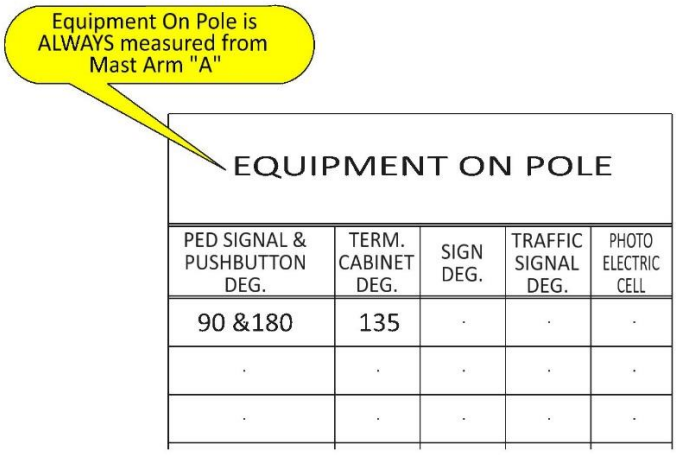


Figure 9-25 | Twin Mast Arm Pole – Equipment on Mast Arm

		See TM650 thru TM653	EQUIPMENT ON MAST ARM (Length in Feet and Equipment Type)								
POLE NO.	DWG. NO.	TYPE	ARM LENGTH	D1	D2	D3	D4	D5	D6	D7	D8
1	12345	SM-X	A: 30	0.5 V2	6.0 SA	10.5 V2	20.5 SNS				
			B: 35	0.5 V2	10.5 V2	25.5 SNS					
2	12345	SM-4									

Arm "A" and Arm "B" are defined and detailed in separate rows

Figure 9-26 | Twin Mast Arm Pole – Foundation Information

A non-standard foundation is typically required and shown in a separate signal detail plan sheet (referenced in the pole entrance chart)

FOUNDATION INFORMATION (See Std. Drg. TM653)	
FOUNDATION NUMBER	REQUIRED FOUNDATION DEPTH
N/A	See TRS Dwg. No.12345

Figure 9-27 | Twin Mast Arm Pole – Luminaires

Luminaire arm degrees is ALWAYS measured from Mast Arm "A"

LUMINAIRES				FIXTURE	
ARM LENGTH	ARM DEG.	MOUNTING HEIGHT	TYPE	TYPE	WATTAGE
15	0	40	HPS	M-S-III	250

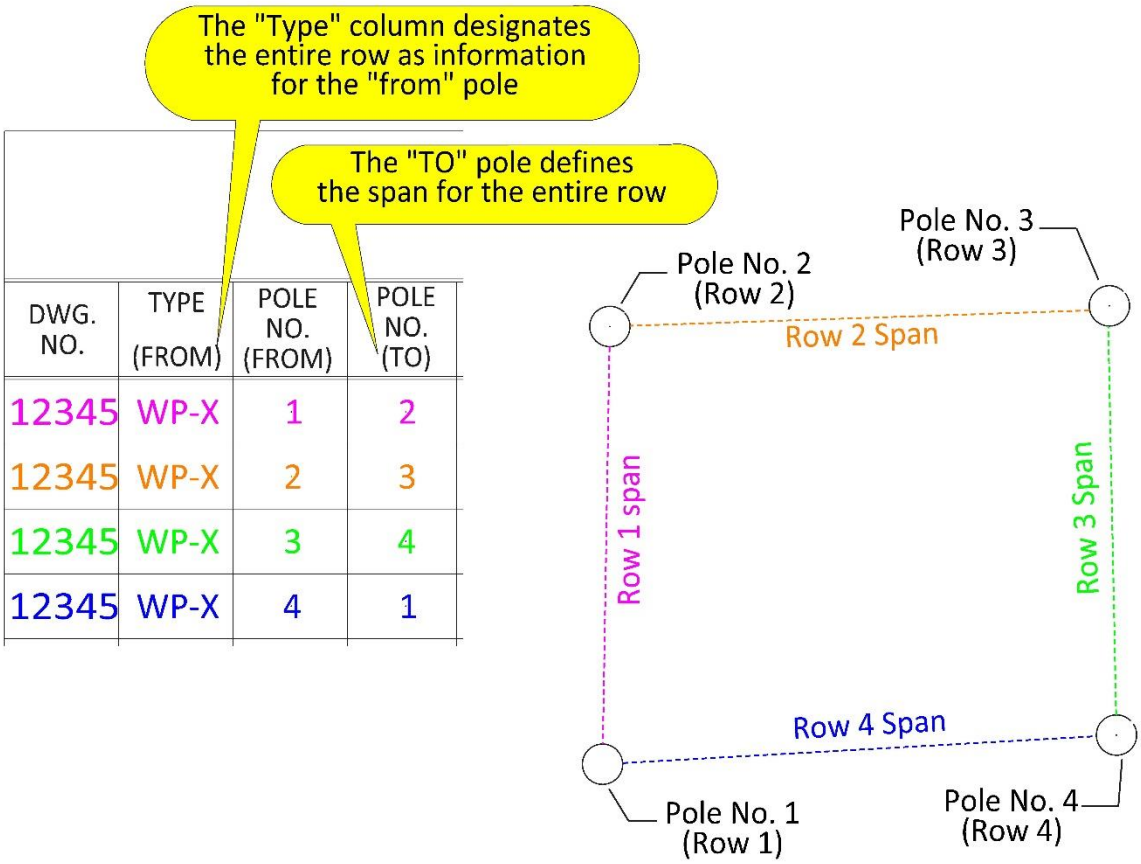
9.4 Pole Entrance Chart – Temporary Strain Pole

The following section discusses how to fill out the strain pole entrance chart properly. If any of the columns do not apply to the pole that is being detailed, leave those columns blank.

9.4.1 First 4 Columns

The first four columns list the basic pole and span identifiers: the signal plan sheet the pole is located on, the type of pole it is (always WP-X, a non-standard wood pole), the unique pole number (designated as the "FROM" pole), and the span (defined by the "TO" pole). See Figure 9-28. By specification 00227.12, the contractor is required to submit structural analysis for approval of the wood pole design based on the following information provided by the signal designer: pole location & span length, equipment & location of equipment on each span, and the messenger cable attachment height (MAH) for each pole.

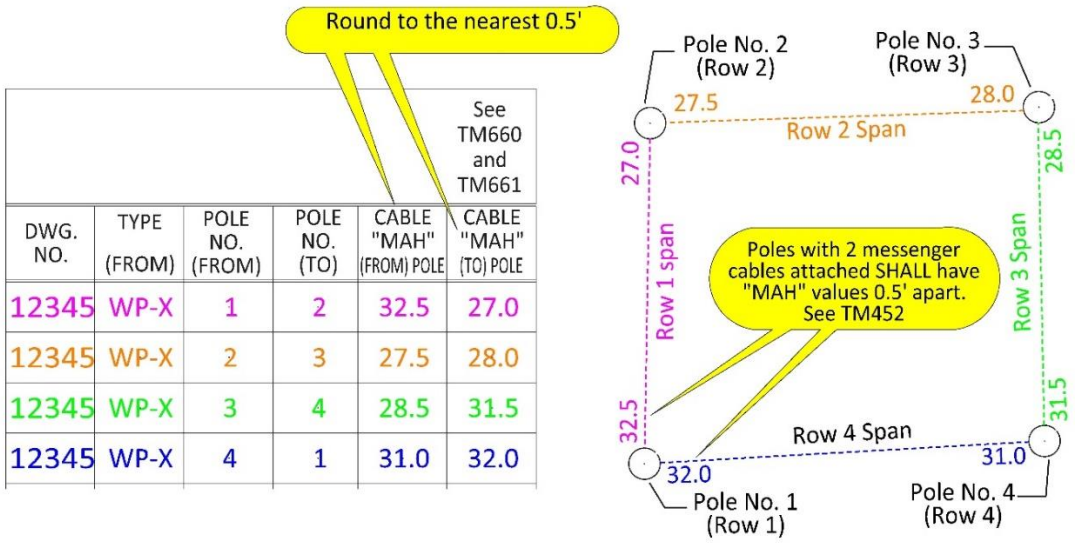
Figure 9-28 | Basic Pole and Span Information



9.4.2 Messenger Cable Attachment Height (MAH)

The next two columns after the basic pole information show the messenger cable attachment height (MAH) for each messenger cable attached to the pole. All values should be reported in increments of 0.5 feet. For poles with 2 messenger cables attached, the MAH values must be separated by 0.5 feet as per standard drawing TM452. See Figure 9-29.

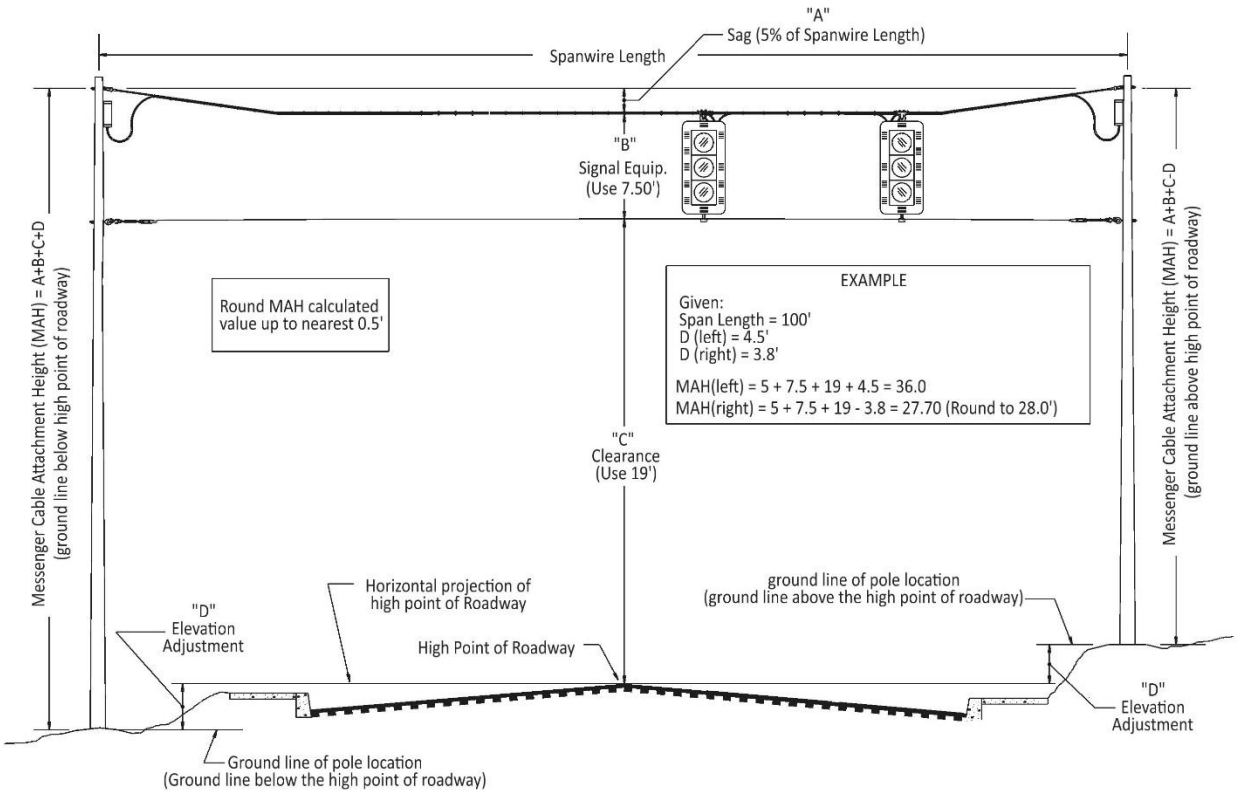
Figure 9-29 | Messenger Cable Attachment Height (MAH)



The MAH is defined as the distance from the ground line for the temporary wood pole to the point of attachment of the messenger cable. To determine the MAH, request a cross-section from the roadway designer for each span. To calculate the MAH, see Figure 9-30 which assumes the following:

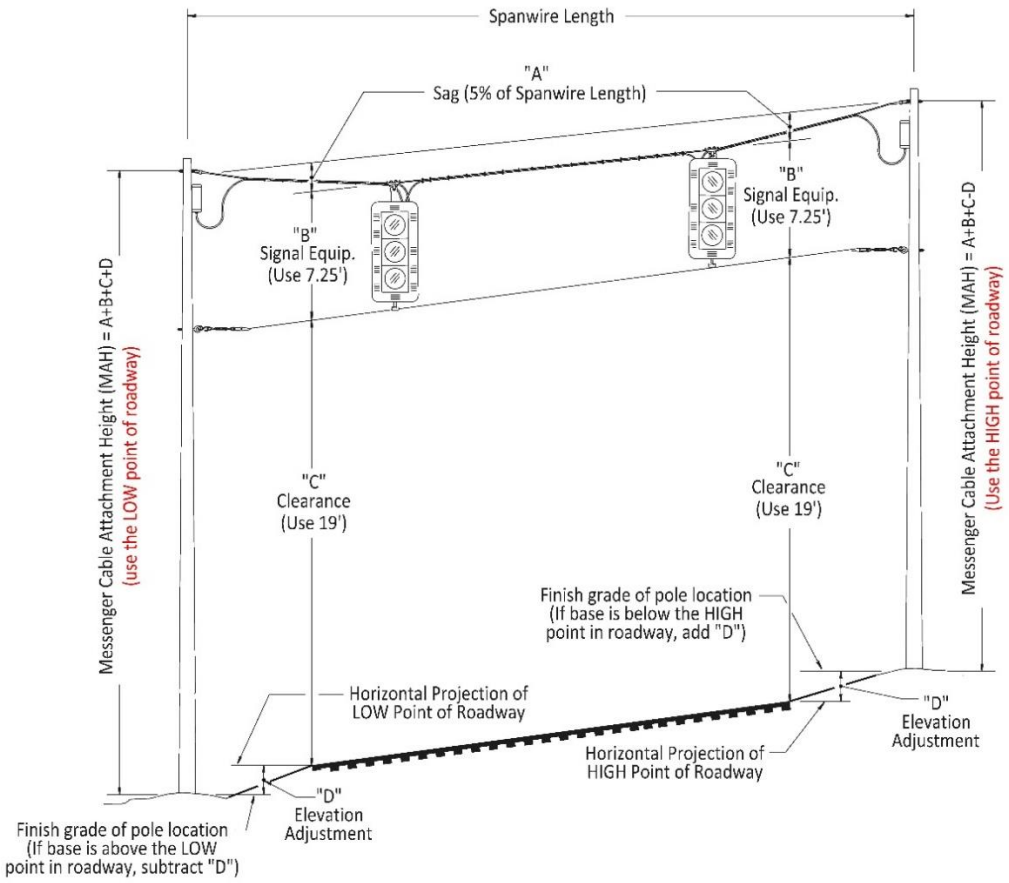
- The MAH values for the span are at approximately equal elevations (typically within 1 foot of each other). If the elevations of the MAH for the span are different by more than 1 foot due to a super elevation or steep vertical grade, see Figure 9-31 for how to calculate the MAH.
- 19 feet maximum roadway clearance. The tolerance for the roadway clearance is 18 feet minimum to 19 feet maximum as per standard drawing TM450. Using the 19 feet maximum value for calculating the MAH results in a conservative MAH value (from the perspective of roadway clearance).
- A type 5 signal head is mounted at the lowest spot on the span which coincides with the highest spot on the roadway. The results in a conservative MAH value and allows for any modifications needed for temporary staging. However, the largest piece of signal equipment to be installed on the temporary span may be used in the calculation in lieu of the type 5 signal head.

Figure 9-30 | Calculating the MAH Value



There are rare cases where the roadway cross-section will result in unequal MAH elevations for the span (e.g., when there is a steep grade or super elevation). In these cases, both the high point of the roadway AND the low point of the roadway is used to determine the MAH for each pole as per Figure 9-31. Using the method shown in Figure 9-31 is oversimplified and results in a conservative estimate for roadway clearance, as the low point in the catenary span will not actually occur at the locations shown when the MAH elevations are not equal.

Figure 9-31 | Calculating the MAH Value – Spans with MAH Elevations Differing by More Than a Foot



Round MAH calculated value up to nearest 0.5'

EXAMPLE

Given:
Span Length = 100'
D (left) = 4.5'
D (right) = 3.8'

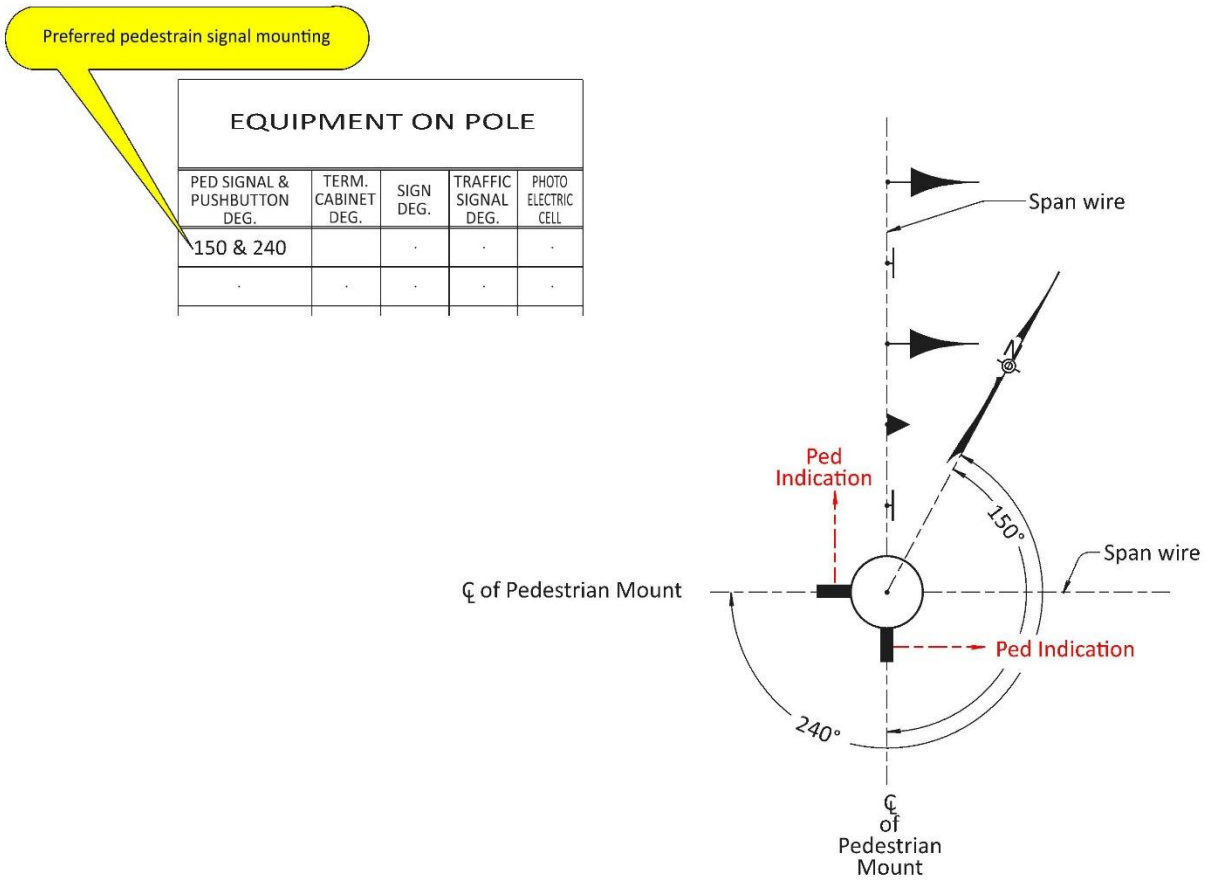
MAH(left) = 5 + 7.25 + 19 + 4.5 = 35.75 (Round to 36')
MAH(right) = 5 + 7.25 + 19 - 3.8 = 27.45 (Round to 27.5')

9.4.3 Equipment on Pole

The next five columns detail all the equipment that is located on the vertical pole. All equipment that is located on the vertical pole is measured by degrees to ensure the correct orientation of the equipment. The degrees are shown to the nearest 5-degree increment.

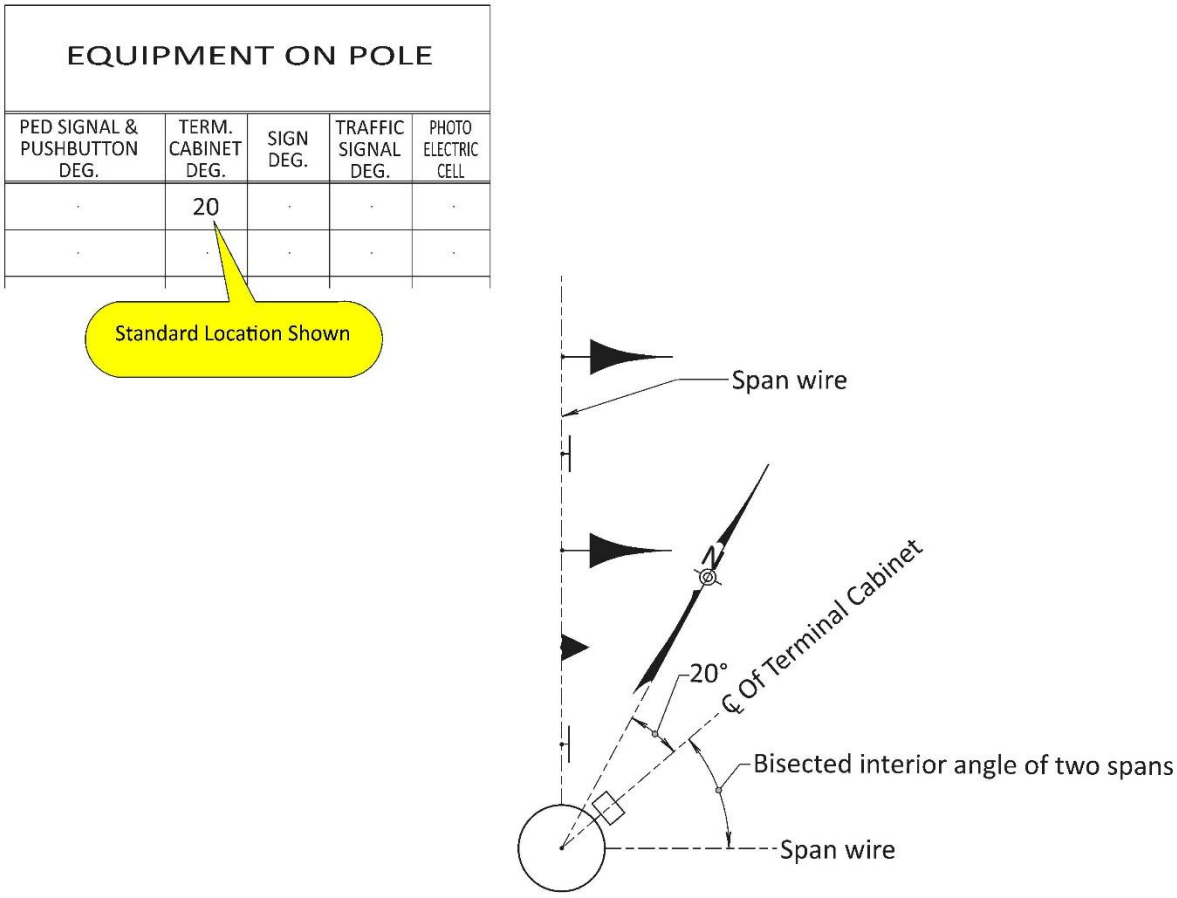
The pedestrian signal and pushbutton degrees column shows the location on the pole to attach the mount for the pedestrian signal (which is 90 degrees from the face of the signal indication) and the mount for the pushbutton. The pushbutton degrees are also included in this column as the pushbutton mount is typically at the same orientation as the pedestrian signal mount. In the case where the pushbutton needs to be at a different orientation than the pedestrian signal indication (180-degree difference), add a column to separate the two pieces of equipment. If more than one pedestrian signal indication/pushbutton is mounted to the pole an "&" symbol is used between the two locations. The degrees for a strain pole are measured clockwise from the north arrow. The preferred mounting on the back side of the strain pole is shown in Figure 9-32.

Figure 9-32 | Pedestrian Signal Equipment



The terminal cabinet degree shows the location to mount the terminal cabinet to the temporary wood pole (see TM454 for additional details). The terminal cabinet should be located on the bisected interior angle formed by the two span wires for ease of maintenance. See Figure 9-33.

Figure 9-33 | Terminal Cabinet on Strain Pole



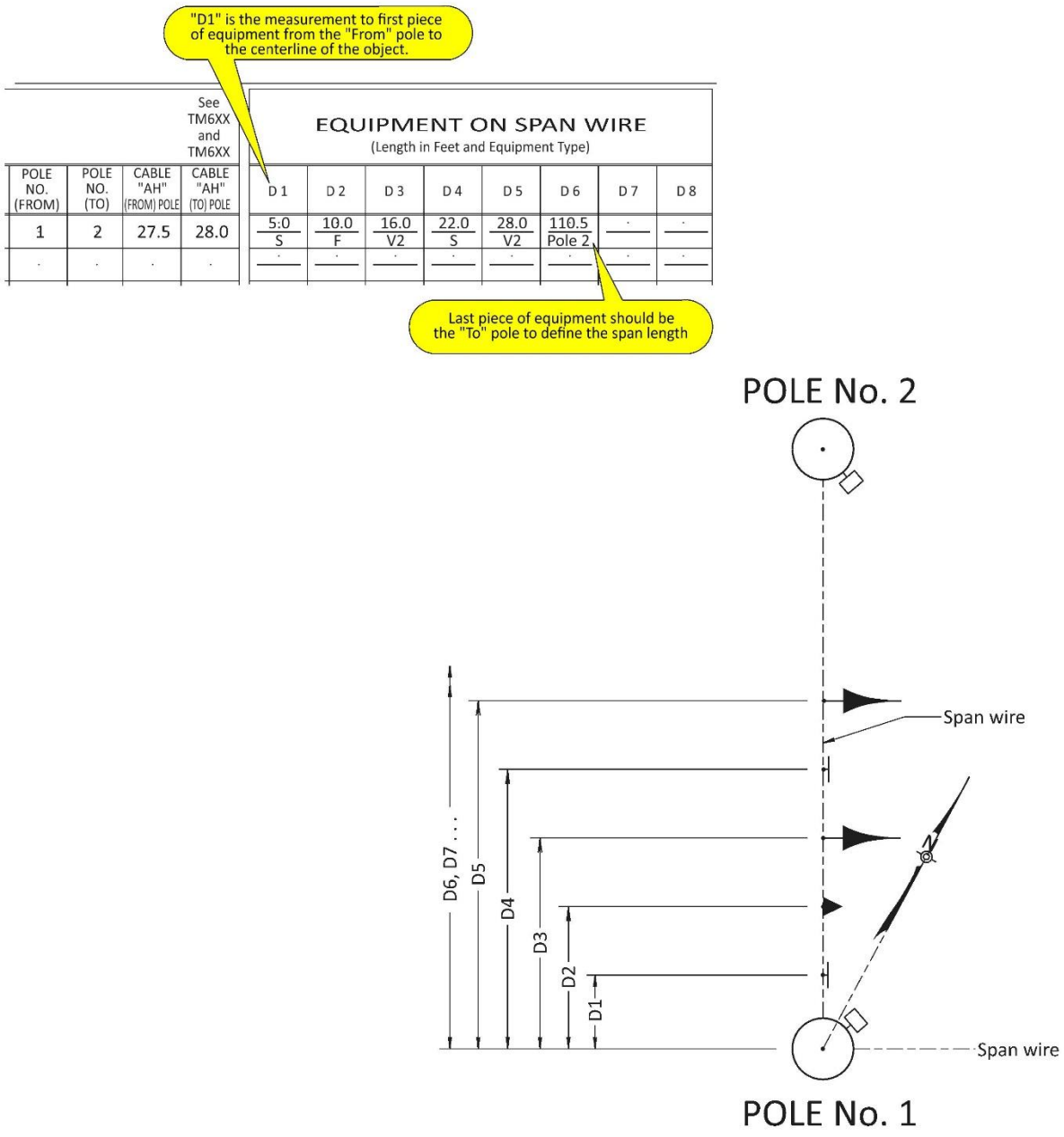
The last 3 columns in the "equipment on pole" (sign deg., traffic signal deg., and photo electric cell) are detailed the same as for a mast arm pole, with the only exception being the origin of degree measurement (strain poles always measure degrees based off of the north arrow). See Section 9.3.2.

9.4.4 Equipment on Span Wire

The equipment on located on the span wire is detailed the same as the equipment located on the mast arm (see section 9.3.3) with the two following exceptions (see Figure 9-34):

- The origin of measurement is based on the "from" pole
- The "to" pole is listed as the last piece of equipment to define the length of the span

Figure 9-34 | Equipment on Span Wire



9.4.5 Foundation Information

Foundation design information for temporary wood poles is provided by the contractor and approved by the traffic structures engineer or the EOR during construction. Therefore, leave these columns blank or state "contractor provided".

9.4.6 Luminaires

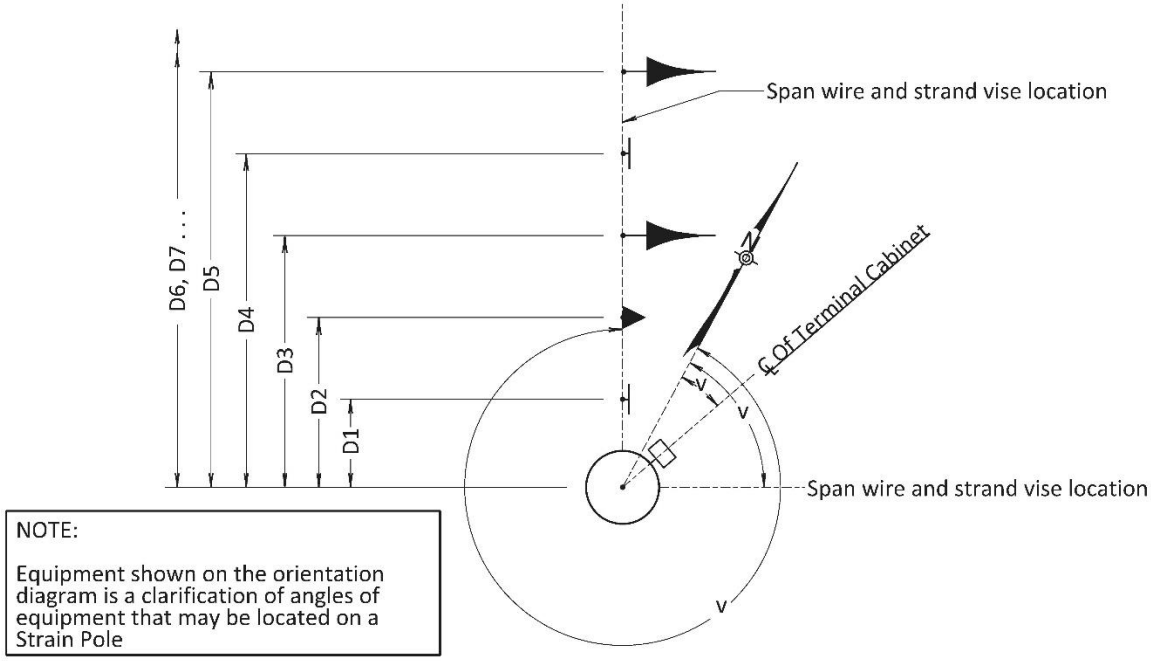
The same information presented in the mast arm pole orientation diagram applies to strain poles. See section 9.3.5.

9.4.7 Orientation Diagrams

The orientation diagram provides a legend for how to read the information provided by the pole entrance chart.

The orientation diagram that is included with the pole entrance chart for a span wire is shown in Figure 9-35.

Figure 9-35 | Strain Pole Orientation Diagram



STRAIN POLE ORIENTATION DIAGRAM

9.5 Custom Details Created from Standard Details

Most custom details that will be shown on a details plan sheet will be created from a standard detail. See chapter 17 for more information on standard details. A custom detail is needed anytime the standard drawings need to be modified to be applicable to the project or a standard drawing addressing the necessary micro details of installation doesn't exist.

9.5.1 ITS Equipment

If the project has ITS equipment such as, fiber optics or communication devices, there will most likely be a need for a detail plan sheet that shows micro details for these installations (e.g., splicing, equipment mounting in the controller cabinet, etc.). See Figure 9-36 through Figure 9-38 for examples of ITS details. Typically, the ITS designer is responsible for the ITS detail sheets.

Detail sheets that contain ITS information should have dual sheet numbers assigned, a TRS dwg. number from the traffic engineering section and an ITS dwg. number from the ITS unit.

Figure 9-36 | ITS Fiber Splice Detail Example

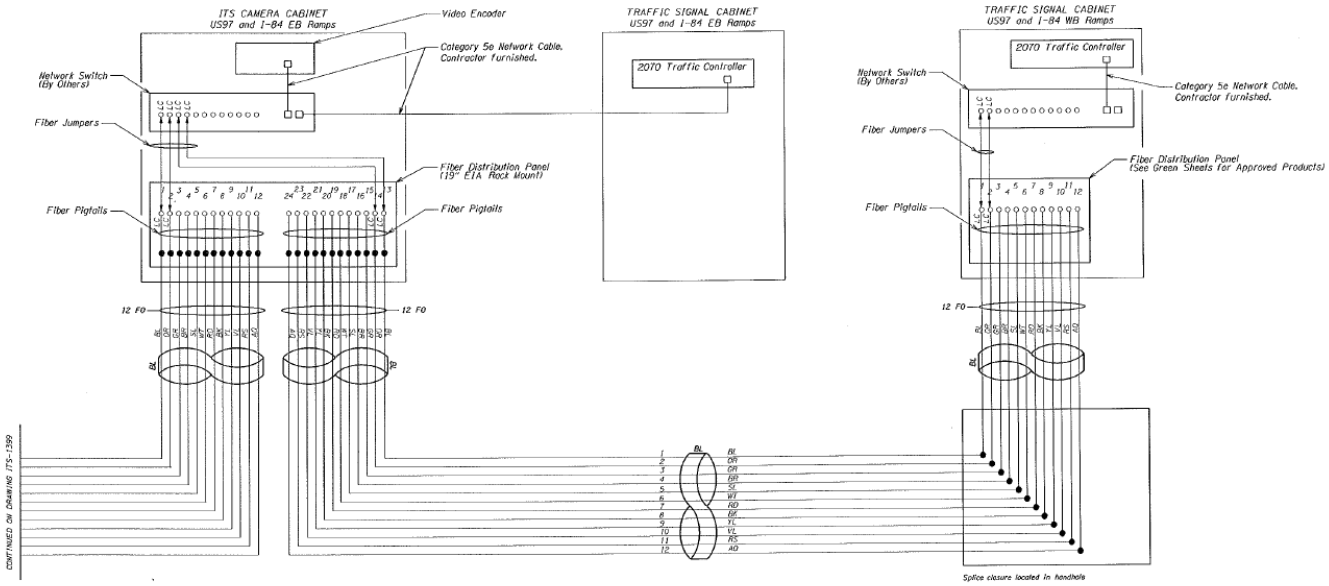


Figure 9-37 | Communication Rack Detail Example

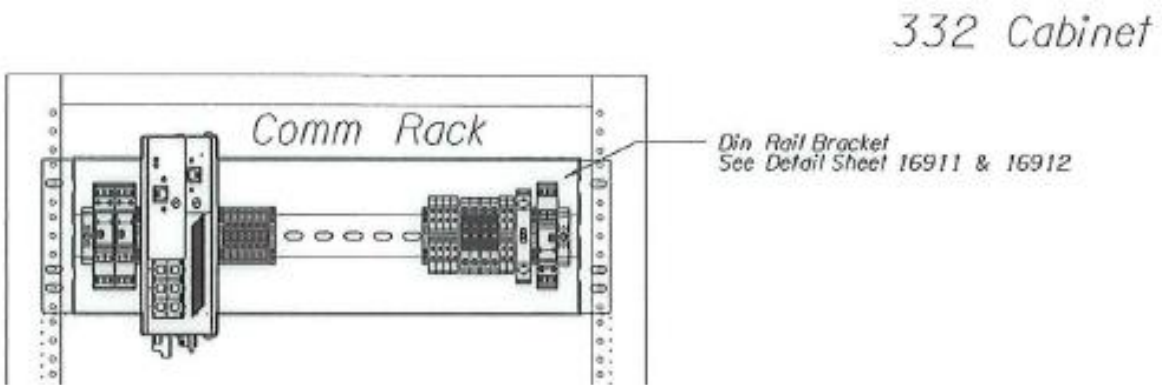
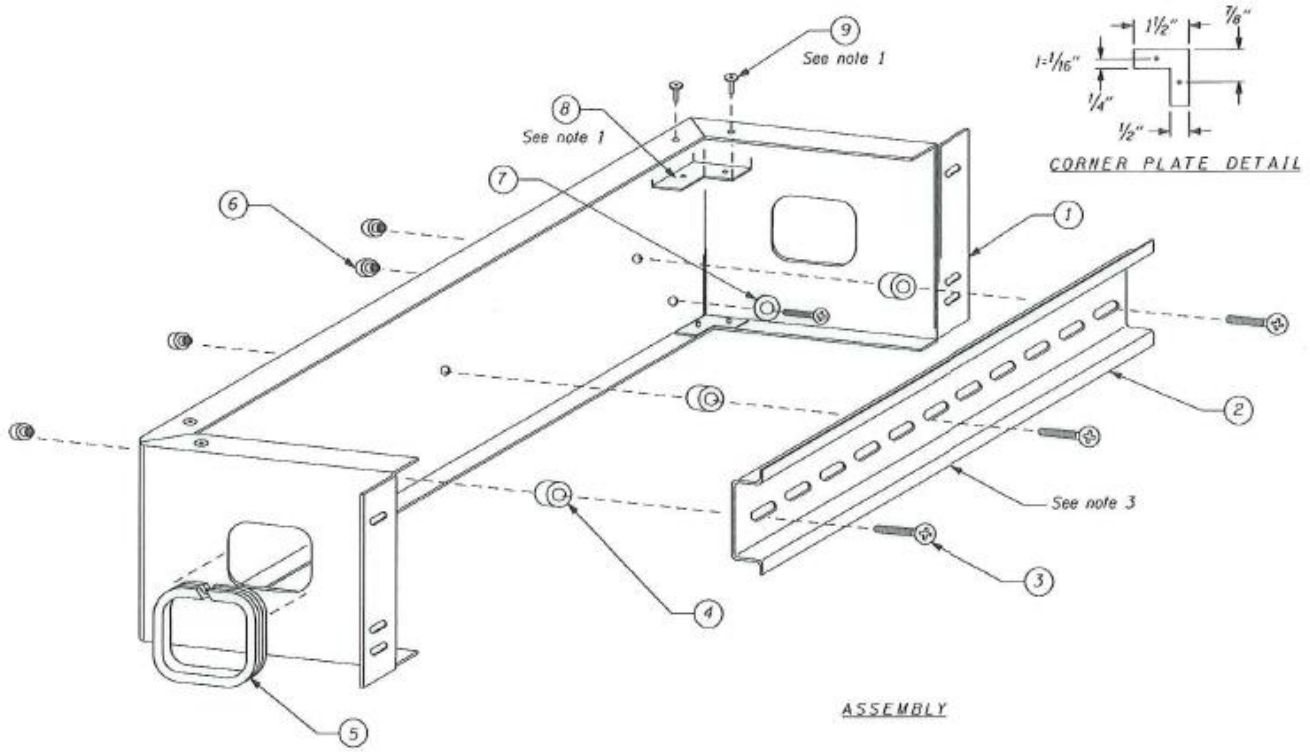


Figure 9-38 | Din Rail Bracket Detail Example

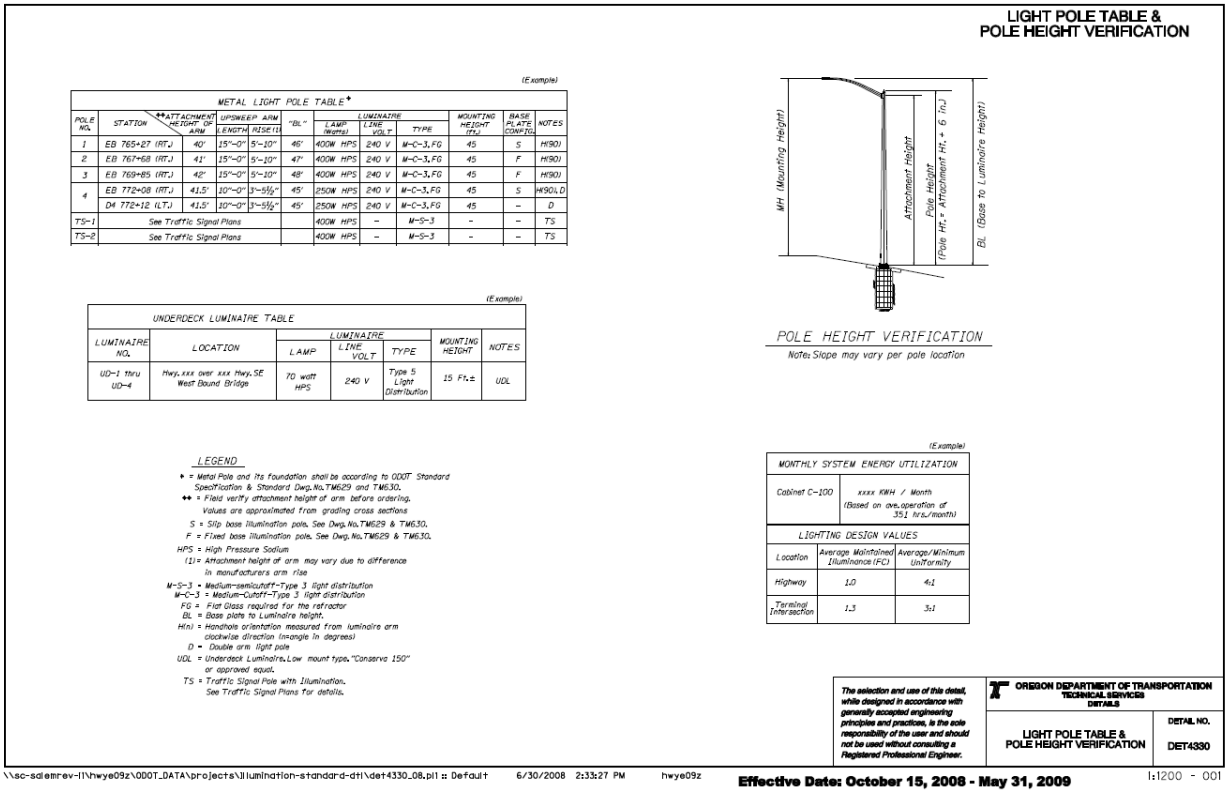


9.5.2 Stand-Alone Luminaire Pole: Light Table

In rare cases, the project may a have stand-alone luminaire pole at the signalized intersection with traffic signal equipment mounted to it or such a small quantity of luminaire poles that illumination plans will not be produced. In these cases, the stand-alone luminaire poles may be shown and detailed on the signal plans.

Stand-alone luminaire poles require additional information than what is shown in the pole entrance chart. If there will be no illumination plans for the project, the stand-alone luminaire pole needs to have a light pole table included in the details plan sheets using DET4330. See Figure 9-39.

Figure 9-39 | Light Pole Table for Stand-Alone Luminaire Pole – DET4330



10 Removal Plan

This chapter will discuss when a removal plan sheet is needed and all the elements that should be shown the plan sheet.

10.1 When is a removal plan sheet needed?

A removal plan sheet is required for the following types of work:

- A complete re-build of an existing traffic signal (where all existing equipment is to be replaced by new equipment)
- Replacing an intersection flashing beacon with a traffic signal (where all existing equipment must be removed)
- Removal of any signal poles

A removal plan sheet is recommended for any other type of removal work that **cannot clearly** be shown on the primary plan sheet or within the special provisions section 00950.02.

A removal plan is NOT required for temporary signal plans as standard specification 00227.42(a) directs the contract how and when to remove the temporary signal, as well as what equipment is property of the contractor.

10.2 Equipment Salvaging and Stockpiling

Unless otherwise specified, all equipment/material that is removed becomes property of the contractor at the place of origin by standard specification. The contractor can then reuse, recycle, or dispose of the equipment/material. However, certain signal equipment may be desirable for the owner of the existing traffic signal to salvage. Typical salvaged equipment includes:

- The signal controller cabinet (includes all components within)
- Signal heads and signal poles (which can be reused for future maintenance if they are in decent condition)
- Any equipment that maintenance crews can easily reuse, such as external communication equipment, video detection cameras, etc.

The region electrical crew will provide direction on the which removed appurtenances, if any, should be salvaged, the location to stockpile, and their contact information. This information is contained within the special provisions section 00950.42 (removal of the item is shown on the plan sheet, salvage information related to the item is shown in the special provisions). In addition, when salvaging materials, a letter of public interest finding (LPIF) must be on file. See chapter 19 for more information on the LPIF process and forms.

10.3 Abandoning Equipment

The removal plan should show any equipment that will be abandoned. Abandoning equipment should only be considered if both of the following conditions are met:

- The process of removal would require extensive repair or replacement of nearby facilities that would otherwise be unharmed (e.g., removal of loop wires from the pavement would require repair of the pavement).
- The equipment can be abandoned without causing confusion or problems in the future (e.g., the signal pole foundation is abandoned by removing only the top two feet below finish grade which makes it clear it is no longer in use and the risk of encountering a problem on a future project or maintenance activity is low).

There are only a few signal appurtenances that meet these requirements:

- Conduit located underground (top two feet below finish grade is removed per standard specification). However, if extensive earth/roadway work will be done in the locations of the conduit to be abandoned, the conduit should be removed instead.
- Loop detectors
- Signal pole foundations (top two feet below finish grade is removed per standard specification)
- Pedestal and cabinet foundations (top two feet below finish grade is removed per standard specification) may be abandoned, but removal is preferred as the majority of these foundations are equal to or not much greater than 2 feet deep.

All other signal equipment should always be removed, NEVER abandoned.

10.4 Removing Equipment

Depending on the type of work being done on the project, certain appurtenances should always be removed (abandoned not allowed).

- Wiring in conduit
- Junction boxes
- Cabinets

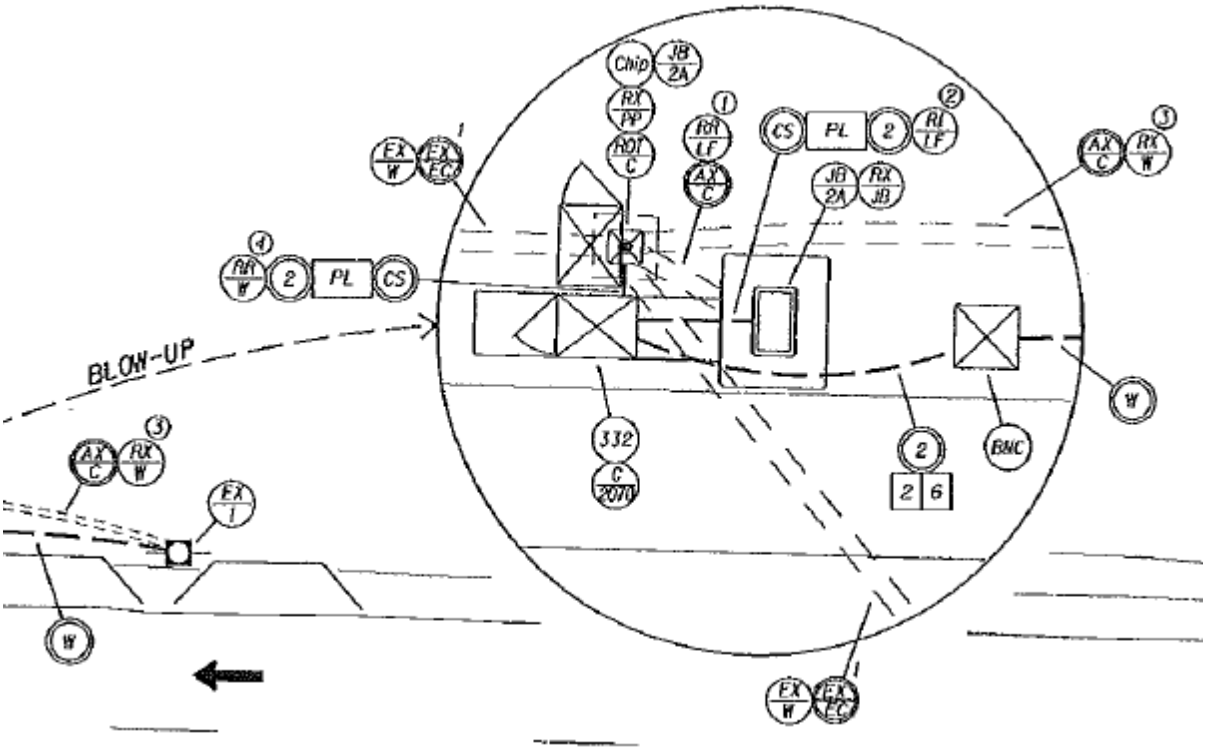
10.5 Removing and Relocating Equipment

The region electrical crew should provide direction on which signal appurtenances may be relocated, as they have the most up-to-date information on the condition and remaining service life. Only equipment that is good condition and meets current standards should be considered for relocation. When in doubt, always remove and install new.

The removal plan should show any equipment that is to be removed and relocated. The removal plan should NOT show where the equipment is to be reinstalled; this information should be shown on the primary signal plan sheet. In some cases, it will be obvious where the

removed item will be relocated just using the standard bubble note designations. In other cases, it might not be so clear. For example, if a lot of the same type of items are to be removed and re-installed (vehicle signal heads) with some to be reinstalled at another intersection or only certain wiring is to be removed and relocated up to a certain junction box and reinstalled into another conduit. In these cases, adding some custom general notes that correspond to the appropriate remove & relocate and reinstall bubble notes is advised. See Figure 10-1 for example of custom notes.

Figure 10-1 | Remove and Relocate Equipment with Custom Notes



GENERAL NOTES

Construction notes shown as ① or ② pertain to this sheet only.

① Pull out existing loop feeder cables from existing controller to junction box.

② Reinstall loop feeder cables to new controller.

③ Coordinate with Power Company for wire removal.

④ Remove existing wiring from existing controller and reinstall wiring to new controller.

10.6 When a Removal Plan Sheet is Required

The examples in Figure 10-2 and Figure 10-3 show extensive removal and thus require a separate removal plan sheet to clearly show the work to be done.

Figure 10-2 | Removal Plan Sheet Example 1

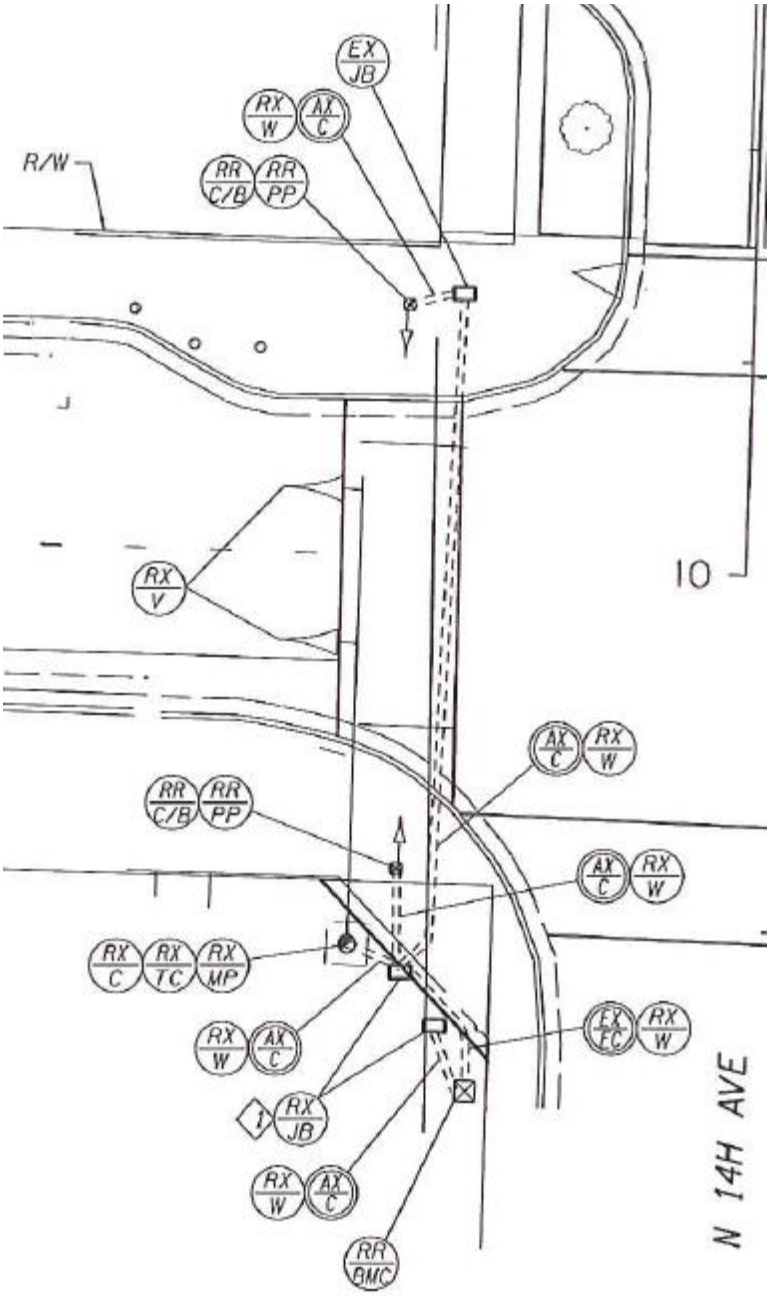
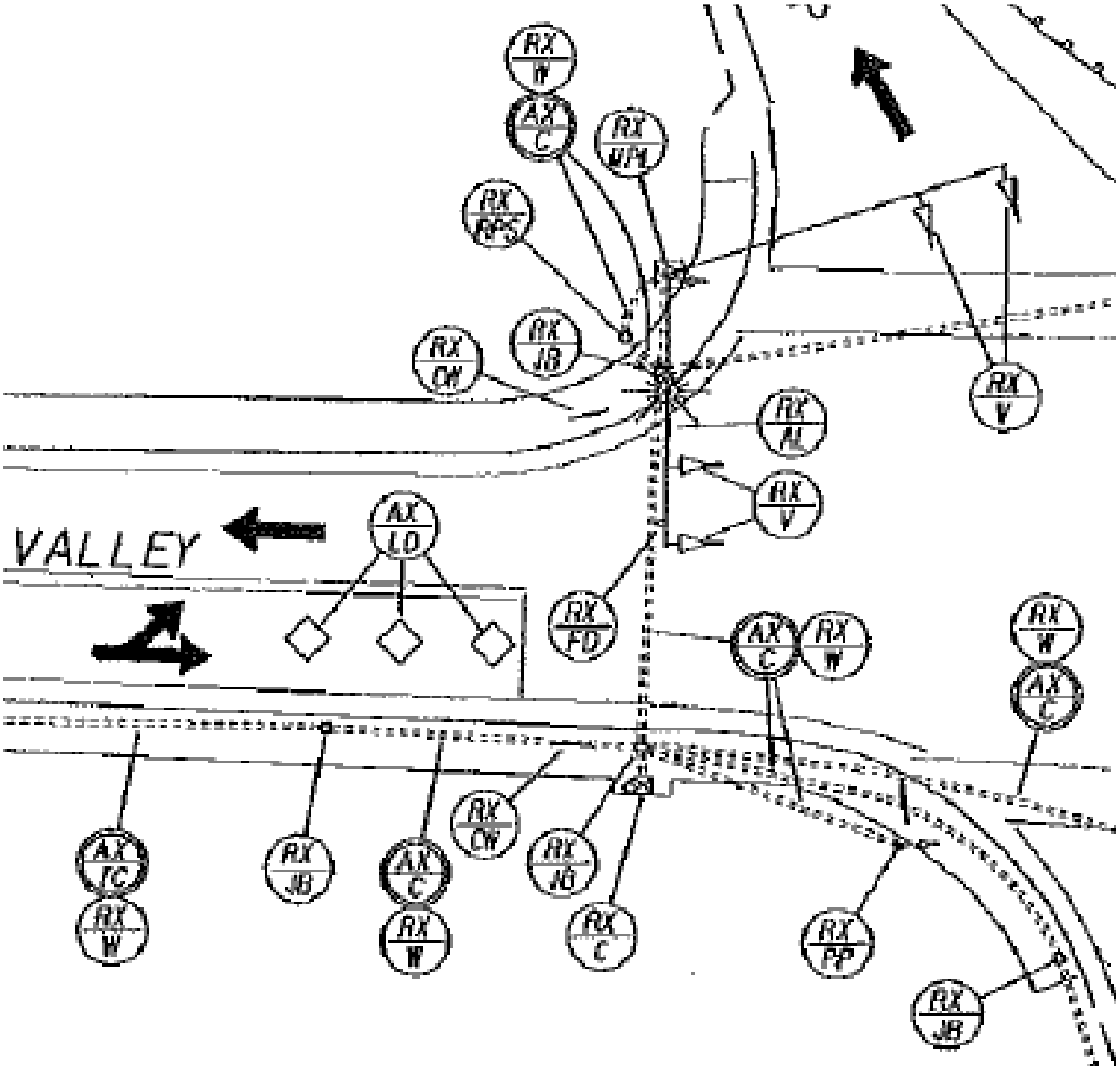


Figure 10-3 | Removal Plan Sheet Example 2



10.7 When a Removal Plan Sheet is NOT Required

In some cases, the removal of items can clearly and easily be shown on the primary plan sheet (e.g., signal plan sheet, detector plan sheet, interconnect plan sheet, etc.). If this is the case, a separate removal plan sheet is not recommended. See Figure 10-4 through Figure 10-6 for examples.

Figure 10-4 | Removal Notes Shown on a Primary Signal Plan Sheet Example 1

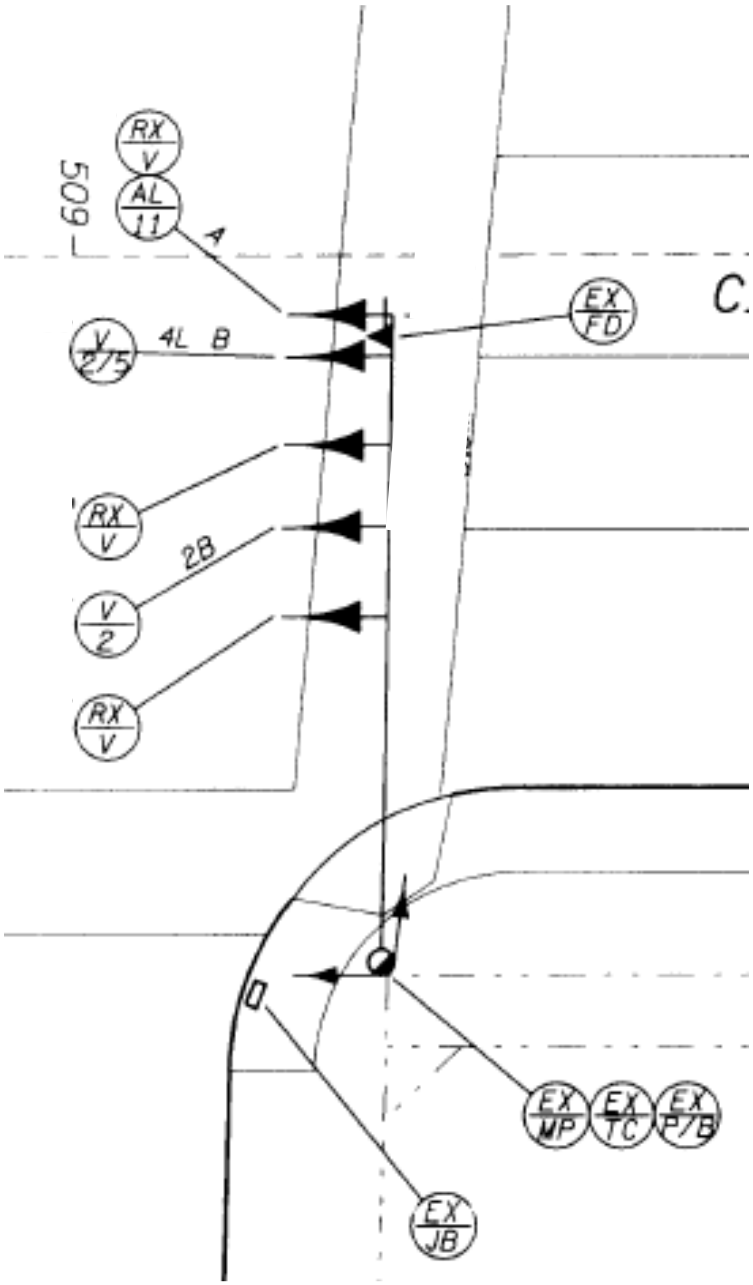


Figure 10-5 | Removal Notes Shown on a Primary Signal Plan Sheet Example 2

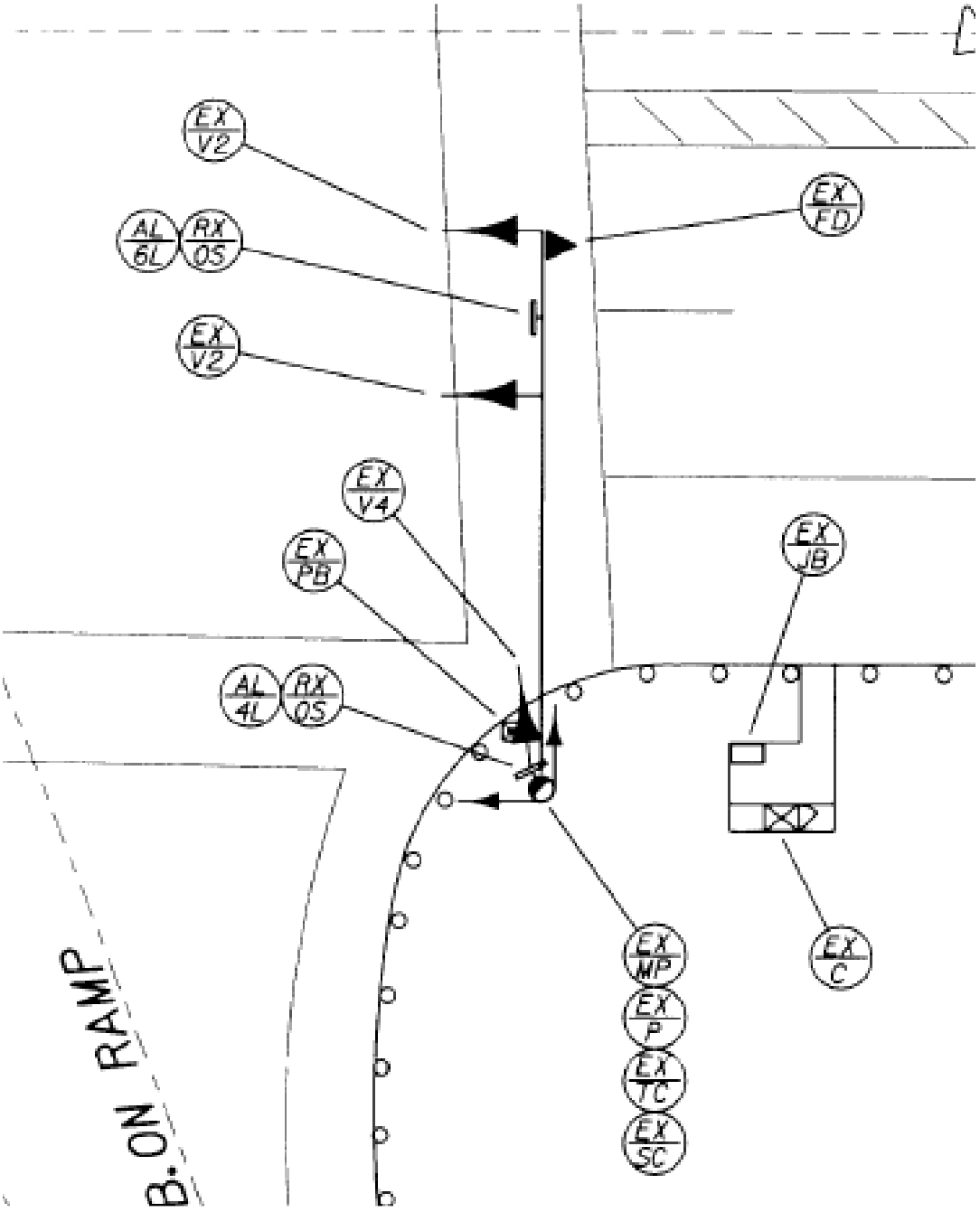
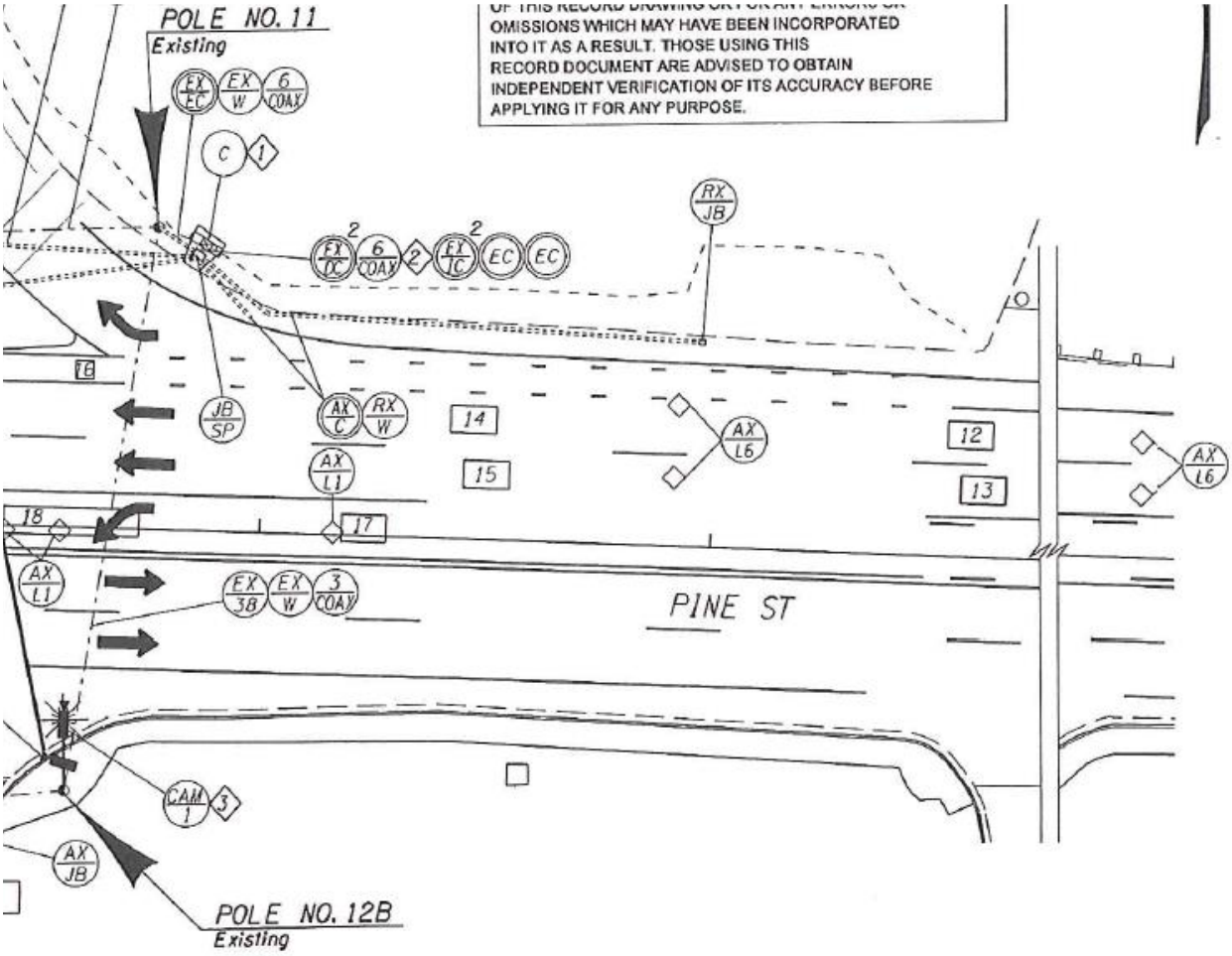


Figure 10-6 | Removal Notes Shown on a Primary Signal Plan Sheet Example 3



11 Temporary Signal Plan

11.1 General

Temporary signals are intended to be used for long-term stationary temporary traffic control zones, yet their appearance, design and operation are held to the same standards as permanent signals. Drivers expect the same meaning from temporary traffic signals as they do from permanent traffic signals, so the signal design and operation shall meet all applicable MUTCD and ODOT standards. The design procedure for a temporary signal shall follow the same standards and guidelines that would be used for a permanent signal.

The ODOT Traffic Control Plans Design Manual, should be consulted for additional information on the use of temporary traffic signals.

11.2 When is a Temporary Signal Needed?

There are two typical design categories that most temporary signals will fit into: temporary bridge signals and temporary signals for modification or replacement of an existing signal.

Temporary signals are required in the following circumstances:

- For construction staging that requires one-lane, two-way traffic AND where use of 24/7 flagging would be cost prohibitive. Either a standard temporary bridge signal or a portable temporary traffic signal could be used for this application.
- When the new signal can't be built without impacting the existing signal.
- When re-building an existing signal that requires staged construction (where lane use and/or signal phasing will be modified based on each stage)
- When the temporary re-alignment or modification of the signal heads at an existing signal is needed to accommodate traffic during the construction of a project in the vicinity of the traffic signal.
- When adjustment to the existing pushbutton locations is required to accommodate temporary pedestrian accessibility routing (TPAR)

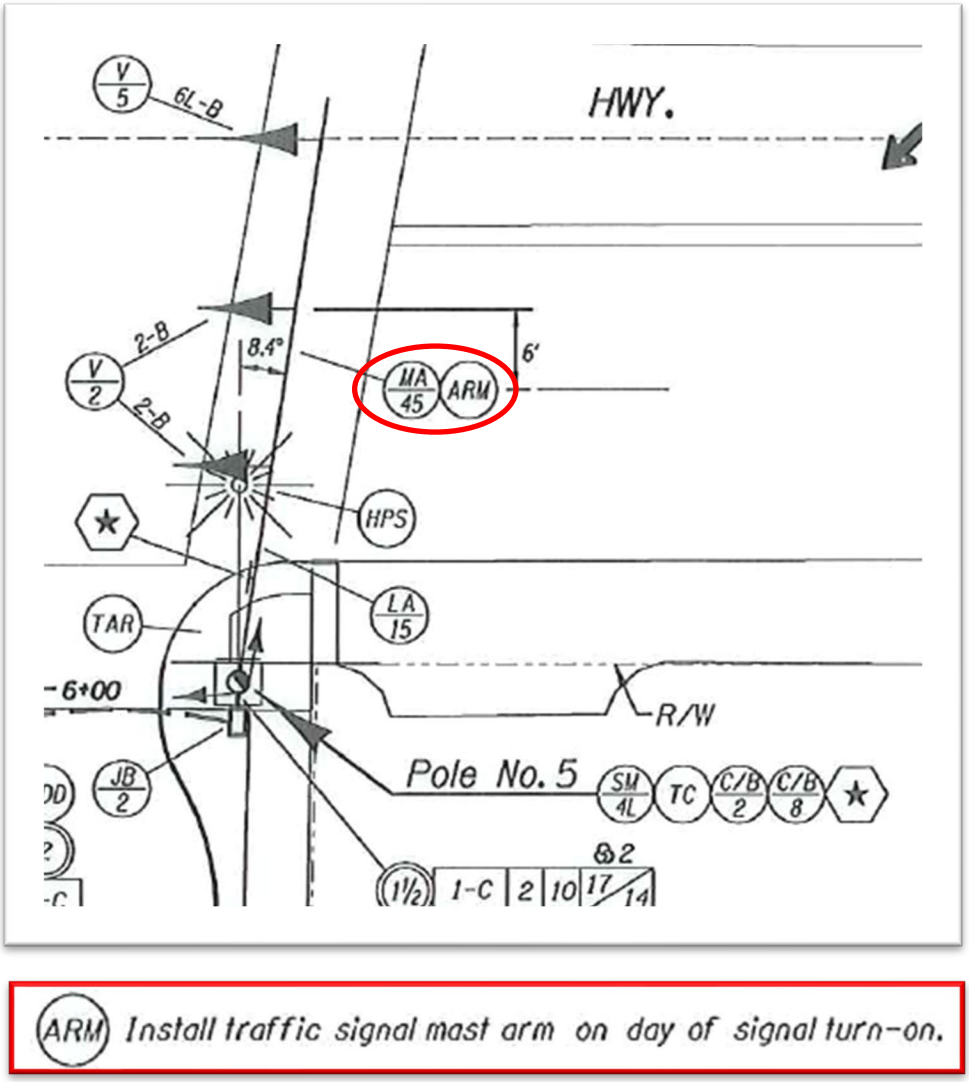
In some cases, re-building an existing signal can be accomplished without a temporary signal if the existing intersection geometry doesn't change (or changes very little) and placement of the new signal equipment is carefully considered (especially poles, conduit, and junction boxes). If possible, place the new poles behind the existing poles so that construction of the new mast arm does not block the existing signal heads. See Figure 11-1 for examples of signal heads being obstructed during construction. If a new signal pole must be placed in front of an existing signal pole, there is an opportunity to save the expense of a temporary signal by requiring that the new mast arm be installed on the day of the signal turn-on. However, to allow for an efficient and successful signal turn-on, only one signal mast arm per intersection may be allowed to be installed at the day of turn on. See Figure 11-2.

Rebuilding an existing traffic signal without a temporary signal is preferred as it saves the throw-away expense of a temporary signal (cost of design, construction, and potentially right-of-way). However, it often requires the contractor to be more careful (e.g., more labor/longer construction time) when installing the new signal equipment to avoid damaging the existing signal equipment before it can be removed. In these cases, engineering judgement should be used to weigh the pros and cons to decide if a temporary signal will result in a more successful installation and better final product.

Figure 11-1 | Obstructing Signal Heads During Construction



Figure 11-2 | Installing Mast Arm the Day of Signal Turn-On



11.3 Operational Approval of Temporary Signals

The following temporary traffic signal applications require STE operational approval (see chapter 3 for more information on operational approvals):

- Portable temporary traffic signals
- Temporary bridge signals (one-lane, two-way operation)
- Temporary signals located at intersections that are not currently under signalized control (e.g., detours that require re-routing large volumes of traffic to existing un-signalized intersections)
- Temporary closure of crosswalks at signalized intersections

Temporary signals installed at the same location with the same operations that mimic an existing signal or mimic the proposed STE approved new signal do NOT require STE or RTE operational approval.

The following temporary traffic signal application requires RTE operational approval (see chapter 3 for more information on operational approvals):

- Stage construction that is significantly different (geometry, lane use, and/or operation) than the existing traffic signal or the approved new traffic signal.

Determining if the geometry and operation is significantly different from the existing or approved signal operations can be a grey area. The main reasons for requiring an operational approval for a temporary signal needed for stage construction is to determine if the operation is safe, meets driver expectation, and will not be detrimental to maintaining traffic flow.

If the temporary signal operational/geometric changes are minor and incrementally made over the course of construction, additional operational analysis beyond what is required for the permanent signal is typically not needed to ensure the temporary signal staging is appropriate. See Figure 11-3. This case study shows a project going from existing conditions to the permanent signal installation where the temporary traffic signals for each stage do NOT require an operational approval.

However, significantly different operations or geometry (especially if the signal will be operating in a coordinated system) typically require a more in-depth analysis to ensure that temporary signal will operate appropriately. See Figure 11-4. This case study shows a project going from existing conditions to permanent signal installation where three of the temporary traffic control stages result in significant lane use and/or operational changes that do require additional operational approval(s) for the temporary staging. The types of changes shown require an RTE operational approval.

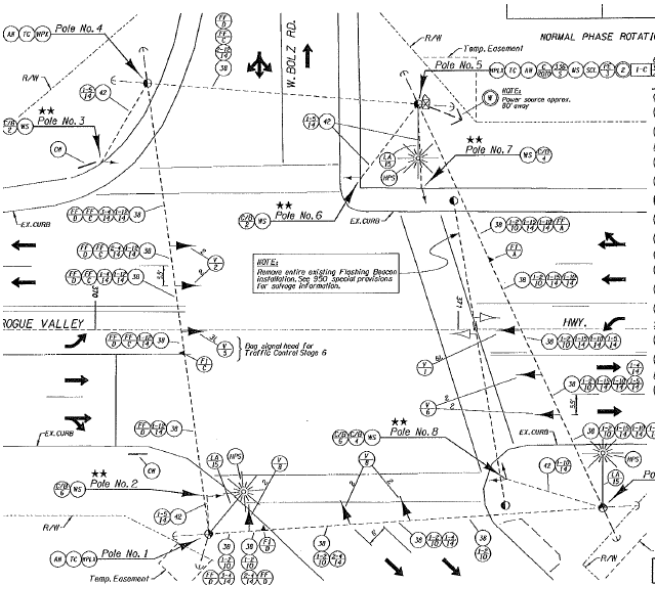
If there is a question as to whether a temporary traffic signal requires an operational approval, contact the state traffic operations engineer. When in doubt, err on the side of caution and submit a request for a STE operational approval.

Figure 11-3 | Case Study 1 – Operational Approval NOT Required for Temporary Signal Staging (Continued on Next Page)

Existing conditions: The existing lane use is a 5-lane section on the mainline, with a right turn only from the top approach and one-way on the bottom approach. Three crosswalks are currently marked. The existing intersection operates as stop control on the side-street and free-flow on the mainline. This intersection has an STE operational approval for a new, permanent traffic signal.



Stage 3: The existing lane use on the top approach has changed from a right turn only to a right-thru-left turn lane, matching the STE approved permanent lane configuration for that approach. The existing marked crosswalks remain the same. The existing intersection operation has changed from stop control to signalized, with the signal phasing very closely matching the STE approved operation.



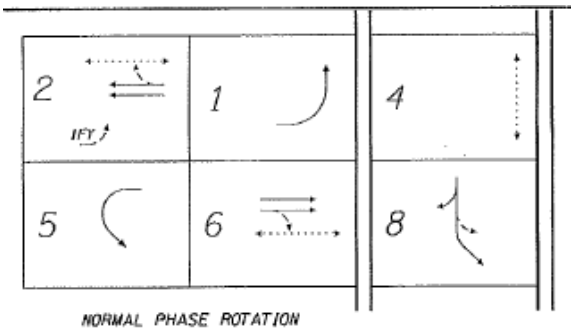
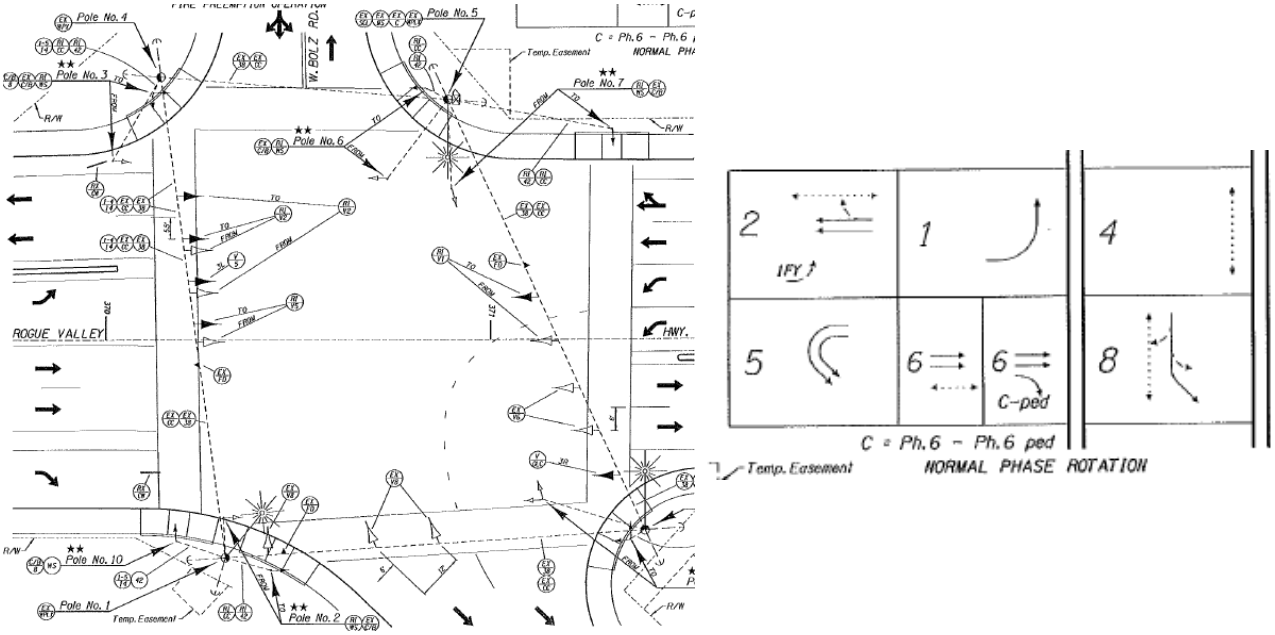


Figure 11-3 continued on next page.

Stage 7: The lane use from stage 3 has changed from a thru-right lane to the addition of right turn only lane on the left approach and from a single left turn lane to a dual left turn lane on the right approach, matching the STE approved permanent lane configuration. All four crosswalks are now open. The operation from stage 3 has changed to allow a not-ped overlap phase for the new right turn only lane, matching the STE approved permanent signal operation.



Permanent Traffic Signal: STE approved permanent signal design and operation.

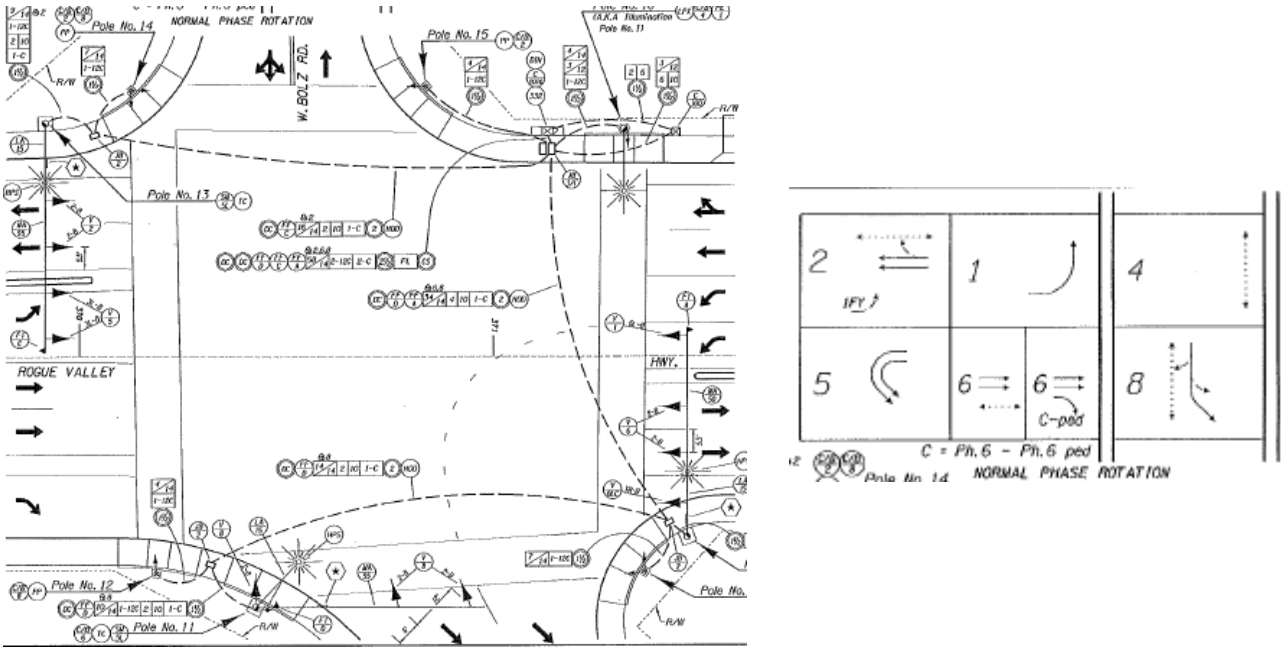


Figure 11-4 | Case Study 2 – Operational Approval Required for Temporary Signal Staging (Continued on Next Two Pages)

Existing conditions: The existing lane use is a 4-lane section on the mainline. The top approach is a freeway off-ramp and the bottom approach is a freeway on-ramp. Three crosswalks are currently marked. The existing intersection operates with PPLT phasing on the highway. This intersection has an STE operational approval for a new, permanent traffic signal.



Stage 1, Phase 2 (RTE operational approval required): The existing intersection geometry has significantly changed, with the top approach moving towards the right almost creating two separate intersections. Two of the existing crosswalks are now closed. This new geometry will require more red clearance time to clear vehicles. Because the geometry and operation of this intersection is significantly different from the existing and STE approved permanent traffic geometry, this stage requires RTE approval. Note that the temporary crosswalk closures require STE operational approval.

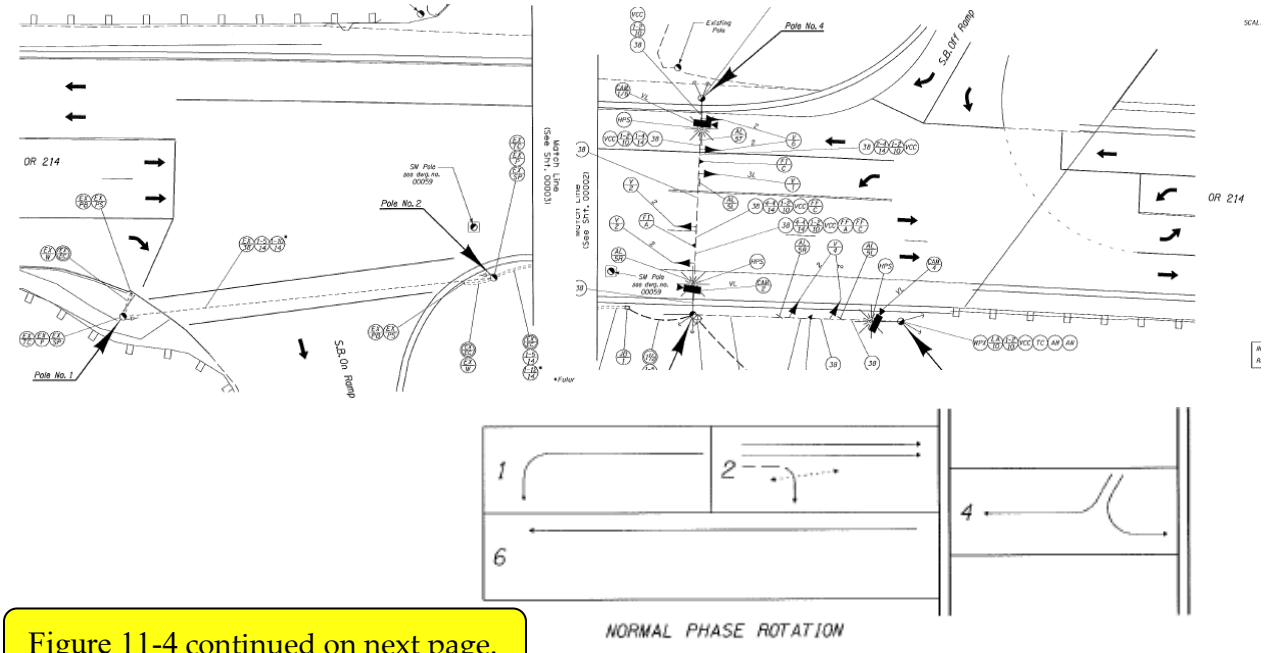
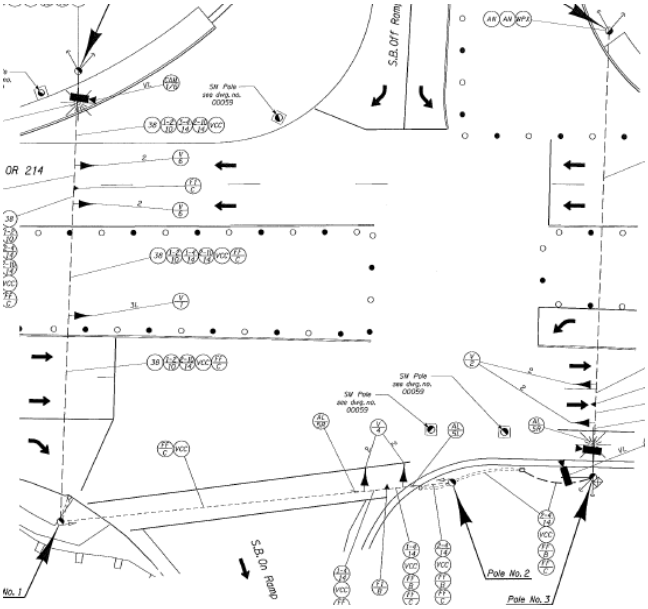
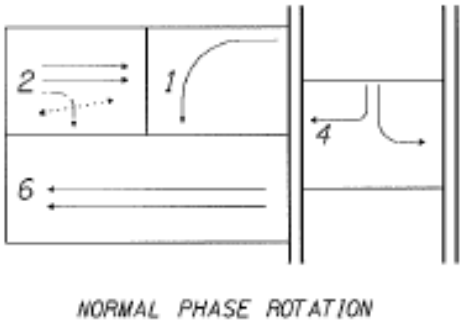


Figure 11-4 continued on next page.

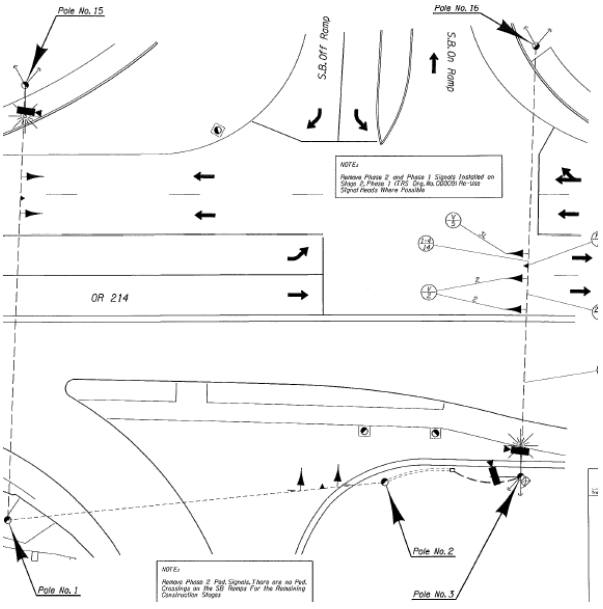
Stage 2, Phase 1 (RTE operational approval NOT required): The lane use from Stage 1, Phase 1 has shifted the top approach alignment back much closer to the original existing location. The crosswalk closures remain the same. Operation changes from the previous stage are minimal. This stage does NOT require RTE approval due to similarities of the existing conditions and previous stage RTE approval.

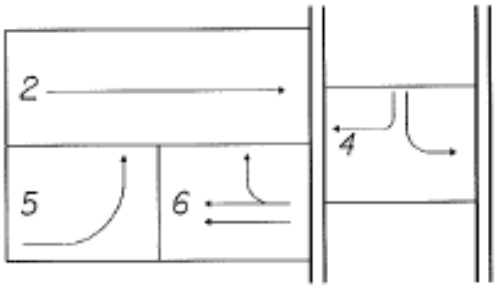




NORMAL PHASE ROTATION

Stage 2, Phase 2 (RTE operational approval required): The lane use from Stage 2, Phase 1 has changed significantly, with the top approach now containing the on-ramp for the freeway. All four crosswalks are now closed. Operation changes from the previous stage are significantly different and do not match the STE approved permanent traffic geometry/operations. This stage requires RTE approval. Note that the temporary crosswalk closure here requires STE operational approval.

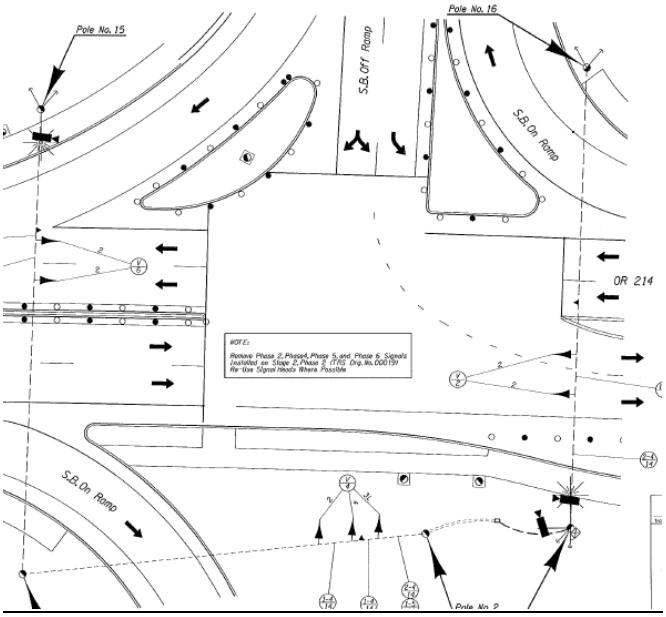


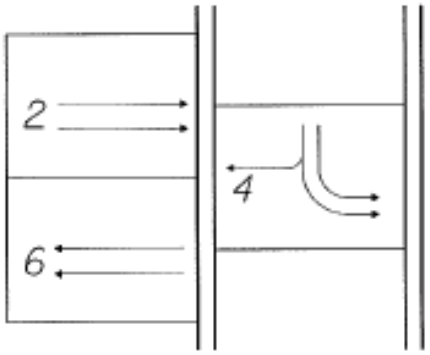


NORMAL PHASE ROTATION

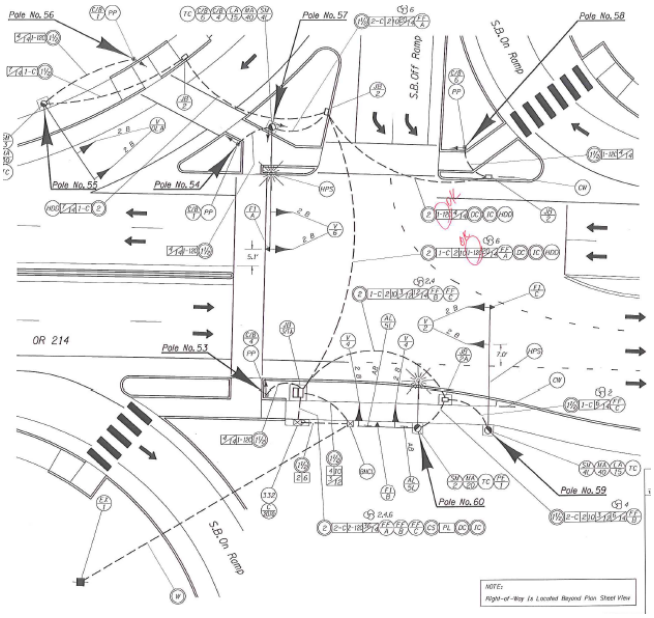
Figure 11-4 continued on next page.

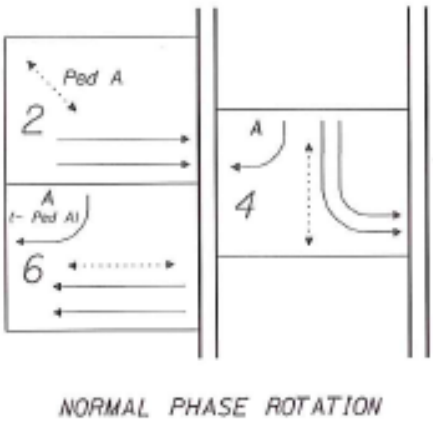
Stage 3, phase 1 (RTE operational approval required): The lane use from Stage 2, Phase 2 has now changed to closely match the STE approved permanent geometry. However, the unusual lane use for the top approach (where the right turn movement is divided – one is free flow and one is controlled by the signal in a left-right lane) warrants documentation. **All four crosswalks remain closed. Operation changes from previous stage are significantly different and now closely match the STE approved permanent operations (minus the top approach right turn overlap and pedestrian phases). This stage requires RTE approval.**





Permanent Traffic Signal: STE approved permanent signal design and operation.





11.4 Design Approval of Temporary Signals

All temporary traffic signals, **except** portable temporary traffic signals, require design approval (see chapter 2 for more information on design approval).

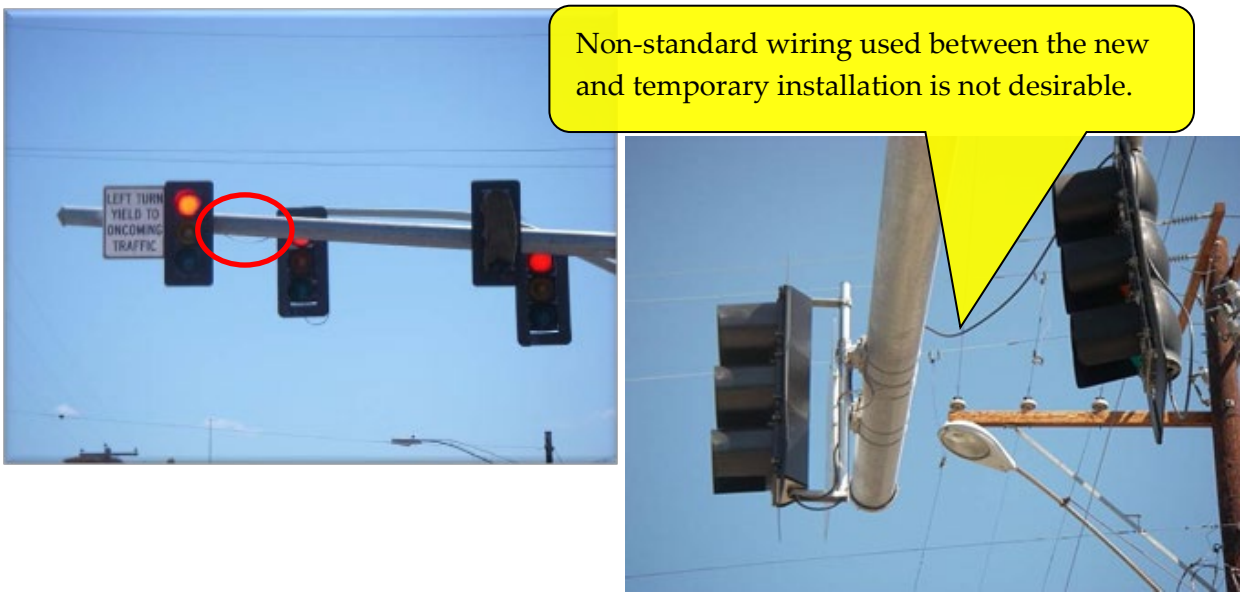
11.5 Using Existing or New Signal Equipment as Part of the Temp. Installation

The practice of using existing or new signal equipment as part of a temporary signal is not allowed, for the following reasons:

- It complicates the contract administration of project (payment issues)
- The responsible party for maintenance of the equipment becomes confusing (per specifications: maintenance of temporary installations is the responsibility of the contractor and maintenance of the permanent signal after turn-on is the responsibility of the agency)
- Equipment most likely will have to modified or wired in a non-standard way to incorporate the permanent or existing equipment into the temporary installation.
- There is a high risk of damage to the new equipment.

See Figure 11-5 showing an example of the undesirable non-standard wiring when using new equipment for a temporary installation.

Figure 11-5 | Use of New Equipment for a Temporary Installation – This Practice Not Allowed



Do NOT mix existing or new signal equipment with temporary signal installations (including conduit, junction boxes, and wiring).

11.6 Temporary Signal Design

Temporary signal design should follow the same design guidelines that are contained in the permanent signal design chapters of this manual. This section discusses design information specific to temporary signals including deviations from permanent design (e.g., use of different materials/equipment).

11.6.1 Poles

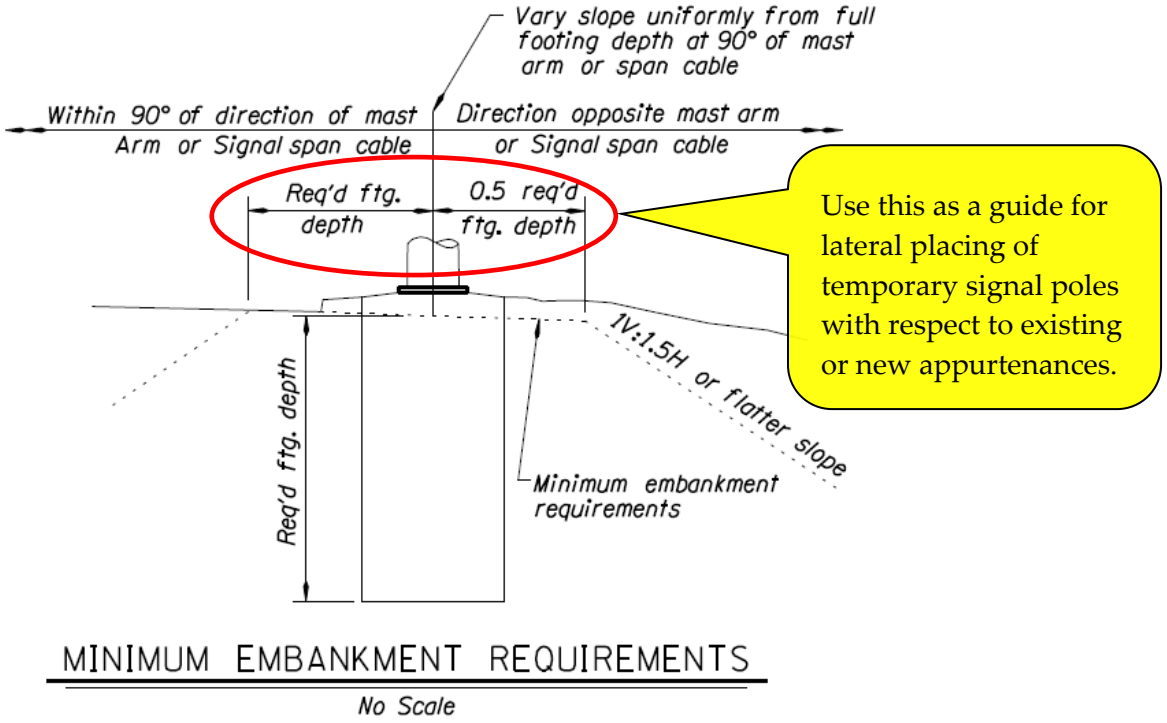
Wood poles with span wire are used for all temporary installations as per standard specification section 00227. Wood poles are considered non-standard (designated as "X" poles, due to the drafting bubble note nomenclature used to define a non-standard pole). It is the contractor's responsibility to submit the wood pole certifications and calculations for review and approval before construction begins. The EOR or the traffic structures engineer will approve the submittal.

A span wire pole entrance chart is required to detail all temporary signal poles. See chapter 9 for more information on the pole entrance chart. The only column in the pole entrance chart that doesn't apply to wood poles is the "Foundation Information" column which should either be deleted or left blank. All other columns should be filled out as applicable to the temporary signal design.

Temporary signals will require modeling of the signal pole, span wires and signal heads that are proposed to pass over the roadway cross section to determine the messenger cable attachment height (MAH) value. See Chapter 9 for how to calculate the MAH. The bottom of the signal heads must not be below 18 feet or above 19 feet during any phase or stage of construction.

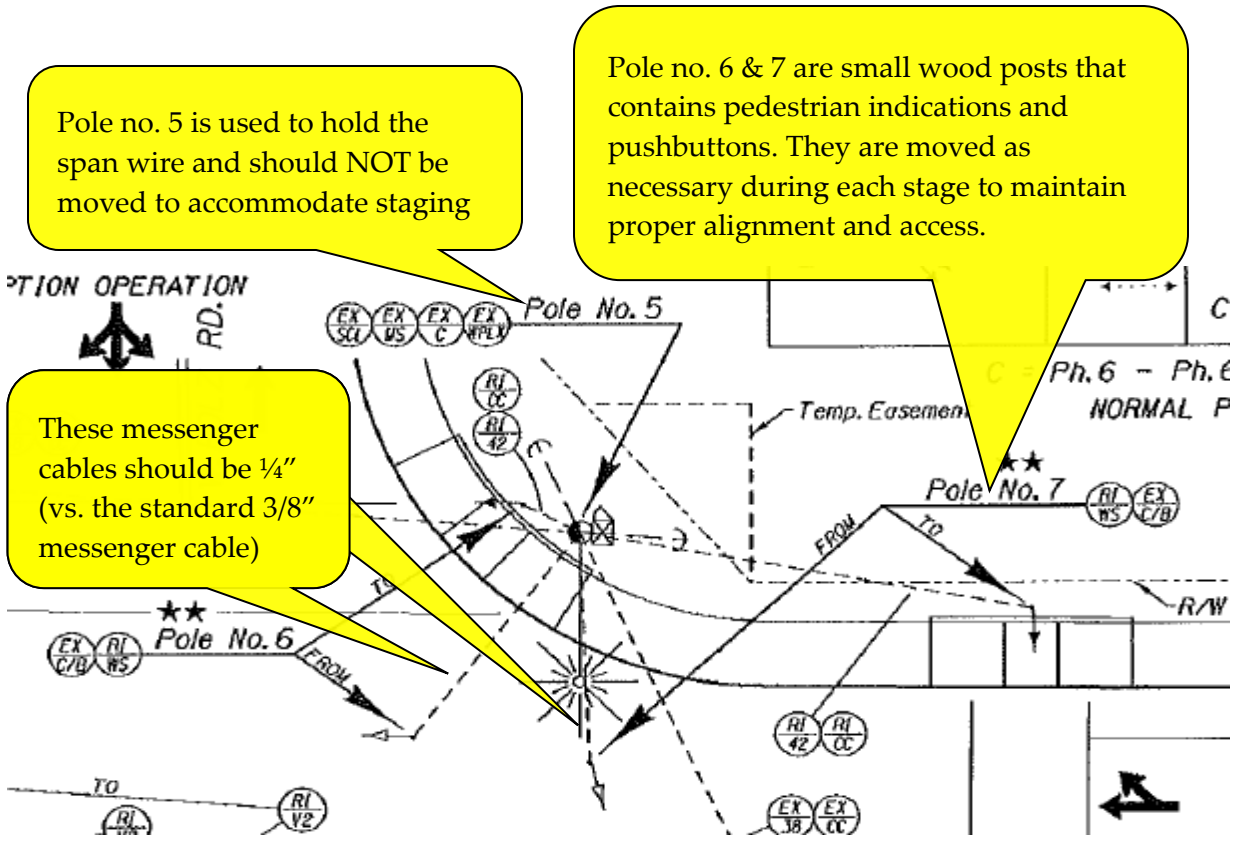
The lateral placement of temporary signal poles next to new or existing appurtenances (e.g., existing/new signal poles, cabinets, etc.) should follow the requirements in standard drawing TM653 that are established for embankments. See Figure 11-6. If a temporary pole is placed closer to an object than as shown in the minimum embankment requirements, contact the traffic structures engineer for further analysis.

Figure 11-6 | TM653 Minimum Embankment Requirements



Large poles (those used for span wires) should be set to accommodate all stages of construction. Small posts (for pedestrian indications and pushbuttons) can and should be moved as needed during each stage/phase. Messenger cable going from the large wood strain pole to the small wood posts only needs to be ¼" (tether cable size) rather than the standard size 3/8" messenger cable due to carrying a significantly reduced load. See Figure 11-7.

Figure 11-7 | Moving Poles During Staging



11.6.2 Controller Cabinet

The 332S controller cabinet mounted on a temporary, precast foundation as per TM454 is the standard for all temporary installations.

11.6.3 Service Cabinet and Meter Base

The service and meter base are pole mounted in the same quadrant that controller cabinet is located in. The service cabinet and meter base for temporary installations is shown in the standard drawings.

The connection from the power source to the service cabinet/meter base is typically aerial.

11.6.4 Junction Boxes

Junction boxes used for temporary applications do not require a concrete apron if located in non-paved areas.

11.6.5 Use of Detection (Vehicle, Bicycle, Pushbuttons, & Preemption Detectors)

Equipment such as vehicle detection, pedestrian pushbuttons, and fire preemption detectors should be evaluated according to their need and should not automatically be included in the design. Several factors should be considered when determining whether detection is needed or not:

ALL DETECTION

- Duration of temporary signal – Detection becomes more beneficial and cost effective the longer it is expected to be in service.

VEHICLE DETECTION

- Speed of the mainline – Detection becomes more beneficial if the mainline of the temporary signal is high speed (greater than 35 mph), due to the increased protection of the dilemma zone.
- Traffic volumes – Detection becomes more beneficial if the traffic characteristics of the intersection are highly variable (e.g., heavy directional movements during the AM or PM peak) or if the intersection operates below capacity the majority of the time. When an intersection is operating at or above capacity for all movements, the detection system is less critical because signal will just be "maxing out" all the green time, which is similar to the operation of a fixed time cycle. However, if the intersection is operating at or above capacity for only a few of the movements, using detection for those under capacity movements can improve the flow and queuing of traffic for the movements that are at or above capacity.
- Temporary signal operating in system vs. isolated – Signals operating exclusively in coordinated systems do not use any detection for the coordinated phases (e.g., the mainline thru phases).

BICYCLE DETECTION

- Bicycle lanes & location – Detection is more beneficial on approaches with phases that are not recalled (e.g., side streets).

PEDESTRIAN PUSHBUTTONS

- Accessibility of pedestrian pushbuttons during construction – Pushbutton detection should NOT be used if the construction work will make accessibility (according to section 5.4) a concern. If this is the case, recalling the pedestrian phase, closing the pedestrian crossing or use of non-invasive pedestrian detection (video, etc.) may be considered. Often temporary signal poles used for the span wire installation must be placed far away from the intersection in order to accommodate the construction work. In these cases, a separate temporary wood post that is used just for the pushbuttons and pedestrian indications would be required so that the pushbuttons can be placed close enough to the intended crossing to meet the requirements stated in section 5.4. The typical installation details for this separate, smaller post is shown in the standard drawings. See Figure 11-8 and Figure 11-9 for examples of pushbutton accessibility that require mitigation.
- Feasibility of recalling pedestrian phases – Detection is less beneficial if the green time of vehicle phase that is compatible with the pedestrian phase is typically always longer than the pedestrian crossing clearance time.
- Pedestrian volumes – Detection is less beneficial if there is a heavy pedestrian volume (e.g., pedestrian phase is serviced every cycle).

Figure 11-8 | Pedestrian Pushbutton Access – Example 1



Figure 11-9 | Pedestrian Pushbutton Access – Example 2



EMERGENCY PREEMPTION DETECTION

- Does the existing or permanent new signal have emergency preemption detection – If the existing signal has preemption detection, the temporary signal should also have preemption detection. If the existing signal does not have emergency preemption but the permanent signal will, the temporary signal should not have preemption detection.
- Needs of the emergency vehicle service providers – The need for temporary emergency vehicle preemption should be discussed with all interested parties. Understanding the main routes that emergency vehicles use can determine if preemption detection is needed primarily for only one or two approaches vs. each approach.
- Use of recalled pedestrian phases - The need for emergency vehicle preemption becomes less beneficial if pedestrian phases must be recalled. This is due to the requirements of the MUTCD which do not allow emergency preemption to shorten a conflicting flashing don't walk pedestrian phase.

11.6.6 Vehicle Detection

When used, the radar (or video) detection equipment should be mounted on a temporary signal pole or on a temporary illumination arm. Span wire mounting is not allowed. Note that the mounting locations are much more limited for a temporary signal and it may not be possible to provide detection for all movements depending on the intersection geometry. Extra detection devices may be considered if they can provide better coverage, but the added expense should be weighed against the expected benefits.

11.6.7 Wiring

Wiring for the temporary signal follows the same basic guidelines contained in chapter 5 for permanent signals. This section notes exceptions to chapter 5 and provides additional information specific to span wire installations. Note there are many ways to wire a traffic signal that work, but to achieve uniformity (which has many benefits for maintenance and construction), we strive to wire traffic signals in a consistent manner. Figure 11-10 illustrates the preferred method for wiring signal phases on a temporary span wire and is described in the following bullet points.

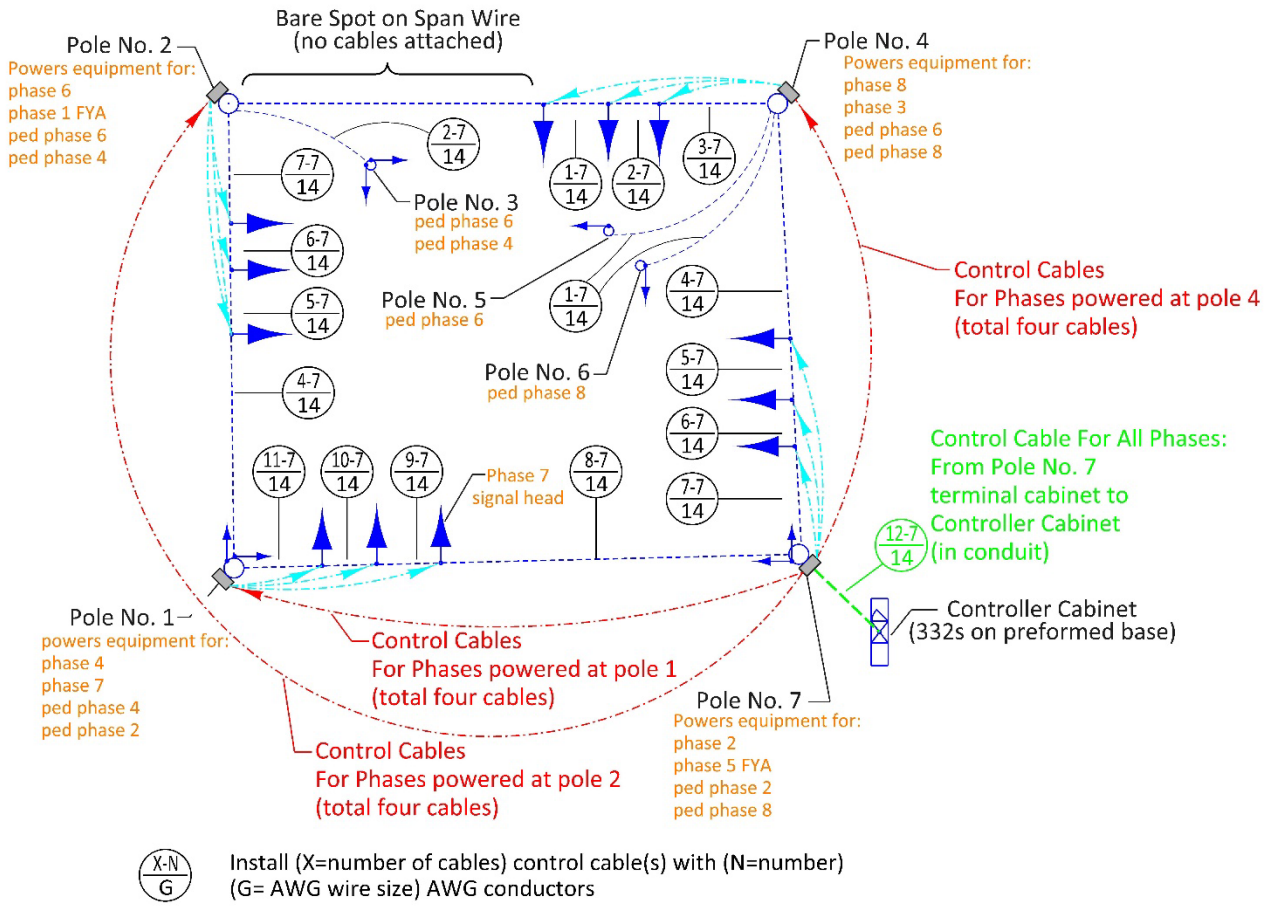
- All wiring for is routed overhead on the messenger cable for ease of installation and removal.
- The control cables for each the phase (drawn in red) goes to each pole terminal cabinet. One control cable is needed for each vehicle phase and each pedestrian phase. For example, the terminal cabinet on pole no. 1 will need 4 control cables from the controller cabinet because the pole no. 1 will provide power to equipment for 4 phases (phase 4 & phase 7 vehicle indications and ped phase 4 & ped phase 2 pedestrian indications and pushbuttons). Pole no. 2 also requires 4 control cables from the controller cabinet but note that those control cables bypass the terminal cabinet on pole no. 1.
- The control cables for the vehicle signal heads (drawn in light blue) come from the terminal cabinet on the pole to each signal head. Each signal head requires one control cable that comes directly from the terminal cabinet. For example, each large pole is powering 3 signal heads, requiring a total of 3 control cables coming from the terminal cabinet going to each piece of equipment. Daisy chaining signal heads is not allowed (e.g., powering one signal head from another signal head). Daisy chaining results in signal heads that have an indirect connection to the terminal cabinet and can make troubleshooting and maintenance more difficult.

  The signal heads should be wired from the pole where a mast arm would be attached if a mast arm was used. However, there is an exception: if the construction staging requires the signal heads to shift location, the signal heads may be wired from the pole that they are shifting towards. This allows for an easier shift of the equipment as the wire from the terminal cabinet to the signal head is getting shorter, not longer. For example, if the signal heads located on the span between pole no. 4 and no. 7 will need

to shift towards pole no. 4 in a future stage, the control cables to each signal head (drawing in light blue coming from pole no. 7) may instead come from pole no. 4. In doing this, remember that control cables for these vehicle phases that were coming from pole no. 7 now need to go to pole no. 4 (pole no. 4 will now require a total of 6 control cables from the controller cabinet: phase 3, phase 8, phase 2, phase 5 FYA, ped phase 6 and ped phase 8).

- The control cables for the pedestrian indications and pushbuttons located on the large poles (poles no. 1 & 7) are installed in conduit attached to the large pole according to the standard drawings and therefore are not detailed on the plan sheets. Note that it is not recommended to place pedestrian indications and pushbuttons on the large pole, but instead on the small posts as described in the next bullet point to ensure that accessibility requirements for pushbuttons (see chapter 5) can be met for all stages of construction.
- The control cables for the pedestrian indications and pushbuttons located on the small posts (poles no. 3, 5, and 6) are from the terminal cabinet of the adjacent large pole. The conduit attached to the small post for wiring the pedestrian equipment is shown in the standard drawings.
- A bare spot will always occur on a portion of the span wire (no wiring attached to the messenger cable). In this example it is between pole no. 2 and pole no. 4
- The bubble notes show how the wiring would be detailed on the plan sheet. The number of control cables shown in each bubble note indicate how many control cables are attached to the messenger cable at that particular location. For example, the messenger cable between pole no. 7 and the first piece of signal equipment to the left (vehicle signal head for phase 7) has a total of 8 control cables attached (4 cables needed to power phases at pole no. 1 and 4 cables needed to power phases at pole no. 2). Moving to the left of the phase 7 signal head, the messenger cable now has 9 control cables attached (same 8 cables as previously described, plus one control cable from pole no. 1 to the phase 7 signal head). Every time the number of wires or cables attached the messenger cable changes a new bubble note is used.

Figure 11-10 | Preferred Method for Wiring Signal Phases on a Span Wire



11.6.8 Staging

Signal designers should coordinate their work early in the process with the traffic control designer and the region signal operations engineer. This will assure the correct operation of the temporary signal and design of traffic control devices during all construction phases.

Depending on the complexity of the project, the temporary traffic control plans may detail specific stages and phases for construction (e.g., Stage I, phase 1; Stage I, phase 2; Stage II, phase 1, etc.). If specific stages/phases have been determined, the signal designer is required to produce a temporary signal plan sheet for each stage/phase that will result in a change to the temporary traffic signal. The following details should be shown for each stage:

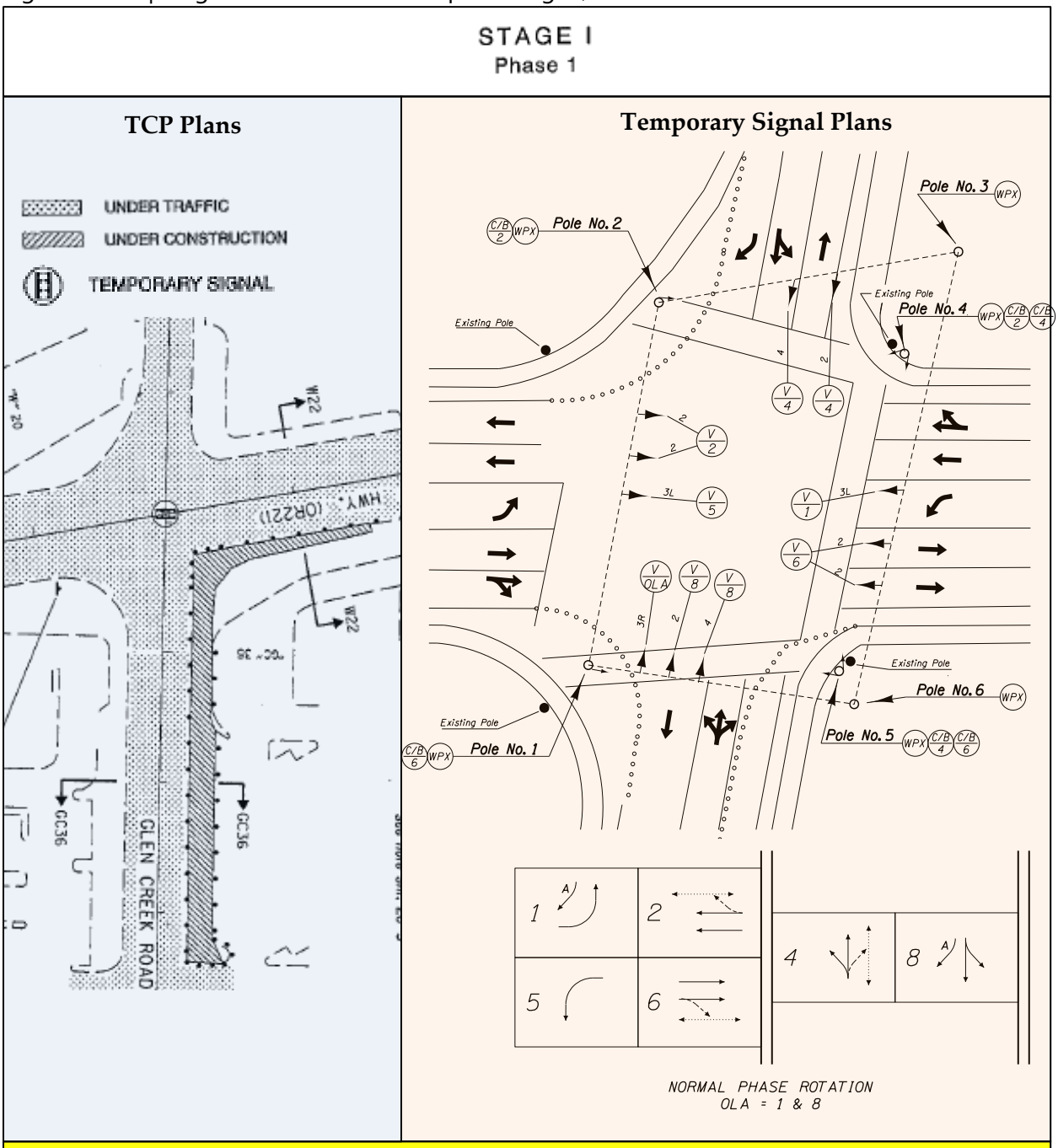
- Lane use at the intersection
- Vehicle signal indications and pedestrian indications
- Lane use signing and other regulatory signing mounted on the signal structure
- Normal phase rotation diagram
- Detection, if used (pushbuttons, loops, etc.)
- Reference existing and/or proposed signal poles or curb lines (to help establish the location of the temporary features in relation to existing and/or proposed conditions)

Keep in mind that the construction staging that is produced for the contract plans is only showing one way to complete the required construction work. There is a strong possibility that the contractor will propose to modify some parts the staging/phasing shown in the plans. There is also the possibility that the contractor will propose an entirely different staging plan. If this occurs, the contractor will submit stamped working drawings for approval as per specification 00221.06.

Figure 11-11 through Figure 11-20 show each stage and phase of an example project with the traffic control plans (TCP) shown on the left side (produced by the traffic control plans designer) and the corresponding temporary traffic signal plans shown in the right side (produced by the signal designer). This example project was a modernization project to add capacity (lanes) at the intersection.

The temporary signal plans must correspond with and match the traffic control plans.

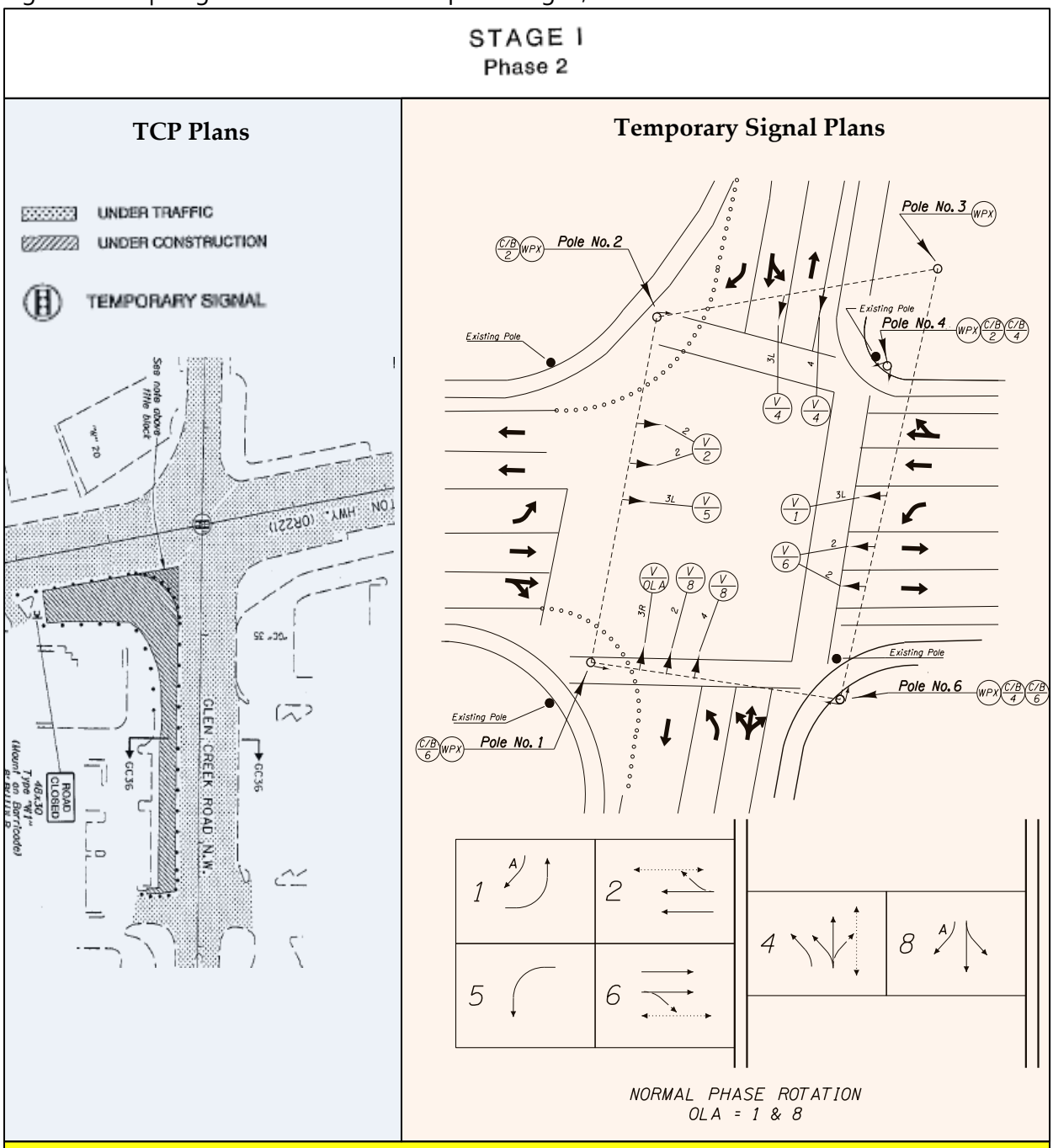
Figure 11-11 | Staged Construction Example – Stage I, Phase 1



NOTE: Construction work taking place in the lower right quadrant will require a change from the existing lane use (left turn only lane & left-thru-right lane) to a left-thru-right lane on the bottom approach. This lane use change requires a change to the signal indications for phase 4.

Poles 1, 2, 3 & 6 (major poles) will stay in same location for entire temp staging.

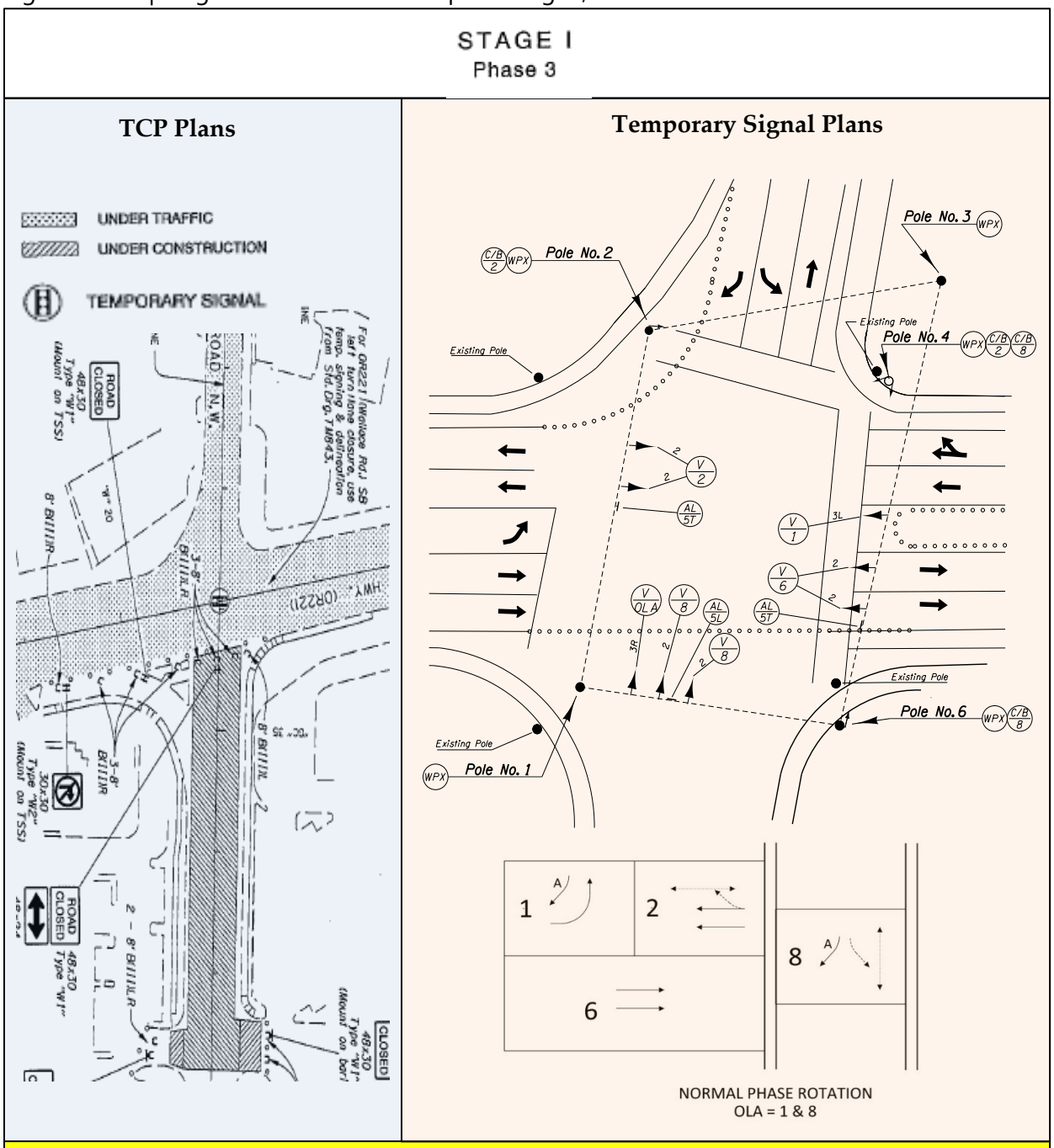
Figure 11-12 | Staged Construction Example – Stage I, Phase 2



NOTE: Lane use on bottom approach changes from Stage 1, Phase 1 which requires a change to the signal indications for phase 4.

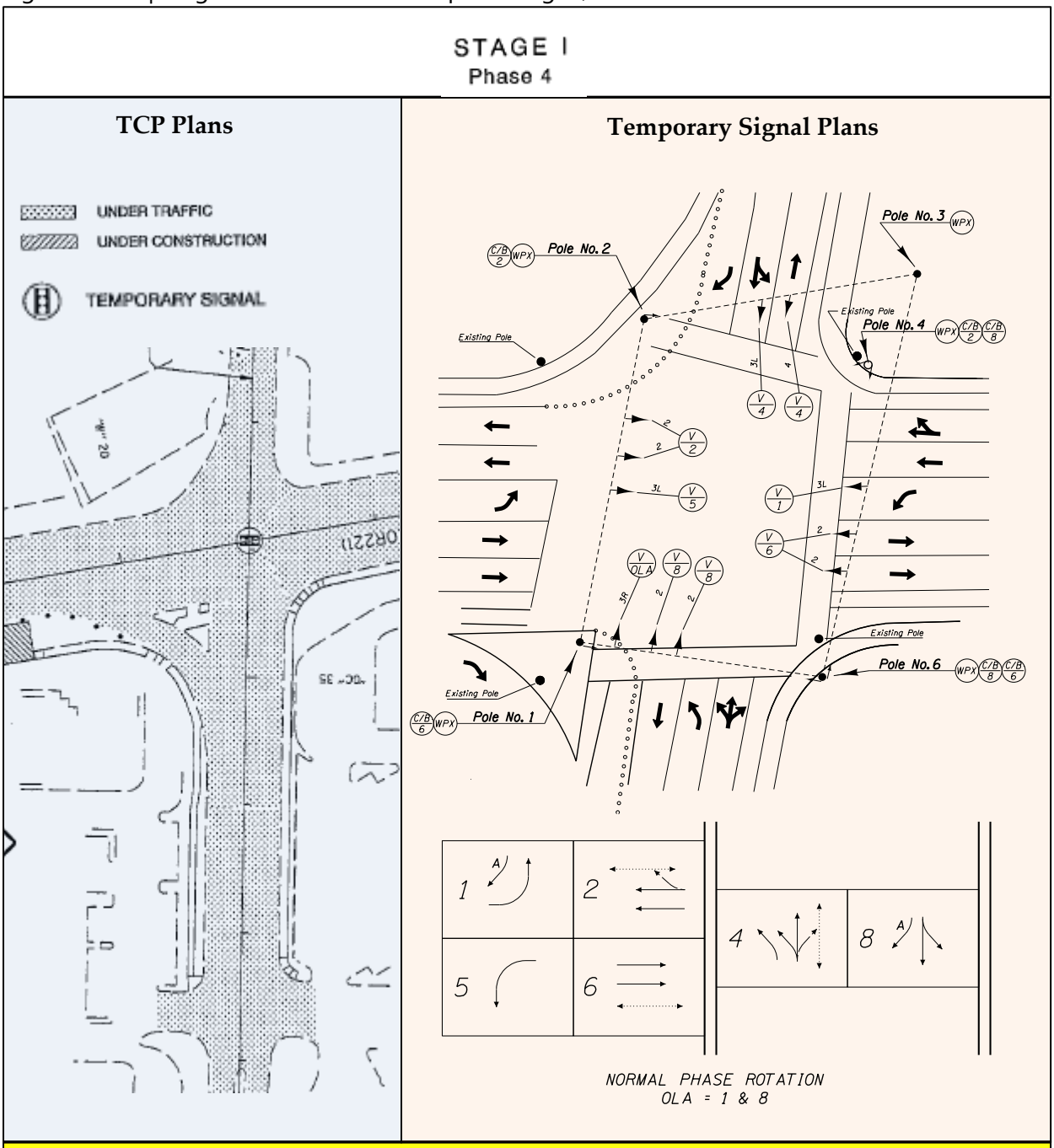
Pole no. 5 no longer needed.

Figure 11-13 | Staged Construction Example – Stage I, Phase 3



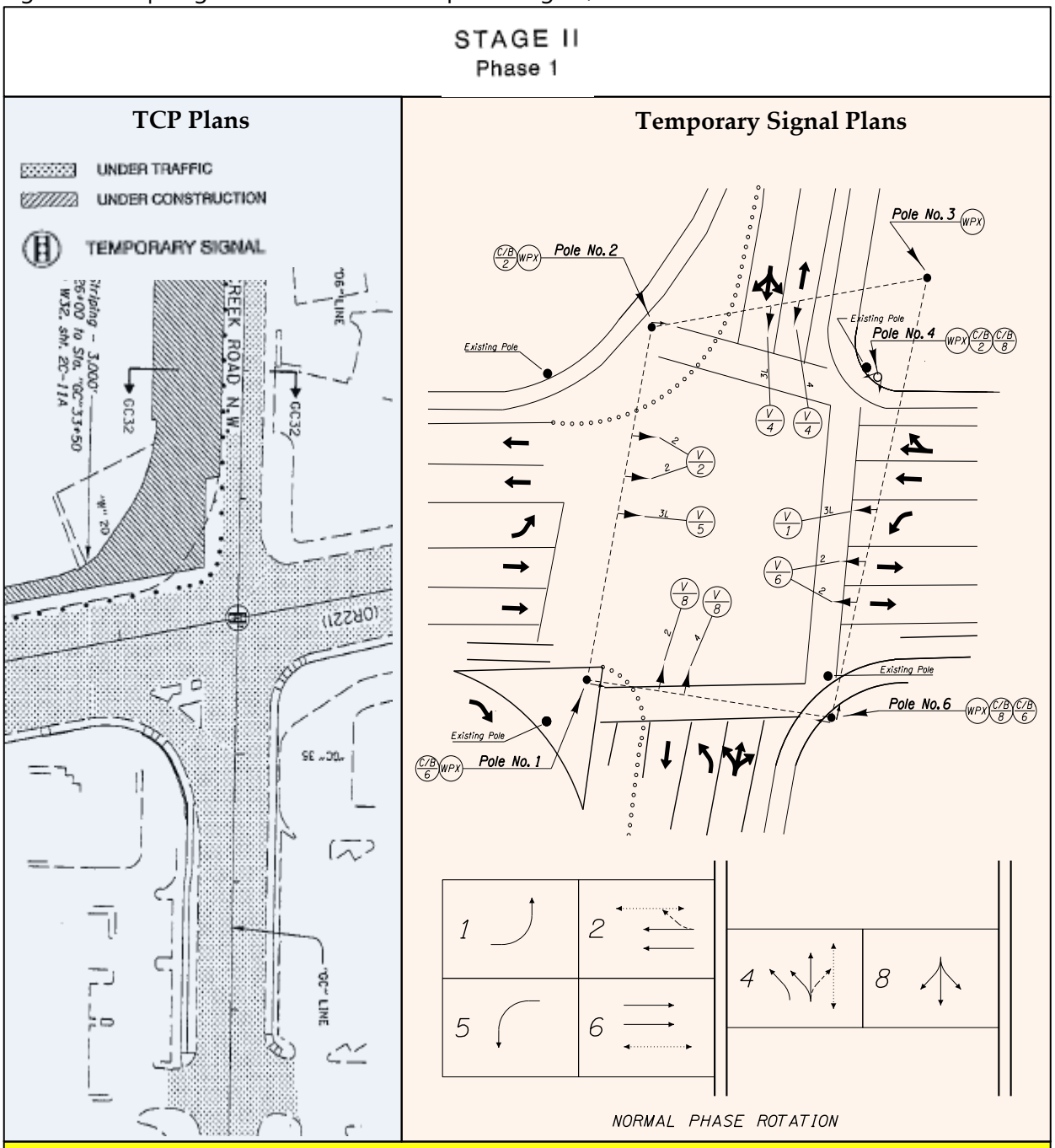
NOTE: The bottom approach is now closed, requiring lane use, regulatory signing, signal indication and signal phasing changes.

Figure 11-14 | Staged Construction Example – Stage I, Phase 4



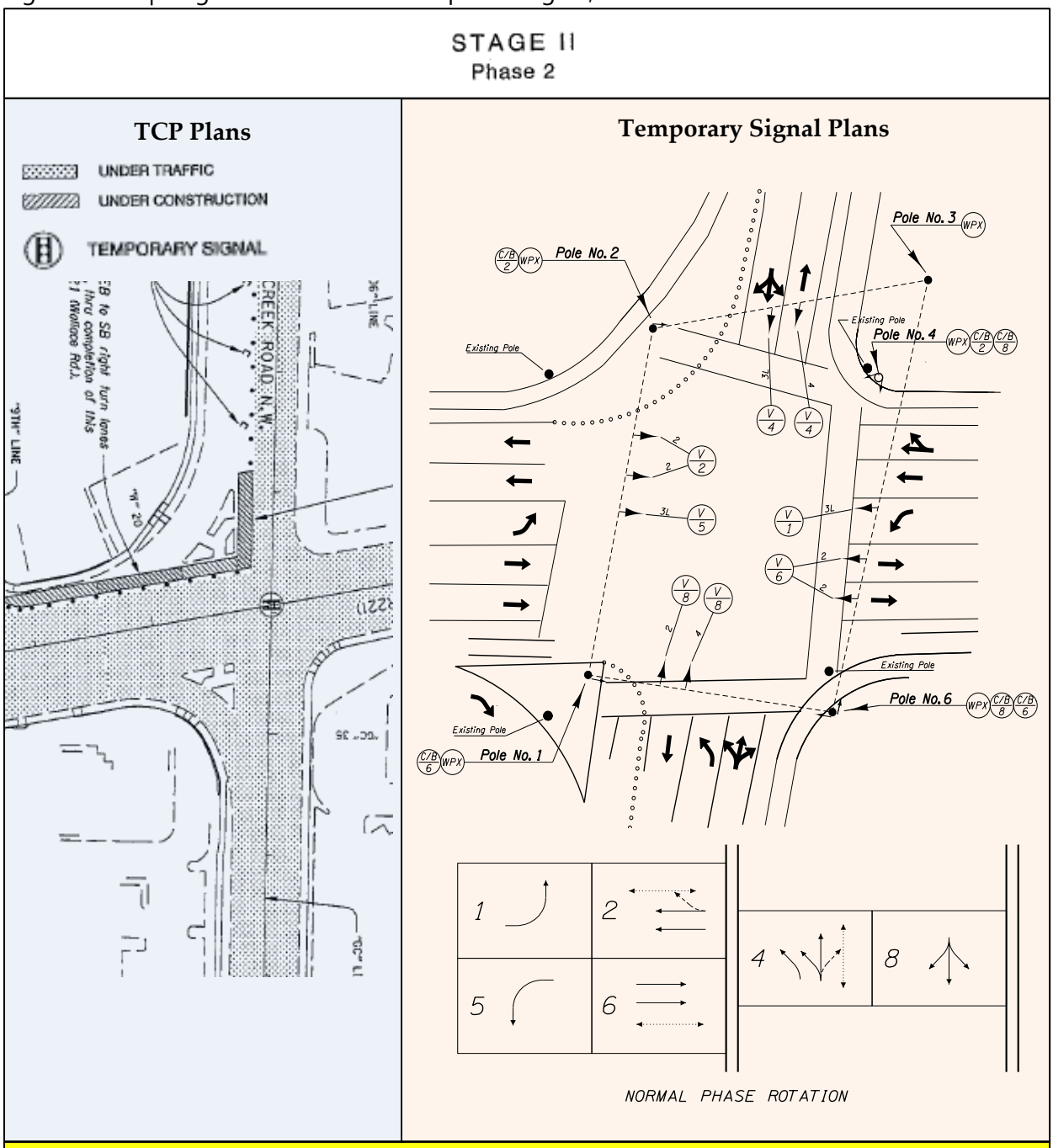
NOTE: The bottom approach final roadway cross-section is complete; however, the final lane configuration for the bottom approach cannot be used yet due to the severe lane off-set for the vehicle going straight thru the intersection from the top approach.

Figure 11-15 | Staged Construction Example – Stage II, Phase 1



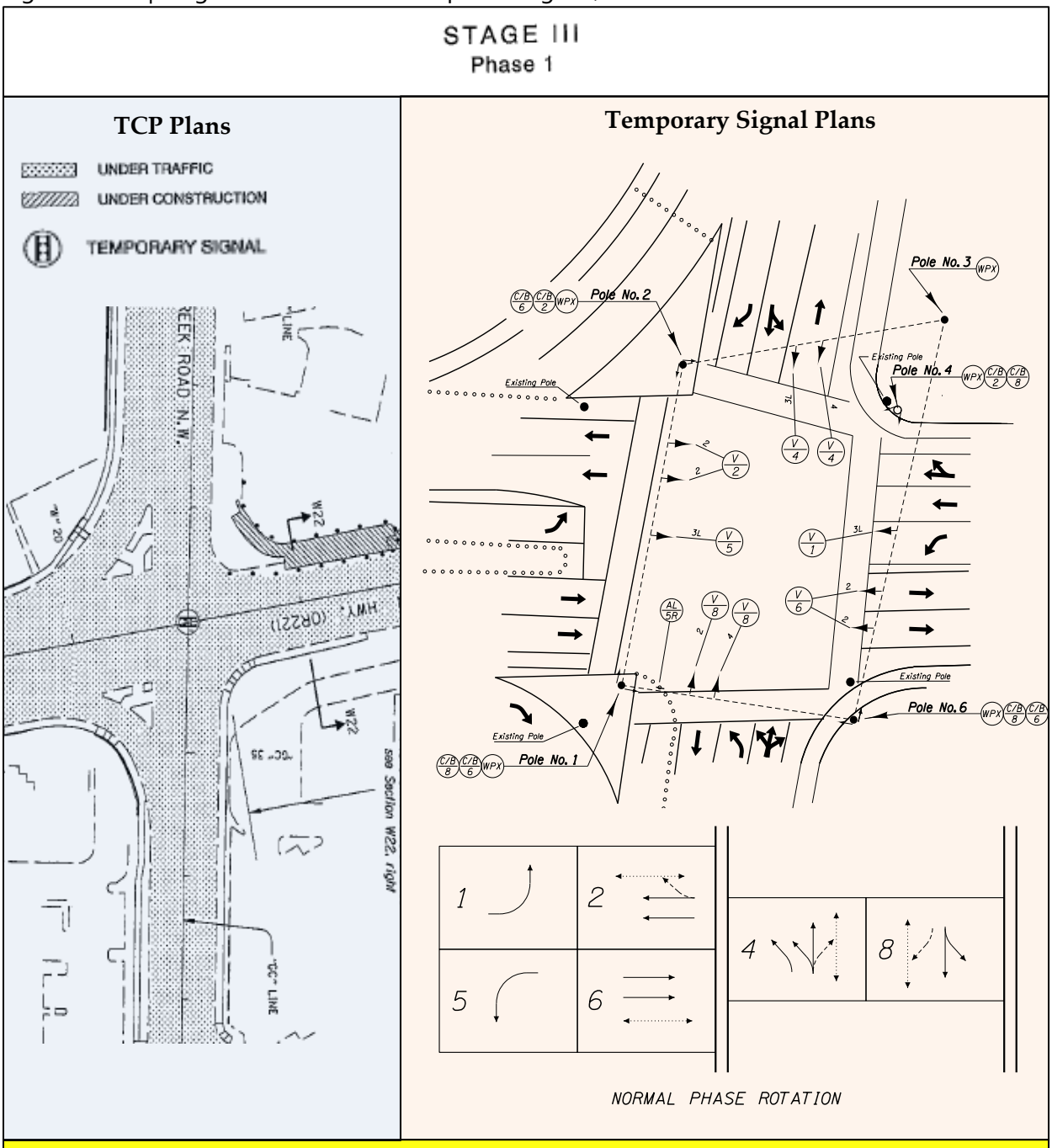
NOTE: The top approach lane use has changed to a single lane, requiring signal head and phasing changes (overlap A has been removed for this stage).

Figure 11-16 | Staged Construction Example – Stage II, Phase 2



NOTE: No changes from Stage II, phase 1 (a separate temporary signal plan sheet for this stage is not needed. The temp signal plan should just indicate the plan sheet is valid for Stage II, phase 1 thru Stage II, phase).

Figure 11-17 | Staged Construction Example – Stage III, Phase 1

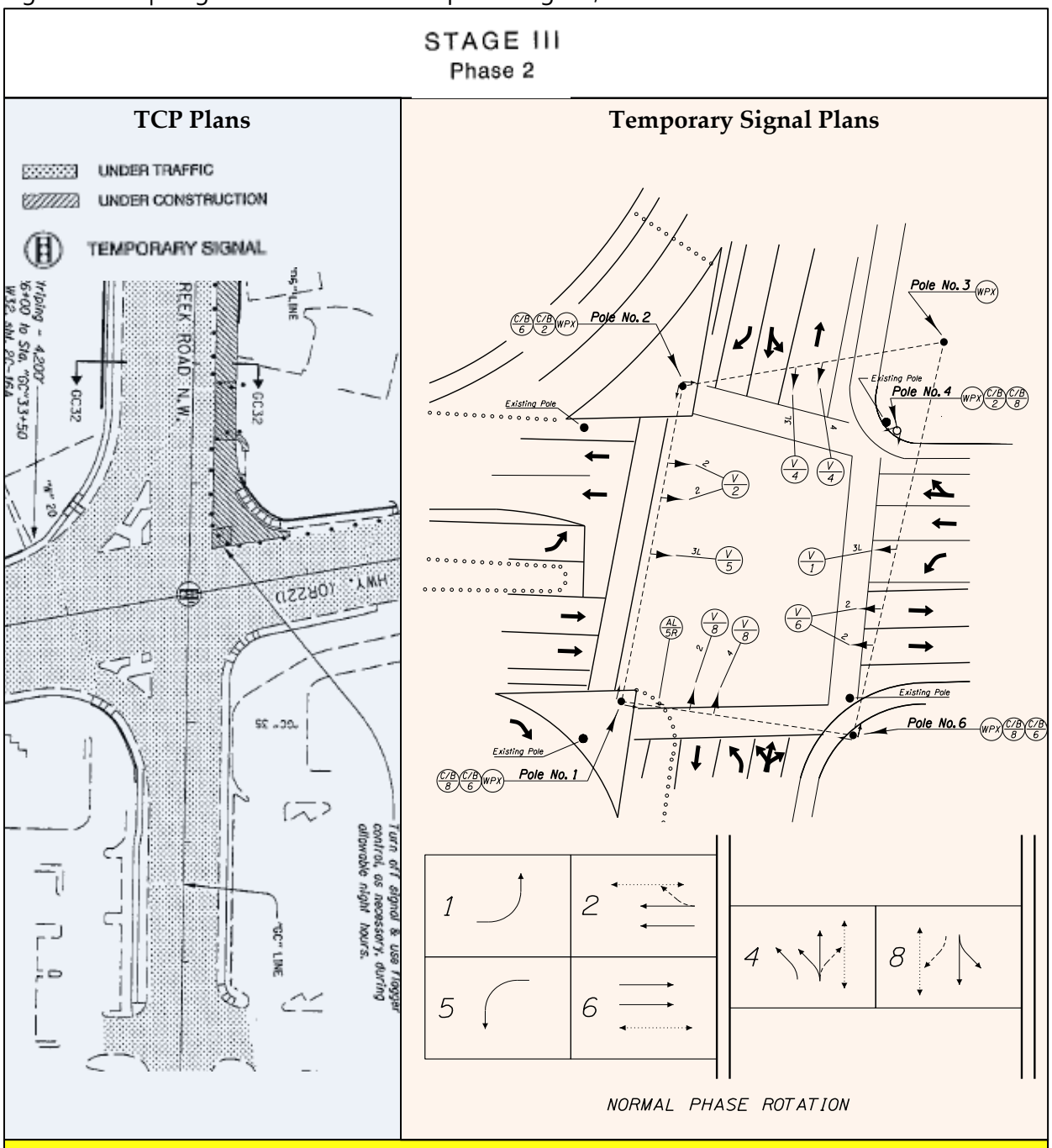


NOTE: The dual right turn lanes for the top approach are built but cannot be used until the permanent signal is turned on (cannot mix and match temporary and permanent signal installations).

All pedestrian crossings are now open.

Left approach dual left turn lane cannot be opened yet (receiving lanes not yet built).

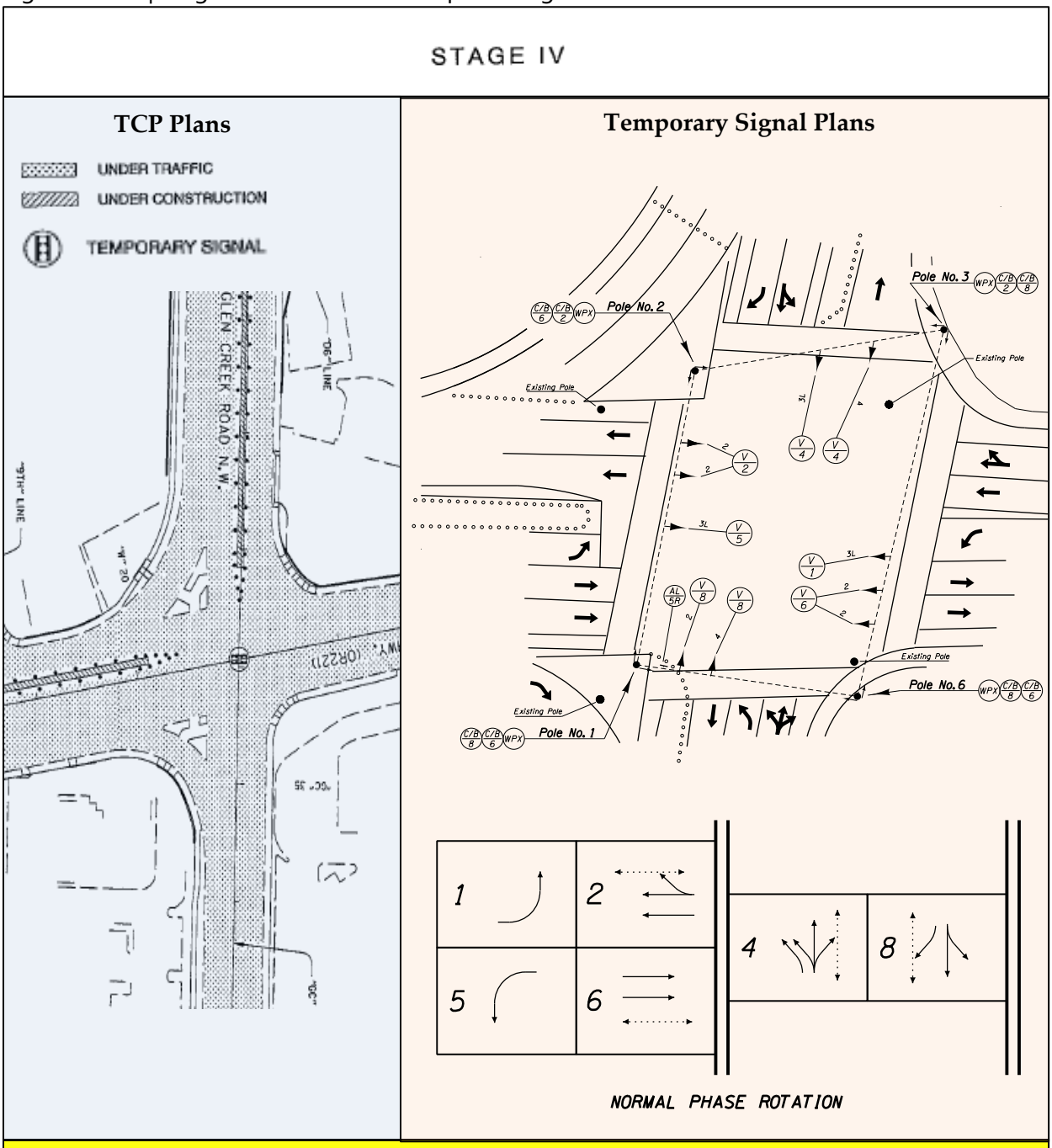
Figure 11-18 | Staged Construction Example – Stage III, Phase 2



NOTE: No changes from Stage III, phase 1

Note that the TCP plans have a note for the contractor about turning off the signal and flagging for the small amount of work to be done in the upper right quadrant.

Figure 11-19 | Staged Construction Example – Stage IV

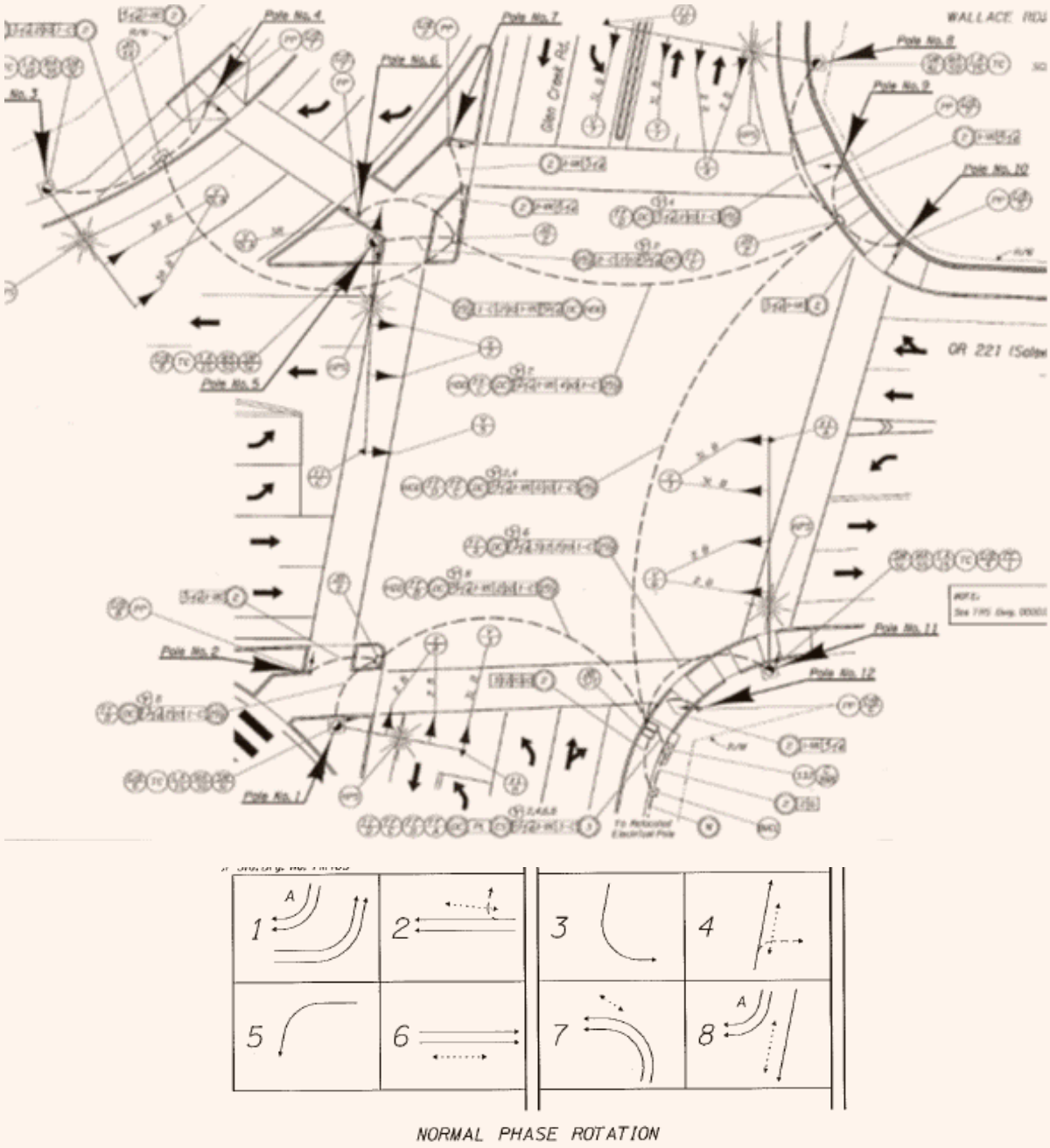


NOTE: The left approach left turn must be shifted to accommodate the median work.

Pole no. 4 no longer needed.

The next stage will be turning on the permanent signal installation.

Figure 11-20 | Staged Construction Example – Permanent Signal



NOTE: Final configuration and phasing.

11.7 Temporary Bridge Signal Design

This type of temporary signal alternates traffic across the bridge one direction at a time in a single lane. Note that this type of operation may occur at other locations besides a bridge, but bridge work comprises the majority, hence the designation of "temporary bridge signal". The location where vehicles will stop at each end of the bridge plus any accesses located between the two stop locations are important to consider early in the design process. All accesses shall be signalized.

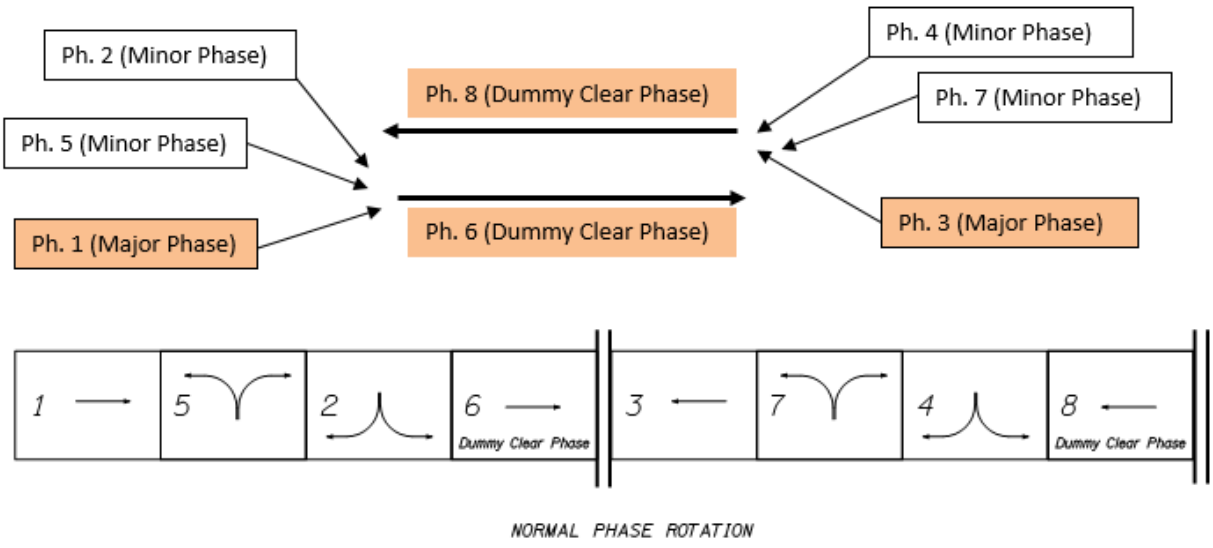
11.7.1 Phasing

One lane, two-way signal operations require exclusive phasing with long all red clearance intervals to clear the "intersection". This is usually accomplished by the use of dummy phases. However, modern signal software may be able to accommodate the long red clearance intervals without dummy phases. Verify with the region signal timer.

The standard phasing for this type of operation is shown in Figure 11-21, which allows for up to 4 separate accesses on each end of the single lane to be signalized. Accesses located in the middle of the single lane are not allowed and should be closed.

Pedestrian phases are typically not used given the typical location where this type of signal operation is used (e.g., rural bridge location), but verify the TPAR needs and requirements with the traffic control designer.

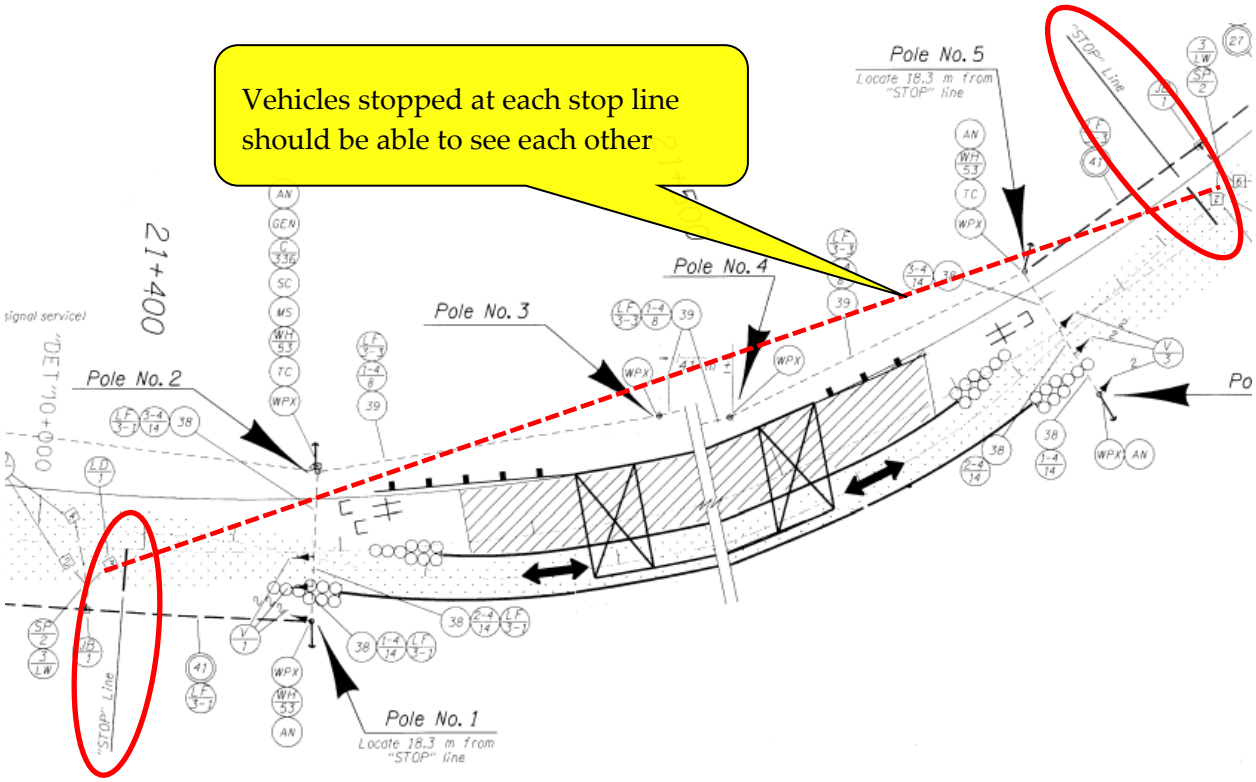
Figure 11-21 | Standard Temporary Bridge Signal Phasing



11.7.2 Sight Distance

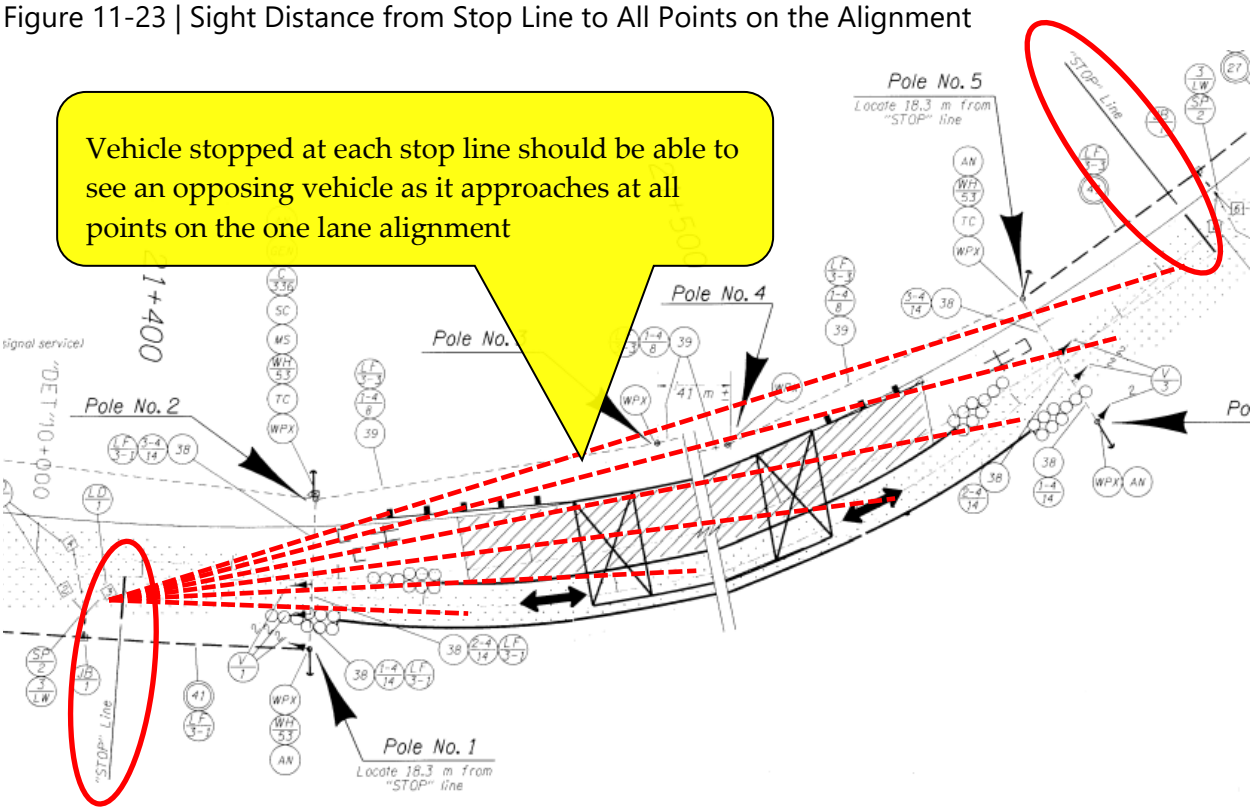
It is important to maintain a good line of sight from stop line to stop line at each end of the single lane in the event that the signal goes into flashing operation. A vehicle stopped at one stop line should be able see a vehicle stopped at the opposing stop line. See Figure 11-22. A vehicle stopped at the stop line should also be able to see an opposing vehicle as it approaches at all points on the one lane alignment. See Figure 11-23. If the line of sight is not good and the signal goes into flash, a driver who cannot see opposing traffic will proceed ahead (after stopping) and may encounter an opposing vehicle in the single lane section, resulting in a crash or the need for one vehicle to reverse.

Figure 11-22 | Sight Distance from Stop Line to Stop Line



The signal designer must understand the traffic control plan layout and coordinate with the traffic control plans designer, the roadway designer, and the region traffic engineer to identify and address/mitigate any sight distance concerns.

Figure 11-23 | Sight Distance from Stop Line to All Points on the Alignment



Things that may negatively affect the line of sight include a single lane section that is long, the roadway horizontal/vertical curvature, vegetation, and/or cut slopes. Some of these things might be addressed relatively easily, such as removal of vegetation. See Figure 11-24.

If a good line of sight between the two stop lines cannot be achieved, other means of traffic control are recommended (e.g., 24/7 flagging or pilot cars). However, a robust back-up plan for the signal going into flash may also be an acceptable alternative if supported by the region traffic engineer and it is detailed in the contract documents (e.g., real-time signal monitoring and alerts with flaggers on stand-by that can respond rapidly).

Figure 11-24 | Sight Distance Condition of Signal Turn-on Example

Note:

Prior to signal operation, remove trees and vegetation south of the straight line identified in the roadway plans, to establish a clear line-of-sight between temporary signal STOP lines.

The sight distance to the signal indications (MUTCD requirement) as well as the sight distance to the end of the expected queue (stopping sight distance) should also be verified. Supplemental vehicle signal heads, alternative detection zones and signal timing strategies, and/or additional temporary traffic control devices (e.g., PCMS) may be appropriate mitigation measures.

11.7.3 Stop Line Location

Standard drawing TM870 shows the typical layout for signing and pavement markings that are used for a temporary bridge signal. The stop line is shown as 60 feet (typical) from the signal heads, which is slightly more than the minimum 45-foot value to provide a more comfortable viewing angle for the driver. The 60-foot value should work well for the majority of applications. However, if it is determined the stop line needs to be placed closer or farther than 60 feet based on site-specific constraints, dimension the distance on the temporary signal plan sheet to properly override the standard drawing.

11.7.4 Signal Head Alignment

The signal heads should be aligned over the receiving lane of the single lane, which depending on the placement of the signal poles and roadway geometry may require a slight shift when the one-lane alignment moves to the other side. Note how the signal head alignment changes between Stage 1 and Stage II in Figure 11-25 and Figure 11-26.

Figure 11-25 | Stage I Signal Head Location

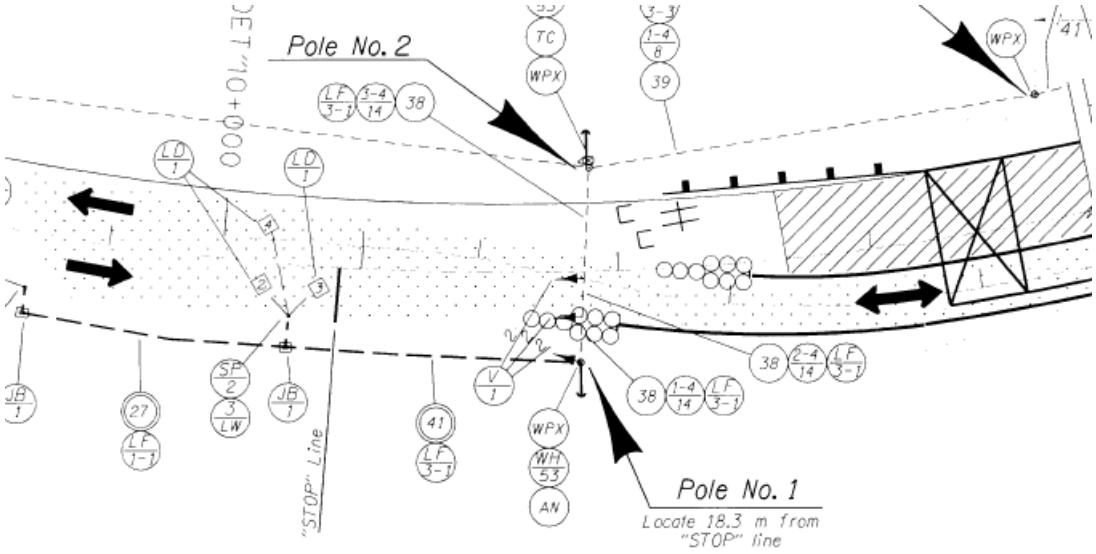
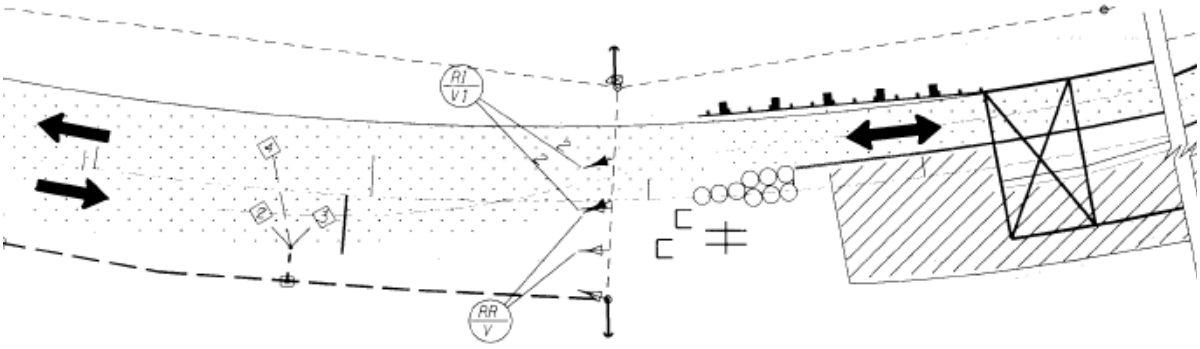


Figure 11-26 | Stage II Signal Head Location



11.7.5 Vehicle Detection

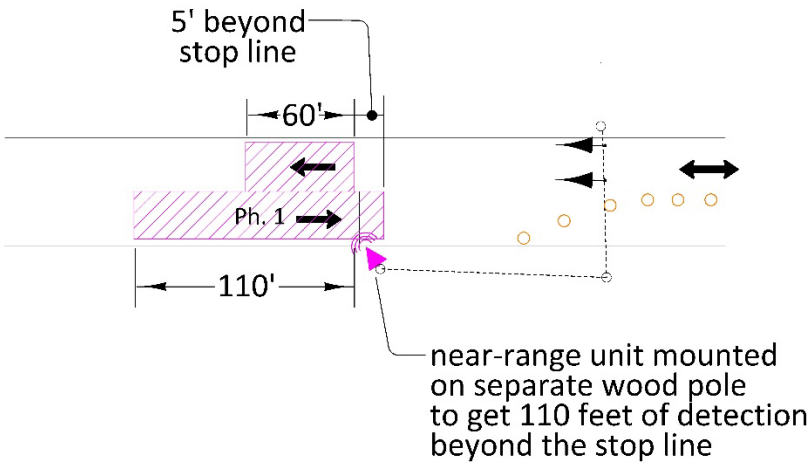
Temporary bridge signals shall have vehicle detection. Detection promotes slower traffic speeds in the workzone and efficient operation:

- It allows the signal to "rest in red" when there is no demand. When a vehicle approaches during the "rest in red" condition, it must slow down prior to getting a green indication.
- It improves the efficiency of an inherently inefficient signal operation (exclusive phasing with long clearance intervals) and manages queues better.

The standard placement for detection zones of the major phases is 110 feet from the stop line with an additional 5 feet beyond the stop line. A detection zone 60 feet from the stop line in the OPPOSING lane should also be included to detect vehicles that are likely to shift out of the approach lane when entering the single lane. This detection is accomplished by a near-range unit. The stop bar is typically located 60 feet from the signal heads, which makes the pole supporting the signal indications too far away to mount the detection unit (the near side device is only capable of 140 feet of detection). Install a separate wood pole to mount the detection unit near the stop line to get the necessary detection zone coverage. Figure 11-27. See chapter 6 for more details on the detection units.

The standard placement for detection of the minor phases follows the standard used for presence detection of permanent signals (total area of detection zone extends approximately 75 from the stop line with 2 small zones in front of the stop line). If the minor phase approach is short in distance (e.g., to a driveway), the detection zone distance should be shorted accordingly. See chapter 6 for more details.

Figure 11-27 | Temporary Bridge Signal Standard Detection - Mainline



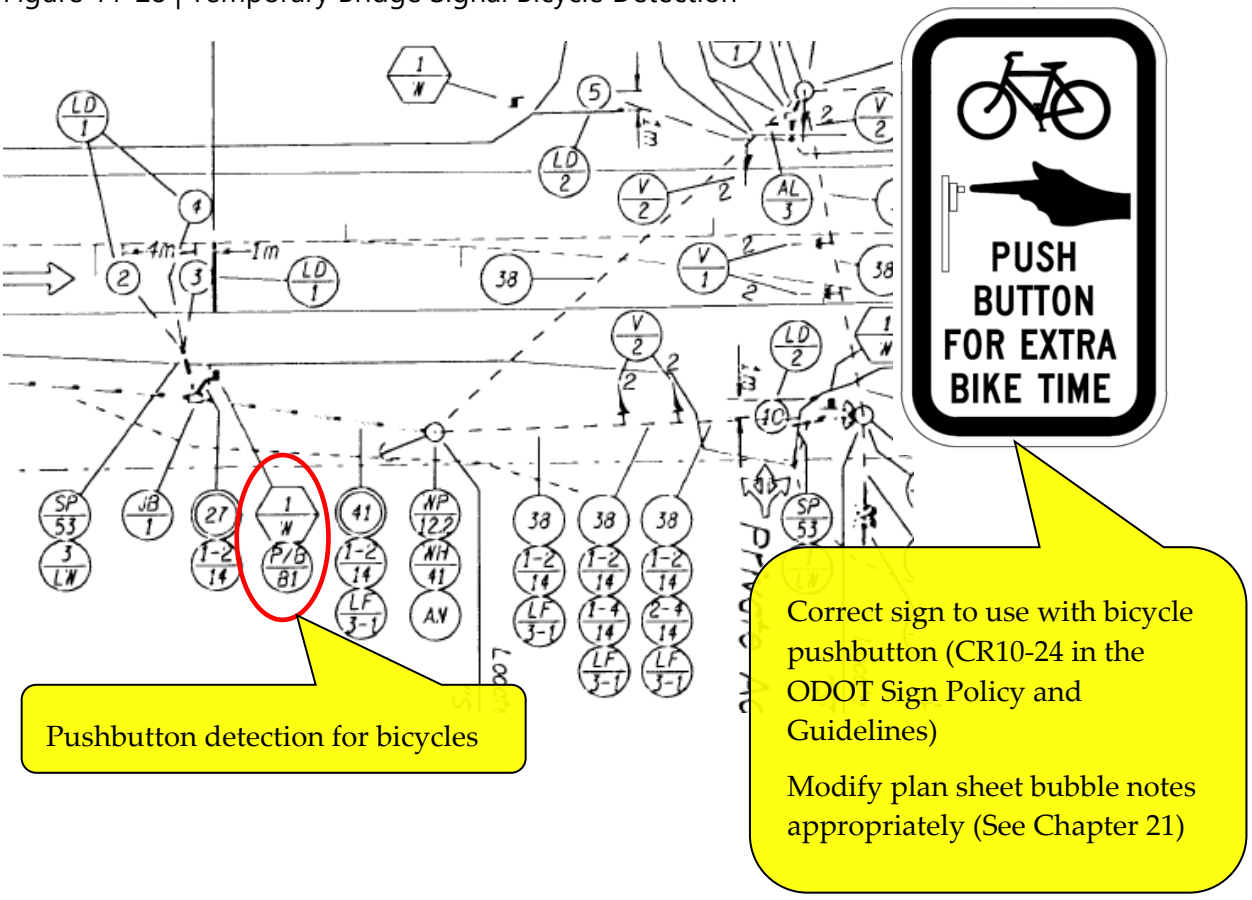
11.7.6 Bicycle Detection

Temporary bridge signals may use detection specifically for bicycles to allow an extension of the green time and clearance phase. The need for bicycle detection should be documented in the operational approval, based on factors such as the temporary bridge signal geometry (length, width, vertical grade, and presence of bicycle lanes), frequency of bicycles, speed differential between bicycles and vehicles, etc.

Pushbuttons have been used in the past and provide the most reliable form of bicycle detection for this type of installation; there is no chance of false call from vehicular traffic and it works for all types of bikes. See Figure 11-28 for an example of pushbutton detection. Radar detection may be used if the detection zones can be placed such that false calls from vehicles will not occur and the region signal timer is confident that the detection zone can adequately accommodate bike traffic. It is important to have proper signing and/or striping in place to let bicycles know how to properly navigate through the signal if detection has been provided.

Portable temporary traffic signals (see section 11.8) cannot accommodate bicycle detection.

Figure 11-28 | Temporary Bridge Signal Bicycle Detection



11.8 Portable Temporary Traffic Signal

This is a very specific type of temporary traffic control, typically used in lieu of a temporary bridge signal (one lane, two-way signal operation). This device requires operational approval but does not require design approval. Because this product is an off-the-shelf system that the contractor is responsible for timing, there is no need for a temporary signal plan sheet. All of the details for installation and operation of this device are contained entirely within the operational approval letter, the temporary traffic control plan sheets, and specification 00227 (in multiple subsections). The EOR for the temporary traffic control plans (not the signal designer) is responsible for detailing the use of this device on the project.

Portable temporary traffic signals are being used more often and their features have improved considerably since their introduction (and continue to rapidly improve). Coordinate with the state traffic operations engineer, the state traffic signal engineer, region traffic, and the traffic control plans designer to determine if a portable temporary traffic signal (which is less costly and more flexible for staging needs) is an acceptable alternative to a standard temporary signal.

STE operational approval is REQUIRED for use of a portable temporary traffic signal.

Temporary signal plan sheets are NOT needed. Design approval is NOT required.

11.9 Standard Drawings and Specifications Applicable to Temporary Signals

The following is a list of standard drawings and specifications that relate only to temporary signals and should be well understood by the signal designer when designing a temporary signal:

- Standard drawings
  - TM870 (bridge construction)
  - TM452 (temporary wood strain pole details)
  - TM453 (temporary pedestrian wood post, guy wire/anchor and luminaire arm details)
  - TM454 (temporary controller cabinet, service cabinet, meter base & terminal cabinet)
  - TM456 (temporary spanwire mounting details for vehicle signals, signs, and fire preemption)
- Specifications
  - Entire 00227 section (temporary traffic signals and illumination)

Other standard drawings/details and specifications (that also apply to permanent signals) will be needed, as applicable, for the installation of a temporary signal. See chapter 17 and chapter 18 for more information on standard drawings and specifications.

12 Flashing Beacon Plan

This page intentionally left blank

12.1 Operational and Design Approval

There are several different types of flashing beacons which require different levels of operational and design approval. Each type of flashing beacon is discussed in more detail in the following sections of this chapter.

	Type of Flashing Beacon	Operational Approval Required	Design Approval Required
WARNING BEACONS	Warning beacon for obstructions	RTE approval	NO if ground mounted using solar power (plan sheet still required)
			YES if mounted overhead OR using commercial power
	Warning beacon for standard warning signs (continuous operation)	RTE approval	NO if ground mounted using solar power (plan sheet still required)
			YES if mounted overhead OR using commercial power
	Warning beacon for ramp meter signs	RTE approval	YES – shown on the RAMP METER plan sheet. See chapter 13.
	BE PREPARED TO STOP WHEN FLASHING & PREPARE TO STOP WHEN LIGHTS FLASH actuated systems	STE approval	YES
	Actuated system for bridges	STE approval	YES
	Actuated system for tunnels	STE approval	YES
	Actuated system for emergency vehicles	STE approval	YES
	Through route activated warning signs (TRAWS)	STE approval	YES
	Rectangular rapid flashing beacon (RRFB)	STE approval (Exceptions apply as per ODOT Traffic Manual section 310.3)	YES
	Speed limit sign beacon (school speed zones only)	STE approval (for the school zone itself). Region traffic decides if beacon is used.	NO if ground mounted using solar power (plan sheet still required)
			YES if mounted overhead OR using commercial power
	Stop sign beacon	RTE approval	NO if using solar power (plan sheet still required)
			YES if using commercial power
	Intersection control beacon	RTE approval	YES
	Pedestrian hybrid beacon	STE approval	YES

12.2 Design Information at a Glance

The following table summarizes the major design feature options and associated references for each type of flashing beacon. Each type of flashing beacon in the table is covered under specification 00990 and paid for as a flashing beacon installation. See the individual sections in this chapter for more detailed information and examples. Note: Speed feedback signs shown in the following table are part of an integrated system with the flashing beacon and are listed in the green sheets. Unintegrated speed feedback signs (stand alone, without a flashing beacon) are not considered a "beacon" but are covered in this chapter and in the green sheets as a separate, unique item. See section 12.3 for more info on unintegrated speed feedback signs.

Coordination with the sign designer will be needed when installing the flashing beacon types listed in table or the unintegrated speed feedback sign in order to specify the appropriate sign design and/or sign size information. The standard details for each beacon type provide instructions for using the hex star sign reference bubble note. The signal designer will use the appropriate standard detail and create a plan sheet that is named as follows:

- For all beacon types listed in the following table, the plan sheet title shall be "flashing beacon plan"
- For all unintegrated speed feedback assemblies (DET4456), the plan sheet title shall be "unintegrated speed feedback assembly" and it will be filed under miscellaneous in filenet.

Type of Flashing Beacon (hyperlink to more info)	Std Dwg/ Detail Reference	Ops	Green Sheet Beacon Assembly*	Power Options	Mounting
Warning beacon for obstructions	DET4457	24/7	N/A – BMCF	Commercial only	Pedestal or custom (If used on a bridge)
Warning beacon for standard warning signs	DET4670, DET4681, DET4450	24/7	24/7 flashing beacon assembly: yellow	Solar	PSST or wood post
			N/A - BMCF	Commercial	Pedestal or mast arm
Curve warning sign beacon **with speed feedback**	DET4451	24/7	24/7 flashing beacon assembly: yellow + speed feedback	Solar or Commercial	Pedestal or mast arm
Warning beacon for ramp meter signs	TM492 & chapter 13	Time of day/day of week	N/A - custom control system	Commercial only	Pedestal
PREPARE TO STOP WHEN LIGHTS FLASH (OR 15-14) system (overhead only)	None	Actuated	N/A - custom control system	Commercial only	Mast arm
BE PREPARED TO STOP (W3-4) WHEN FLASHING (W16-13P) system	DET4558	Actuated	N/A - custom control system	Commercial only	Pedestal
Actuated system for bridges	DET4453	Actuated	Actuated flashing beacon assembly: ped/bike	Solar or Commercial	Pedestal
Actuated system for tunnels	None	Actuated	N/A – custom control system	Commercial only	Custom (typical) or mast arm
Actuated system for emergency vehicles	DET4459	Actuated	N/A – custom control system	Commercial only	Pedestal or mast arm
Through route activated warning signs (TRAWS)	None	Actuated	N/A – custom control system	Commercial only	Pedestal
Rectangular rapid flashing beacon (RRFB)	TM493	Actuated	RRFB assembly	Solar or Commercial	Pedestal or mast arm
School speed limit sign beacon	DET4454	Time of day/day of week	Actuated flashing beacon assembly: school	Solar or Commercial	Pedestal or mast arm
School speed limit sign beacon **with speed feedback**	DET4455	Time of day/day of week	Actuated flashing beacon assembly: school + speed feedback (small or large)	Solar or Commercial	Pedestal or mast arm
Stop sign beacon	DET4670, DET4681, DET4452	24/7	24/7 flashing beacon assembly: red	Solar	PSST or wood post
			N/A - BMCF	Commercial	Pedestal
Intersection control beacon	None	24/7	N/A – BMCF	Commercial only	Mast arm
Pedestrian hybrid beacon (PHB)	None	Actuated	N/A – custom control system	Commercial only	Mast arm

*Only beacon types that require a BMCF service for power AND a control system are listed and shown in red. Use a BMC for all other flashing beacons when using commercial power.

12.3 Speed Feedback Signs (Unintegrated)

Unintegrated speed feedback signs are a stand-alone electrical device (e.g., not integrated with a flashing beacon system). There are only two situations where an unintegrated speed feedback sign is used in conjunction with another sign:

1. Speed limit sign (R2-1)
2. Curve warning sign (W1-1 thru W1-5, W1-11, W1-15)

An unintegrated speed feedback sign shall be mounted on the same support with the appropriate accompanying sign. Do not install a speed feedback sign alone on a separate support.

Solar power is the only option for this device.

It is a green sheet item: unintegrated speed feedback assembly. Use standard detail DET4456 and special provision 00991. DET4456 also contains additional design information and how to properly detail this device on a plan sheet.

See the ODOT Traffic Manual for more information on the proper application and required approvals for speed feedback signs.

12.4 Power Source

Certain flashing beacons can be powered either by commercial power or solar power. Beacons that require a custom control system (as opposed to a turn-key control system listed on the green sheets) require commercial power. See section 12.2. If the beacon installation can be either commercial or solar, the decision on which one to use should be made in conjunction with the region electrical crew. There are pros and cons to each one, shown below.

COMMERCIAL POWER	
Pros	**Cons**
Reliable	Monthly power bill
Easy access and cost effective installation in urban areas	May not be available or cost effective in rural areas
SOLAR POWER	
Pros	**Cons**
Good performance with unimpeded view of the sun	More costly initial installation
No monthly power bill	Requires maintenance/replacement of solar system in the future (array and batteries)
Good option where use of commercial power is impractical	Locations with impeded views will require larger (or additional) arrays/batteries
	May be subject to theft or vandalism

Standard solar power systems are designed for an unimpeded view of sun during daylight hours. If solar power is going to be used in a location that has an impeded view during the daylight hours (blocked by trees, buildings, etc.) contact the state traffic signal engineer to correctly size the array and number of batteries. If solar power is an acceptable option for the type of beacon, it will be shown in the applicable standard detail (see table in section 12.2 for power options of all beacon types and the associated standard drawing/standard detail reference).

If commercial power is used, the support post shall be a pedestal. Standard sign supports such as wood posts and PSST are NOT allowed for mounting a flashing beacon when commercial power is used due to the necessity of conduit and wiring along the length of the support which negatively affects the break-away characteristics of the post. A separate base mounted flasher cabinet (BMCF) is required to power AND provide the control system for all 24/7 flashing beacons, with the exception of the curve warning beacon + speed feedback that requires a standard BMC. All other flashing beacon types require a standard BMC for power only. See table in section 12.2 and standard drawing TM485.

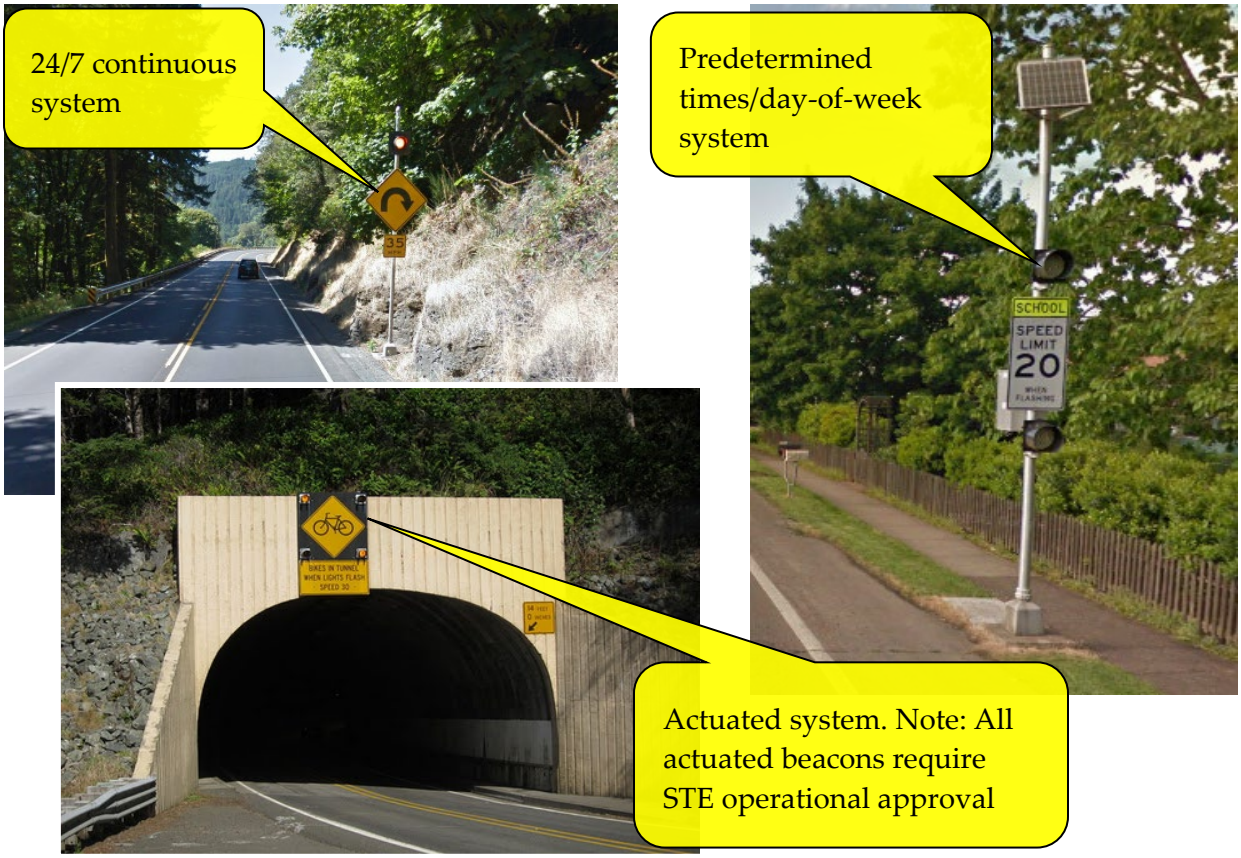
Design approval is required if commercial power is used.

12.5 Beacon Operation

Depending on the application of the flashing beacon, they may operate in the following ways (see Figure 12-1):

- **Continuously.** This operation is used when the condition or regulation exists at all times, for example, obstructions in or near the roadway, "signal ahead" and "curve ahead" warning signs.
- **Only during certain times/day-of-week.** This operation is used when the condition or regulation exists for a predetermined duration, for example, school speed zone regulatory signs and ramp meter warning signs. This type of operation typically includes the phrase, "WHEN FLASHING" in the sign legend.
- **Actuated (either passive or pushbutton).** This operation is used when the condition or regulation exists only when there is actual demand, for example, peds using a mid-block crossing, bikes/peds using a tunnel or bridge, and BE PREPARED TO STOP WHEN FLASHING systems. This type of operation also usually includes the phase, "WHEN FLASHING" in the sign legend (one major exception is mid-block crosswalk signing, which does not use the phrase "WHEN FLASHING").

Figure 12-1 | Beacon Operation Examples



12.6 Sight Distance Considerations

Flashing beacons should meet requirements stated in MUTCD chapter 4L, which includes the provisions of chapter 4D, and therefore the sight distance for visibility to the flashing beacon should strive to meet the requirements in Table 4D-2 if possible. However, many of the flashing beacon assemblies are associated with a regulatory or warning sign that requires placement of the sign in a particular location as per chapter 2 of the MUTCD (e.g., Table 2C-4). As long as the MUTCD sign placement requirements are satisfied (visibility, legibility, and perception/reaction time to the sign message), the visibility to the associated flashing beacon should also be adequate.

It is also important to be aware of obstructions that may partially or fully block the sign and/or flashing beacon as a vehicle approaches it, such as a closely spaced sign immediately prior to the flashing beacon assembly. See Figure 12-2 for example. The possible solutions will vary depending on the site-specific conditions but could include removing a sign, laterally offsetting the signs, adding more spacing between the signs, adjusting the signs mounting height, or using an overhead mount.

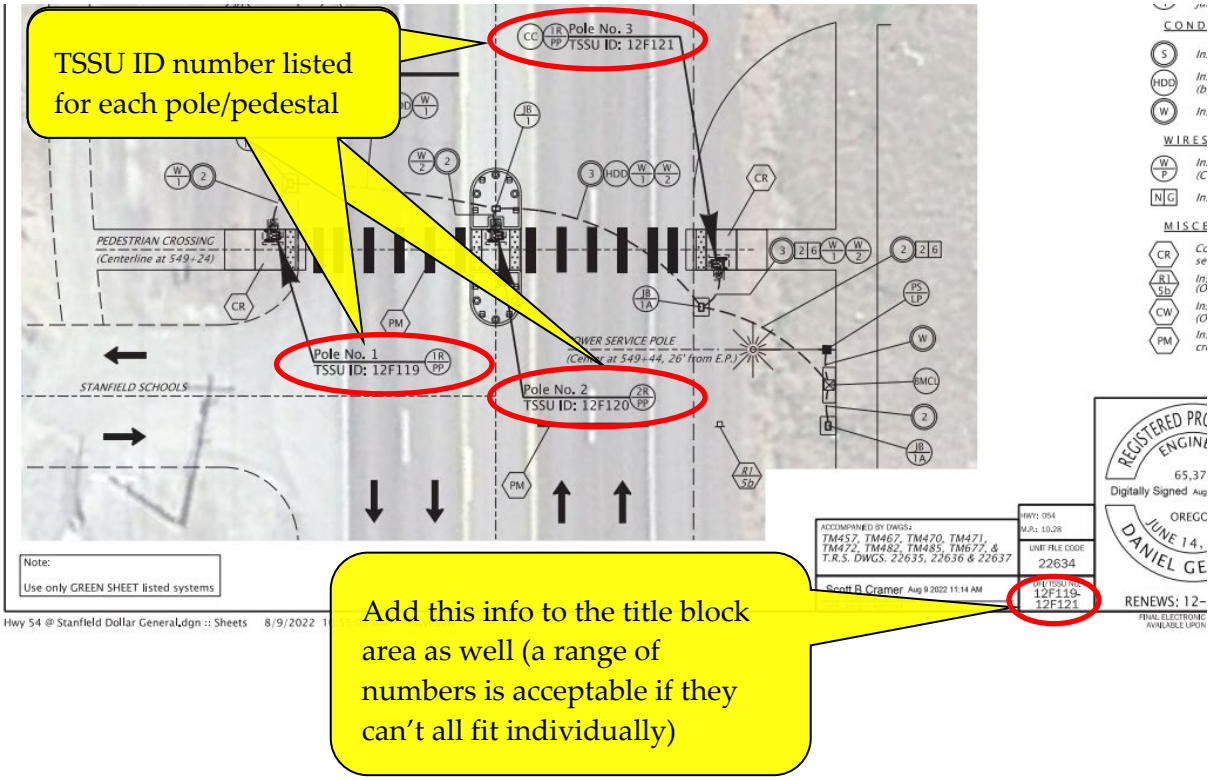
Figure 12-2 | Sight Distance Considerations – Closely Spaced Sign Can Obstruct the Flashing Beacon



12.7 TSSU ID Numbers for Flashing Beacon Installations

Flashing beacon installations are now being tracked and evaluated as part of the traffic signal asset management program. This requires a unique TSSU ID number for each pole/pedestal that is used for a flashing beacon installation. The TSSU ID number is assigned by the traffic engineering section. See chapter 2 for more information about obtaining the TSSU ID number. Showing the TSSU ID number(s) on the plan sheet for a flashing beacon installation should be done as per Figure 12-3.

Figure 12-3 | Showing TSSU ID Numbers for Flashing Beacon Installations on Plan Sheets



12.8 Warning Beacon

A warning beacon provides supplemental emphasis for warning signs, regulatory signs, or markers. See MUTCD Section 4L.03 for more information. The following subsections list the common types of warning beacons used on the state highway.

Warning beacons are generally ground mounted, but they may be mounted overhead for greater conspicuity.

12.8.1 Warning Beacons for Obstructions

On the state highway, warning beacons are typically only used to emphasize one type of obstruction: impact attenuators located within the gore area of highway bifurcations. See Figure 12-4 and Figure 12-5 for examples.

This type of flashing beacon is NOT a green sheet item.

For this application, two vertically oriented, 12-inch circular yellow indications (custom signal head type) are mounted on a pedestal. A BMCF is used for both the power and control system. See standard detail DET4457 for more design information and how to properly detail this type of flashing beacon on a plan sheet.

Figure 12-4 | Warning Beacon for an Obstruction, Example 1



Figure 12-5 | Warning Beacon for an Obstruction, Example 2



12.8.2 Warning Beacons for Warning Signs (Continuous Operation)

The common signs where warning beacons are used include:

- Signal ahead signs
- Curve signs
- Intersection ahead signs

This type of flashing beacon is a green sheet item and has two categories:

- 24/7 flashing beacon assembly: yellow FOR SOLAR ONLY (note: if this beacon is using commercial power, it is NOT a green sheet item and will require a BMCF for the power and the control system).
- 24/7 flashing beacon assembly: yellow + speed feedback assembly (integrated system)

For ground mounted applications, one type 1Y signal head is mounted directly above the sign on the support post. If solar power is used, the support post may be either a standard wood post or a perforated steel square tube (PSST). There are two standard details, DET4681 (PSST) and DET4670 (wood post) that should be used. See Figure 12-6 for an example. If commercial power is used, the support post is required to be a pedestal. See standard detail DET4450

(pedestal support, without speed feedback assembly). See standard detail DET4551 for a pedestal support, with speed feedback sign (integrated system) – note that this detail is only applicable for curve warning signs. Both standard details DET4450 and DET4451 also contain additional design information and how to properly detail these types of flashing beacons on a plan sheet.

For overhead mounted applications, two type 1Y signal heads are mounted on either side of the sign. A mast arm should always be used if feasible. Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum. See Figure 12-7 for an example.

Figure 12-6 | Warning Beacon for a Warning Sign, Post Mounted



Figure 12-7 | Warning Beacon for a Warning Sign, Overhead



12.8.3 Warning Beacons for Ramp Meter Signs

Ramp meter signs with warning beacons are part of the standard installation for a ramp meter and are shown on the "RAMP METER" plan sheet, not a "FLASHING BEACON" plan sheet. See chapter 13 for information on ramp meter plan sheets.

12.8.4 Actuated Warning Beacons – Bridges

Actuated warning beacons for bridges consist of one type 1Y signal head located above the warning sign. The warning sign legend should contain "WHEN FLASHING" text to inform the motorist of when the condition is applicable.

This type of flashing beacon is a green sheet item: actuated flashing beacon assembly: ped.

For ground mounted applications, one type 1Y signal head is mounted directly above the sign on the support post. See Figure 12-8 for an example. The support post is required to be a pedestal. See standard detail DET4453 for more design information and how to properly detail this type of flashing beacon on a plan sheet.

For overhead mounted applications, two type 1Y signal heads are mounted on either side of the sign. A mast arm should always be used if feasible. Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum.

A pushbutton is the standard form of detection. Pushbuttons shall be located according to the requirements stated in chapter 5 and where they are easily accessible for all intended users (pedestrians and/or cyclists).

Bridges are usually illuminated and therefore, commercial power for the actuated warning beacon system can typically be obtained from the illumination service cabinet. Work with the ODOT bridge section if any conduit or wiring for the actuated warning system needs to go across the structure.

Figure 12-8 | Warning Beacon for a Warning Sign, Actuated Operation, Post Mounted



12.8.5 Actuated Warning Beacon – Tunnels

Actuated warning beacons for tunnels consists of an Oregon specific sign (OBW1-8) which has four 8-inch circular yellow indications within the sign boarder. See Figure 12-9 which shows sign OBW1-8 from the ODOT Sign Policy and Guidelines, chapter 8. This sign assembly should be mounted overhead on the tunnel entrance, centered over the tunnel entrance. Ground mounted installations are not allowed. See Figure 12-10 and Figure 12-11 for examples.

A pushbutton is the standard form of detection. Pushbuttons shall be located according to the requirements stated in chapter 5, and where they are easily accessible for all intended users (pedestrians and/or cyclists).

This type of flashing beacon is NOT a green sheet item. A custom control system using time-delay relays is used for these systems. Contact the state traffic signal engineer for assistance in designing the proper control system.

Tunnels are always illuminated and therefore, commercial power for the actuated warning beacon system can typically be obtained from the illumination service cabinet.

Figure 12-9 | Actuated Warning Beacon – Tunnel Signing

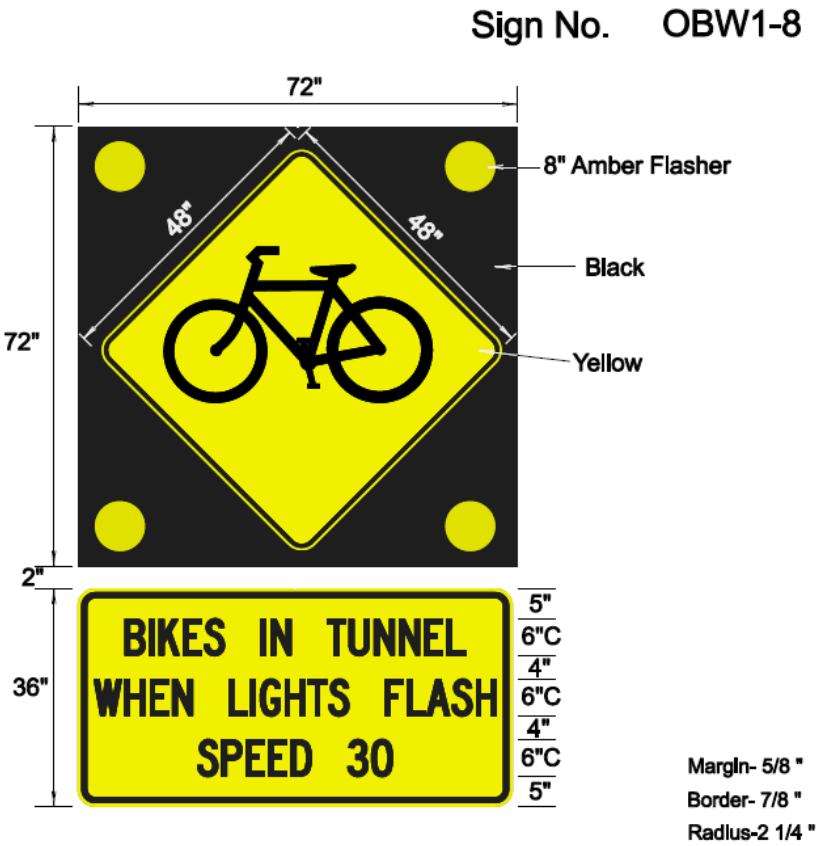


Figure 12-10 | Actuated Warning Beacon – Tunnel, Example 1



Figure 12-11 | Actuated Warning Beacon – Tunnel, Example 2



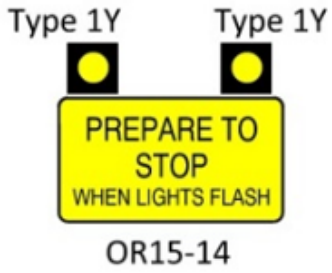
12.8.6 Actuated Warning Beacon – PREPARE TO STOP WHEN LIGHTS FLASH

PREPARE TO STOP WHEN LIGHTS FLASH warning beacons are typically used in advance of a traffic signal, or a special application thereof, such as for a location of roadway that has poor sight distance and experiences frequent back-ups. They are also commonly used for moveable bridges (see chapter 23 for more information on movable bridges) and for railroad crossings (see chapter 16, section 16.9 for more information on how this device is used at a railroad crossing).

This type of flashing beacon is NOT a green sheet item.

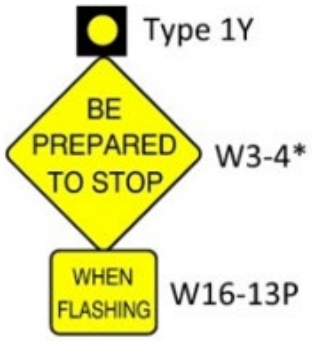
PREPARE TO STOP WHEN LIGHTS FLASH warning beacons consist of an Oregon specific sign (OW15-14) with two type 1Y signal heads located above the sign. See Figure 12-12 which shows sign OW15-14 from the ODOT Sign Policy and Guidelines, chapter 4. This assembly should be mounted overhead centered over the travel lane(s). See Figure 12-14 for an example.

Figure 12-12 | Actuated Warning Beacon – Overhead Application



If this message doesn't need to be displayed overhead based on engineering judgment, the ground mounted version consisting of a BE PREPARED TO STOP sign (W3-4) with a WHEN FLASHING sign rider (W16-13P) mounted on a pedestal may be used. See Figure 12-13.

Figure 12-13 | Actuated Warning Beacon – Ground Mounted Application



Radar detection is the standard. The location of the detection and sign is critical to the proper operation of the beacons and is determined by an engineering study and documented in the STE operational approval. A stand-alone pole or pedestal may be required to mount the radar detector unit in the proper location.

If this type of system is used in advance of a traffic signal, it needs to be connected to the traffic signal controller.

If this type of system is NOT used in advance of a traffic signal, a custom control system using time-delay relays is used. Contact the state traffic signal engineer for assistance in designing the proper control system.

Figure 12-14 | Warning Beacon Supplementing a Warning Sign, Passive Activation Operation, Overhead



12.8.7 Actuated Warning Beacon – Mid-block Crosswalks

Actuated warning beacons for mid-block crosswalks were used in the past at marked crosswalks before rectangular rapid flashing beacons (RRFB). See Figure 12-15 for an example. They are no longer installed and existing installations should be replaced with an RRFB. See Section 12.9 for information on RRFB design.

Figure 12-15 | Warning Beacon for a Warning Sign, Actuated Operation, Ground Mounted



12.8.8 Actuated Warning Beacon – Emergency Vehicles

Actuated warning beacons for emergency vehicles are a good alternative to traditional fire signals (described in chapter 17). They are less expensive and provide an accurate, advance warning to drivers that they need to yield to an emergency vehicle accessing the roadway.

This type of flashing beacon is NOT a green sheet item.

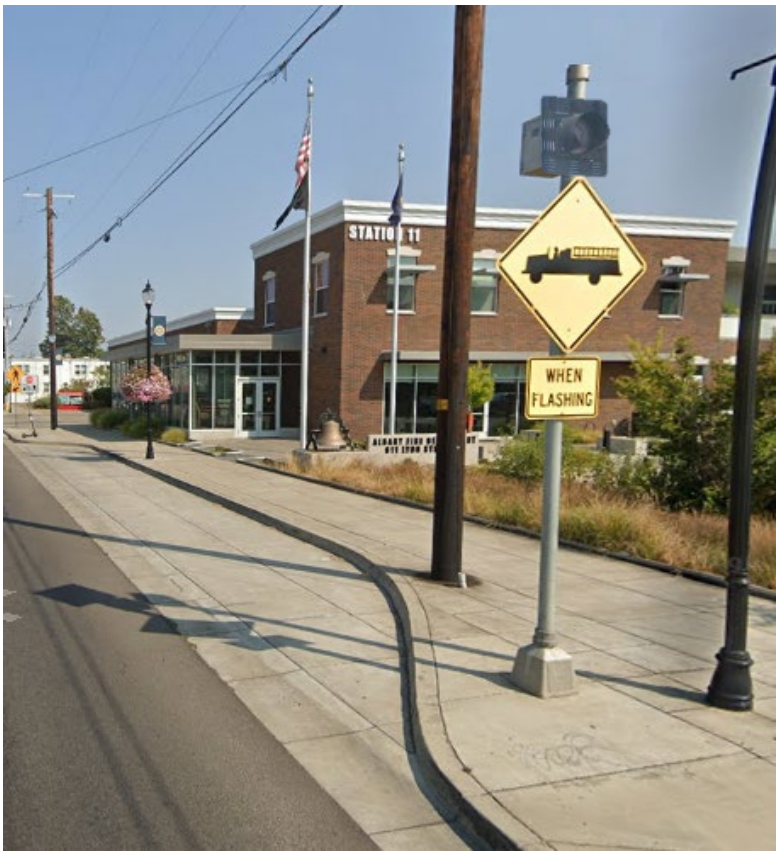
For ground mounted applications, one type 1Y signal head is mounted directly above the sign on the support post. See Figure 12-16. The support post is required to be a pedestal. See standard detail DET4459 for more design information and how to properly detail this type of flashing beacon on a plan sheet.

One assembly is required per approach, located on the right side of the roadway.

For overhead mounted applications, two type 1Y signal heads are mounted on either side of the sign. A mast arm should always be used if feasible. Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum.

Contact the state traffic signal engineer for assistance in designing the proper control system.

Figure 12-16 | Warning Beacon for an Emergency Vehicle Sign, Actuated Operation, Ground Mounted



12.8.9 Actuated Warning Beacon – TRAWS

Through route activated warning signs (TRAWS) are used to help reduce the potential and severity of right-angle collisions at stop-controlled intersections.

This type of flashing beacon is NOT a green sheet item.

Detection for the side street (stop controlled approach) activates flashing beacons on the mainline to alert drivers to watch for entering vehicles.

One assembly is required per approach, located on the right side of the roadway. However, a supplemental assembly on the left side of the roadway is recommended for added conspicuity/emphasis or if there are concerns about sign occlusion. See Figure 12-17. They are located 500 to 1000 feet from the intersection. This allows the needed flexibility to work around other conflicts (such as signing, environmental, drainage, etc.) while still providing adequate warning time to the motorist. Work with region traffic to determine the best location based on the site specifics.

For ground mounted applications, one type 1Y signal head is mounted directly above the sign and one below the sign on the support post (typically a pedestal). See Figure 12-18. They operate in a wig-wag pattern.

Other design requirements:

- The controller cabinet is a 334 with and ATC controller
- The service cabinet is a BMC
- Three No. 12 AWG THWN wires required for each assembly. See Figure 12-19.
- Near range radar detector unit mounted on a pedestal or pole to provide a detection zone at least 75 feet in length from the stop line.

For overhead mounted applications, two type 1Y signal heads are mounted on either side of the sign. A mast arm should always be used if feasible. Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum.

Figure 12-17 | TRAWS Location and Placement Example



Figure 12-18 | TRAWS Assembly Example

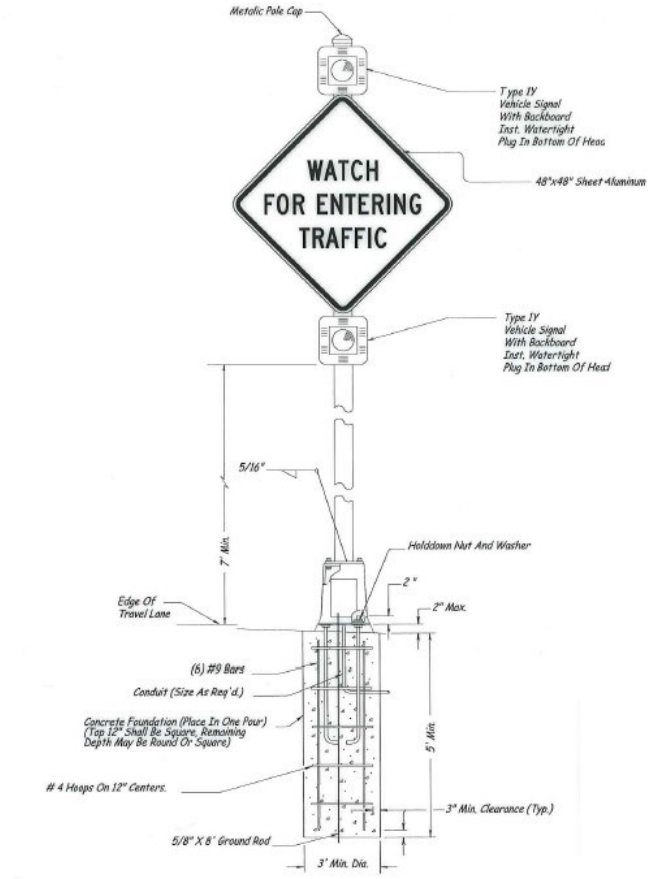
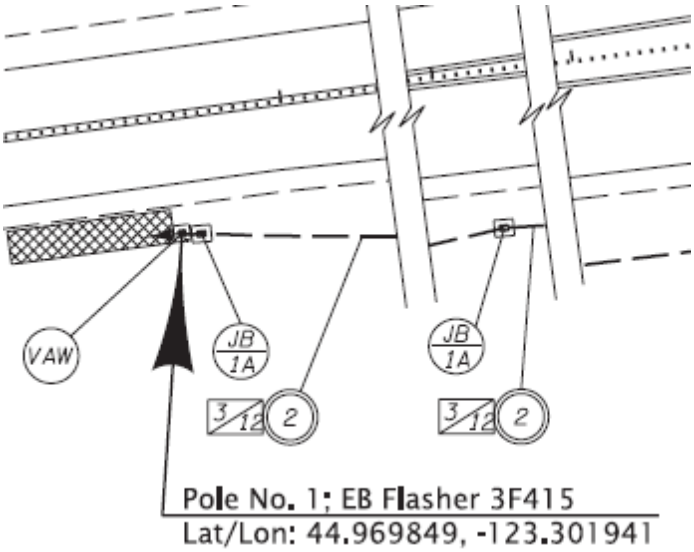


Figure 12-19 | TRAWS Wiring Example



12.9 Rectangular Rapid Flashing Beacon (RRFB)

A rectangular rapid flashing beacon is different from an actuated warning beacon for mid-block crosswalk discussed in section 12.8.7. The RRFB operation is the same, but it uses a unique shape and flash pattern to supplement a W11-2 (pedestrian), W11-15 (trail) or S1-1 (school) crossing warning sign with a diagonal downward arrow (W16-7p) plaque only. It has been proven as an effective device and is now the only option for an actuated warning beacon for a mid-block crosswalk.

12.9.1 MUTCD Interim Approval

The RRFB was granted interim approval by FHWA for the 2009 version of the MUTCD. It has now been incorporated into the 11th edition of the MUTCD in chapter 4L. The signal designer should follow the guidance in MUTCD chapter 4L in addition to the guidance presented in this manual. The ODOT Traffic Manual also contains additional information about the use of RRFBs.

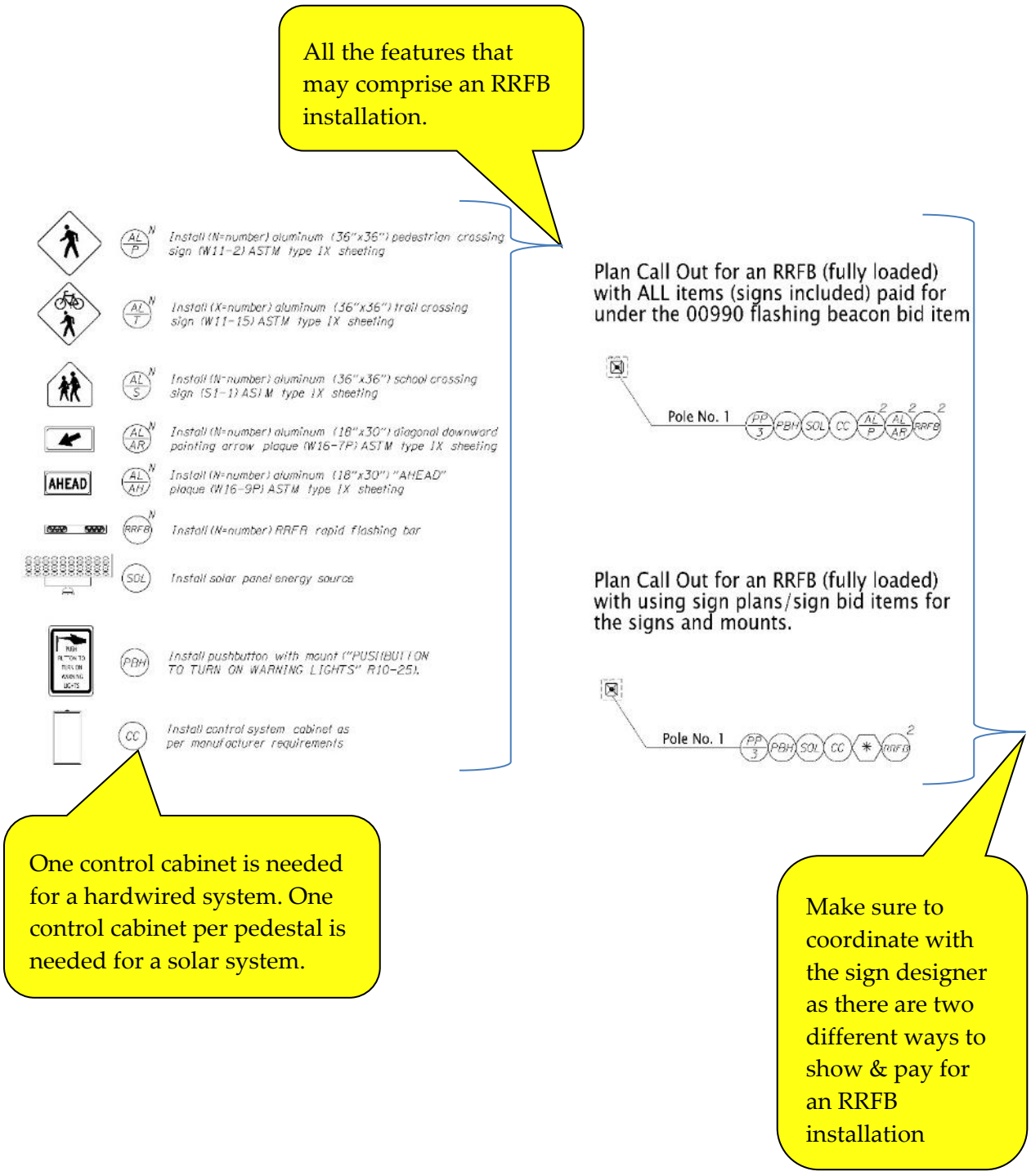
12.9.2 Device Assembly Requirements

The traffic engineering section has prequalified RRFB assemblies that meet the MUTCD device requirements and listed them on the green sheets (see chapter 20 for more information on the green sheets).

Use the most current microstation workspace for the new RRFB bubble notes and plan call out structure. Note there are two different ways to show/pay for an RRFB installation (coordinate with the sign designer). See Figure 12-20.

Use standard drawing TM493 for RRFB assemblies. The drawing contains the basic installation details for mounting an RRFB to a pedestal, signal pole, or mast arm.

Figure 12-20 | RRFB Bubble Notes and Plan Call Out Structure



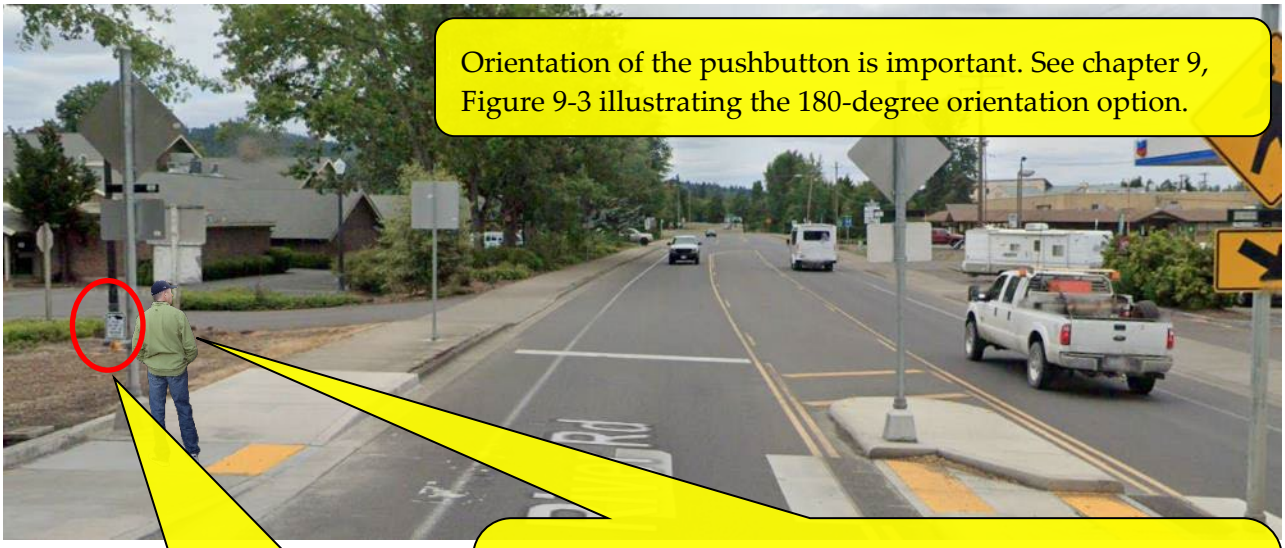
12.9.3 Pushbutton Requirements

Pushbuttons shall be provided according to the requirements stated in chapter 5. The Additional guidance presented below only applies only to RRFB installations.

General:

- See standard details DET 1770 and DET 1771 for the typical layout/geometry of a mid-block crossing and pushbutton locations.
- When possible, combining the pushbutton with the RRFB assembly is preferred to avoid installation of multiple support structures.
- When possible, the pushbutton should be located in such a way that when the pedestrian pushes the pushbutton, they will be facing oncoming traffic. In general, pedestrians will tend to face the pushbutton sign (so they can read it) when they push the pushbutton. See Figure 12-21.

Figure 12-21 | Preferred Pushbutton Placement to Provide Line of Sight to Oncoming Traffic



Pedestrian refuge islands:

Section 5.1.5 raised median islands and crosswalk alignment does not apply to RRFB installations. This is because an RRFB is only a warning device and does not assign right-of-way to the pedestrian or the vehicle (e.g., a pedestrian is not required to activate the RRFB to legally enter the crosswalk and vehicles must still stop for a pedestrian legally entering the crosswalk). Pushbuttons in median islands as discussed in section 5.1.5 applies only to pushbuttons that assign right-of-way (e.g., require activation to legally enter the crosswalk via a pedestrian phase).

A refuge island is common for an RRFB installation (see ODOT Traffic Manual). The design and operation of a typical RRFB will allow for the majority of pedestrians to traverse the entire crosswalk without needing to take refuge and re-activate the RRFB via a pushbutton in the refuge island. Typically the refuge island is small, crosswalk alignment is straight, and the RRFB indications for both directions of traffic activate simultaneously and are timed for the entire crossing upon any pushbutton activation. However, this is not true for all design configurations or all potential users and therefore it is important to consider providing a way to re-activate the RRFB when there is higher likelihood that users will desire or need to take refuge in the island. As such, a pushbutton should be installed in the refuge island in any of the following conditions:

- The RRFB is installed at a roundabout. Locate the pushbutton in the splitter island separating the entry and exit vehicles. See Figure 12-22. Additional roundabout specific considerations are shown in Figure 12-23.
- The total motor vehicle lanes crossed by the pedestrian is 4 or greater. See Figure 12-24.
- The refuge island is wide and/or requires pedestrians to walk a significant distance due to a staggered crosswalk alignment. See Figure 12-25 and Figure 12-26. These configurations may be good candidates to operate as a two-stage crossing.
- A CQCR request has been made.

A pushbutton shall be installed in refuge island when:

- The RRFB devices operate as a two-stage crossing (i.e., RRFBs for each direction of vehicle travel are activated independently).

The operational approval will state the requirements for the RRFB operation and crosswalk location(s).

Figure 12-22 | Refuge Island Pushbutton Recommended: RRFB Installed at a Roundabout

RRFB indications are typically required for multi-lane pedestrian crossings at roundabouts.





Note: A single entry or exit lane is considered a part of the entire crosswalk and will require RRFB indications if there is a multi-lane crossing on the same approach leg.



The roadway alignment for vehicles entering and exiting a roundabout makes it much harder for a pedestrian to judge when a vehicle will stop, especially for pedestrians with visual impairments. The roadway alignment also makes it difficult to place the RRFB indications that are in the driver's line of sight at all times. Based on these conditions, a pushbutton in the splitter island is recommended. It allows a pedestrian to take extra time in the refuge island to ensure vehicles have time to perceive and react to them and the RRFB indications.

A two-stage crossing operation at a roundabout may be an option, but given the roadway alignment issues, a one-stage crossing operation may be desirable to provide a longer duration of flashing time to improve the odds of drivers seeing the activated RRFB device BEFORE the pedestrian even reaches the splitter island.

Figure 12-23 | Roundabout Specific Considerations: By-Pass Lane

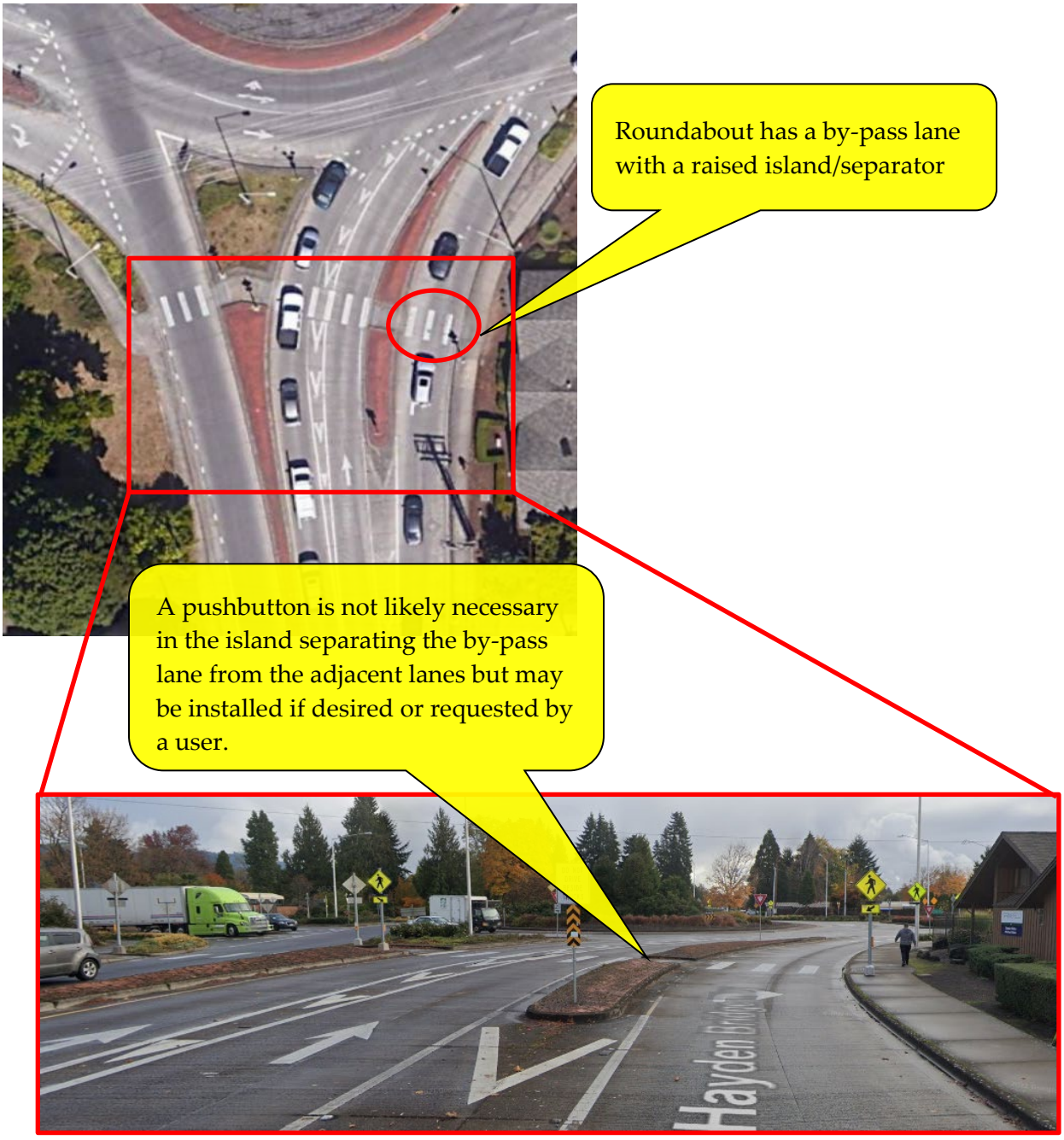


Figure 12-24 | Refuge Island Pushbutton Recommended: Total Number of Lanes Crossed by the Pedestrian is Greater Than Four



Figure 12-25 | Refuge Island Pushbutton Recommended: Wide Refuge Island



Wide refuge island requires pedestrians to walk a significant distance: Refuge island pushbutton is recommended.

Note: In this example, two pushbuttons are likely required to meet section 5.4.2 requirements. A two-stage crossing operation is also an option.

Figure 12-26 | Refuge Island Pushbutton Recommended: Staggered Crosswalks Requiring Pedestrians to Walk a Significant Distance



Staggered crosswalks require pedestrians to walk a significant distance: Refuge island pushbutton is recommended.

Note: In this example, two pushbuttons are likely required to meet section 5.4.2 requirements. A two-stage crossing operation is also an option.

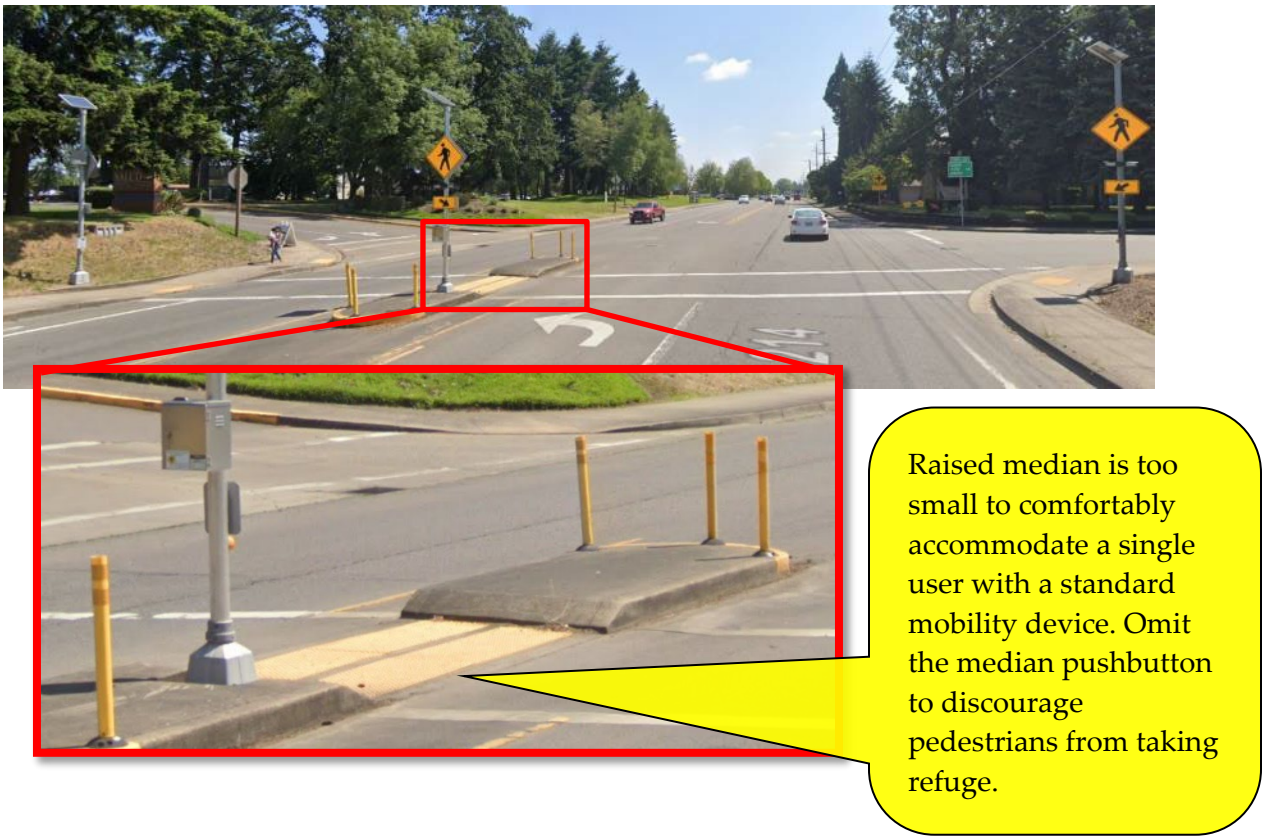
A one-stage crossing operation will activate all RRFB devices simultaneously upon activating any pushbutton (the most common type). This requires only one pushbutton in the refuge island to properly activate the RRFB devices. It should be placed in the center of the refuge

island to provide the best access for both directions of pedestrian travel and to lessen the chance of being struck by an errant vehicle. For really wide refuge islands or refuge islands with crosswalks staggered by a large distance, two pushbuttons may be required to meet the 15-foot maximum path of travel from the pushbutton to the curb ramp edge (see section 5.4.2).

A two-stage crossing operation will activate the RRFB devices for each direction of travel independently (for each stage of the crossing). This requires two pushbuttons in the refuge island to properly activate the RRFB devices. Adequate separation/staggering of each crossing is required to clearly indicate to all users that the entire crossing is always traversed in two distinct, independent stages. See Figure 12-25 and Figure 12-26 for examples where two-stage crossing operation may be a good solution.

A pushbutton is not recommended in a raised median, refuge island, or splitter island that is not wide enough to accommodate a single user with a standard mobility device (e.g., a 5-foot wide or smaller). See Figure 12-27. In these cases, it is best to discourage all pedestrians from taking refuge in the median/island by omitting the pushbutton. If a pushbutton is requested or desired at a location where the median/island is not ideal for all pedestrians to take refuge, the median/island and roadway cross section should be re-designed accordingly.

Figure 12-27 | Omit Pushbutton in Small Raised Medians



If the pushbutton is omitted from any refuge island, the refuge island shall still be designed to allow an accessibility compliant installation of the pushbutton in the future (e.g., in the event of a CQCR request). Conduit for future use shall be installed with a junction box located where the future pushbutton pedestal foundation should be located. Alternatively, if an RRFB assembly is placed in the refuge island, locate it in such way that a pushbutton could easily be added to the pole.

12.9.4 Location of Assemblies

RRFBs are located at or immediately adjacent to an uncontrolled, marked crosswalk. For each approach on which RRFBs are used, two assemblies are required, one on the right side of the roadway and one on the left side of the roadway. On a divided highway or a roadway with a median island pedestrian refuge, the left side assembly should be installed in the median. See the ODOT Traffic Manual for additional information.

12.9.5 Advance Sign Assemblies

Advance warning signs with an RRFB may be required if sight distance is not adequate to the crosswalk where the RRFBs are used. This requirement, if necessary, will be contained in the operational approval. The RRFBs on the advance warning signs shall be activated and cease operation simultaneously with the RRFBs at the crosswalk location.

12.9.6 Illumination

Illumination (front-lighting the pedestrian) is the standard for RRFB installations. This will often result in one luminaire at each end of the crosswalk, located in front of the crosswalk for each direction of approaching vehicle traffic. See Figure 12-28. Refer to the ODOT Traffic Manual and the Traffic Lighting Design Manual for additional information.

Figure 12-28 | RRFB Illumination Example



12.9.7 Service Cabinet and Wiring to RRFB Controller Cabinet

When commercial power is used for an RRFB, a BMC or a BMCL (as appropriate) should be used. The wiring from the service cabinet to the RRFB controller cabinet is two No. 10 AWG XHHW wires.

Note that No. 10 AWG wires are smaller than the No. 6 AWG XHHW wires used from the service cabinet to a traffic signal controller cabinet, as the No. 6 AWG wires can be too big to terminate easily (or at all) in the RRFB controller cabinet. As such, TM485 contains a note requiring a 20A circuit breaker for the RRFB (appropriately sized for using smaller No. 10 AWG wire) vs. the 60A circuit breaker for the traffic signal (appropriately sized for using the larger No. 6 AWG wire). Appropriately sizing the circuit breaker and the wires is important for the circuit breaker to function appropriately and avoid a fire hazard.

12.10 Speed Limit Sign Beacon

The only speed limit sign beacon that is allowed on the state highway system is for school speed zones, in accordance with Oregon Revised Statute 811.111.

This type of flashing beacon is a green sheet item and has two categories:

- Actuated flashing beacon assembly: school
- Actuated flashing beacon assembly: school + speed feedback (integrated system)

See standard detail DET4454 (school) and DET 4455 (school + speed feedback) for more design information and how to properly detail these types of flashing beacons on a plan sheet.

Beacons for school speed zones (without a speed feedback sign) consist of two type 1Y signal heads (one mounted above the sign and one mounted below the sign) on a pedestal as shown in standard detail DET4454. See Figure 12-29 for an example. Beacons for school speed zones with a speed feedback sign (integrated system) consist of one type 1Y signal head mounted above the sign with the speed feedback sign mounted below the sign as shown in standard detail DET4455.

The location of this sign is determined as per the requirements shown in the ODOT Sign Policy and Guidelines, chapter 7. Work with the sign designer and region traffic to ensure this sign is located correctly.

One option to be aware of for the school zone warning beacon is the use of a rear-facing type 1Y signal head. The rear-facing beacon should be used in the situation where side road traffic (that DOES NOT have a warning beacon) enters from within the designated school zone.

Figure 12-29 | Speed Limit Beacon for School Speed Zone



12.11 Stop Sign Beacon

Stop sign beacons are installed above the STOP sign and can be an effective and less costly measure to install when compared to an intersection control beacon.

This type of flashing beacon is a green sheet item: 24/7 flashing beacon assembly: red FOR SOLAR ONLY (note: if this beacon is using commercial power, it is NOT a green sheet item and will require a BMCF for the power and the control system).

Stop sign beacons require one type 1R signal head mounted directly above the sign on the support post. If solar power is used, the support post may be either a standard wood post or a Perforated Steel Square Tube (PSST). There are two standard details, DET4681 (PSST) and DET4670 (wood post) that should be used. See Figure 12-30. If commercial power is used, the support post is required to be a pedestal. See standard detail DET4452 (pedestal support). Standard detail DET4452 also contains additional design information and how to properly detail this type of flashing beacon on a plan sheet.

Figure 12-30 | Stop Sign Beacon



12.12 Intersection Control Beacon

Intersection control beacons are used at intersections to supplement the traffic control at the intersection. ODOT takes a conservative approach to installing intersection control beacons as other treatments may be more effective in warning traffic of an upcoming intersection. See the ODOT Traffic Manual for more information and alternative solutions.

Intersection control beacons are always mounted overhead. See Figure 12-32 and Figure 12-33 for examples. Standard practice is to use a mast arm pole and mount the flashing beacons on a single mast arm oriented diagonally across the intersection. See Figure 12-34. This will allow the beacons to be as close to the center of the intersection as possible.

Intersection control beacons typically have beacons that face each approach of the intersection. However, there may be cases where only the mainline approaches or only the side street approaches have beacons, as determined by the engineering study documented in the RTE operational approval. Each approach requiring beacons shall have 2 beacons:

- Type 1Y signal heads for free flow operation
- Type 1R signal heads for stop controlled operation

The red indication for stop-controlled operations is only supplemental to a STOP sign and therefore a STOP sign is required on each approach having a red flashing beacon. Flashing yellow indications shall not face conflicting vehicular approaches.

Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum. Lateral placement of the beacons should be as shown in Figure 12-31.

A base mounted flasher cabinet (BMCF) provides power and serves as the control system. See standard drawing TM485 for the wiring diagram. ODOT uses a model 204 flasher, which provides two alternating flash circuits. Beacons are wired with one 7-conductor No. 14 AWG control cable for each direction (flash circuit).

Figure 12-31 | Intersection Control Beacon Placement

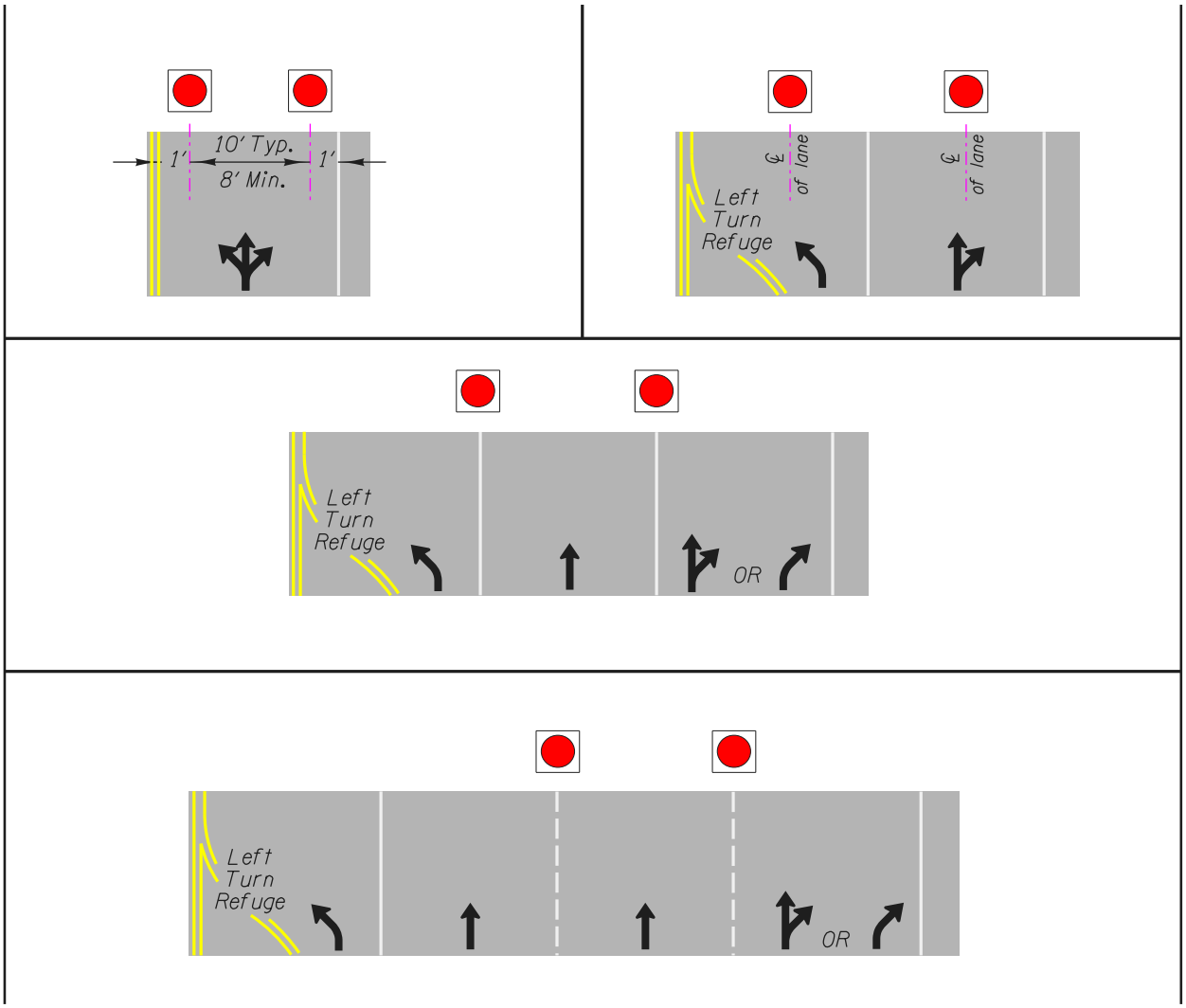


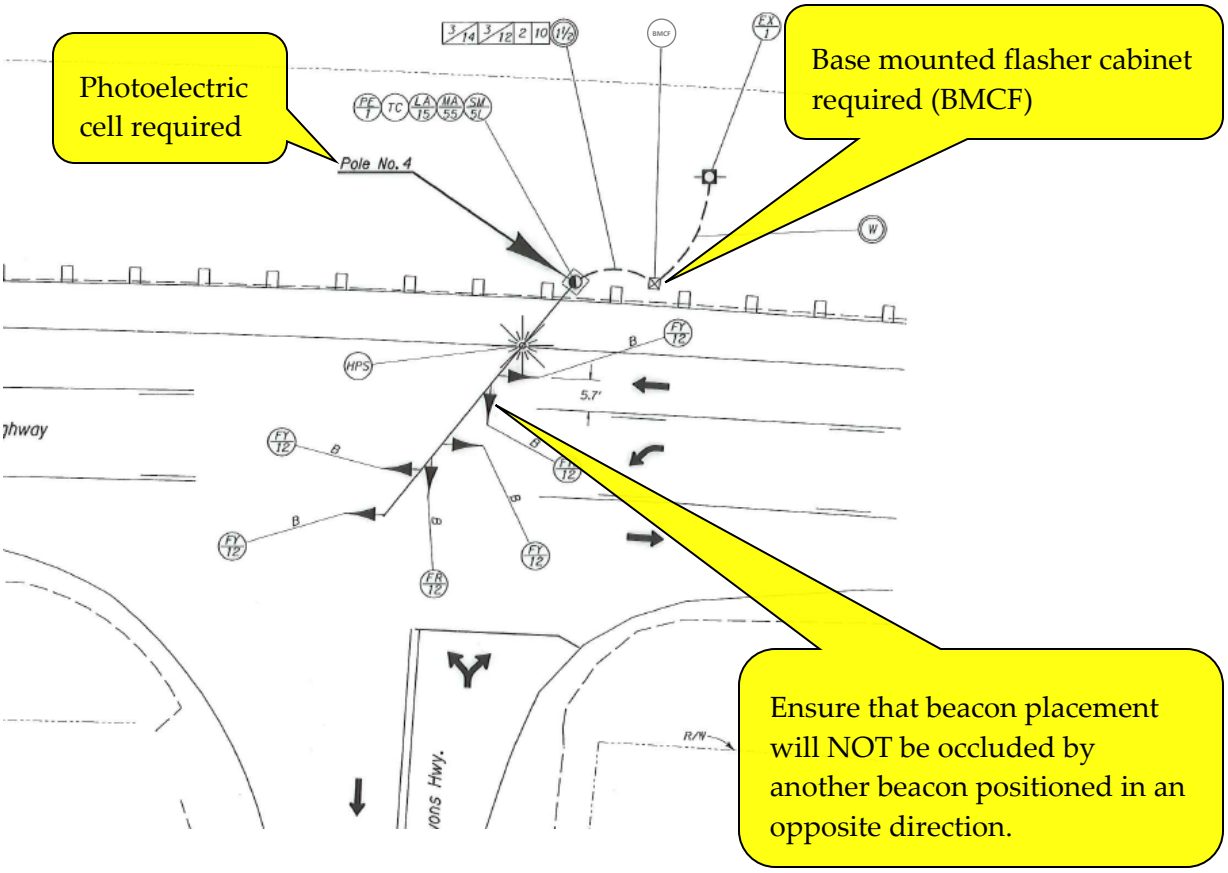
Figure 12-32 | Intersection Control Beacon, Mast Arm Example 1



Figure 12-33 | Intersection Control Beacon, Mast Arm, Example 2



Figure 12-34 | Intersection Control Beacon, Span Wire, Example 3



12.13 Pedestrian Hybrid Beacon

Pedestrian hybrid beacons (PHB) are generally not installed on the state highway for the following reasons:

- ODOT and local agencies have installed PHBs in the past with minimal success due to driver confusion, even after trying various different strategies beyond local education to improve driver understanding.
- Local agencies have reported that coordinating a PHB in a signal system leads to additional confusion for both the pedestrian and driver. Because PHB indications for the driver rest in "dark" mode until just prior to the pedestrian phase being served, a coordinated PHB will result in drivers approaching a dark PHB that will remain dark for a certain duration after the pedestrian activates the pushbutton and makes their intent to cross clear. Dark traffic signals are treated as an uncontrolled intersection (as per ORS 811.275) and drivers must then follow ORS 811.028 which requires them to stop and remain stopped for a pedestrian that moves into the crosswalk with the intent to proceed. However, a pedestrian at the PHB will still be facing a solid don't walk indication and therefore shouldn't start the crossing. The longer the delay between the pushbutton activation and the activation of PHB indications for the driver (to allow the pedestrian phase to be served), the more unpredictable driver and pedestrian behavior becomes. The only way to prevent this type of confusion is to always immediately activate the PHB indications for the driver upon pushbutton activation (e.g., coordination is not possible).

In lieu of a PHB, a pedestrian signal (see chapter 14) or an overhead RRFB (see section 12.9) are preferred alternatives to consider. See the ODOT Traffic Manual and contact the state traffic operations engineer for more information about completing the engineering study and requesting operational approval for pedestrian signals or RRFBs.

13 Ramp Meters

This chapter discusses only ramp meter specific design information. Other general information that also may also pertain to ramp meters (e.g., signal wiring, detection, etc.) can be found in the previous chapters of this manual.

Installation of a new ramp meter or modification of an existing ramp meter requires region traffic engineer operational approval as per chapter 3.

13.1 Ramp Meter Operation

Ramp meters are used to control the frequency of traffic entering a highway facility. By controlling the rate of vehicles entering the highway, the traffic flow on the highway facility becomes more consistent and allows for more efficient use of existing highway capacity. They are programmed to release one vehicle at a time. Just prior to activating, the ramp meter indications will flash yellow (from the yellow indication of the type 2 signal head) for a short, predetermined amount of time to warn traffic that the ramp meter is starting up. The ramp meter will then display a solid yellow interval followed by an all red interval prior to the start of the normal red-green alternating ramp meter cycle.

For ramp meters that control two or more lanes of traffic, each indication for each lane must operate on a separate phase to properly alternate the red-green phase between each lane.

Ramp meters remain dark when not in use.

13.1.1 Location of the Ramp Meter Stop Line

The location of the ramp meter stop line is determined by engineering judgment. Each ramp alignment is unique, and the site specifics play a major role in determining the most appropriate location. The basic goal is to place the stop line far enough down the ramp to provide reasonable storage of vehicles but not so near the highway that acceleration and merging onto the highway becomes a problem. Some things to consider determining the most appropriate location:

- Design hour queue length: The operational analysis and RTE operational approval will determine the required length for storage.
- Ramp alignment length (from ramp entrance to the painted gore point): the ramp alignment length should accommodate the design hour queue length if possible.
- Number of lanes controlled by the ramp meter: the number of lanes needed will be addressed in the operation analysis and RTE operational approval. This will directly affect the required queue length. Single and dual lane ramp meters are common.
- The vertical grade: a downhill vertical grade will allow the stop line to be placed closer to the highway, while an uphill vertical grade will require additional space between the stop line and the merge point.

- The length of acceleration lane (from painted gore point to the downstream acceleration lane taper point): a standard length acceleration lane will allow the stop line to be placed closer to the highway, while a substandard length acceleration lane may require additional space between the stop line and the merge point.
- Sight distance from stop line to the highway: the location where vehicles stop should have adequate sight distance to the highway to help facilitate a safe and efficient merge.
- Percentage of truck traffic using the ramp: trucks require more distance to come up to speed and may require additional space between the stop line and the merge point.

Work with region traffic and the roadway designer when determining the appropriate location.

13.2 Ramp Meter Signal Indication Mounting

There are two choices for mounting ramp meter signal indications: on a pedestal or overhead (mast arm). The pedestal mount is used unless there is a specific reason that requires an overhead mount, such as:

- The ramp meter will control more than 2 lanes of traffic. See Figure 13-1 for an example.
- The ramp meter will control 2 lanes of traffic with the stop line located beyond the physical gore point of ramp. See Figure 13-2 for an example.
- Physical constraints prevent proper location of pedestal(s), such as: retaining walls, bridges, barrier, sound walls, etc.). See Figure 13-3 for an example.

Figure 13-1 |Ramp Meter Controls More Than 2 lanes of Traffic – Requires Overhead Mount



Figure 13-2 |Ramp Meter Controls 2 Lanes of Traffic with Stop Line Located Beyond Physical Gore Point – Requires Overhead Mount

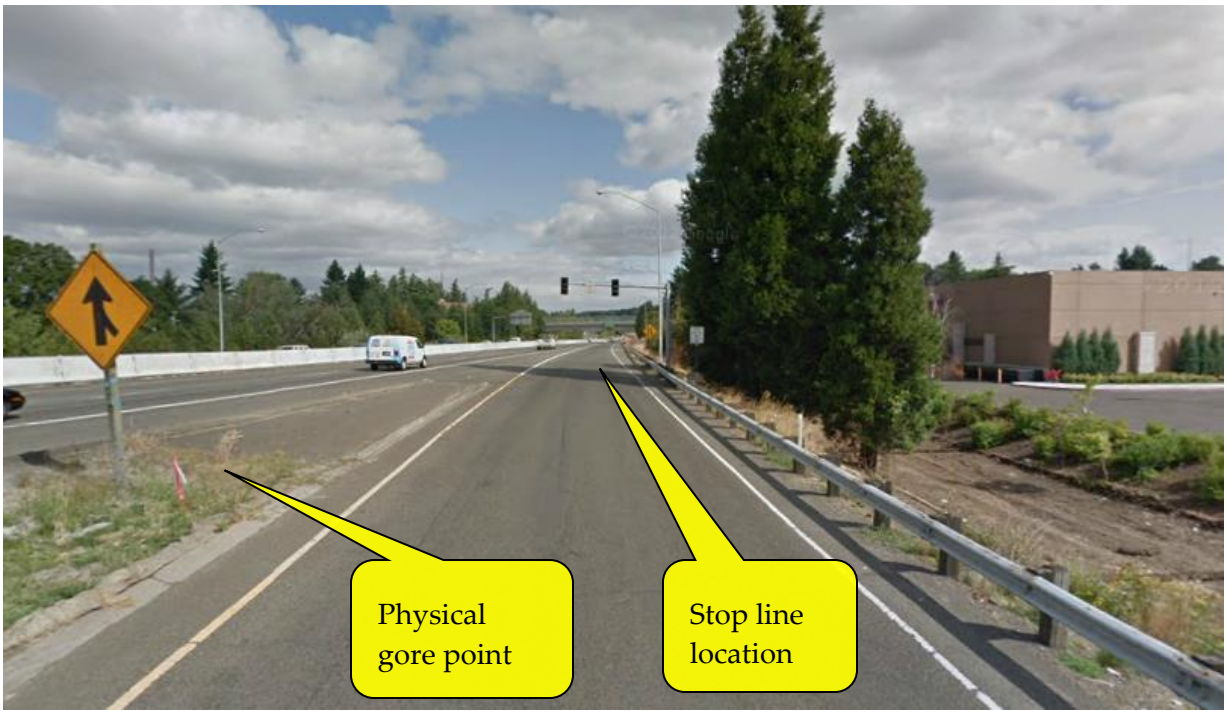


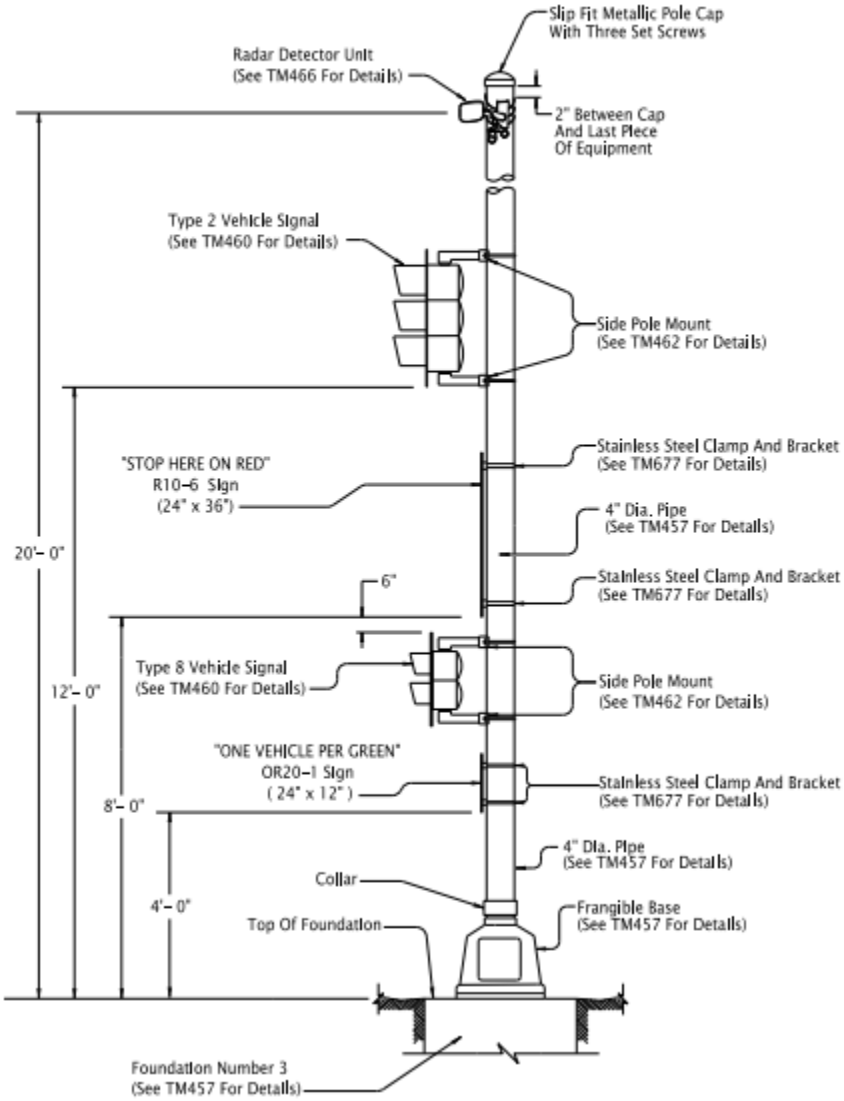
Figure 13-3 | Physical Constraints (Barrier on Left Side) - Requires Overhead Mount



13.2.1 Ramp Meter Signal Assembly (Pedestal)

The ramp meter signal assembly is mounted on pedestal (foundation number 3) and includes the following four traffic control devices as per standard drawing TM492 (listed from top to bottom of pedestal): a type 2 vehicle signal head, a "STOP HERE ON RED" aluminum sign, a type 8 vehicle signal head, and a "ONE VEHICLE PER GREEN" aluminum sign. A near-range radar detector unit is also typically mounted at the top (one detector unit for the stop location). See Figure 13-4.

Figure 13-4 | Ramp Meter Signal Assembly TM492 (Pedestal)



For a ramp meter that will control a single lane of traffic, this pedestal assembly is required only on the right side for a ramp. See Figure 13-5. For a ramp meter that will control two lanes of traffic, this pedestal assembly is required on both the sides of the ramp. See Figure 13-6.

Figure 13-5 |Ramp Meter Signal Assembly Example – Controlling a Single Lane of Traffic

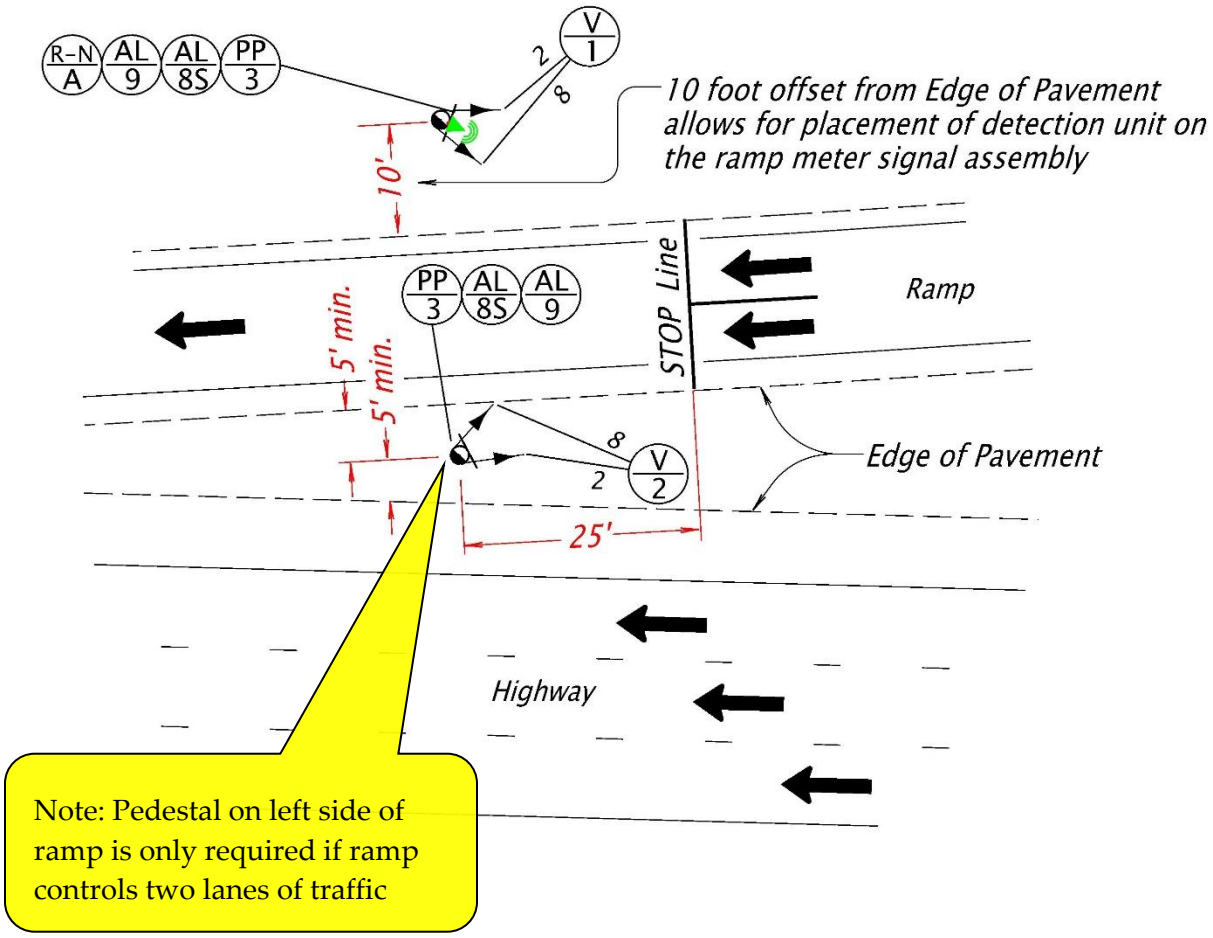


Figure 13-6 |Ramp Meter Signal Assembly Example – Controlling Two Lanes of Traffic



The ramp meter signal assembly is placed 25 feet from the stop line location. Lateral placement on the right side of the ramp is 10 feet from the edge of pavement to allow for placement of a detector unit. Lateral placement on the left side of the ramp is 5 feet minimum from both edges of pavement. See Figure 13-7.

Figure 13-7 | Location of Ramp Meter Signal Assembly from the Stop Line



13.2.2 Overhead Mounted (Mast Arm)

Overhead mounted ramp meter signals require a type 2 vehicle signal head and an aluminum "ONE VEHICLE PER GREEN" sign for each lane that is controlled by the ramp meter. The "ONE VEHICLE PER GREEN" sign used overhead is 24"x30". Type 8 heads are NOT used when indications are mounted overhead. The overhead signal indications are located 55 feet from the stop line. The mast arm pole should be 10 feet from the edge of pavement to allow for placement of the detection unit on the mast arm or pole. Two aluminum "STOP HERE ON RED" signs are located at the stop line, one on each side of the ramp (these signs are standard ground mounted signs that are shown and detailed on the sign plan sheets). See Figure 13-8 and Figure 13-9 for an example.

Figure 13-8 | Overhead Mounted Details

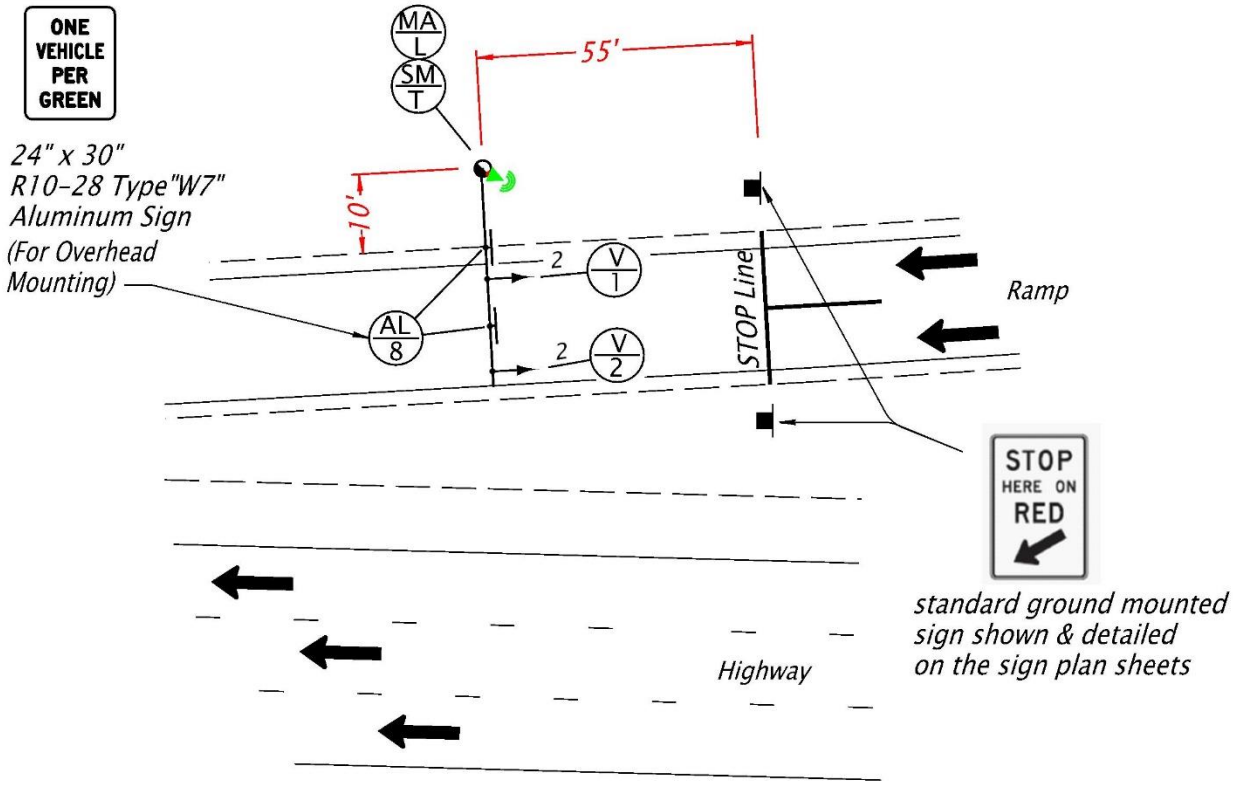


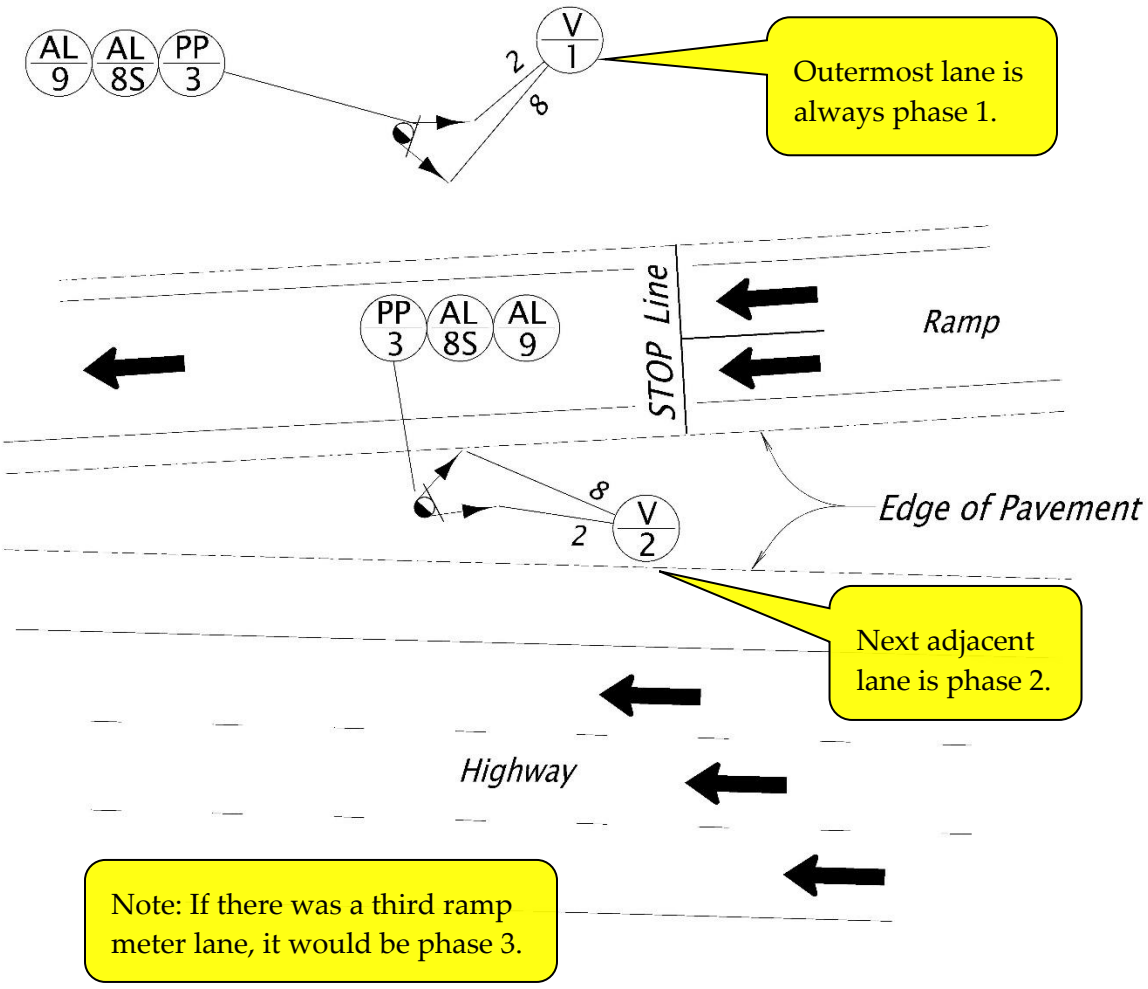
Figure 13-9 | Overhead Mounting Example



13.2.3 Ramp Meter Phasing

Each lane controlled by the ramp meter will be assigned a unique phase, starting with phase 1. When two (or more) lanes are controlled by the ramp meter, phase 1 is always the outermost lane of the ramp, which each adjacent lane towards the highway being assigned the next consecutive phase. See Figure 13-10.

Figure 13-10 | Ramp Meter Phasing



13.3 Ramp Meter Signs

The standard layout for ramp meter signing is discussed and shown in the following sections. See Figure 13-11 for ramp meter signal assemblies and Figure 13-12 for overhead mounted ramp meters.

13.3.1 Ramp Metered When Flashing Sign (With Flashing Yellow Beacon)

This sign is required for all ramp meter installations. It is located at the entrance to the ramp, and it should be visible to each legal move that enters the ramp. This may require more than one sign depending on the ramp terminal geometry. The main purpose of this sign is to provide advance warning that the ramp meter is operating, and drivers should be prepared to stop as they proceed down the ramp. Depending on the ramp configuration and ramp terminal geometry/lane use, it also can provide information before the driver commits to entering the ramp, allowing the driver to seek an alternate route if desired. However, use of this sign to make a decision on an alternate route is not a critical message the following reasons:

- There may not be a viable alternate route in the immediate vicinity after seeing the sign.
- At the majority of ramp configurations, the driver must commit to making the movement onto the ramp well in advance of the ramp entrance when these signs aren't yet visible (typically getting into a right or left turn only lane at an intersection or just proceeding on a roadway that ends as a ramp merging onto the highway).
- Many drivers use modern navigation systems that can provide excellent directions and alternate routes based on real-time traffic data. This allows drivers to plan their routes better and have advance notice of traffic congestion.

The standard placement of this sign (at the entrance of the ramp) should provide adequate advance warning of the ramp meter operation at the majority of ramps, even when the visibility to the ramp meter indications does not meet minimum MUTCD requirements. However, this sign may also be used further down the ramp if an engineering study deems an additional supplemental warning sign is necessary due to a unique ramp geometry (e.g., a very long ramp with multiple curves). If used as a supplemental warning, two signs are required (one on each side of the ramp) and they should be located upstream from the anticipated queue length. The need for these supplemental signs will be documented in the RTE operational approval.

This sign is mounted on a pedestal as per standard drawing TM492. It is detailed on the ramp meter plan sheet and paid for under the ramp meter lump sum bid item.

13.3.2 Form 2 Lanes When Metered Sign

This sign is required only for single lane ramps with ramp meters that control two lanes of traffic. It is located upstream from the anticipated queue length. Two signs are required, one on each side of the ramp.

This sign is mounted on an appropriate standard sign support (e.g., wood post or square tube sign support). It is detailed on the signing plan sheet (NOT on the ramp meter plan sheet) and is measured and paid for under the applicable sign and post bid items.

13.3.3 Stop Here on Red Sign

This sign is required at the stop line. If the ramp meter only controls one lane of traffic, only one of these signs is required, preferably with the ramp meter assembly on the right side of the ramp. For all other applications, two of signs are required, one on each side of the ramp.

For ground mounted installations, this sign is part of the standard ramp meter signal assembly which is detailed on the ramp meter plan sheet and paid for under the ramp meter lump sum bid item.

For overhead mounted ramp meters, this sign is ground mounted at the stop line on an appropriate standard sign support (e.g., wood post or square tube sign support) which is detailed on the signing plan sheet (NOT on the ramp meter plan sheet) and is measured and paid for under the applicable sign and post bid items.

13.3.4 One Vehicle Per Green Sign

This sign is required for all installations, one for each lane of traffic controlled by the ramp meter.

For ground mounted ramp meter installations, this sign is a part of the standard ramp meter signal assembly. For overhead mounted ramp meters this sign is installed with an adjustable sign bracket adjacent to each signal indication. Note the ground mounted sign is a smaller in size than the overhead sign (making it a different sign number). In both cases, it is detailed on the ramp meter plan sheet and paid for under the ramp meter lump sum bid item.

13.3.5 Coordinating Sign Placement on Ramp

Other signs on the ramp (e.g., merge, lane transition, curve w/advisory speed, etc.) will need to be taken into consideration when locating the signs and equipment specific to the ramp meter. Work with the sign designer to coordinate the locations of all traffic control devices needed on the ramp.

Figure 13-11 | Ramp Meter Sign Layout – Ramp Meter Signal Assemblies

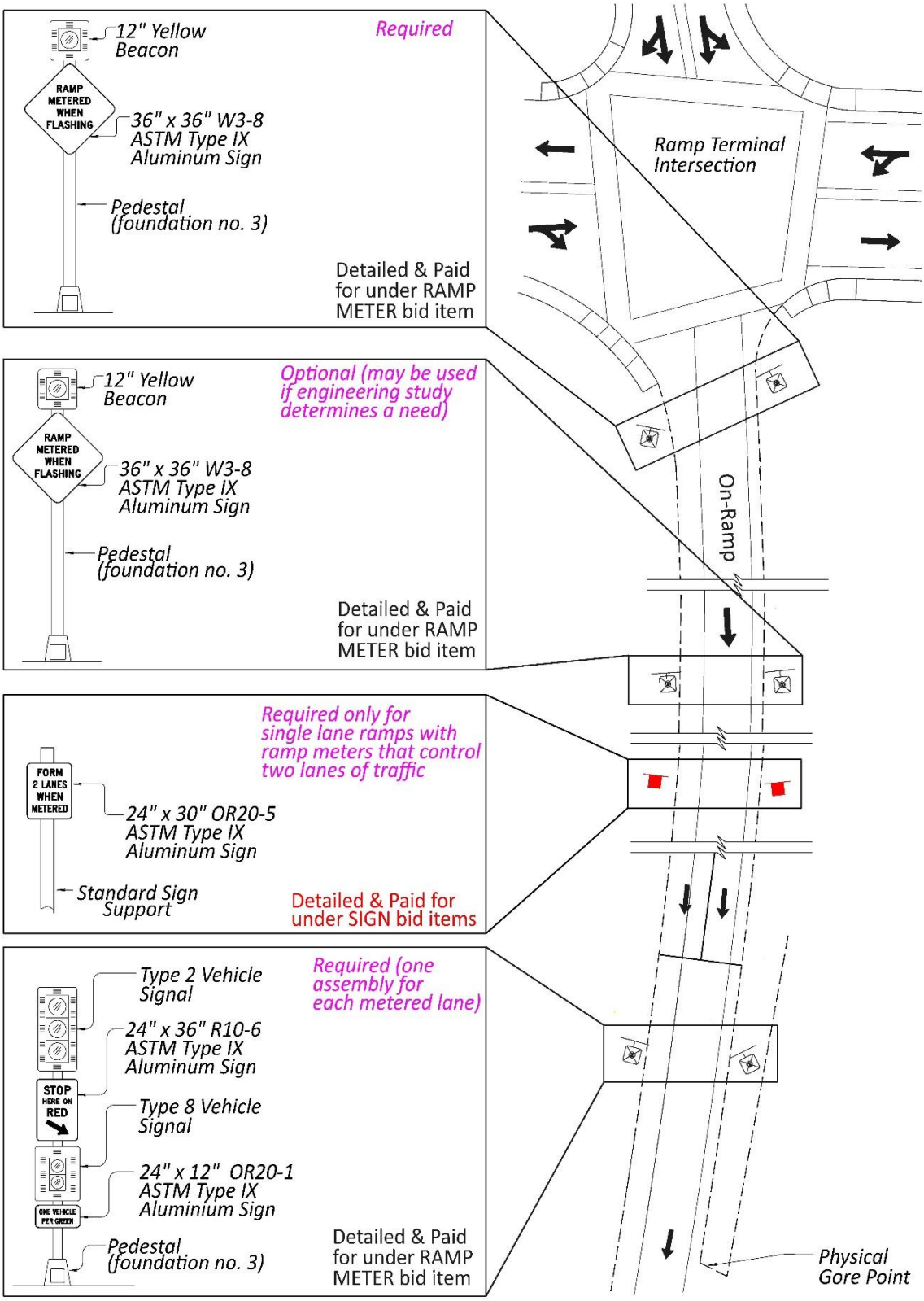
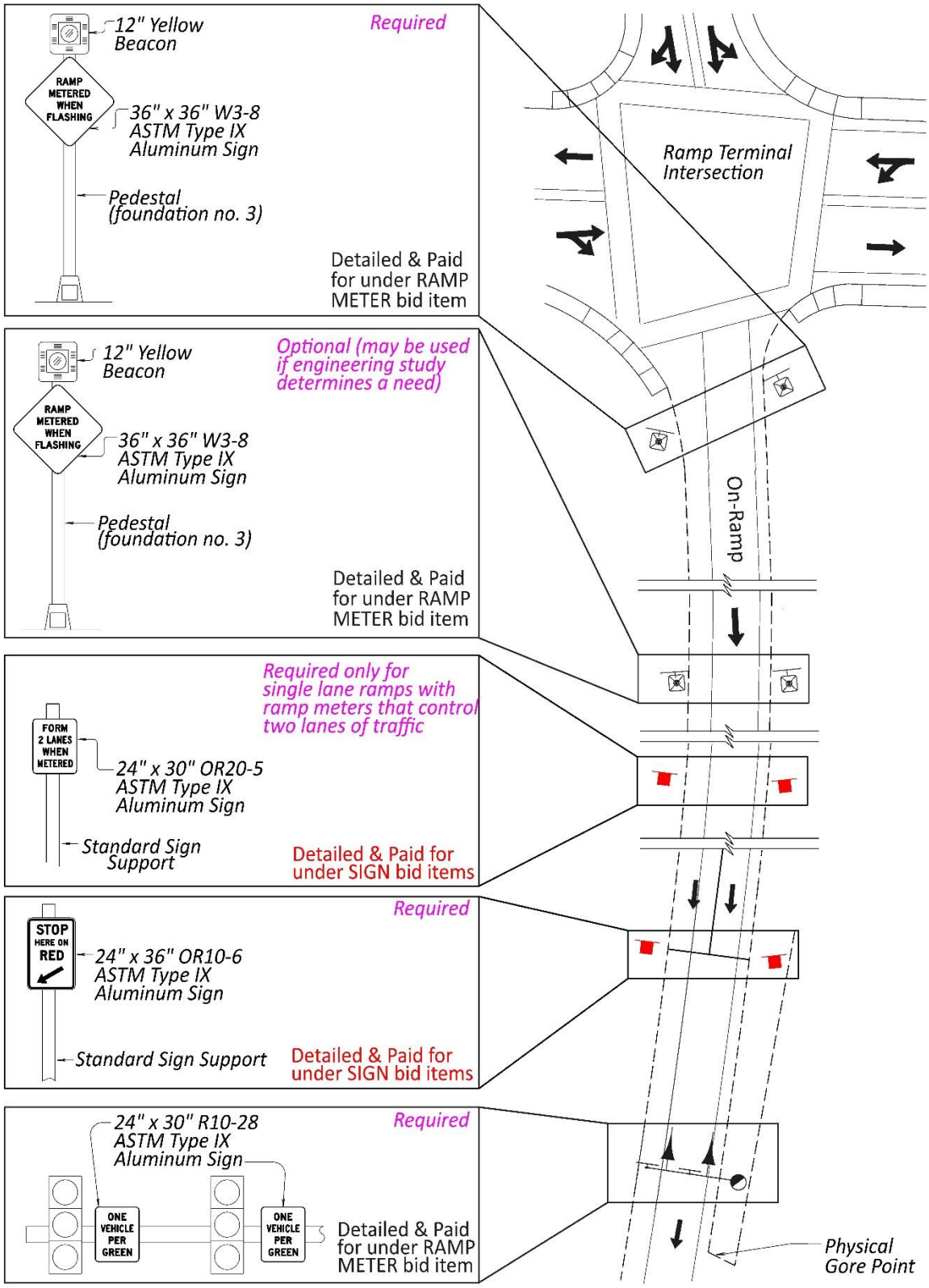


Figure 13-12 | Ramp Meter Sign Layout – Overhead Mounted Ramp Meter Assemblies

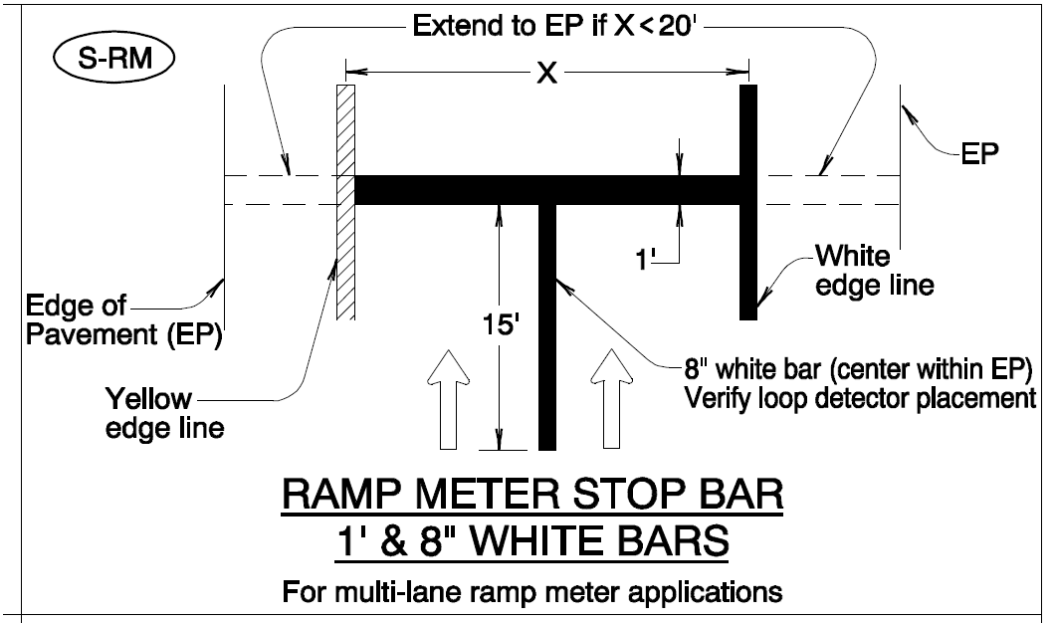


13.4 Ramp Meter Striping

The ramp meter requires a stop line. For single lane ramps with a ramp meter that controls two lanes, an 8-inch wide white line is extended back from the stop line as per standard drawing TM503, detail "S-RM". See Figure 13-13.

Ramp meter striping is detailed on the striping plans and paid for under the striping bid items. Work with the striping designer.

Figure 13-13 | Ramp Meter Striping (TM503)



13.5 Ramp Meter Cabinets and Controllers

Ramp metering devices are controlled by an ATC controller in a model 334 ground-mounted controller cabinet. The ATC controllers are agency supplied and purchased by the agency through a price agreement managed by ITS.

The service cabinet for ramp meters is the standard base mounted service cabinet (BMC) that is also used for traffic signals.

The controller cabinet and service cabinet should be located near the ramp meter signal indications for ease of maintenance and operational convenience. Include a maintenance landing pad for maintenance vehicle access near the controller (see standard drawing RD160).

13.6 Ramp Meter Detection

Radar detection is the standard form of detection for ramp meters. This section provides ramp meter detection specific information. Refer to chapter 6 for more general information related to detection.

13.6.1 Detector Functions, Location, and Placement

Ramp meter detection serves three different functions as described below. Queue detection is no longer used.

- Demand: This type of detection is approximately 15 feet long and located at the stop line. It is used to place a call into the controller to bring up the green phase of the ramp meter cycle.
- Passage: This type of detection is a small zone located 15 feet downstream from the stop line. It is used count ramp meter traffic, perform truck extension, and violation extension.
- Count: This type of detection is located on the freeway main line. Typically this detection is installed just downstream of where the on-ramp merges onto the highway, but the exact location on the freeway is determined by region traffic and the ITS unit.

Near-range radar units are used for demand and passage detection zones. See Figure 13-14 and Figure 13-15 for an illustration of the detection zones and placement of the radar detector unit (either on the ramp meter signal assembly or on the mast arm). The signal designer is responsible for detailing the demand and passage detection system on the ramp meter plans.

Side fire radar units are used for count detection zones. See Figure 13-16 for an illustration of the count detection zones and general placement of the side-fire detection unit. Coordinate with both region traffic and the ITS unit for determining the count detection location, necessary equipment, and responsibility for design work. There are two options for providing the count detection (note that the side fire radar unit will become an ITS asset regardless of which option is chosen, so coordination with the ITS unit is always required):

- Count detection provided via a stand-alone ITS count site (with ITS controller cabinet), separate from the ramp meter controller cabinet: This is the typical arrangement in region 1 with the ITS count site often co-located with PTZ cameras. In this case the ITS designer is responsible for detailing the entire count detection system on ITS plan sheets. If the ITS unit does not provide an ITS designer for the project, the signal designer may produce the ITS plan sheets, under the direction of the ITS unit using their unpublished design aids.
- Count detection provided via the ramp meter controller cabinet: If the count detection will be provided by the ramp meter controller cabinet, the signal designer is responsible for detailing the entire count detection system on the ramp meter plan sheets.

Mounting radar detector units to stand-alone pedestals or poles may be necessary to get the

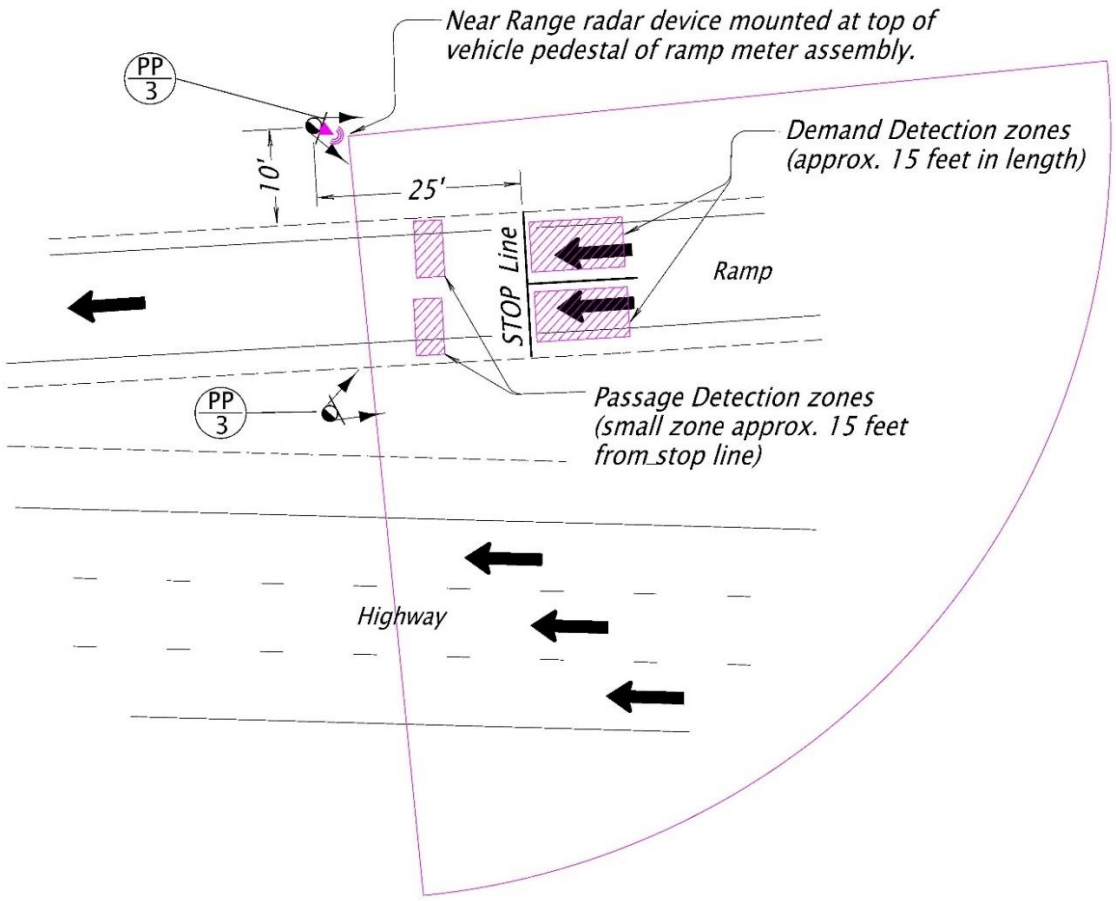
desired detection zone coverage. If a pedestal will not provide the proper mounting height (as per the manufacturer requirements), the ITS unit has some details for fiberglass poles that may be used instead. Contact the ITS unit for these details. Mounting detector units on luminaire poles is also a possibility if the power for the detector unit and the illumination comes from the same service cabinet.

Verify maintenance access to each radar unit with the electrical crew. Evaluating the cross-section slopes, available shoulder, detector unit mounting heights, and bucket truck/ladder limitations is critical to safely maintaining a ramp meter installation, both for the public and the maintainer. If a location does not meet the needs for maintenance, the following solutions should be considered:

- A maintenance landing pad (see standard drawing RD160)
- Flattening a slope
- Widening a shoulder
- Alternative device location

Note: The ITS unit has a price agreement for certain radar units. If radar devices are installed on a project, ALL radar devices on the project need to be consistent. Either ALL are Agency supplied (using the price agreement and adding "(Agency supplied)" to the appropriate bubble notes), or ALL are supplied by the contractor (using the standard bubble notes). **Contact the ITS standards engineer to notify and coordinate using the radar price agreement on a project.**

Figure 13-14 | Demand & Passage Detection Layout, Detector Unit Mounted on Pedestal



NOTE: If pedestal cannot be placed as shown with respect to the stop line and edge of pavement, the detection unit should be mounted on a stand-alone pedestal or pole that can provide proper coverage for the detection zones.

Figure 13-15 | Demand & Passage Detection Layout, Detector Unit Mounted on Mast Arm

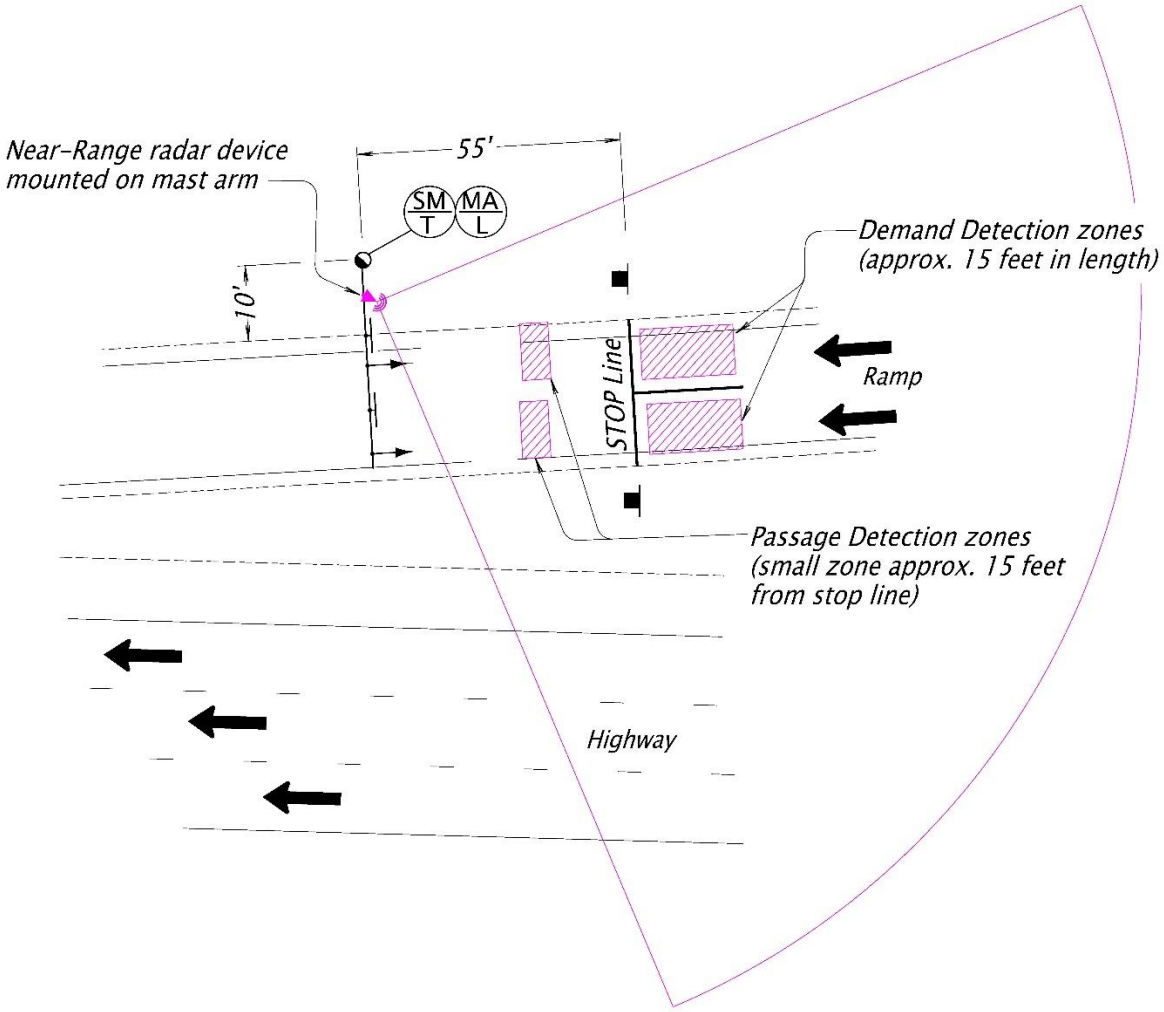
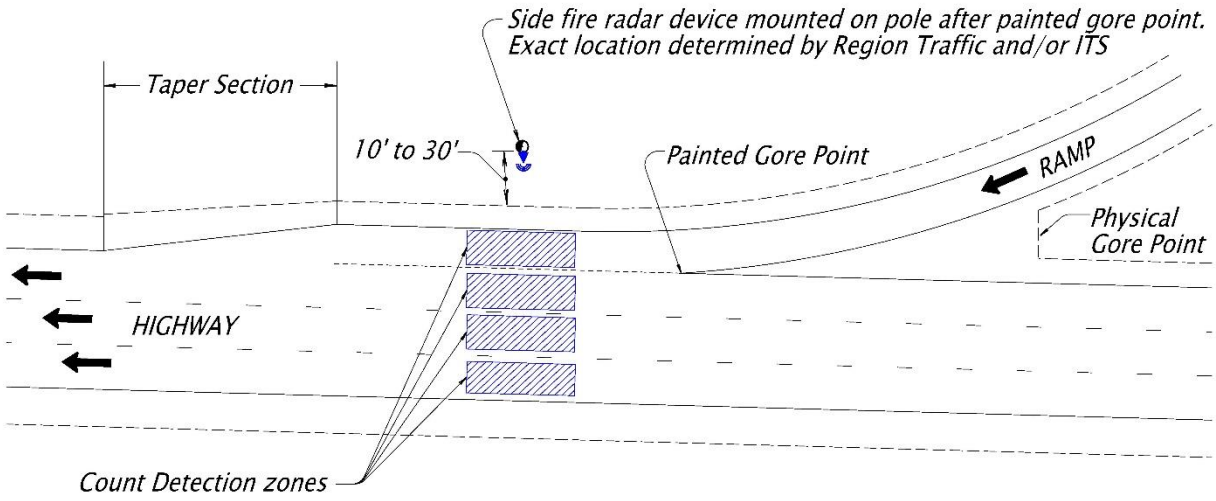


Figure 13-16 | Count Detection Layout, Detector Unit Mounted on Stand-Alone Pole



Note: not drawn to scale

13.6.2 334 Controller Cabinet Input Detection File

An SDLC connection is the default standard. When an SDLC connection is used, the input file is not used and will remain blank on the cabinet print. See chapter 6 and chapter 20 for more information. If the input file is used (e.g., loop detection), refer to older versions of the Signal Design Manual or contact the state traffic signal engineer for guidance on using the input file.

13.6.3 Detector Wiring Diagram

The detector wiring diagram for a ramp meter is no longer needed on the ramp meter plan sheet when non-invasive detection (radar) is used. The ramp meter timer will configure and document the detection zone set-up as per chapter 6 and chapter 20. If not using SDLC, coordinate with the ramp meter timer to ensure that the cabinet print accurately reflects the appropriate equipment in the input file.

13.7 Wiring

Ramp meters can have the potential for long distances of wire/cable (from the cabinet to the devices). The signal designer should verify the voltage drop and wire size of wiring for long runs of wire/cable as per chapter 5. The radar cable length should be less than 2000 feet. However, if more than 2000 feet is necessary, contact the state traffic signal engineer and the manufacturer for design solutions.

13.8 Background/Reference Information

This section contains more in-depth information to aid in understanding the guidance presented in this chapter and for documentation purposes.

13.8.1 Queue Detection History

Queue detection was a small zone located upstream of the stop line used to detect an extensive queue length. When an extensive queue length was detected (by a vehicle stopping on the queue detector for a pre-determined amount of time), the meter rate was increased as necessary to quickly dissipate the extensive queue. These queue detectors also activated a "BE PREPARED TO STOP" with "WHEN FLASHING" sign or a "STOPPED VEHICLES AHEAD" PTR sign if one was present.

Queue detection is longer used as there are now better ways to manage the ramp queue via the traffic signal timing at ramp terminal. The signal timing and ramp meter rate balances the needs of local and through traffic by allowing the ramp to queue at an acceptable level. Splitting single lane on-ramps into two-lanes when the ramp meter is active also helps provide more storage of vehicles on the ramp. The goal is to prevent overflowing queues onto the city street without the need to "flush" the ramp queue onto the freeway.

A review of all existing ramp meters revealed the "BE PREPARED TO STOP" with "WHEN FLASHING" or "STOPPED VEHICLES AHEAD" signs are rarely used. The older "STOPPED VEHICLES AHEAD" PTR sign was activated by the queue detection but has been retired since 2014 and is no longer used in new installations. See section 13.8.2 for more info. The PTR sign was replaced by the "BE PREPARED TO STOP" with "WHEN FLASHING" sign, but it was activated whenever the ramp meter was active (not activated via the queue detection).

Due to the "BE PREPARED TO STOP" with "WHEN FLASHING" not being activated by the queue detection, this sign is now retired as per the 2021 update to this manual. It has been replaced with a supplemental "RAMP METER ON WHEN FLASHING" sign if the sight distance to the ramp meter signal/queue is inadequate or a concern. The 2021 manual update simplifies the sign layout and warning message given to the driver. See section 13.3.1 and Figure 13-11 and Figure 13-12 for current guidance.

13.8.2 PTR sign History

In the past, ramp meters used three different part time restriction (PTR) signs for the standard ramp meter sign sequence:

- "RAMP SIGNAL ON"
- "FORM 2 LINES"
- "STOPPED VEHICLES AHEAD"

All three PTR signs were replaced with static aluminum signs (with a flashing beacon as appropriate) in January 2014. This change resulted a reduced initial installation cost and a reduced cost and time savings for maintenance repairs while still providing the necessary messages/information to the driver.

14 Pedestrian Signal Plan

14.1 General

A pedestrian signal is a very specific type of traffic signal. It is installed mid-block, consisting of type 2 signal heads mounted overhead to control vehicles and pedestrian signals with pushbuttons to control pedestrians. The signal heads remain green until the pushbutton is activated. See Figure 14-1, Figure 14-2, and Figure 14-3 for examples. Design of pedestrian signals (mast arm poles, signal heads, pushbuttons, conduit, junction boxes, wiring, detection, etc.) should follow the applicable parts of chapter 5 and chapter 6.

Pedestrian signals require STE operational approval. See the ODOT Traffic Manual and contact the state traffic operations engineer for more information about completing the engineering study and requesting operational approval for pedestrian signals.

Note that many of the old archived "pedestrian signal" plan sheets in FileNet are actually overhead continuous operation warning beacons with pedestrian crossing signs, not true pedestrian signals.

Figure 14-1 | Pedestrian Signal Installed Mid-Block, Example 1



Figure 14-2 | Pedestrian Signal Installed Mid-Block, Example 2



Figure 14-3 | Pedestrian Signal Installed Mid-Block, Example 3



14.1.1 Controller and Service

Pedestrian signals use a standard base mounted service cabinet (BMC) and 332S signal controller cabinet with an ATC controller.

14.1.2 Striping and Signing

Pedestrian signals require a marked crosswalk with a stop line installed at least 45 feet in advance.

A minimum of one CROSSWALK STOP ON RED (R10-23) sign per approach shall be mounted between the type 2 signal heads. Note that the pedestrian warning sign (W11-2) used in the past is no longer used for new construction.

A STOP HERE ON RED (R10-6) sign shall be used near the stop line.

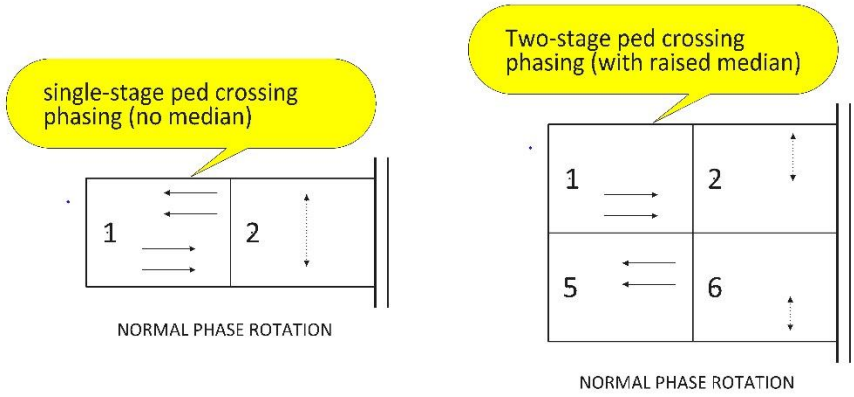
14.1.3 Detection

The operational approval will specify if the pedestrian signal needs to be coordinated with other nearby signals and/or needs advance detection to better protect the dilemma zone. If the pedestrian signal will always be in coordination, detection is not necessary. Other detection functions, such as count detection may also be desirable. See chapter 6 for more info on detection design. Work with region traffic to determine the appropriate detection needs.

14.1.4 Phasing and Fire Preemption

A ring and barrier diagram on the plan sheet is required, typically with phase 1 as the vehicle phase and phase 2 as the pedestrian phase for a single-stage pedestrian crossing with no raised median. If a two-stage crossing with a raised median is used, phase 5 (for vehicles) and phase 6 (for pedestrians) are added for the second stage. See Figure 14-4. Fire preemption is also typically installed if the jurisdiction is approved for use of fire preemption.

Figure 14-4 | Typical Pedestrian Signal Phasing



14.1.5 Bicycle Design Considerations

If the pedestrian signal will be serving higher numbers of people riding bicycles, the operational approval may require a bike phase that operates concurrent to the pedestrian phase. A bike phase can improve the user experience and reduce minimum green times when only a bicyclist is present.

When bicycle phases are used, a type 2B signal head is required. Type 2BM signal heads are optional and used when engineering judgement indicates a need.

Bicycle-specific detection buttons or passive detection zones (with bicycle detection pavement marking) should be used.

14.2 Half Signals

In the past, some pedestrian signals were installed at intersections and are commonly referred to as "half-signals" as the mainline traffic is controlled by signal indications that cycle based on pedestrian actuations while traffic on a full-access side street is controlled by STOP signs. Half-signals are prohibited on the state highway system. See Figure 14-5 for an example of a half signal.

Figure 14-5 | Pedestrian Signal Installed at Intersection (Half-Signal), Prohibited



Half-signals are PROHIBITED on the State Highway.

15 Red Light Enforcement Plan

15.1 General

This chapter will discuss red light enforcement plan details from two perspectives, the ODOT signal designer and the third-party signal designer:

- The ODOT signal designer will have a very minimal amount of involvement associated with this type of plan sheet because red light enforcement plans are ALWAYS designed by third parties and constructed under the district permit process. The role of the ODOT signal designer will range from no involvement at all to just design review.
- The third-party signal designer is responsible for designing the plan sheet.

15.2 Operation and Approvals

The installation of a red light running system requires STE operational approval. The red light running system may also include automated speed enforcement (when approved by the STE), which is now an option under Oregon law. Modifying existing red light running systems to include automated speed enforcement requires meeting all the requirements stated in this chapter. See the current version of the Red Light Running (RLR) Camera Guidelines for State Highways for more information on conducting the engineering study, the operational approval process, and standard conditions of approval.

The plan sheets require design approval as per chapter 2.

15.3 When is a Plan Sheet Required?

A red light running plan sheet is required for all intersections where this technology will be used. A plan sheet is also required if the red light running system is removed. These plan sheets are always designed by a third party that is affiliated with the company providing the red light running equipment. ODOT signal designers do not design red light enforcement systems. While ODOT has ownership of the intersection and signal equipment within the right-of-way, the red light running equipment is NOT owned or maintained by ODOT.

15.4 Mitigation Requirements

Prior to installation of a red light running system, modifications to the traffic signal may be required. These modifications, if needed, shall be shown in a signal plan sheet that is separate from the red light enforcement plan sheet. The modifications typically include the following:

- Change in the number, size and/or location of the vehicle signal heads
- Enforcement “tattletale” lights
- Speed zone changes (which may result in detection zone/detection location changes)

15.5 Red Light Running Signing

Installation of a red light running system requires specific signing on all major routes entering the jurisdiction and near the location where each camera is installed. These signs should be shown in a signing plan sheet. See the current version of the Red Light Running (RLR) Camera Guidelines for State Highways and the ODOT Sign Design Manual for more information.

15.6 Construction

Red light running systems are always constructed under the district permit process.

15.7 Separation of Systems

The traffic signal system and the red light running system are required to be completely separate from each other. The only exception is current clamps (and wiring from the current clamps) that are used inside the controller cabinet, placed around the field output wires that enable the red light running system to determine which signal indication is on. A current clamp is an electrical device having two jaws which open to allow clamping around an electrical conductor. This allows the electric current in the conductor to be measured, without having to make physical contact with it, or to disconnect it for insertion through the clamp.

The wiring from the current clamp then exits the controller cabinet through a conduit to the first junction box. These wires do not have to be in a separate conduit if there is enough room in an existing conduit with traffic signal wiring. From the junction box closest to the controller cabinet, **every** piece of equipment used for the red light running system (cameras, conduit, wiring, detection, etc.) shall be separated from the traffic signal equipment. For example, the following scenarios are not allowed:

- Placement of red light running equipment on a traffic signal mast arm or pole.
- Placement of red light running wiring in conduits and junction boxes that are used for the traffic signal. EXCEPTION: the junction box nearest the controller cabinet and the conduit between this junction box and the controller cabinet).
- Use of the power to the traffic signal. EXCEPTION: unless ODOT district authorizes the use. In the case where the red light running system power is provided by the traffic signal, it must be on its own clearly identified circuit breaker.

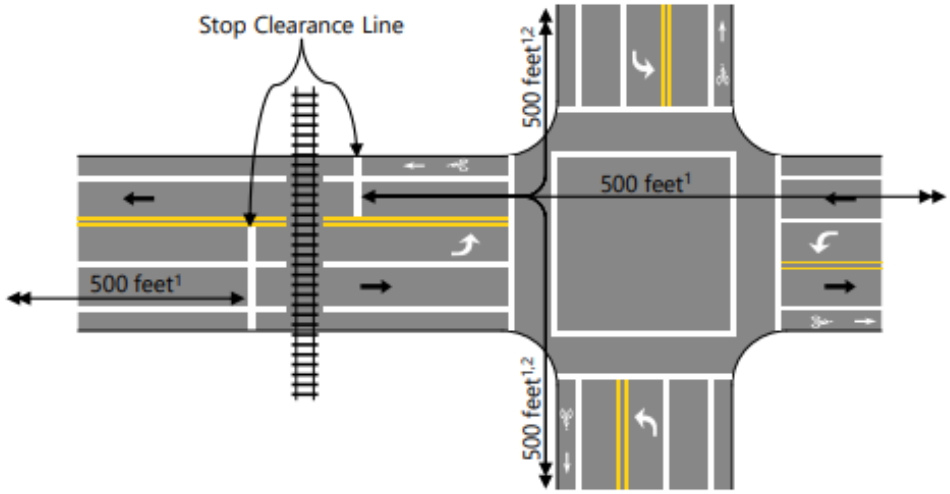
15.8 Removal of Red Light Running Systems

If removal of the system is required, a red light enforcement plan sheet is required showing the removal of the equipment. All wiring, junction boxes, external equipment (cameras, mounts, etc.), and equipment in the controller cabinet must be removed. Conduits and loop detection may be abandoned.

16 Railroad & Preemption Plan

The regulation of railroad-highway grade crossings are under the jurisdiction of the ODOT commerce and compliance division (includes staff formally known as rail division). Their jurisdiction extends a distance equal to the safe stopping distance (SSD) for the posted or statutory speed, measured back from the location of the stop clearance line at the railroad crossing (OAR 741-100-0005). See Figure 16-1.

Figure 16-1 | SSD at Railroad At-Grade Crossings and Signalized Intersections



SSD Requirement	
Speed (MPH)	SSD (Feet)
15	80
20	115
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645

[1] ODOT Commerce and Compliance Division jurisdiction extends the safe stopping distance from the stop clearance line (assume 500 feet for simplicity).

[2] ODOT Commerce and Compliance Division jurisdiction extends along the parallel roadway because turns from an intersection near the railroad crossing might have an impact on the railroad crossing.

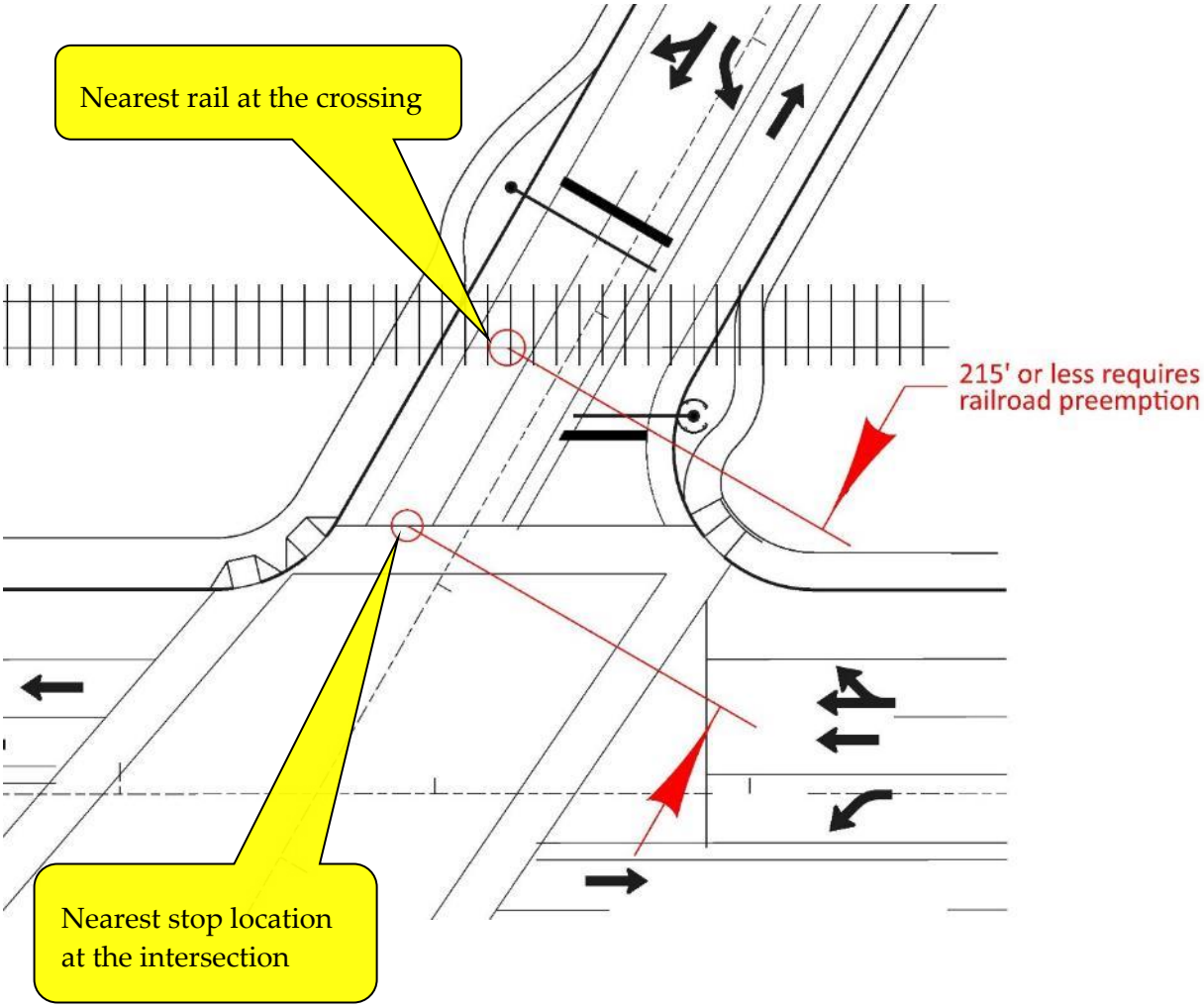
Because ODOT commerce and compliance division has jurisdiction within the SSD from the stop clearance line, it is important to include them in project scoping and early in the project design process so that there is enough time to obtain a rail crossing order if needed. See the ODOT Traffic Manual for additional procedural and coordination information related to rail crossings.

NOTE: Failure to coordinate with the ODOT commerce and compliance division can result in excessive delays to your project schedule.

16.1 When is Railroad Preemption Needed?

Railroad preemption is required if a traffic signal has an approach located within 215 feet of a railroad crossing as per the ODOT Traffic Signal Policy and Guidelines. See Figure 16-2. Depending on the site-specific circumstances, railroad preemption may be desirable for an approach located further than 215 feet from a railroad crossing (e.g., high volume approach with queues routinely reaching or exceeding the rail crossing, high percentage of heavy/long trucks, etc.). See section 16.1.2 for additional information on evaluating preemption and other traffic control devices when the rail crossing is located further than 215 feet. In these cases, the need for preemption will be determined by the field diagnostic review.

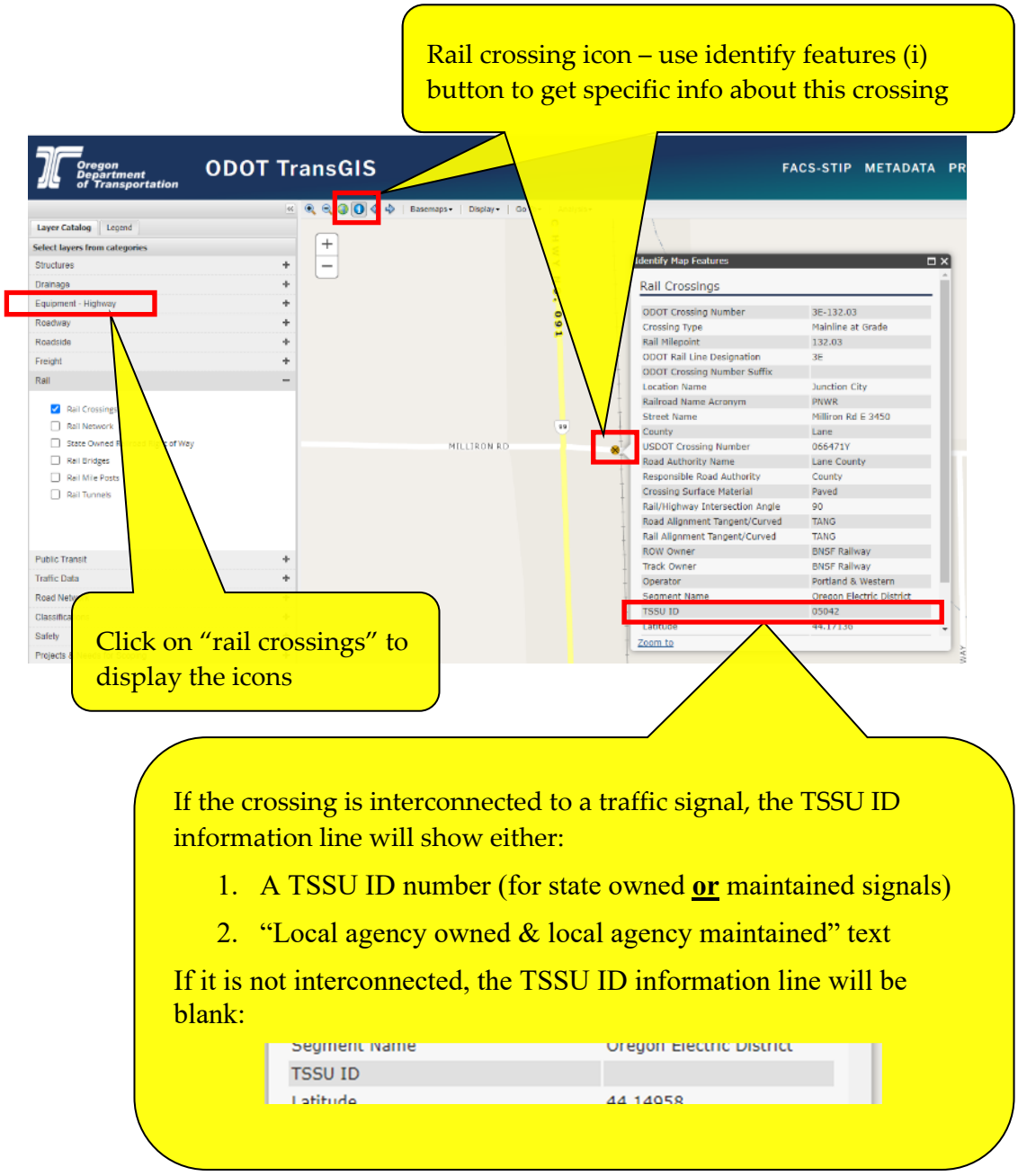
Figure 16-2 | Railroad Preemption Required



16.1.1 Verification of Railroad Interconnection at Existing Traffic Signals

TransGIS can be used to determine if an existing signal is interconnected. See Figure 16-3. ODOT commerce and compliance division also stores this information in the rail crossing safety system database.

Figure 16-3 | TransGIS Rail Crossing Information



16.1.2 Evaluating Preemption and Traffic Control Devices at Rail Crossings Further Than 215 Feet from a Signalized Intersection

The potential for queues to extend to or go beyond the tracks, which can lead to vehicles inappropriately stopping on the tracks, is the main concern to address for tracks located further than 215 feet from a signalized intersection. A traffic queue analysis should be conducted by region traffic. If the potential is low (the traffic analysis shows that the 95th percentile queue will not extend to tracks), additional treatments should not be necessary. If the potential is medium (the traffic analysis shows that 95th percentile queue will extend to the tracks, but the 50th percentile queue will not) additional treatments may be desirable. If the potential is high (traffic analysis shows that 50th percentile queue will extend to the tracks), additional treatments should be considered.

Rail crossings that are located more than 215 feet from the signalized intersection are typically not well suited for interconnection as it will take a considerably long VCOI phase (track clearance green time) before a vehicle stuck on the track will be able to move forward and clear the track. We generally want to limit the VCOI track clearance green time to 20 seconds maximum as this works within the typical time frame the rail owner uses for activating the simultaneous railroad input (which activates the VCOI phase). FRA requires this input is active a minimum of 20 seconds before a train arrives in the crossing, with most rail owners programing this input between 25 to 35 seconds before a train occupies the crossing. VCOI track clearance green times in excess of 20 seconds are undesirable as it pushes both the simultaneous railroad input and the advance preemption railroad input (used to activate the PCOI phase) further out which can result in less consistency of the input timing and also be prohibitively expensive. As such, rail owners strongly prefer that all inputs are activated within 55 seconds or less of the train occupying the crossing.

Due to the issues described above for interconnecting a traffic to a rail crossing located more than 215 feet away, the recommended treatments (alone, or in combination) listed below should be considered first to address any queuing concerns.

Recommended treatments:

- Grade separation
- Signal timing, phasing and/or intersection geometry modifications that prioritize queue reduction on the approach leg with the rail crossing (e.g., removing split phasing, adding overlap phasing, modifying lane use, adding PPLT, adjusting max green times & gap timing, etc.)
- Extra wide shoulder just beyond the rail crossing to function as an escape route for a vehicle stuck on the tracks when the queue ahead can't move

- Static DO NOT STOP ON TRACKS signs (consider overhead mounting, or an additional supplemental sign on the left side for more conspicuity)
- Illumination of the rail crossing
- Dynamic envelope pavement marking
- A "do not stop on tracks" PSA and enforcement campaign

Other treatments to consider if an adequate trial of the above treatment(s) has failed to reduce the frequency of vehicles stopping on the tracks, or if the potential for queues is high (note: all treatments below require STE operational approval):

- Flashing beacons on a static DO NOT STOP ON TRACKS sign, or a DO NOT STOP ON TRACKS PTR sign that is activated by detection of queued vehicles. Operated via the traffic signal controller cabinet.
- Queue cutter signal (operates independent of the downstream traffic signal and is trigger by detection of queued vehicles). Operated via a separate traffic signal controller cabinet.
- Use of dump detection at the downstream traffic signal.
- Railroad preemption with downstream traffic signal.

16.2 Field Diagnostic Review

The field diagnostic review is required by the ODOT commerce and compliance division to determine the appropriate traffic control devices for the crossing and produce a rail crossing order. This will occur early in the design process (project scoping or prior to DAP plans) and is coordinated by the ODOT commerce and compliance division. The review typically includes:

- Project team leader
- ODOT commerce and compliance division representative
- Railroad company representative
- Region traffic signal operations representative
- Construction representative
- Designers (signal, roadway, and others as needed)

The field diagnostic review team will meet on-site to determine the required upgrades to the railroad crossing. The findings from the field diagnostic review are the starting point for:

- Identifying design constraints and work to be done;
- Completing the railroad-highway public crossing safety application (which is required to obtain the rail crossing order); and
- Obtaining any region and/or state traffic engineer operational approvals.

16.3 Rail Crossing Order

Each public railroad crossing is required to have a rail crossing order. Rail crossing orders are issued by the ODOT commerce and compliance division and authorize the alterations to the grade crossing. Private crossings are not regulated by the ODOT commerce and compliance division (except for the STOP sign and PRIVATE CROSSING sign as per OAR 741-115-0060) and therefore do not typically require a rail crossing order. The majority of projects involving a railroad crossing will require a rail crossing order. New at-grade crossings are rarely approved because state law directs ODOT commerce and compliance division to eliminate at-grade railroad crossings wherever possible. Grade separated railroad crossings are strongly preferred by the railroads and ODOT.

Rail crossing orders contain specific requirements for installation, operation, and maintenance of traffic control devices, roadway geometry, and roadway features. The rail crossing order must be completed prior to PS&E. In order to obtain a rail crossing order, a railroad-highway public crossing safety application must be completed and submitted to ODOT commerce and compliance division. This application is typically done by the project team leader or designer, with assistance from the ODOT commerce and compliance division.

Existing rail crossing orders can be accessed online (ODOT staff link or external staff link) or by contacting the ODOT commerce and compliance division.

Plan sheets must comply with the rail crossing order.

16.4 Railroad Utility Permits

If any signal equipment crosses over or under the railroad right-of-way, the railroad requires a utility permit. This permit is separate from the other construction permits that the contractor must obtain as per standard specification 00170.02 and the rail crossing order. It should be obtained as early as possible in the design phase (prior to PS&E) to avoid unnecessary delays during design and construction. Follow all design requirements stated in the permit.

Typical signal work that triggers the need for this permit includes conduits for detection, traffic signal interconnection and/or railroad interconnection. The signal designer should contact the state utility and railroad liaison for assistance in obtaining this permit.

Contact: State utility and railroad liaison

Nicole Frankl

503-385-6594

E-mail: UtilityandRailProgra@odot.oregon.gov (note: the "m" is intentionally missing in "program")

16.5 Railroad Preemption Operation

ODOT's standard for railroad preemption is comprised of the following sequence:

1. Pedestrian clear-out interval (PCOI)
2. Vehicle clear-out interval (VCOI)
3. Return to normal operation

The rail diagnostic review determines the type of preemption operation and necessary traffic control devices to accommodate the desired operation. Any deviations from the standards should be documented and approved as per the direction of the state traffic engineer (STE) in consultation with the ODOT rail crossing safety manager.

16.5.1 PCOI – Advance Preemption

The pedestrian clear-out interval (PCOI) value (in seconds) is shown on the railroad preemption plan sheet and is calculated and provided by the region signal operations engineer. This value is placed in the railroad controller by railroad employees. NOTE: at existing railroad interconnected traffic signals, the existing PCOI value should be field verified and then calculated (based on current standards) to determine if the existing PCOI value is adequate. Typically, existing PCOI values should be increased by several seconds. The decision to increase an existing PCOI value is determined by the field diagnostic review. The calculated PCOI value should be used whenever possible, but it may not always be feasible (e.g., cost prohibitive, outside the scope of the project, railroad equipment limitations, etc.).

The PCOI is used to give pedestrians time to finish crossing a crosswalk prior to the vehicle clear-out interval (VCOI). Without the PCOI, pedestrians could get stranded in the crosswalk when the VCOI sequence starts. This is because the traffic signal controller will immediately truncate the walk or flashing don't walk interval upon receiving the input to activate the VCOI sequence.

The operation of a PCOI requires train detection provided by the railroad to activate an "advance preemption railroad input". The advance preemption railroad input initiates the "pedestrian inhibit" traffic signal software feature which starts the following operation:

1. No change to vehicle phase sequence
2. All active pedestrian phase walk intervals immediately advance to and complete the flashing don't walk interval
3. All pedestrian phase calls are inhibited from being serviced
4. PTR signs remain off
5. Rail crossing equipment (flashing lights, audible devices and gates) remain off and up.

16.5.2 PCOI – Advance Preemption Used to Move Vehicles

The PCOI may also be used to clear vehicles queued between the intersection and the tracks (like the VCOI operation described in the following section) and help provide a free-flow condition for the VCOI phases prior to the simultaneous preemption input IF NO PEDESTRIAN CALLS ARE ACTIVE. The need for this type of operation will be determined by the diagnostic field review. If this operation is used, the appropriate traffic signal railroad preemption sequence text used on the railroad preemption plan sheet can be found in the ODOT workspace under "rail matrix advanced".

16.5.3 VCOI – Simultaneous Preemption

The VCOI value is NOT shown on the railroad preemption plan sheet (this value is calculated by the region signal operations engineer and placed in the traffic signal controller), but the vehicle clear-out phases and the limited service vehicle phases (phases with movements that don't conflict with the rail crossing) are listed on the railroad preemption plan sheet.

The VCOI is used to give vehicles on the road approach crossing the railroad track (stopped between the railroad tracks and intersection) time to advance through the intersection and away from the railroad crossing. This accomplished by providing green signal indications to the signal phases that cross the tracks (commonly called "green clear-out"). In the past, a flashing yellow indication was used for the VCOI (commonly called "yellow clear-out"), but this practice was ended in the late 1990's because it tended to result in driver confusion.

The VCOI requires train detection equipment that will provide a "simultaneous preemption railroad input" to activate the rail crossing equipment and the VCOI signal operation sequence. The simultaneous preemption railroad input follows the advance preemption railroad input (and operation sequence of the PCOI) and initiates the "railroad preemption" traffic signal software feature which starts the following operation at the traffic signal:

1. PTR signs turn on
2. Rail crossing equipment (flashing lights and audible devices) activate. After a three to six second delay, the railroad automatic gates start to descend. The total time from activation of the flashing lights to when the gates are horizontal may be 10 to 15 seconds.
3. All active pedestrian phase flashing don't walk intervals immediately advance to solid don't walk.
4. Any active vehicle clear out phase displaying green remains green and all non-vehicle clear out phases displaying green immediately terminate by advancing through their yellow and red clearance intervals.
5. Once all vehicle clear out phases display green simultaneously, the signal controller programmed VCOI is timed followed by the vehicle clear out phases advancing through their yellow and red clearance intervals.

6. All programmed limited service vehicle phases and their associated pedestrian phase are serviced in their normal sequence based on demand. Limited service vehicle phases consist of any phase that does not conflict with crossing the track.

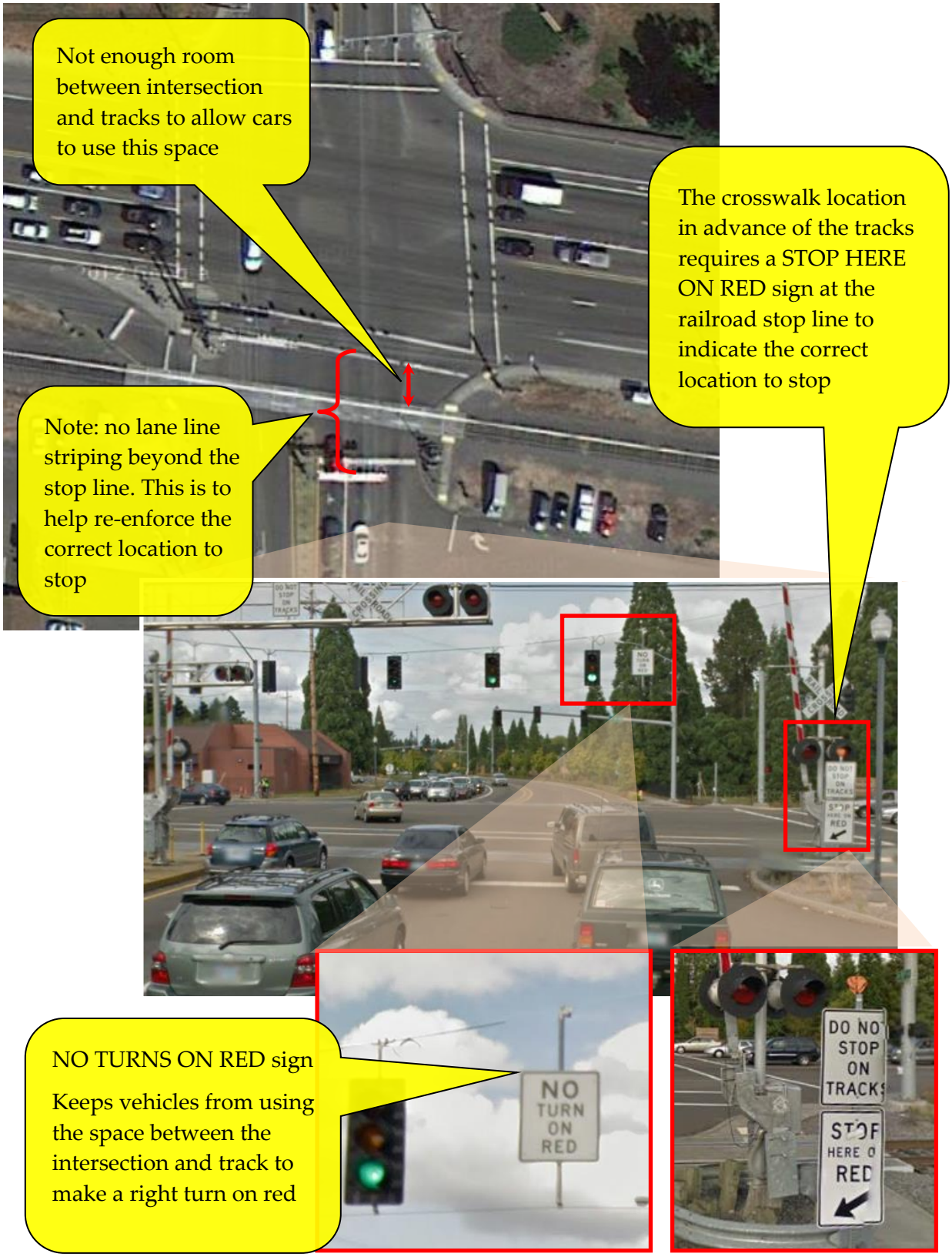
Note: The railroad owner may elect to program the railroad controller to deliver the simultaneous input to the traffic signal controller slightly before the rail crossing equipment activates. If used, approx. 5 to 10 seconds is common, based on site specifics. This is not shown on the preemption plan. Starting the VCOI sequence a little early can help mitigate equipment lag issues and better protect the railroad gate arms from breakage.

A VCOI is not always required. If the diagnostic field review determines that vehicles should stop prior to the track under normal signal operation (typically because the distance between the intersection and the track is less than the length of a passenger vehicle) the VCOI may not be needed (e.g., no vehicles to clear-out between the intersection and the track). This type of operation typically includes a post mounted STOP HERE ON RED sign at the railroad stop line, with a NO TURN ON RED sign mounted on signal pole or mast arm. Site specifics such as intersection geometry, normal signal operation, placement of all traffic control devices, traffic volumes, and driver behavior/expectations should be considered when determining if no VCOI is an appropriate treatment. See Figure 16-4 and Figure 16-5 for examples.

Figure 16-4 | VCOI is Not Required, Example 1



Figure 16-5 | VCOI is Not Required, Example 2



16.5.4 Return to Normal Operation

After the railroad preemption inputs return to non-preempt status, normal operation of the signal phasing resumes, the PTR sign turns off, the rail signal equipment turns off and gates go up.

16.6 Required Plan Sheets

On a project with railroad preemption, there will be coordination between the rail company, the road authority, and the ODOT commerce and compliance division for determining who is responsible for installation, maintenance, and costs of the required traffic control devices. Depending on the scope of the project and the requirements in the rail crossing order, some or all of the plan sheets will be required:

1. Signal plan sheet
2. Railroad preemption plan sheet
3. Other plan sheets (disciplines outside of signal design, such as roadway, striping and signing)

Refer to the Railroad Final Drawings Manual for additional information on producing plan sheets specifically for the crossing order (i.e., railroad preemption plan sheet) and the following sections of this manual for more design and plan sheet information specific to railroad interconnected signal design.

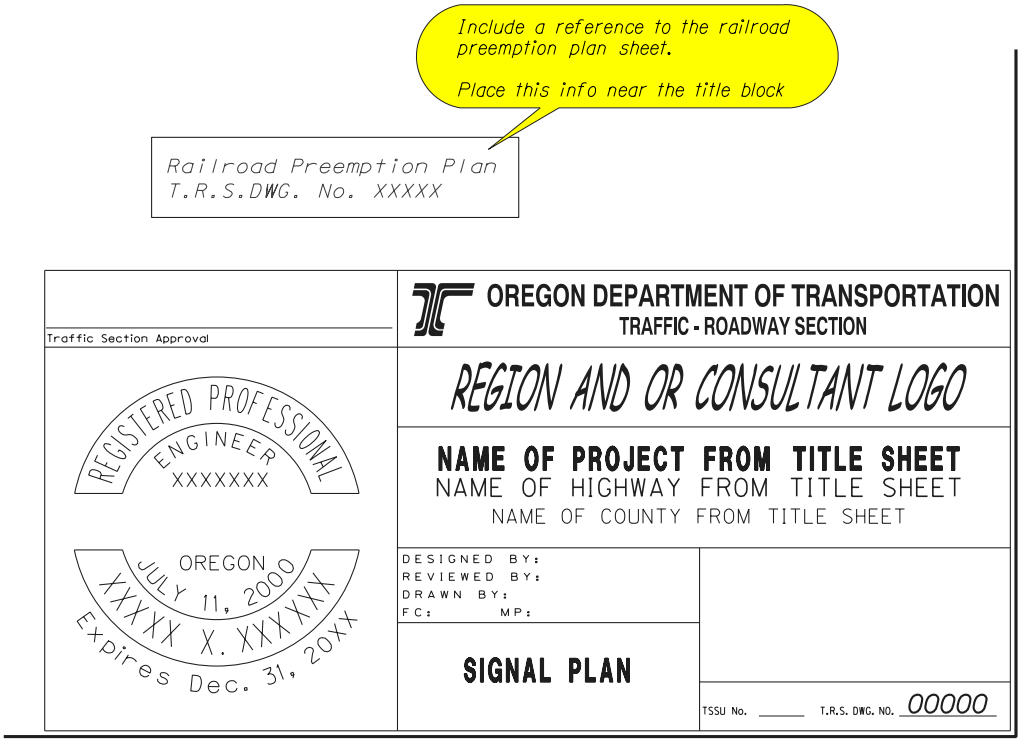
NOTE: It is important to keep equipment owned and maintained by the rail owner (e.g., gate arms, cantilever structures, etc.) completely separate from equipment that is owned and maintained by ODOT or a local agency (e.g., signs, signal heads, etc.). This will clearly define responsibilities for maintenance and avoid issues with other parties accessing and potentially impacting equipment that they are not responsible for. Mixing infrastructure between two or more different responsible agencies becomes very complicated and should be avoided.

16.7 Signal Plan Sheet References

The signal plans will need to detail all work that the contractor will be responsible for. See section 16.8 for more information on work that the contractor will be responsible for.

Do NOT detail work that the contractor is NOT responsible for. References to other work the contractor is not responsible for should be shown on the signal plan sheets as per Figure 16-6 (for the railroad preemption plan sheet) and section 16.10 (for the rail equipment).

Figure 16-6 | Referencing Other Work on the Signal Plan Sheets – Preemption Plan Sheet



16.8 Interconnected Traffic Signal Specific Design Elements and Considerations

Interconnected traffic signals have several unique design elements and considerations due to the preemption operation and coordination with rail equipment. The design elements for all interconnected signals must be considered on a case-by-case basis as each site and each project will have different characteristics, issues, constraints, and goals. The following subsections are common design elements that pertain to interconnected traffic signals:

- Pre-signals
- Supplemental signals
- Queue cutter signals
- Queue activated warning devices
- Detection
- Channelized right turn lanes
- Median islands
- Crosswalk placement and stop lines
- PTR signs
- STOP HERE ON RED and NO TURN ON RED signs
- DO NOT STOP ON TRACK signs and high level warning device
- Lane use signs
- Conduit and wiring
- Pedestrian features
- Type 7 signal heads
- Permissive left turn phasing using flashing yellow arrow
- Limited right-of-way for equipment

The following subsections provide definitions and general guidance. They should be used to evaluate the appropriate treatment(s) to be implemented at a particular project/site and facilitate communication between the stakeholders. Consistency of traffic control devices used on a corridor, historical observations, crash history, & risk assessment should also be considered when evaluating treatments. Include the diagnostic team in this decision making process to obtain stakeholder feedback and to help make the rail crossing order process go smoothly.

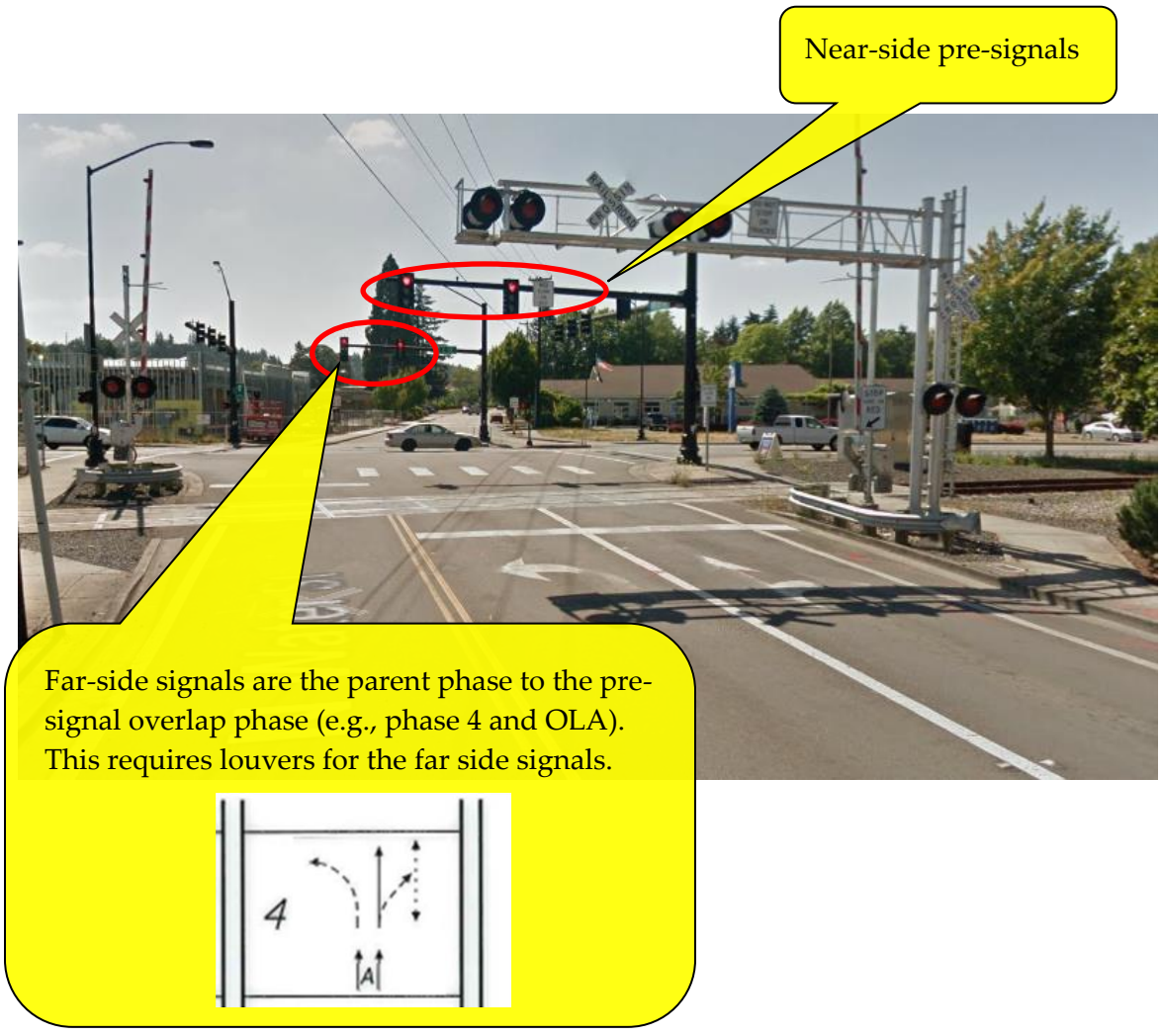
Good communication between the signal designer and the various stakeholders on the diagnostic team is important to determine the most appropriate treatment(s) to be used. Note that the road authority (e.g., traffic staff) and rail owners may use the same terms/acronyms but have different definitions for them (e.g., VCOI) and each party has unique terms/acronyms specific to their discipline that the other party will not readily understand. Always take the time to explain and make sure everyone is actually on the same page.

We are striving to correct these issues to improve communication in future but this is a long-term task that will require high level agreement from both parties.

16.8.1 Pre-Signals

Pre-signals are defined as near-side signals that operate on an overlap phase with the normal signal phase rotation. The far-side signal phase will be the parent phase for the near-side pre-signal overlap phase. This allows the near-side pre-signals to operate in conjunction with the far-side signals plus the flexibility for the far-side signals to display a different indication than the near-side pre-signals as necessary. Pre-signals should operate with a VCOI sequence. During the VCOI sequence, the overlap phase (pre-signals) will be red while the far-side signals display green to clear any vehicles that may have queued between the intersection and the tracks (even though theoretically they should never be there). This operation eliminates the option of using the advance preemption (PCOI) to move vehicles as described in 16.5.2 (because the VCOI phase green is only associated with the far side signals, not the pre-signals). See Figure 16-7 for an example.

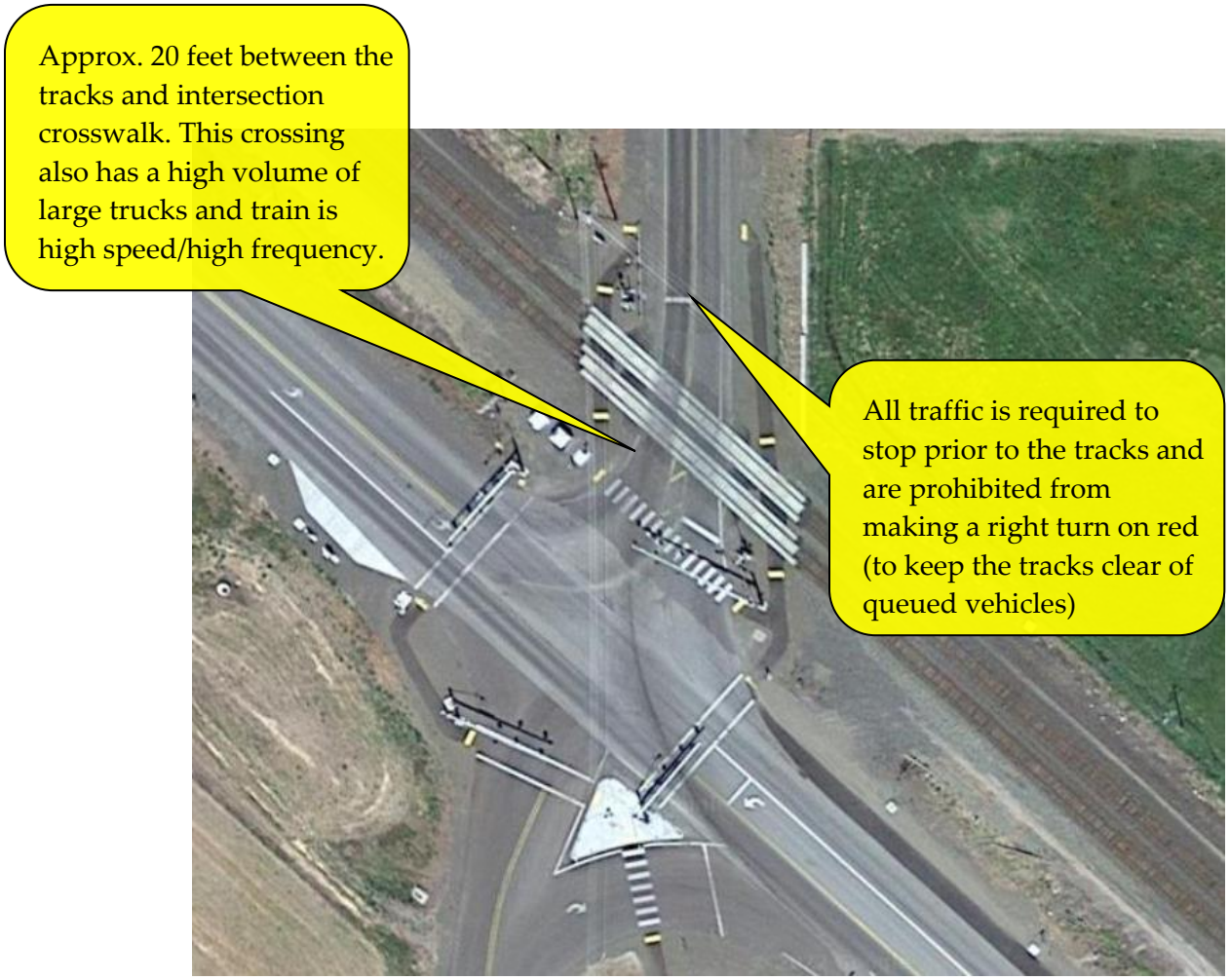
Figure 16-7 | Pre-Signal Example 1



Because pre-signals do not always display the exact same indications as the far-side signals and they are located relatively close to the far-side signals, the far-side signals are required to have louvers in all indications so that the driver can only see the far-side signals AFTER they lose sight of the near-side pre-signals. Also, drivers must stop and remain stopped at the stop location for the pre-signal, which is the location of the rail crossing stop line (this requires the use of STOP HERE ON RED and NO RIGHT TURN signs as per section 16.8.10).

Pre-signals may be beneficial when tracks are located such that it is not even possible for a passenger vehicle to queue without stopping on the tracks or when the risk is deemed too high to allow vehicles to even attempt to queue between the tracks and the intersection (e.g., a high percentage of heavy trucks and/or the train is frequent and/or the train is high speed). See Figure 16-8. However, the drawbacks of a pre-signal must be seriously considered before using this treatment.

Figure 16-8 | Pre-Signal Example 2



Pre-signals drawbacks that should be considered:

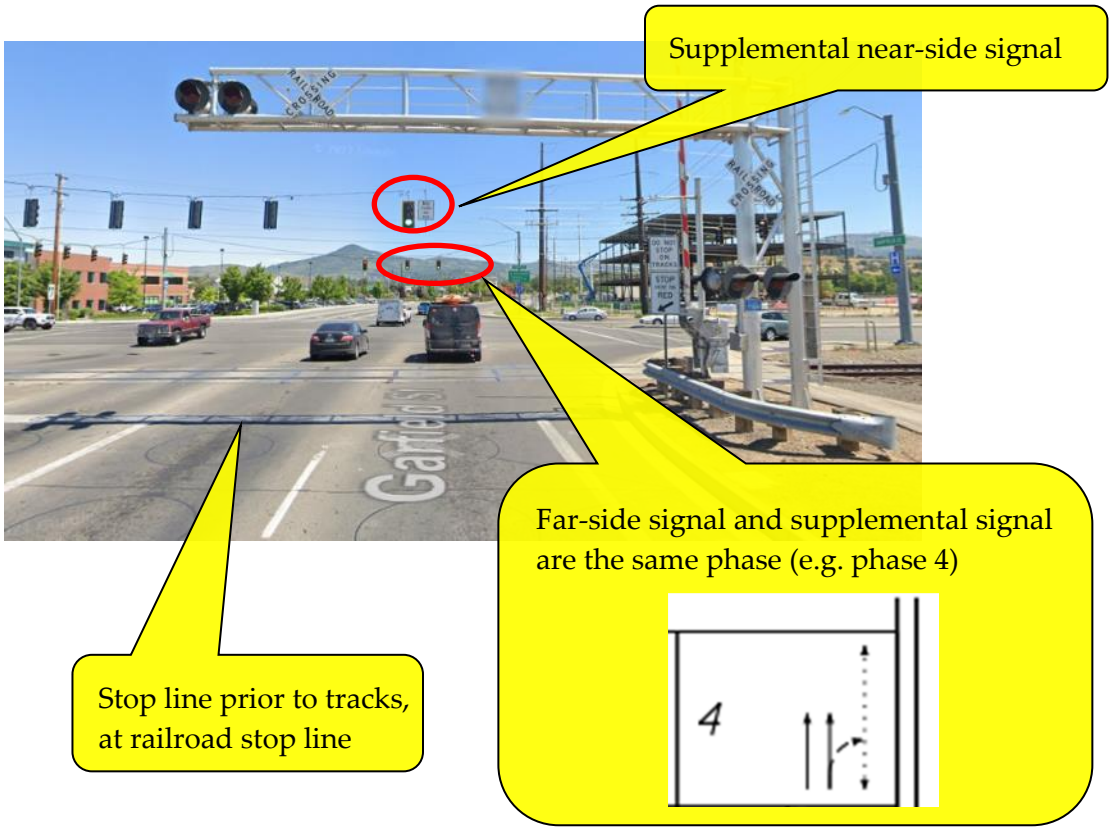
- Eliminates the option of using the PCOI to move vehicles as per section 16.5.2. Using the PCOI to move vehicles addresses queueing and any vehicles stopped on the tracks when the train is approaching, which may be a more desirable operation than using a pre-signal given the next three bullet points.
- If the right turn volume is heavy and there is also a good line of sight, the STOP HERE ON RED and NO TURN ON RED signs may not be respected by drivers and result in numerous intentional violations that would require heavy enforcement to correct.
- As the distance between the pre-signal stop line and the intersection stop location increases, a driver may not expect or respect the need to stop before the tracks, especially if they are in a smaller vehicle.
- Pre-signals add complexity of the driving task. Louvered signal heads are not ideal in this application as it is difficult to adequately block the line of sight of the far side signal indications due to the challenging geometry angles of the approaching driver's eye. This can result in far-side signals that are visible before they should be or blocked longer than they should be.

If possible, geometric solutions to modify the distance between the tracks and the intersection or using the PCOI to move vehicles are preferred alternatives to a pre-signal.

16.8.2 Supplemental Signals

Supplemental signals are defined as near-side signals that have the same output terminations as the far-side signals. Unlike a pre-signal, a supplemental signal will always display the exact same indications as the far-side signals. As such, louvers are not necessary. See Figure 16-9 for an example.

Figure 16-9 | Supplemental Signal Example



Near-side supplemental signals are typically only installed to mitigate for a large intersection (signal heads located at the normal location are over 180 feet from the stop location), mitigate for sight distance limitations due to approach geometry, or to improve conspicuity/visibility to the signalized intersection (as per chapter 5), and not specifically for rail preemption interconnection operation. However, if near-side supplemental signals happen to be needed at on the approach with the tracks at a rail interconnected signal, it is very important to determine the proper stopping location to reduce driver confusion. Having the stop line prior to the tracks is ideal, as shown in Figure 16-9. See section 16.8.8 for more information on crosswalk placement and stop lines adjustment considerations. If the stop line is prior to the tracks, a VCOI phase may not be necessary as per section 16.5.3.

If possible, geometric solutions to eliminate the need for supplemental signals is the preferred solution.

16.8.3 Queue Cutter Signals

Queue cutter signals are defined as a completely stand-alone traffic signal that only controls vehicles at the rail crossing. It operates independently of any adjacent traffic signals. The queue cutter signal remains green until a queue is detected which will terminate the green phase.

The detection zone should be placed beyond the tracks so the signal will terminate the green phase when queue is forming but hasn't yet crossed the tracks. The exact location and amount of delay on the detection will need to be field verified to ensure the device activates at the proper time for approaching vehicles to react to it.

Queue cutter signals may be beneficial at locations where:

- Vehicles are routinely observed stopping on the tracks, and
- The rail crossing is located beyond 215 feet from the signalized intersection, and
- The observed typical queue (or 50th percentile queue) will reach to or go beyond the rail crossing.

As of 2022, there are no true queue cutter signals operating on the state highway system. As such, contact the state traffic signal engineer for more guidance on using/designing this device if it is being considered on a project. Also, see section 16.1.2 for alternatives to queue cutter signals.

16.8.4 Queue Activated Warning Devices

Queue activated warning devices are either a flashing beacon for a DO NOT STOP ON TRACKS sign or a DO NOT STOP ON TRACKS part time restriction (PTR) sign.

Queue activated warning devices may be beneficial at locations where:

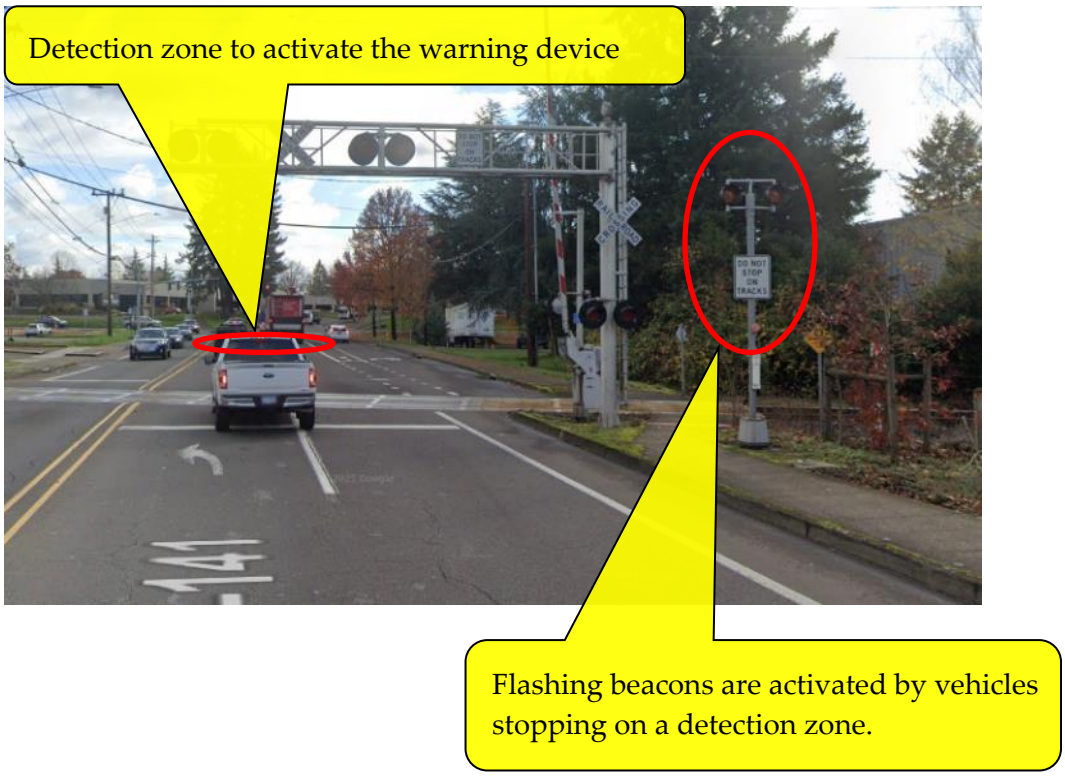
- Vehicles are routinely observed stopping on the tracks, and
- The rail crossing is located at least 100 feet from the signalized intersection, and
- The observed typical queue (or 50th percentile queue) will reach to or go beyond the rail crossing.

The detection will activate the warning device via a traffic signal controller cabinet (it may be the same cabinet for a rail interconnected traffic signal) when a vehicle stops on the detection zone for a set amount of time (approx. 3 to 5 seconds). It does NOT preempt an interconnected traffic signal. Note that a queue activated warning device could be installed at a crossing that isn't interconnected to a traffic signal or even near a traffic signal. This would be a stand-alone queue activated warning device.

The detection zone should be placed approximately 2 to 3 car lengths beyond the tracks so the warning device will turn on when queue is forming but hasn't yet crossed the tracks. The exact location and amount of delay on the detection will need to be field verified to ensure the device activates at the proper time for approaching vehicles to react to it.

The default standard detection for this application is a near-side radar unit. See chapter 6 for information about placement of detection devices.

Figure 16-10 | Queue Activated Warning Device Example



16.8.5 Detection

SIDE STREET DETECTION

Typically the rail crossing is located on the side street approach of a signalized intersection. Side street phases are only serviced if there is demand. Non-invasive detection should be placed to provide normal side street detection zones from the vehicle stop location. Detection zones should also be located in the area between the crosswalk and tracks even if vehicles will not normally occupy that area. This allows the traffic signal the opportunity to serve the side street phase in the rare event of a vehicle stopping in a location they shouldn't occupy.

QUEUE DUMP DETECTION

Queue dump detection may be beneficial at locations where:

- The rail crossing is located over 200 feet from the signalized intersection, and
- The observed typical queue (or 50th percentile queue) will reach to or go beyond the rail crossing, and
- The normal max green time for the approach is not long enough to clear the observed or expected 95th percentile queue.

The queue dump detection would trigger the traffic signal to provide a longer max green to dissipate the queue on the next phase cycle when a vehicle stops on the detection zone for a set amount of time (approx. 3 to 5 seconds). It does NOT preempt the traffic signal.

The detection zone would need to be placed according to the queue analysis but will typically be located near the rail crossing. However, using a normal max green time with appropriate gap timing that can clear the observed or 95th percentile queue is strongly preferred over using queue dump detection for two main reasons:

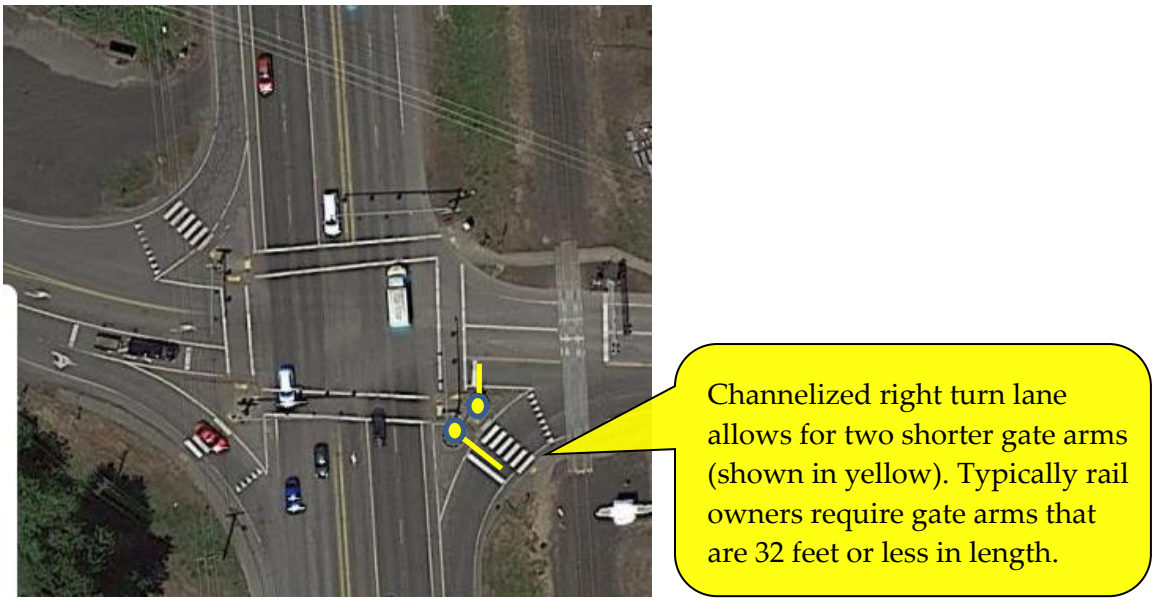
- The dump detection is only truly beneficial if the triggered max green time needs to be substantially longer than a reasonable normal max green time for the approach. While increasing a reasonably normal max green by a nominal amount (to dissipate the queue) will be slightly less efficient if detection isn't functioning, it is a simple and effective solution to address the queue dissipation.
- The cost of extra equipment, maintenance, and labor to keep it functioning as intended.

The default standard detection for this application is a near-side radar unit. See chapter 6 for information about placement of detection devices.

16.8.6 Channelized Right Turn Lanes

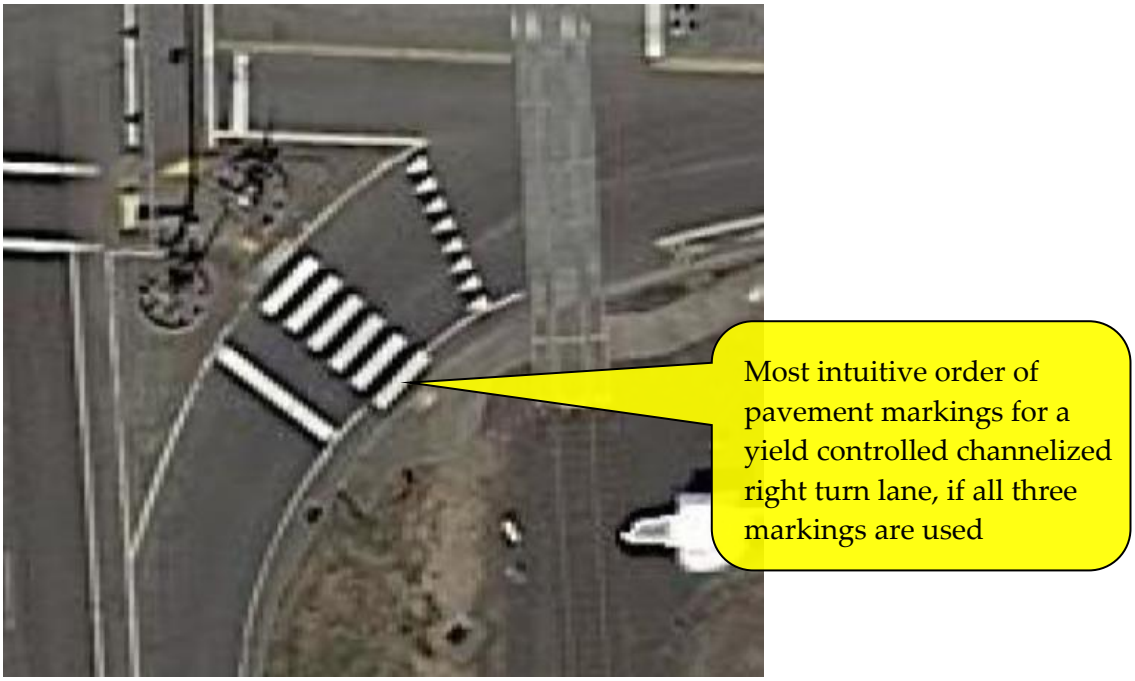
If a right turn only lane exists or is needed, a channelized right turn lane (typically from the mainline onto the side street) is a common request from rail owners. It is typically used at intersections with a rail crossing that is located very close to the intersection in order to keep the rail gate arm lengths to a minimum, especially at locations that have a large radius to accommodate large truck off-tracking. See Figure 16-11. Channelized right turn lanes typically don't require PTR signs. See section 16.8.9.

Figure 16-11 | Channelized Right Turn Lane Example



Yield controlled right turn lanes will have a stop line for the rail gate arm and may also have markings for a crosswalk and a yield line. If all three markings are used, the best order is rail stop line followed by crosswalk marking followed by yield line. This order will help determine the placement of the related traffic control devices. See Figure 16-12.

Figure 16-12 | Yield Controlled Channelized Right Turn Lane Pavement Marking Example

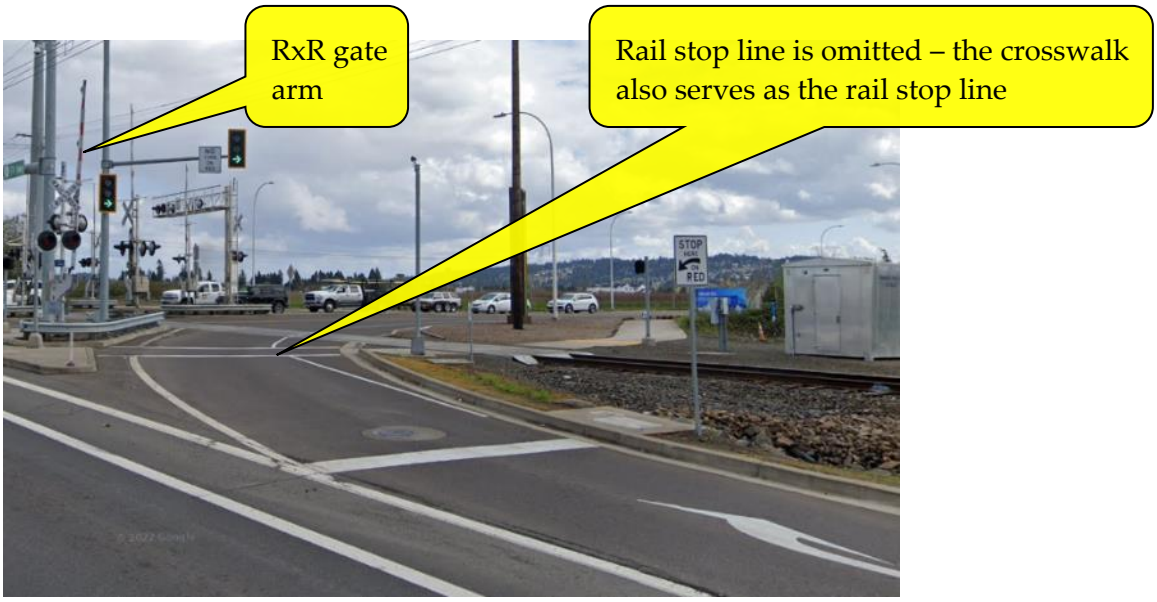


Signal controlled channelized right turn lanes can present a challenge for determining the proper placement of all the necessary traffic control devices, such as the stop line necessary for the signal indications, the crosswalk markings, and the stop line necessary for the rail gate arm. Consider the following standards, that when used together in a small area like a channelized right turn lane, will require some compromise so that final product is not a confusing mess of traffic control device clutter and three different locations for the driver to stop:

- The standard placement of the signal indications for the channelized right turn lane is overhead on a mast arm. This then requires a stop line that is 45 feet from these indications.
- Standard placement of the rail stop line is one foot prior to the gate arm
- The signalized crosswalk requires crosswalk markings and is dependent on the channelized island cut through/ramp geometry

It is nearly impossible to get the crosswalk location to function as the stop line for the signal indications (which would be ideal), but it is typically possible to get the crosswalk location to function as the stop line for the rail gate arm. See Figure 16-13 for example.

Figure 16-13 | Signal Controlled Channelized Right Turn Lane Pavement Marking Example 1



Having the stop line for the right turn lane 45 feet from the signal indications makes that location pretty far away from the crosswalk and normal stopping location of the adjacent through phase; this may not get good compliance from drivers. If a driver pulls too far forward, they won't be able to see the signal indications. To mitigate this concern and also allow some flexibility to move the stop location closer to the intersection (to a more intuitive stop location), a low mounted supplemental signal head (14' to bottom of signal head) on the mast arm pole is recommended. See Figure 16-14. For a low mounted signal head (14' to the bottom of signal), the stop line can be placed a min. of 30' from signal head by interpolating MUTCD figure 4D-3.

Figure 16-14 | Signal Controlled Channelized Right Turn Lane Pavement Marking Example 2



16.8.7 Median Islands

Median islands are common on the approach leg of a railroad crossing. They typically serve two main purposes. See Figure 16-15.

- To keep vehicles from driving around a gate arm that is down
- To keep the rail gate arm lengths to a minimum (maximum length allowed is typically 32 feet)

Figure 16-15 | Median Island Example



16.8.8 Crosswalk Placement and Stop Lines

Crosswalk and stop line locations at a rail interconnected signal are important considerations as they have an impact on preemption operation and driver compliance.

When the tracks are located very close to the intersection, there may be an opportunity to place the crosswalk for that approach prior to the railroad tracks. This provides a very clear stop location (only one marking) vs. two separate stop locations (a stop line prior to the tracks and a crosswalk marking after the tracks). A VCOI phase may not be needed. However, it does typically pull the crosswalk farther back from the intersection which can impact sight lines (see chapter 5 for more info on sight lines) and typically requires a NO TURN ON RED sign. See Figure 16-16 and Figure 16-17 for examples.

Figure 16-16 | Crosswalk Prior to Railroad Crossing Example 1

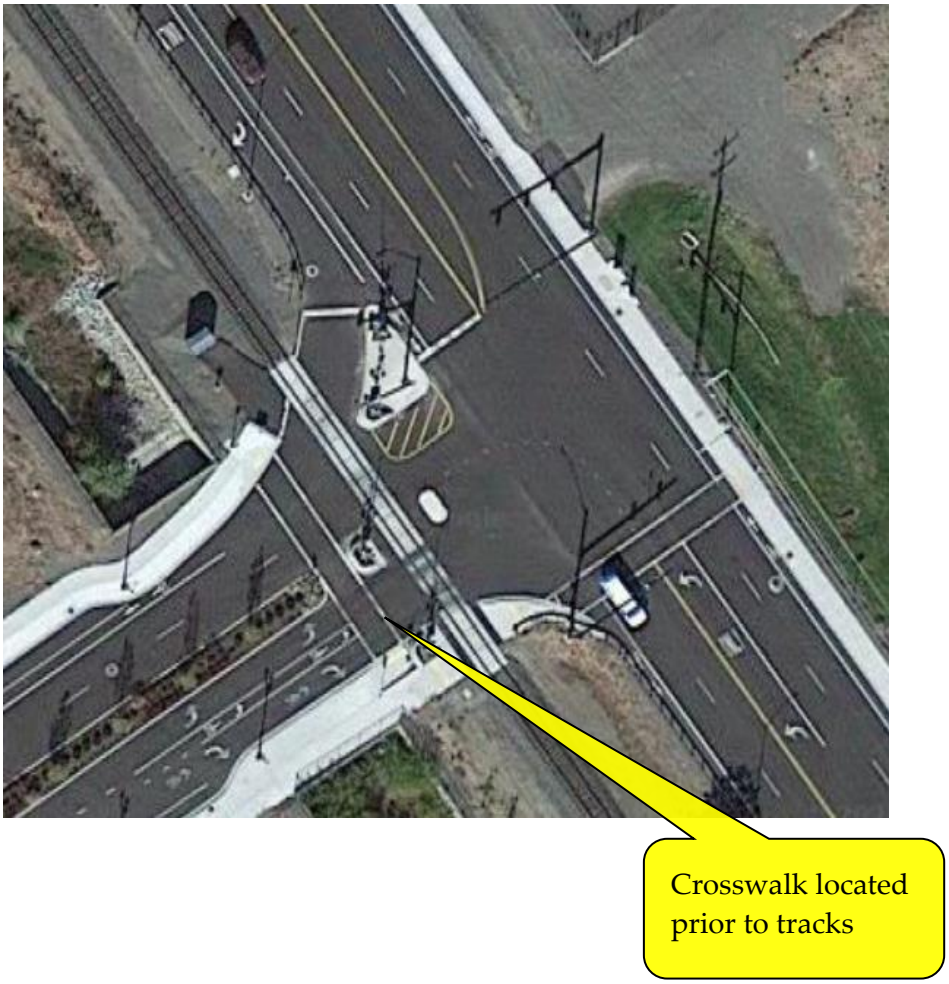


Figure 16-17 | Crosswalk Prior to Railroad Crossing Example 2



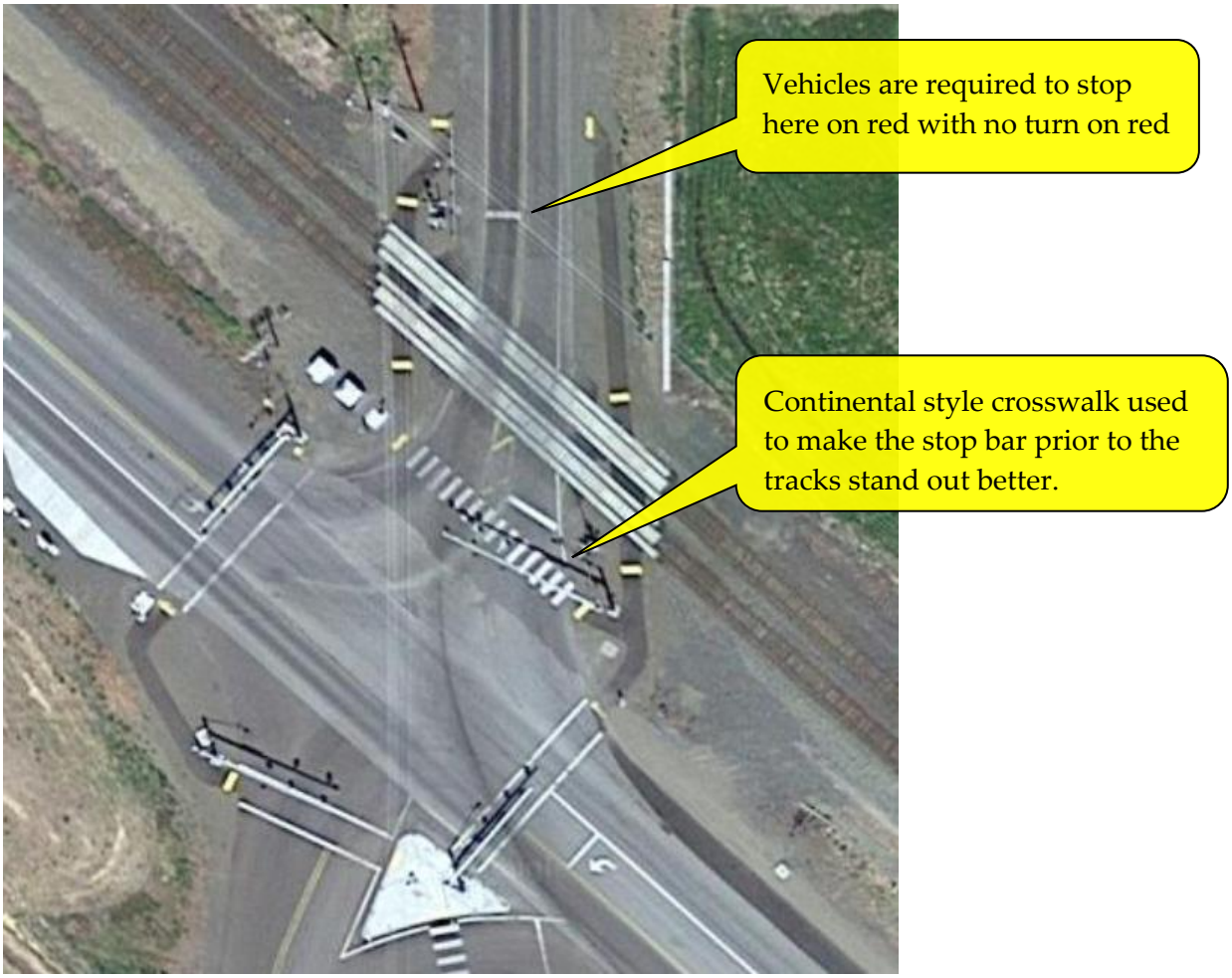
Two separate stop locations: A marked crosswalk after the tracks and a stop bar prior to the tracks. Drivers may inappropriately decide to stop at crosswalk. Below is a potential solution



Same intersection as above, but with marked crosswalk moved prior to the tracks. One clear place to stop now, driver compliance may improve, but sight lines and ped circulation path may be impacted.

Using a continental style crosswalk, instead of the standard transverse bars, when two separate stopping locations must be marked may also be beneficial to make each marking stand out better and in theory help with driver compliance (when the intent is for all drivers to stop and remain stopped at the stop line prior to the tracks).

Figure 16-18 | Continental Crosswalk Used at a Rail Crossing with an Advance Stop Location



It is best to keep crosswalk distances as short as possible at rail interconnected traffic signals as the PCOI time needed at the intersection is based on the longest flashing don't walk time. The extra seconds from an unnecessarily long crosswalk can add a lot of expense and may be very difficult or not even feasible for the rail owner to provide in certain cases.

For channelized right turn lanes crosswalk and stop line information, see section 16.8.6.

16.8.9 Signs – Part Time Restriction (PTR)

Part-time restriction (PTR) signs are typically installed at the traffic signal based on MUTCD section 8B.08 and the field diagnostic review. These signs state a turn restriction, such as NO LEFT TURN sign (R3-2) or NO RIGHT TURN sign (R3-1) that are used for permissive only turns that will cross the railroad tracks when the simultaneous input is triggered (e.g., PTR sign will be ON and restrict the turn movement only during the VCOI and limited service phases). See Figure 16-19 and Figure 16-20.

Figure 16-19 | Part-Time Restriction "NO LEFT TURN" Sign Example



Figure 16-20 | Part-Time Restriction "NO RIGHT TURN" Sign Example



The NO RIGHT TURN sign (R3-1) is the most common PTR sign used for rail preemption, as most right turn movements toward the rail crossing are permissive and right turns on red are typically allowed. The NO LEFT TURN sign (R3-2) is rarer, as the left turn toward the rail crossing is typically not a permissive only left turn and left turns on red are typically not legal. These PTR signs are valuable in most circumstances to provide additional warning of a train preemption and a necessary prohibition of turning movements (which can also help prevent damage to the railroad gate arms when tracks are located very close to the intersection), but they should be omitted for certain geometries or signal phasing (to avoid the PTR sign contributing to traffic control device clutter):

- The distance from the intersection to the rail crossing is greater than 100 feet (e.g., there is adequate sight distance for the turning vehicle to see and react to the RxR lights/gate and room to store the design vehicle without blocking the intersection or crosswalk. See Figure 16-21.
- The left or right turn movement toward the rail crossing is a protected only or protected/permitted movement and turns on red are not allowed (e.g., the signal head for the turn movement is capable of displaying an independent red indication when the simultaneous preempt input is triggered and statue or signs prohibit turns on red). See Figure 16-22 and Figure 16-23.
- The right turn is channelized with YIELD or STOP control. See Figure 16-24.

When used, these signs are mounted on the signal mast arm (preferred) or on the signal mast arm pole and are detailed on the signal plan sheet.

Figure 16-21 | Omitting the Part-Time Restriction Signs Example 1



Figure 16-22 | Omitting the Part-Time Restriction Sign Example 2

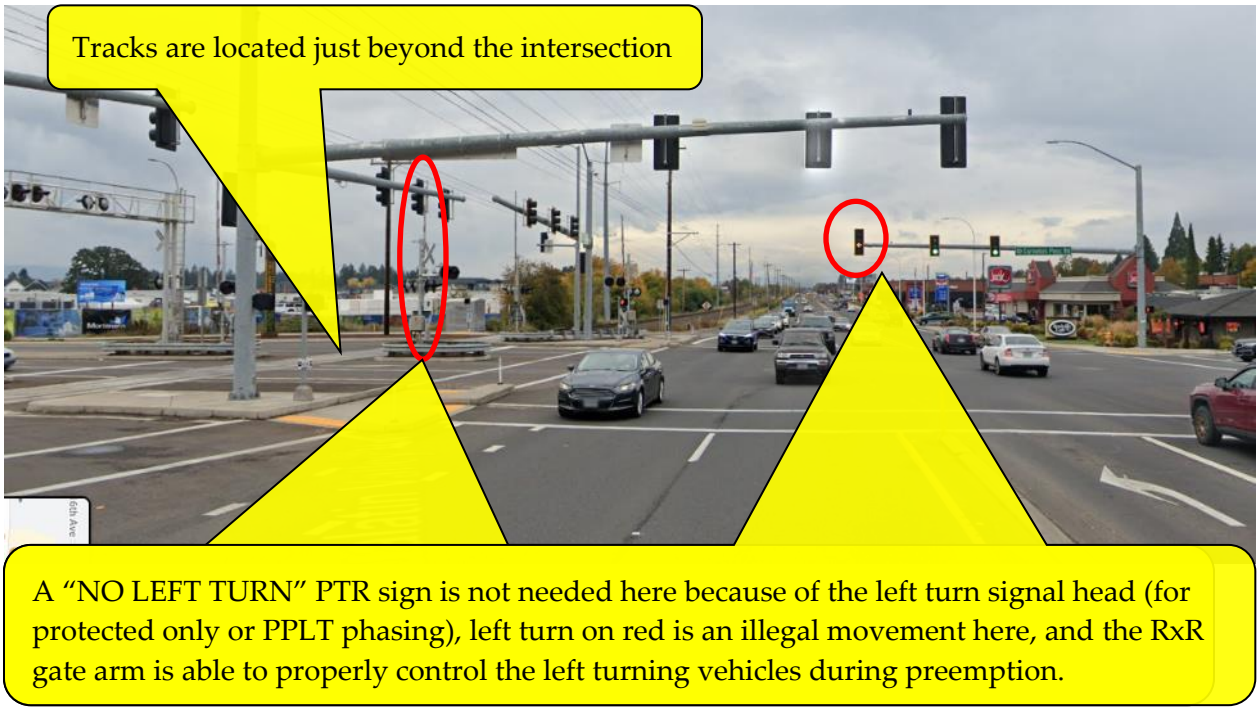


Figure 16-23 | Omitting the Part-Time Restriction Sign Example 3

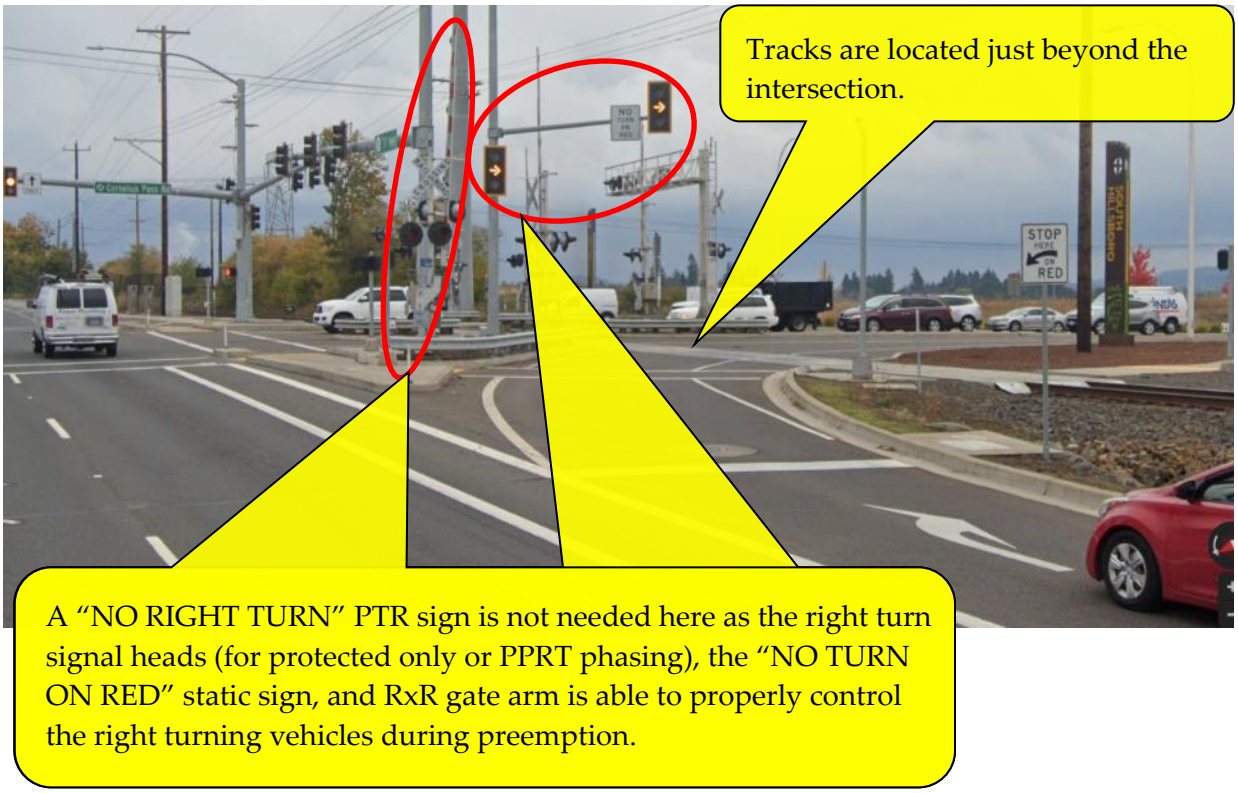


Figure 16-24 | Omitting the Part-Time Restriction Sign Example 4



16.8.10 Signs – STOP HERE ON RED & NO TURN ON RED

The STOP HERE ON RED sign (R10-6) and the NO TURN ON RED sign (R10-11a) can be beneficial at interconnected rail crossing with certain geometries and are critical signs for how the preemption will operate.

The STOP HERE ON RED sign is placed at the railroad stop line (see Figure 16-25) and should be considered when:

- There is not enough room for a single passenger vehicle to safely queue without stopping on the tracks. The volume/frequency of freight and other larger vehicles should also be taken into consideration.
- If the crosswalk for the intersection is located prior to the railroad tracks. In this case, there is not a separate railroad stop line and the STOP HERE ON RED sign would be located at the near side of the crosswalk line (the near side of the crosswalk line functions as the stop location for the intersection as well as for the tracks). See Figure 16-26.

Figure 16-25 | STOP HERE ON RED sign example 1



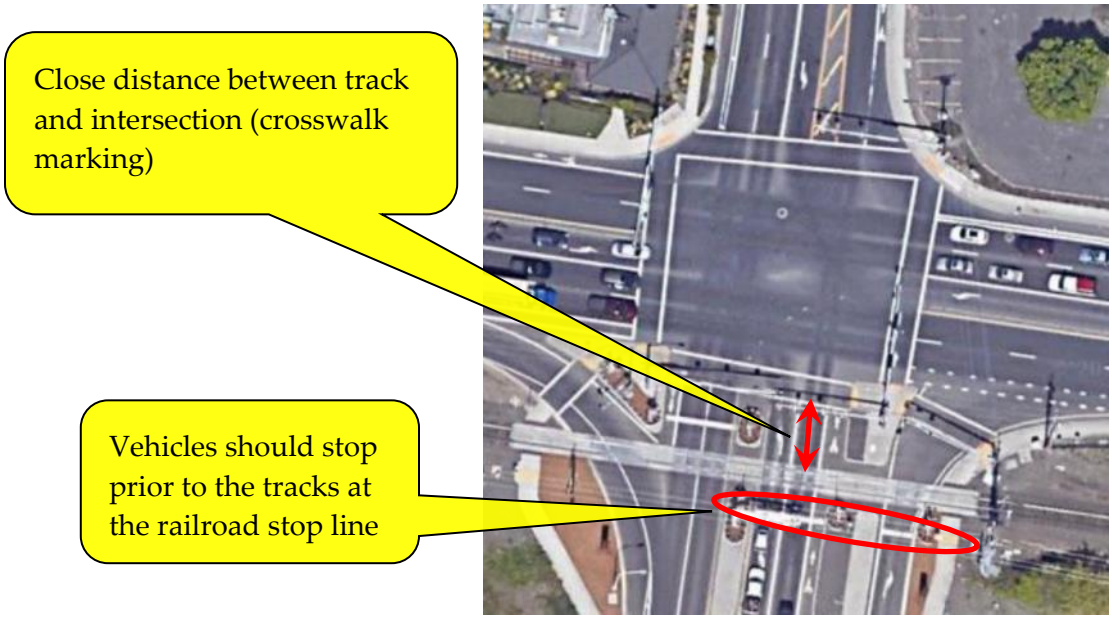
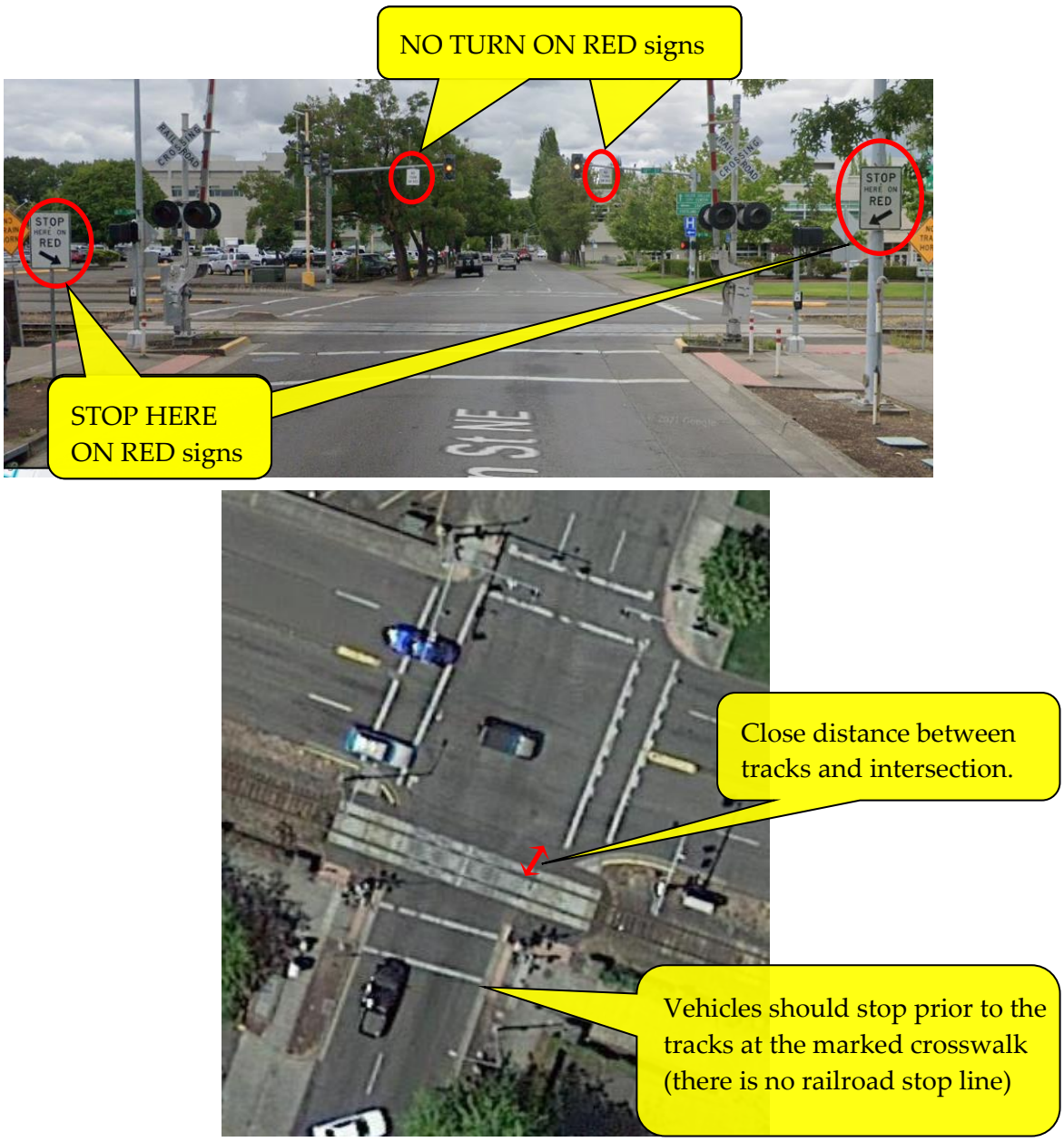


Figure 16-26 | STOP HERE ON RED sign example 2



The NO TURN ON RED sign for the right turn movement (or left turn movement if a left turn on red is legal) shall be used in conjunction with the STOP HERE ON RED sign to reduce the risk of a right on red vehicle stopping on the tracks.

If pre-signals are used at the intersection, the NO TURN ON RED sign should be placed only with the pre-signals, not with the downstream signals. If the sign is placed on the downstream signals, a driver that was inattentive of the NO TURN ON RED sign at the pre-signals and

pulled forwarded between the tracks and the intersection (to get better sight distance to judge gaps) might remain stopped there if they happen to notice a NO TURN ON RED sign placed with the downstream signals. If they missed sign at the pre signal (and they are now stopped where they should not be), it is better that they just complete their turn on red rather than remaining stopped on the tracks.

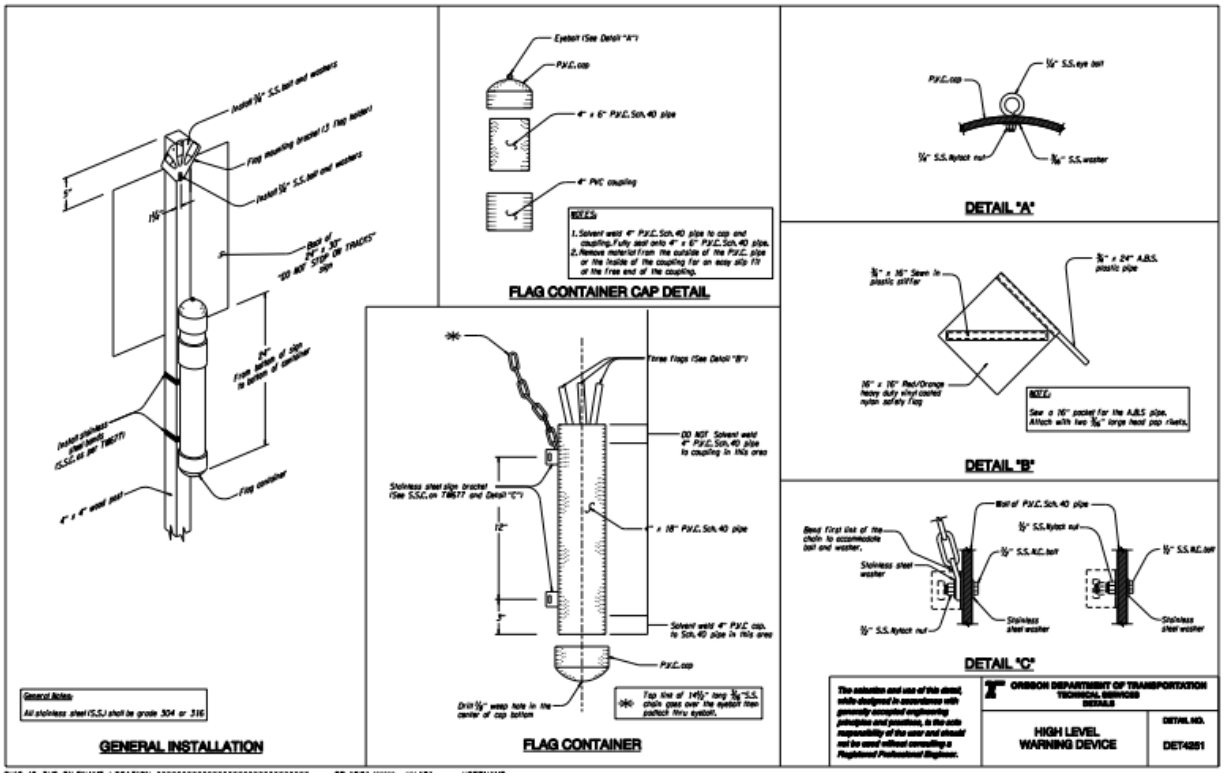
The NO TURN ON RED sign is typically mounted on the signal mast arm or signal mast arm pole and is detailed in the signal plan.

The STOP HERE ON RED sign is typically ground mounted near the stop line and is shown and detailed in the sign plan sheets only.

16.8.11 Signs – DO NOT STOP ON TRACKS & High-Level Warning Device

All rail interconnected traffic signals require a DO NOT STOP ON TRACKS sign (R8-8) that is capable of holding 3 flags (i.e., the high-level warning device) as per OAR 741-115-0040. The high-level warning device fabrication and installation is shown in standard detail DET4251. This sign with the high-level warning device is ground mounted near the railroad tracks and is shown and detailed in the sign plan sheets only. See Figure 16-27.

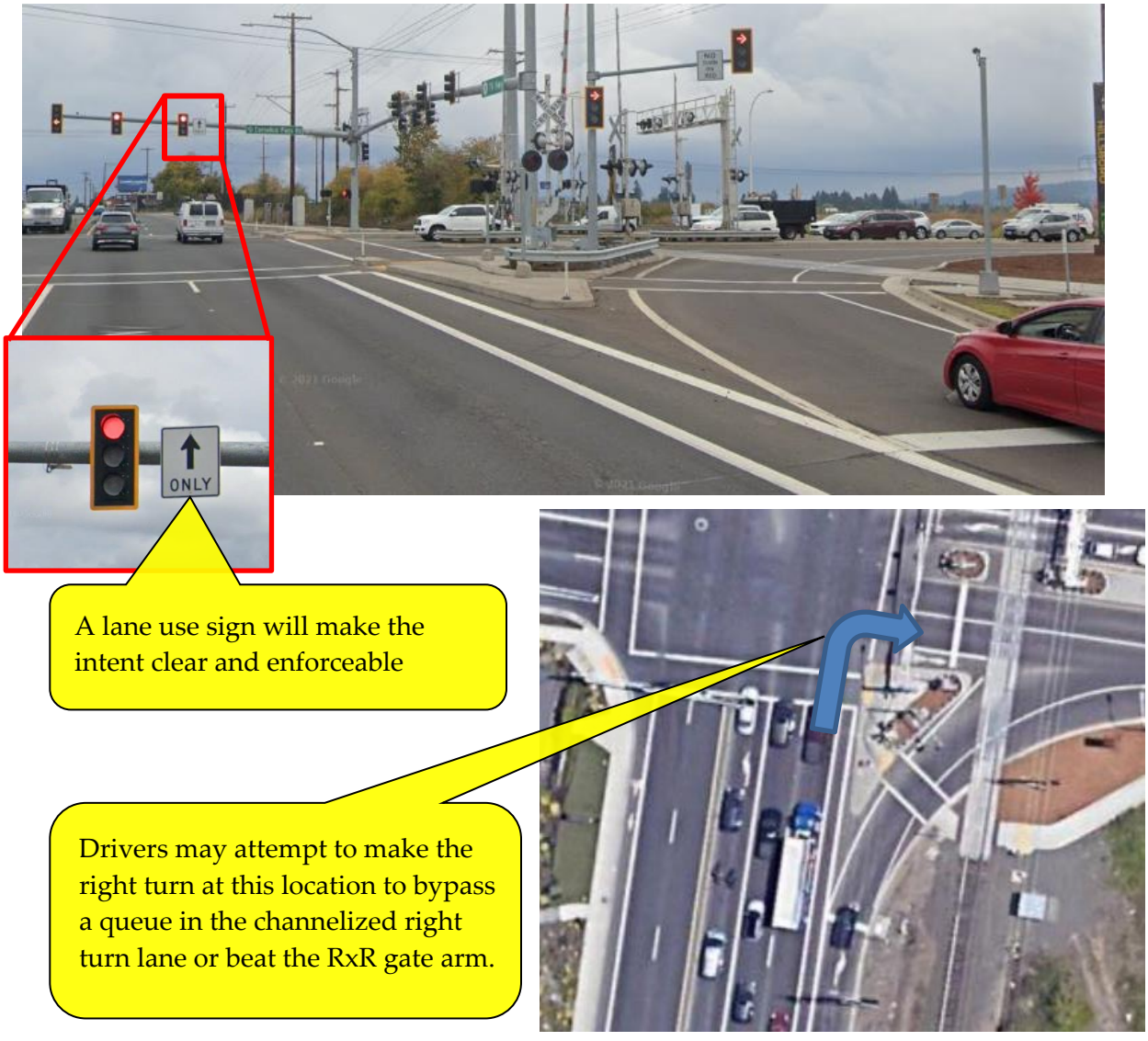
Figure 16-27 | High Level Warning Device – DET4251



16.8.12 Signs – Lane Use

Lane use signs can also be beneficial for certain intersection geometries to help deter drivers from attempting to go around/beat the RxR gate arm or bypass the right turning queue. When a channelized right turn is provided towards the tracks, it can still be physically possible (and debatably legal) for a vehicle to make a right turn from the adjacent thru lane past the pork-chop island even though that is not the intent. A THRU ONLY sign (R3-5) installed on the mast arm for the lane adjacent to the right turn slip lane is a good solution to make the intent clear and enforceable when there is an actual or expected issue with this driver behavior. See Figure 16-28.

Figure 16-28 | Lane Use Sign Example



16.8.13 Conduit and Wiring

The railroad preemption operation is triggered by the railroad controller that monitors the railroad tracks and detects an approaching train. The traffic signal receives the preemption inputs from the railroad controller via the interconnect circuits, which are hardwired from the signal controller cabinet to the railroad control cabinet.

The conduit and wiring required to connect the traffic signal controller to the railroad controller, providing the ability for railroad preemption, is shown on the signal plan sheet. This wiring consists of one 10 conductor No. 12 AWG gauge control cable from the controller cabinet to the railroad cabinet. In retrofit situations, eight No. 12 AWG THWN wires can be used if conduit fill rate is an issue. An exclusive conduit for this wire should be used for new construction.

Figure 16-29 shows an example of how this should be detailed on the signal plan sheet. The railroad will typically install an access box on the outside of their bungalow for the conduit and wiring. See Figure 16-30. The contractor needs to coordinate with rail owner when installing the conduit and wiring at the railroad bungalow.

Figure 16-29 | Railroad Preemption Wiring Example

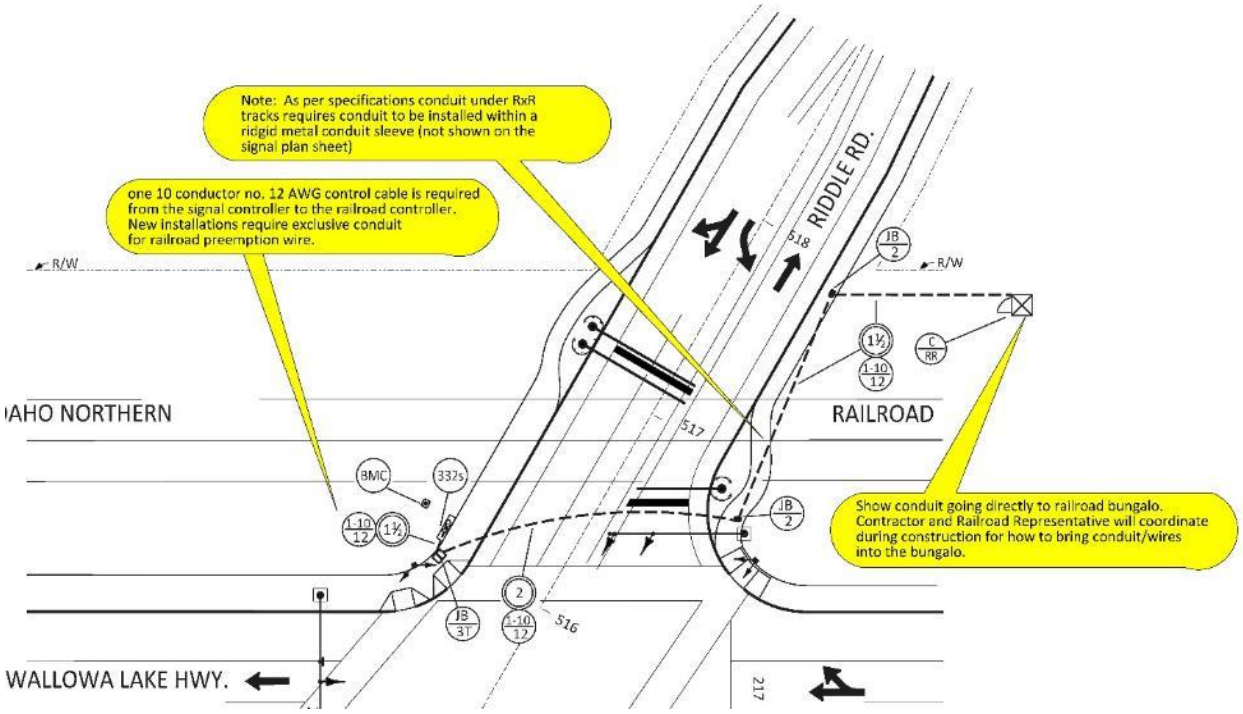


Figure 16-30 | Railroad Bungalow Access Box for Interconnect Conduit and Wiring



16.8.14 Pedestrian Features

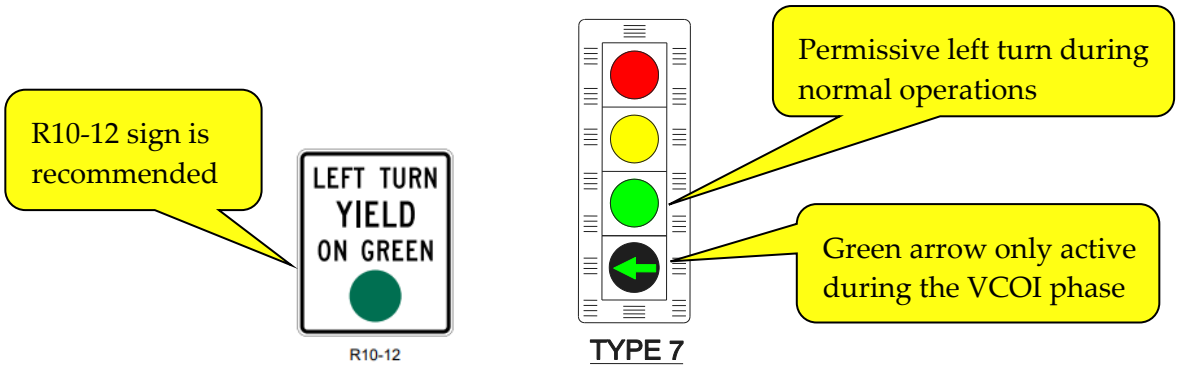
When upgrading existing traffic signals that have railroad preemption, the PCOI time will need to be recalculated using the 2009 MUTCD guidelines. The recalculated PCOI will likely result in a longer PCOI, which requires a rail crossing order for the alteration of the rail detection equipment. If funding is available and the project timeline allows, a rail crossing order and alteration of the rail detection equipment should be completed.

In situations where the recalculated PCOI is longer than the existing PCOI and funding is not available or there is not enough time to process a rail crossing order, the use of two pedestrian change intervals may be used. This allows the use of a consistent flashing don't walk time with two different walk times in order to satisfy the MUTCD requirements AND keep the countdown pedestrian heads functioning as normally as possible during and after a preemption event. See chapter 5 "Extended Pushbutton Press Feature" section for more information.

16.8.15 Type 7 Signal Heads

A type 7 signal head is required for the vehicle clear-out phase when the vehicle clear-out phase contains a permissive only left turn movement AND there is no left turn only lane or there are controller cabinet limitations. See Figure 16-31. The "LEFT TURN YIELD ON GREEN ball" sign (R10-12) should be installed when a type 7 head is installed. This allows use of a green arrow only during the vehicle clear-out interval (VCOI) so that vehicles will be aware they have a protected left turn movement during the railroad preemption sequence. In the past when green balls were used during the VCOI, motorists would often hesitate when making a left turn as they weren't sure if/why the opposing through traffic was stopping.

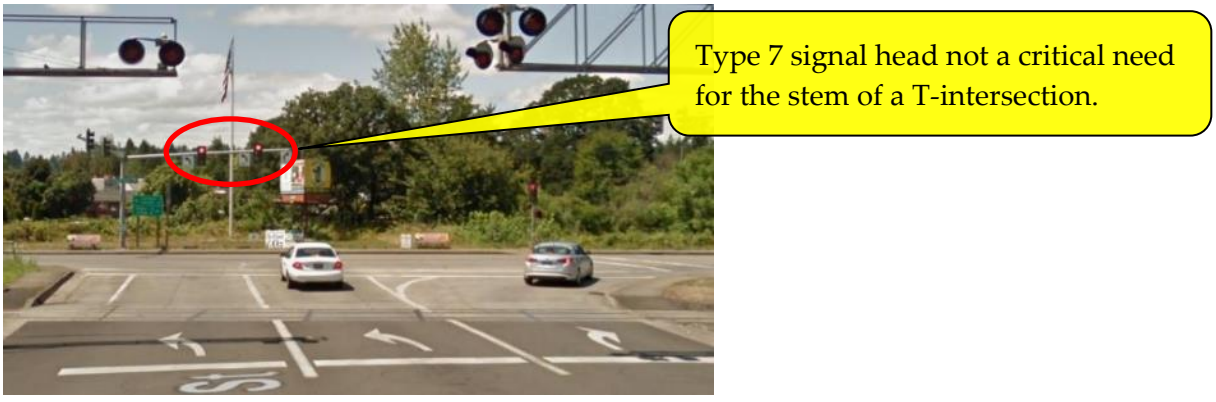
Figure 16-31 | Type 7 Signal Head



Verify if a type 3LCF head can be used instead of a type 7 head as per section 16.8.16

Note that permissive only left turns from the stem of a t-intersection or permissive only left turns with no opposing vehicular traffic (e.g., one way street) can operate acceptably during preemption without a type 7 signal head. See Figure 16-32. However, a type 3LCF or a type 7 signal head should still be used for new construction for consistency/uniformity.

Figure 16-32 | Permissive Only Left Turn (No Oncoming Traffic) – Type 7 Signal Head Not Critical for Proper Preemption Operation

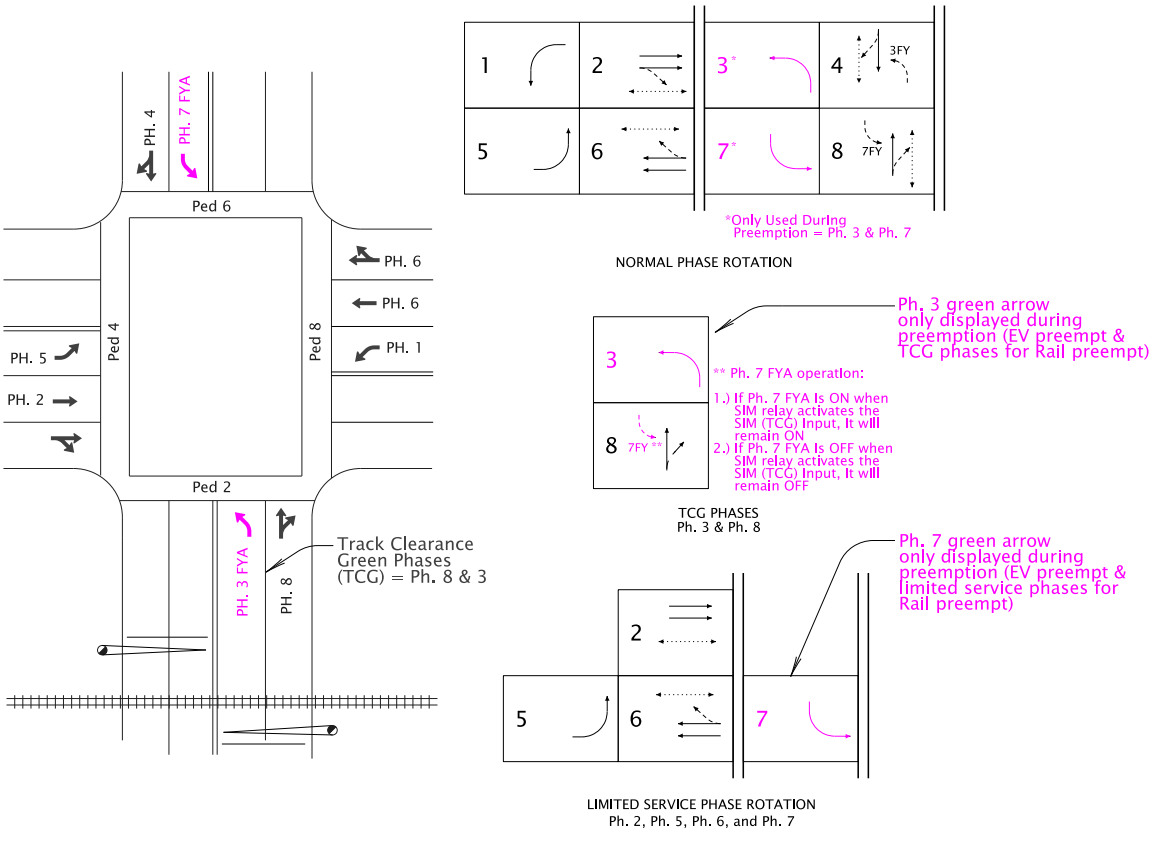


16.8.16 Permissive Left Turn Phasing Using Flashing Yellow Arrow

As per chapter 5, when permissive only left turn phasing is appropriate, a left turn only lane exists, and there are no controller cabinet limitations, a type 3LCF signal head should be used to display only the flashing yellow arrow during normal operation. See Figure 16-33. Work with region traffic to determine if the controller cabinet has any limitations. When a type 3LCF head can be used for permissive only left turn phasing, it has the following benefits for preemption operation (for both railroad and emergency vehicle preemption):

- When the type 3LCF signal head is used for the vehicle clear out phase, it results in less traffic control devices than the alternative (i.e., type 7 signal head plus R10-12 sign) which reduces driver cognitive load.
- When the type 3LCF signal head is used for the phase opposite of the vehicle clear out phase, it eliminates the yellow trap.

Figure 16-33 | Permissive Only Left Turn Phasing Using Flashing Yellow Arrow



Unique ring and barrier illustrations (in pink) to show the normal and preemption operation when using type 3LCF signal heads

16.8.17 Limited Right-Of-Way for Equipment

It can be challenging at times to fit in all the required rail equipment and all the required traffic signal equipment while still maintaining proper clearances, sight lines to all traffic control devices, and meeting all standards. In these cases, work closely with the state traffic signal engineer and ODOT commerce and compliance division to determine if any unique solutions can be implemented or where compromises can be made. See Figure 16-34 and Figure 16-35 for examples.

Figure 16-34 | Unique Solutions – Example 1

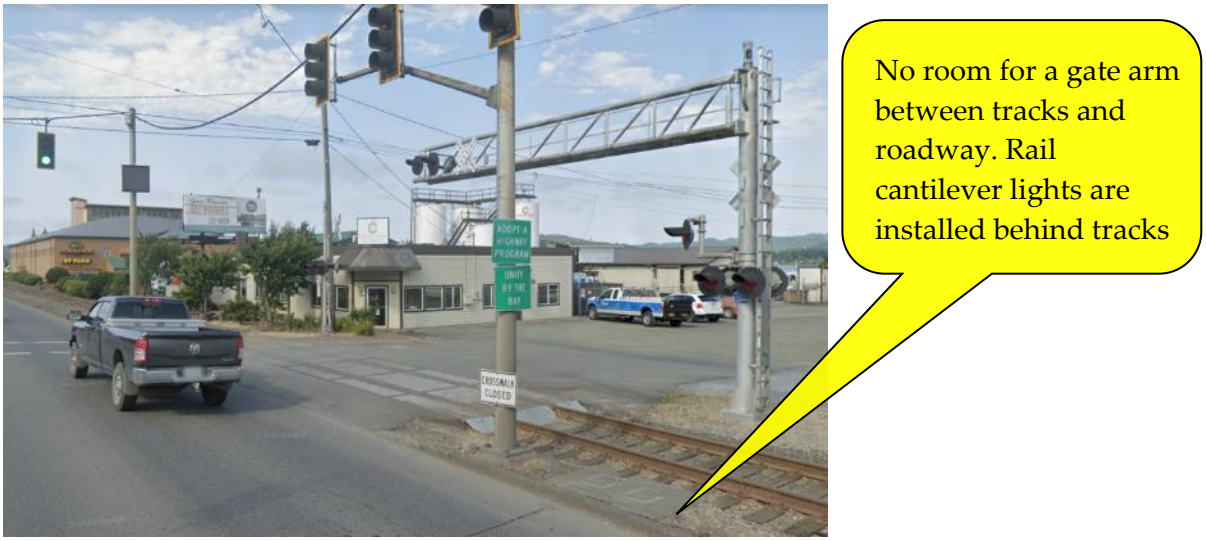


Figure 16-35 | Unique Solutions – Example 2



16.9 Traffic Control Devices Activated by The Rail Controller Cabinet

It is rare, but not uncommon to have traffic control devices (TCD) directly and exclusively activated via the rail controller cabinet rather than going through a traffic signal controller. Typical examples of these type of systems include "be prepared to stop when lights flash" signs, PTR signs, and VMS. See Figure 16-36 and Figure 16-37 for examples.

Figure 16-36 | Example 1 of Rail Controller Cabinet Activated Traffic Control Device



x

Figure 16-37 | Example 2 of Rail Controller Cabinet Activated Traffic Control Device



When a project has a rail controller cabinet activated traffic control device, follow the guidance listed below:

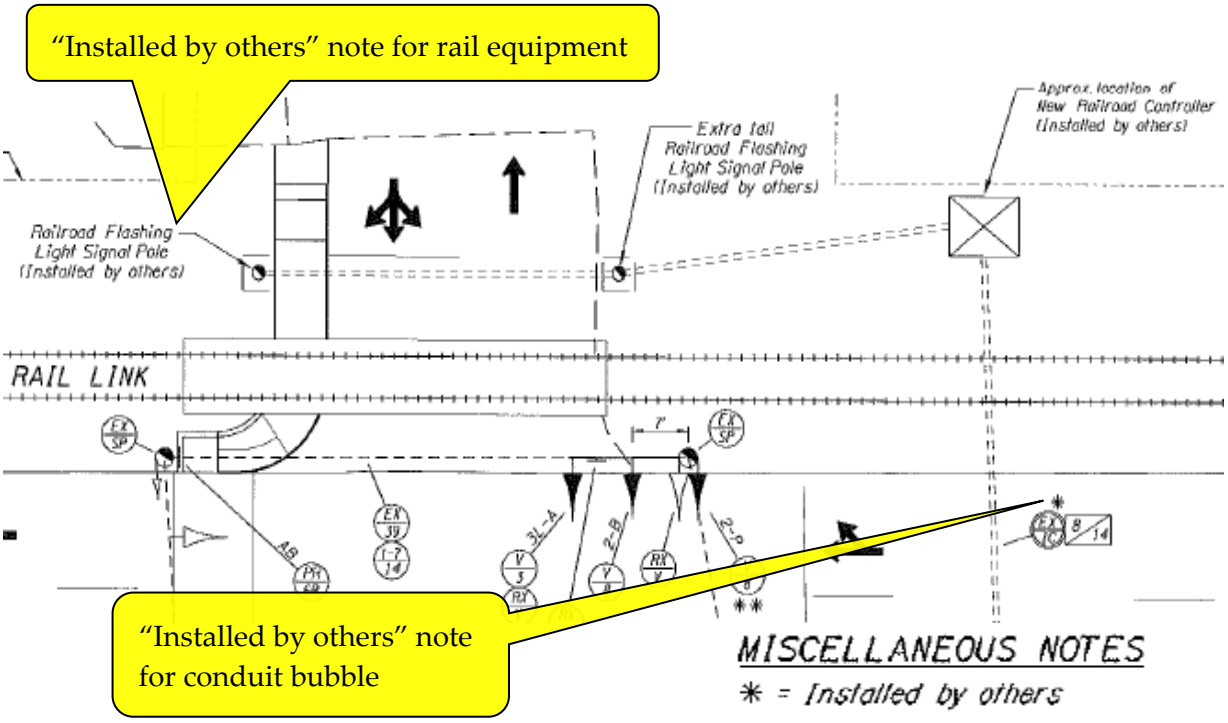
- The signal designer will produce a plan sheet that shows the TCD, junction boxes, & conduit and wiring (up to the rail bungalow). The contractor will install these devices.
- The rail owner will provide an interface box on the outside of their bungalow.
- The rail owner is responsible for the control system that activates the TCD. The rail owner will install wiring/devices in their cabinet.
- On state highways, the rail activated TCD requires STE operational approval (the STE operational approval will state requirements as necessary, with concurrence from ODOT commerce and compliance division).
- Off state highways, the ODOT commerce and compliance division shall document any necessary operational/design requirements as per the diagnostic team in the rail crossing order. The local agency's policies/procedures for TCDs shall also be followed.
- The rail crossing order will establish who owns and maintains the TCD. Typically, the road authority will own and maintain the TCD (and the conduit/wiring from the TCD to the railroad bungalow). The rail equipment and TCD should be powered from separate services. If the TCD is powered from the rail equipment service, a power disconnect that that highway agency can easily access will be necessary to safely maintain the TCD.
- When the TCD will go into service, the owner & maintainer of the TCD will be on-site and verify proper operation and approve the installation.

16.10 Other Work – Railroad Grade Crossing System

The railroad owner is typically responsible for installing the grade crossing system, including train detection equipment on the rails, gate arms, railroad flashing beacon assemblies, and the railroad cabinet. This work is paid for through railroad agreements and typically not shown in ODOT contract plans. The resident engineer's office will coordinate with the contractor and the railroad owner to install these items.

The grade crossing system may be symbolically shown, but not detailed, on the signal plan sheets. If needed, these features may also be noted as "installed by others" to clarify which features the contractor is NOT responsible for. See Figure 16-38.

Figure 16-38 | Railroad Equipment Installed by Others



Other disciplines will be responsible for detailing work that is needed as per the crossing order.

Roadway plans will detail the following:

- The location of the crossing signal equipment, foundations, railroad signal house.
- The quantity of new crossing surfacing materials
- Sidewalk work to be constructed up to the crossing surface

Sign plans will detail ground mounted signs required by the crossing order.

Striping plans will detail the pavement markings required by the crossing order.

16.11 Other Work – Railroad Preemption Plan Sheet

ODOT commerce and compliance division requires a separate, sealed railroad preemption plan sheet to be included with the railroad-highway public crossing safety application. This plan sheet contains the operational requirements of the preemption. See chapter 21 for the drafting requirements and examples. In the past, this plan sheet was included in the contract plans, but is now contained within the rail crossing order (as it doesn't include any information pertinent to the contractor's work). It is still archived in filenet and now also included with the cabinet print (see chapter 20 for more information about the cabinet print).

NOTE: The field diagnostic review determines the type of preemption operation and necessary traffic control devices to accommodate the desired operation. The railroad preemption plan sheet is part of the operational documentation required for the rail crossing order.

The railroad preemption plan sheet will be completed early on in the project, DAP or preliminary plans, prior to completion of the other signal plan sheets for the project. Therefore, the traffic engineering section will issue a TRS drwg. no. for ONLY the railroad preemption plan sheet at this time.

The rail preemption plan sheet shall be reviewed by region traffic, ODOT commerce and compliance division, and the traffic engineering section.

The final stamped and digitally signed rail preemption plan sheet should be sent to the traffic engineering section for approval. The traffic engineering section will then submit an electronic copy of the approved plan sheet to the ODOT commerce and compliance division for use in the rail crossing order and archive the plan sheet.

The railroad preemption plan sheet is NOT part of the contract plan set.

16.11.1 Signal Modifications That Require Updating the Preemption Plan Sheet

It is important to always contact the ODOT commerce and compliance division when any work or maintenance is being considered within their jurisdiction, no matter how minor. See the ODOT Traffic Manual for more information about the process and coordination.

The rail preemption plan is part of the crossing order and needs to be accurate for the initial installation and future routine maintenance inspections performed by ODOT commerce and compliance division inspectors and TSSU. Therefore, the following list states common intersection/traffic signal modifications that require updating the preemption plan sheet in the

crossing order, even if they don't have a direct impact on the rail crossing. Note that the crossing order process may be abbreviated if the changes are minor or they do directly impact the rail crossing.

- Adding or removing lanes
- Changing existing lane use
- Opening or closing crosswalks
- Adding or removing type 7 signal heads
- Adding or removing any vehicle/pedestrian signal phases
- Adding or removing split phasing
- Changing existing left turn phasing (e.g., protected to PPLT, etc.)
- Adding or removing any signs used for or are critical to railroad preemption (e.g., PTR signs, NO TURN ON RED signs, STOP HERE ON RED signs)
- Modifying anything in the rail preemption operation sequence

This list is not all inclusive. It is intended to inform you of when a preemption plan sheet is likely needed for retro-fit projects and to help facilitate communication with the ODOT commerce and compliance division.

Certain traffic signal items are purposely not shown on the preemption plan sheet, such as fire preemption, signal head types (except for type 7), signal head spacing, conduit, wiring, etc. Changes to these items don't require an updated preemption plan sheet. However, even if an updated preemption plan sheet is not required, a crossing order could still be required depending on the scope of work, which is why it is important to always contact the ODOT commerce and compliance division. ODOT commerce and compliance division is the final authority regarding the requirements within their jurisdiction.

17 Fire (Emergency) Signal Plan

17.1 General

A fire signal is a special type of traffic control signal that assigns the right-of-way to an authorized emergency vehicle (typically fire trucks). This type of signal is usually installed at a location that doesn't meet other traffic signal warrants, such as the access for the emergency vehicle. They are not used at roundabouts.

Actuated flashing beacon systems for emergency vehicles are a good alternative to the traditional fire signal described in this chapter.

Traditional fire signals are typically more expensive than actuated flashing beacon systems (mast arms vs. pedestals), especially if the fire signal will be located at an intersection (where a fully actuated signal is then required).

See chapter 12 for design information on actuated flashing beacon systems for emergency vehicles.

17.2 Operational Approval

A fire signal requires STE operational approval.

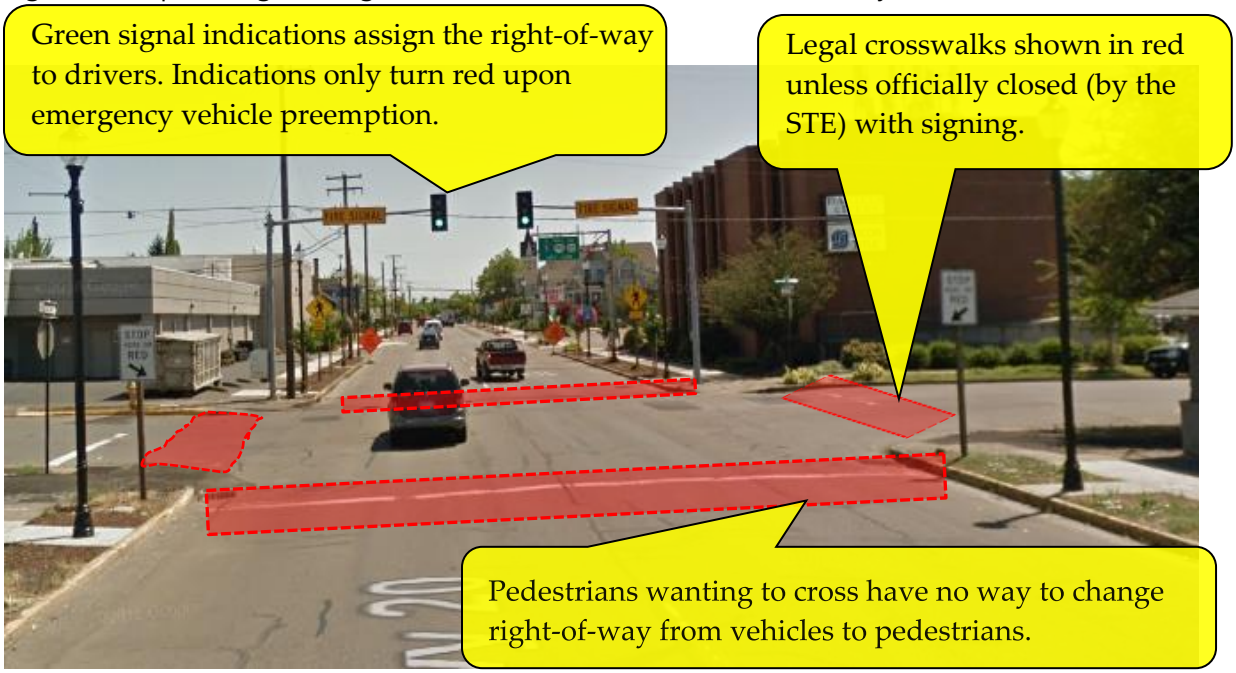
17.3 Fire Signal Located at an Intersection

When a fire signal is located at the intersection of a public road, a standard fully actuated signal shall be provided. While the purpose of the fire signal is to help emergency vehicles access the mainline, a standard fully actuated signal is not technically a fire signal from a design standpoint and chapters 5 and 6 of this manual should be consulted for design information.

17.3.1 Solutions for Existing Fire Signals Located at Intersections

Recently developed requirements for ADA ramps, crosswalks, and pushbuttons due to the ODOT ADA litigation settlement have highlighted a need to address existing fire signals (that are not standard fully actuated signals) installed at intersections. The case study shown in Figure 17-1 illustrates the problems created when a fire signal is located at an intersection.

Figure 17-1 | Existing Fire Signal Located at Intersection – Case Study



The five solutions listed below are acceptable in order of preference (note: all of them require STE operational approval):

1. Removal of the existing fire signal.
2. Removal of the existing fire signal and installation of actuated flashing beacons with sign W11-8. See chapter 12 for design information.
3. Removal of the existing fire signal and installation of fully actuated traffic signal.
4. Change solid green indications of existing fire signal to flashing yellow indications.
5. Retain existing fire signal and officially close the crosswalks that are in conflict with the green indications (because there is no way for the pedestrians to change the green indications which are assigning right-of-way to the vehicle, the crosswalks within the stop bar locations are effectively closed).

The appropriate solution to implement will be based on site-specific factors (e.g., volumes, warrants, etc.) and the scope of the project that is impacting the existing fire signal. Solutions 1 thru 3 meet current standards and should be implemented if possible. Solutions 4 and 5, while acceptable, are not desirable and should only be considered if solutions 1 thru 3 are not feasible.

Two other solutions were considered, but deemed unacceptable for the following reasons:

1. Adding pushbuttons and pedestrian heads to the existing fire signal - this creates a half-signal which is prohibited by the MUTCD.
2. Keeping the crosswalks open that are in conflict with the green indications - this creates a conflict with the appropriate driver response when considering ORS 811.260 (appropriate driver responses to traffic control devices) and ORS 811.028 (failure to stop and remain stopped for pedestrians).

17.4 Fire Signal Located at Mid-Block Access

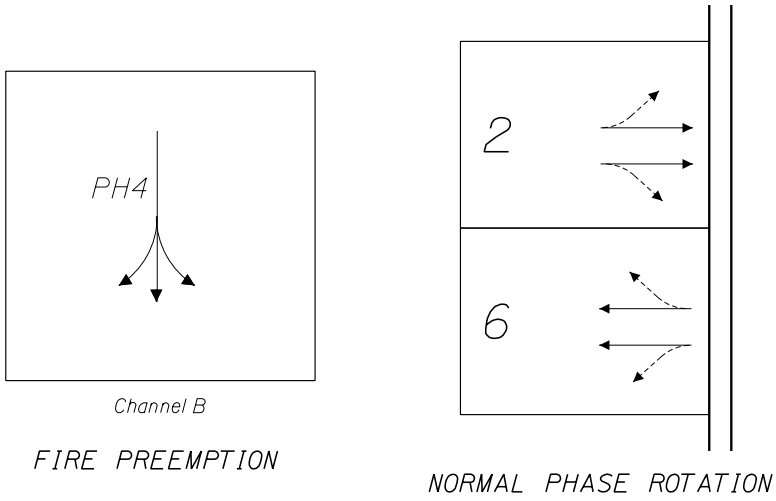
Fire signals are typically located at a mid-block access used only by emergency vehicles. The following section discusses specific design requirements for mid-block fire signals.

17.4.1 Operation

The operation of a fire signal located mid-block will remain green on mainline until the emergency vehicle preempts the signal. In the past, flashing yellow was commonly used, but is no longer allowed unless it is documented in the STE operational approval. The preemption can be either a manual input (e.g., pushbutton at the fire station) that is pre-timed or a standard preemption detector unit that will wirelessly provide and hold the input until the emergency vehicle has cleared the access.

The mainline phases are 2 and 6. The preemption phase is phase 4 on channel B. The normal phase rotation and fire preemption operation should be shown on the plan sheet. See Figure 17-2.

Figure 17-2 | Phase Rotations for Fire Signal



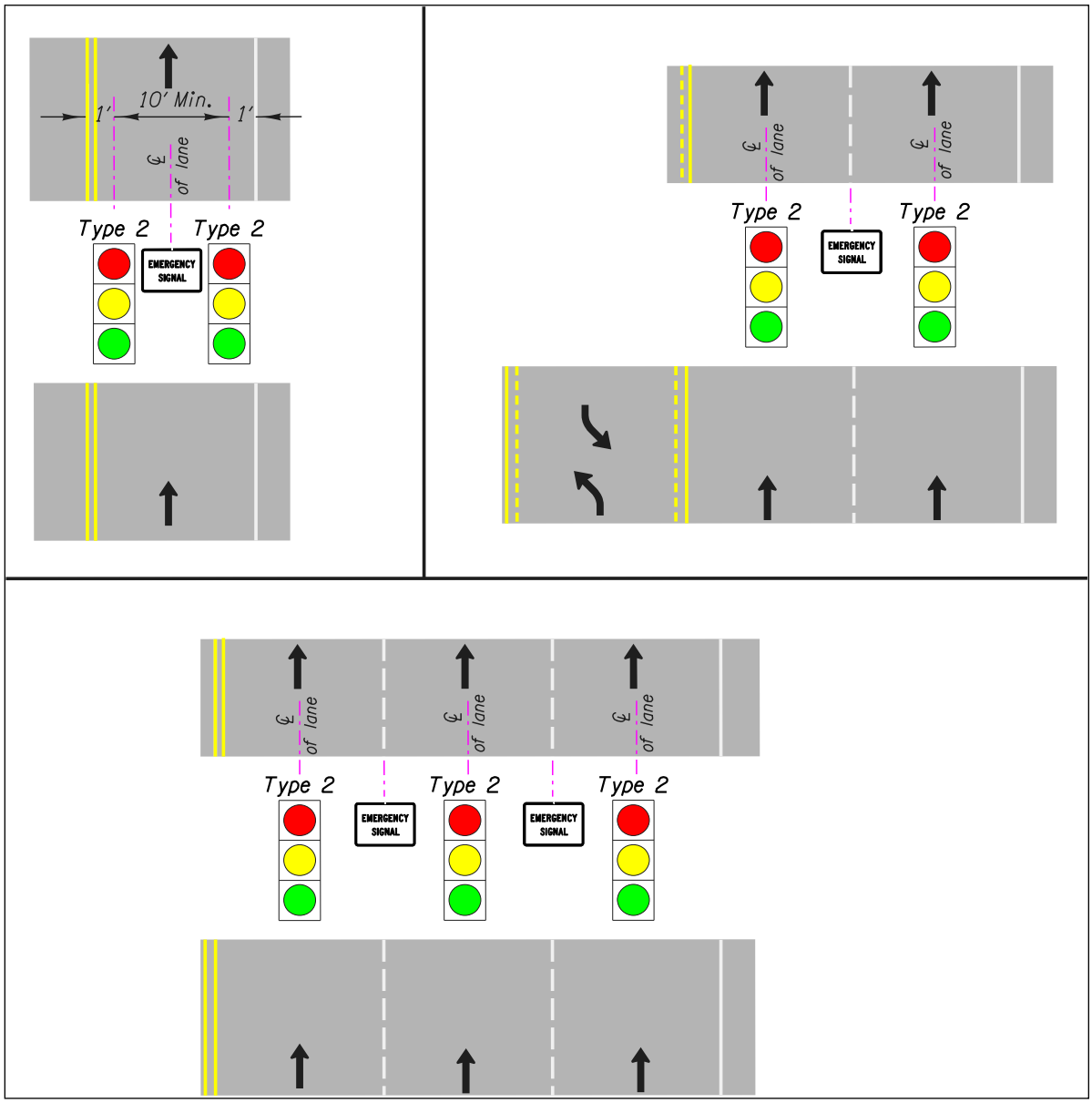
17.4.2 Controller and Service

A 332S controller cabinet with a base mounted service (BMC) should be used.

17.4.3 Signal Head Type and Layout

The mainline approach is required to have at least two type 2 signal heads. See Figure 17-3.

Figure 17-3 | Signal Head Layout for Mid-Block Fire Signal



The default standard is NO signal indications for the emergency access approach. This is because it is important for the emergency vehicle driver to watch traffic, not a signal indication when accessing the mainline. This is especially critical at a fire signal, where the mainline phase is normally green and local drivers don't expect the signal to change. However, if the fire department requests a form of preemption confirmation on the access approach, a tattletale indicator may be used. See section 17.4.5 for more information.

The tattletale indicator can clearly inform the fire department that the preemption is working (the tattletale will be ON when the mainline indications are red) by a simple, direct hardwire vs. more complex systems that have been used in the past that required additional phases/outputs in a controller cabinet (e.g., a type 2 signal head, a single green circular indication, and flood lights). As such, these more complex systems are no longer allowed. See Figure 17-4 thru Figure 17-6.

Figure 17-4 | Confirmation Indication – NO LONGER ALLOWED



Figure 17-5 | Confirmation Indication – NO LONGER ALLOWED



Figure 17-6 | Confirmation Indication – NO LONGER ALLOWED



17.4.4 Signs

Several specific signs are required for a fire signal. Coordinate with the sign designer for any ground mounted signs.

An emergency vehicle sign (W11-8) with an EMERGENCY SIGNAL AHEAD supplemental plaque (W11-12p) is required to be installed in advance of the fire signal. See Figure 17-7. A warning beacon may be used to supplement this advance warning sign if deemed necessary by the operational approval.

Figure 17-7 | Emergency Vehicle Sign (W11-8) with Emergency Signal Ahead Plaque (W11-12p)



An EMERGENCY SIGNAL sign (R10-13) shall be mounted overhead, typically between the two signal heads. See Figure 17-8.

Figure 17-8 | Emergency Signal Sign (R10-13)



A STOP HERE ON RED sign (R10-6) shall be mounted near the stop line. See Figure 17-9.

Figure 17-9 | Stop Here on Red Sign (R10-6)



17.4.5 Tattletale Indicators

Tattletale indicators are typically used at the request of law enforcement to aid in enforcing red light running violations by clearly indicating a red indication is active from certain viewing angles. The tattletale light is directly hardwired to the RED indication. This simple direct hard-wire design also works well for a fire signal confirmation indication. If a confirmation indication is requested, use standard detail DET4400 and coordinate with the fire department to determine the best placement for the tattletale, as it is a directional device.

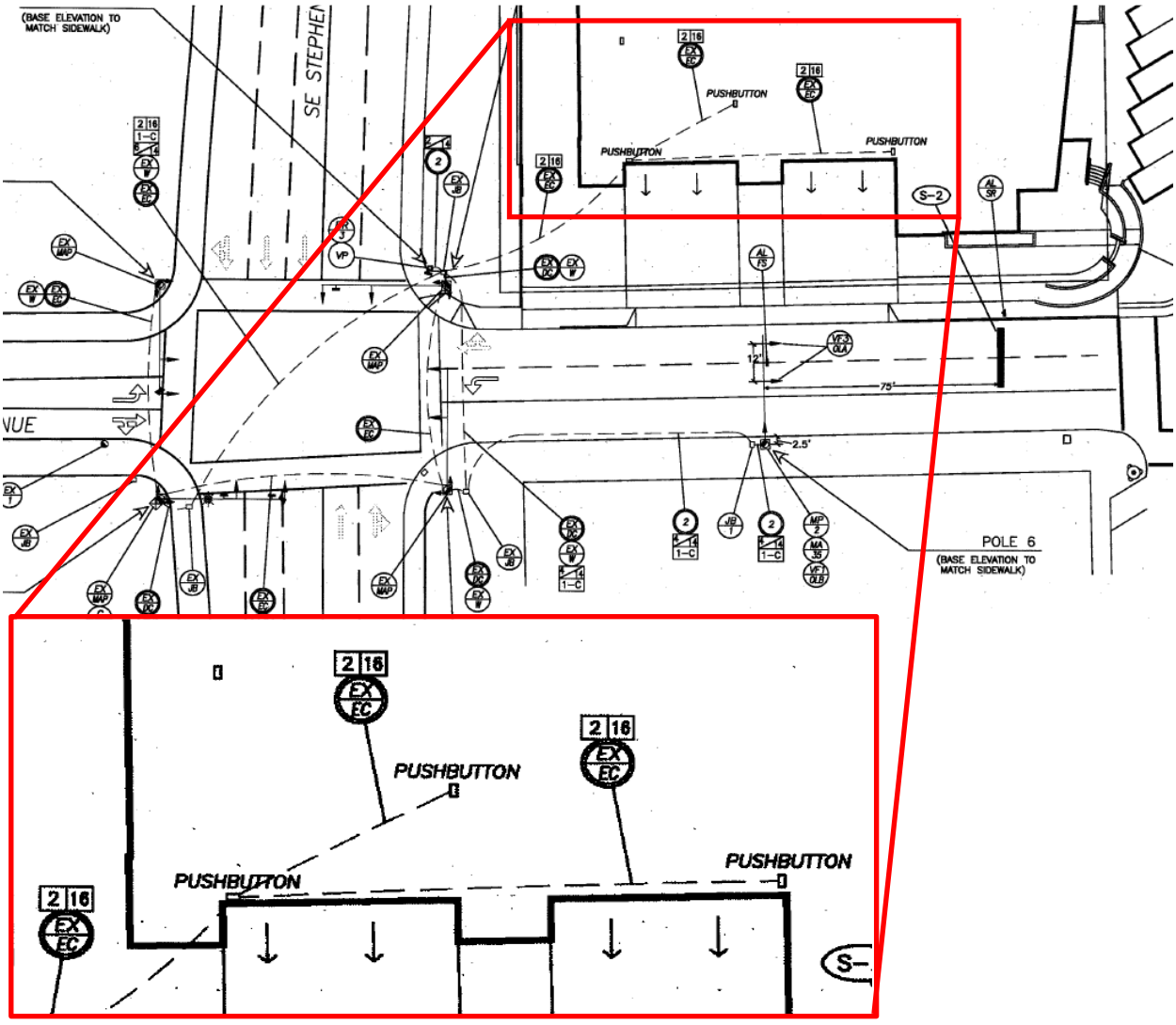
17.4.6 Preemption Devices

Two types of preemption can be used:

- Pushbutton located inside the fire station
- Preemption detection devices

Pushbuttons are not as common anymore due to the invention of preemption detection devices and their widespread use. However, this is the only option if the fire department is not using the standard preemption detection devices, or they wish to maintain their legacy preemption system. Coordination with the fire department is critical to determine the proper location and mounting for the pushbutton and the conduit routing to the pushbutton. Multiple pushbuttons may also be needed. See Figure 17-10.

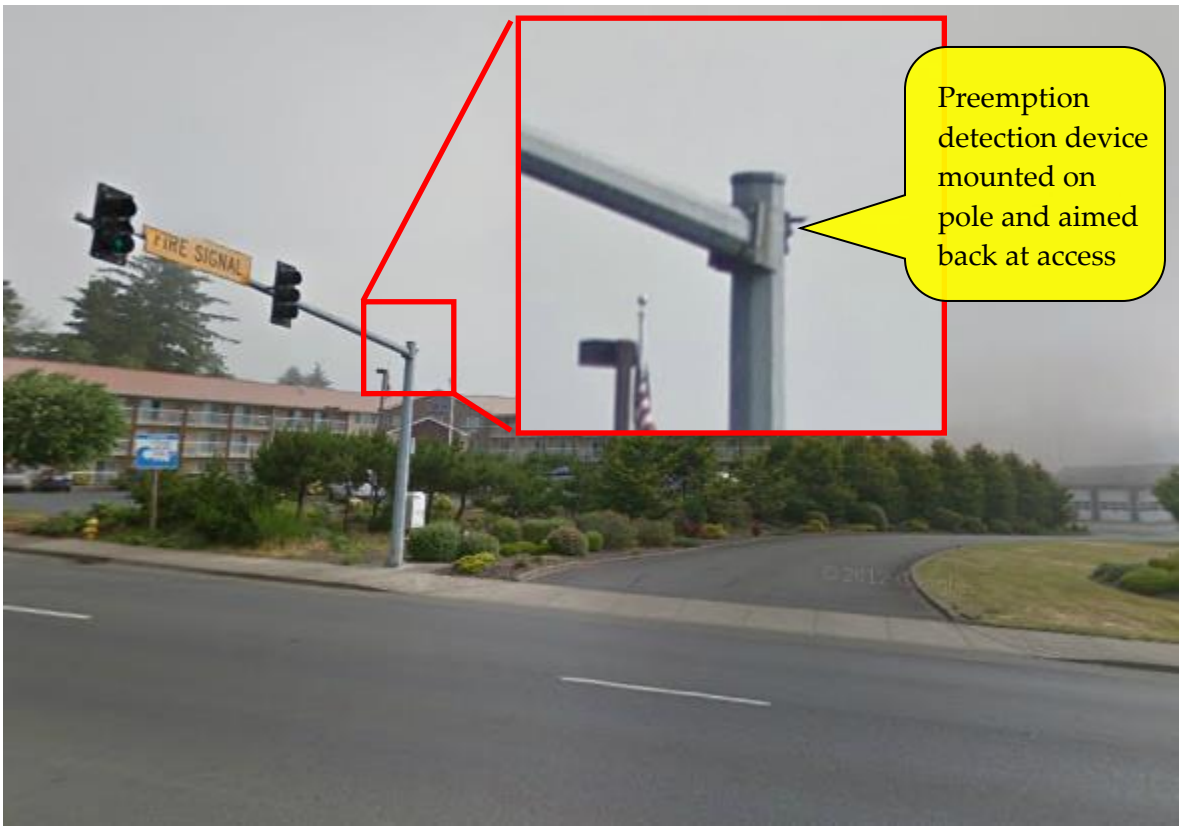
Figure 17-10 | Pushbutton Preemption – Placement and Conduit Routing Example



Installation of pushbuttons, conduit and wiring is allowed to be installed off of right-of-way via an intergovernmental agreement (IGA) for this type of preemption. The IGA is with the associated city or county, who then have an agreement with the fire department. Typically, the region electrical crew will maintain the entire installation, including the equipment that is located off right-of-way. Therefore, it is necessary to show the conduit, wire, junction boxes and pushbutton(s) located off right-of-way on the plan sheet.

Preemption detection devices are the most common type of preemption used for new construction. The device should be placed such that emergency vehicle leaving the station will activate it as soon as possible. This will depend on the configuration of the property and the typical path of the emergency vehicle when it uses the access. Multiple devices may be used at different locations to properly hold the preemption input, or a single preemption device may be used in conjunction with a pre-set time if the device would lose the input too soon. Coordinate with the fire department and region signal timer to determine the best preemption operation. See Figure 17-11 for an example of placement.

Figure 17-11 | Preemption Detection Device – Placement Example



Typical vehicle detection (loops, radar, video, etc.) shall NOT be used as a preemption device. This is due to the fact that when vehicle detection fails, the fire signal will remain preempted until it is fixed. This would cause enormous traffic back-ups and disrespect for the fire signal.

17.4.7 Detection

Vehicle detection is not needed for a fire signal.

17.4.8 Pedestrian Accommodation

Pedestrian phases shall not be used for a fire signal.

17.5 Emergency-Vehicle Hybrid Beacon

Emergency-vehicle hybrid beacons shall not be used as an emergency traffic signal.

18 Standard Drawings and Standard Details

18.1 Standard Drawings

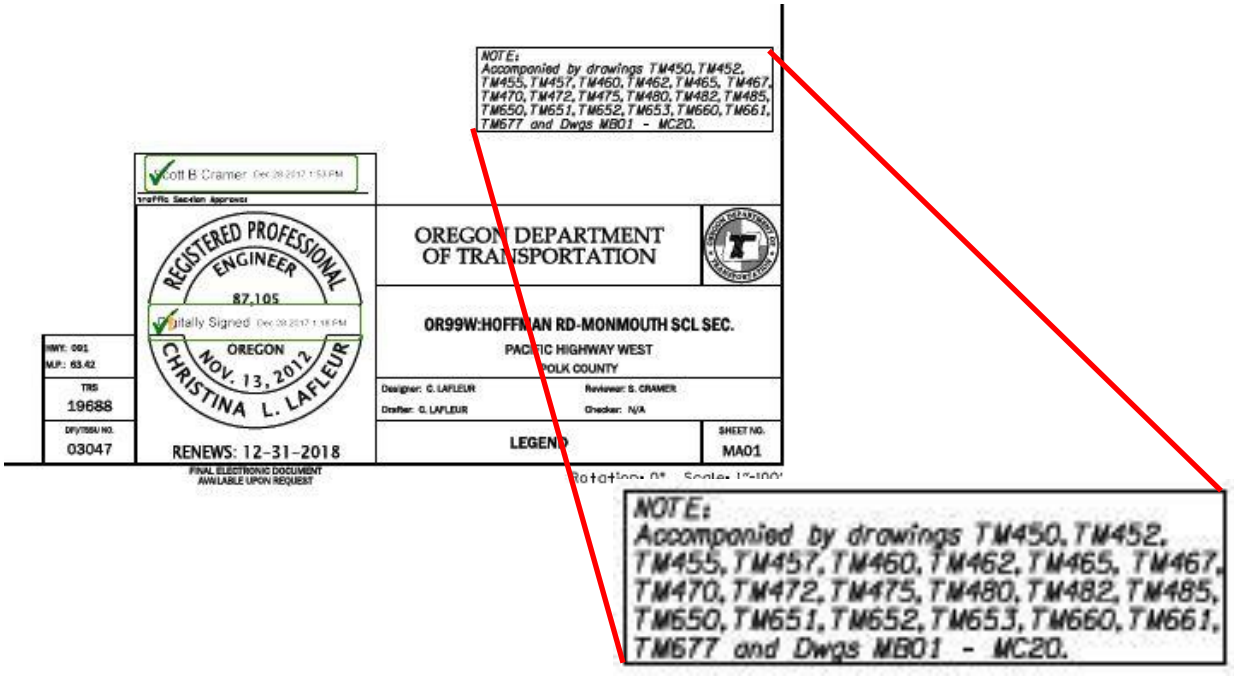
Standard drawings provide micro detail construction information for typical installations and are referenced by the contract plans via the signal plans. The signal designer is responsible for selecting the appropriate standard drawings that are applicable to the project. The applicable signal related standard drawings are listed only on the first sheet of the signal plan set. See Figure 18-1. The entire set of applicable standard drawings for the whole project is shown in the main index (usually the second sheet of the contract plans). Verify the main index to ensure signal related standard drawings are listed correctly.

The standard drawings that are applicable to signal design are found in the TM400 series (signal design), TM600 series (traffic structures), and TM700 (common electrical systems). Standard drawings for temporary work zones (temp. bridge signals) are found in the TM800 series (work zone).

Standard drawings cannot be modified by the designer. However, if a standard drawing doesn't quite work for a particular project due to a non-typical condition, the standard drawing content can be used to create a details plan sheet that is then signed and sealed by the engineer of record.

All standard drawings and standard details can be found at this website.

Figure 18-1 | List of Applicable Standard Drawings on Signal Plan Sheet



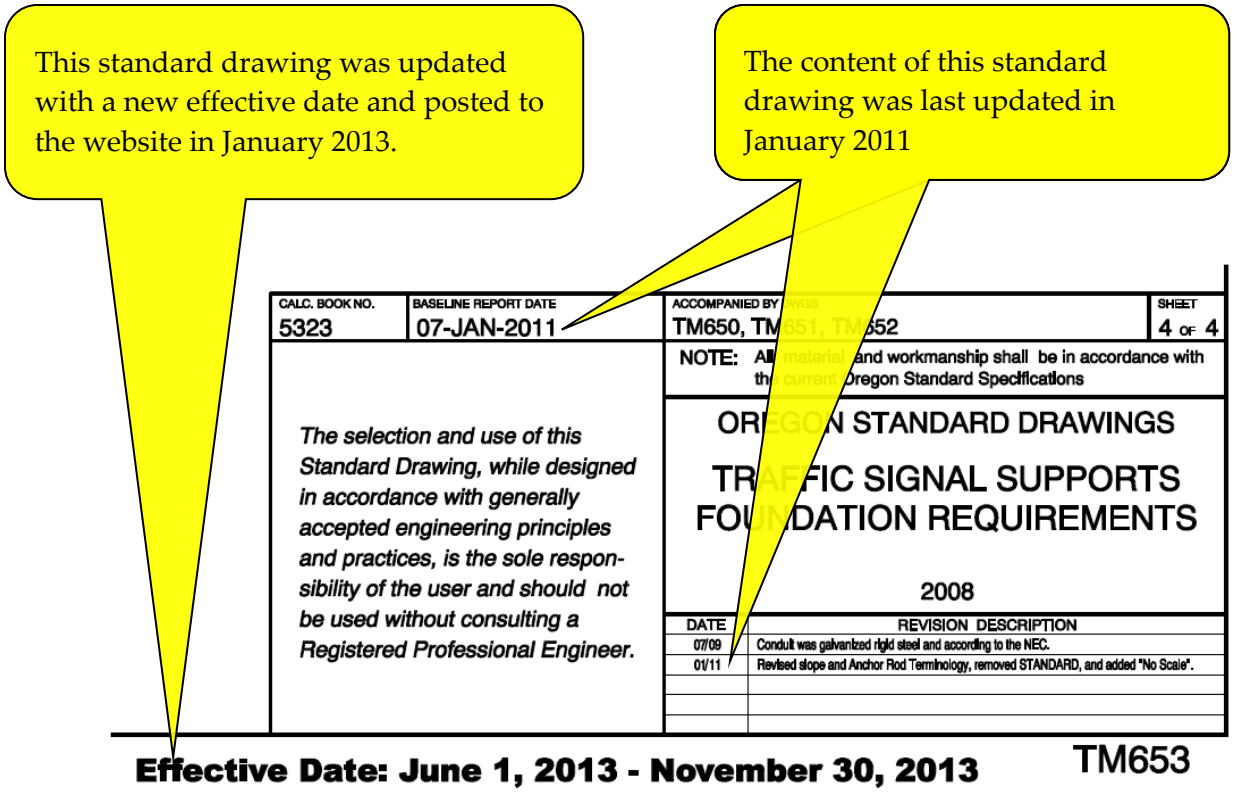
18.1.1 Effective Dates and Updates

An effective date is placed on each standard drawing. The bid date of the project will be within the range of the effective date. This assists with identifying the correct drawing for the project. The standard drawings used on the project are valid for the life of the construction.

Standard drawings are maintained by the traffic engineering section and are updated twice a year, once in January and once in July. At each revision update, every standard drawing will get a new effective date, regardless of any content changes. If any content changes are made, they will be listed and dated in the standard drawing title block. See Figure 18-2. Always check to make sure the standard drawing effective date falls within the project bid let date and be aware of the status of content changes. The effective dates for each revision update are shown below:

- January update – effective date from June 1 to November 30
- July update – effective date from December 1 to May 31 of the following year

Figure 18-2 | Standard Drawing Effective Date and Content Change Information



18.1.2 Standard Drawing Reports

Each standard drawing has been signed and sealed by an ODOT engineer of record and are backed by engineering analysis, calculations, and/or other justification to support the content contained within. The engineering analysis, calculations, assumptions, and other information used in the development of the standard drawing is documented in the standard drawing report (formally called the baseline report). See Figure 18-3 showing standard drawing report information in the standard drawing title block. See Figure 18-4 for an example of a standard drawing report. If content changes are made during the revision update periods, the standard drawing report is also updated.

Standard drawing reports are available on the standard drawings website next to the actual standard drawing dgn and pdf files. The signal designer should review the reports to ensure proper application of the standard drawings on the project.

Figure 18-3 | Standard Drawing Baseline Report Info in Title Block

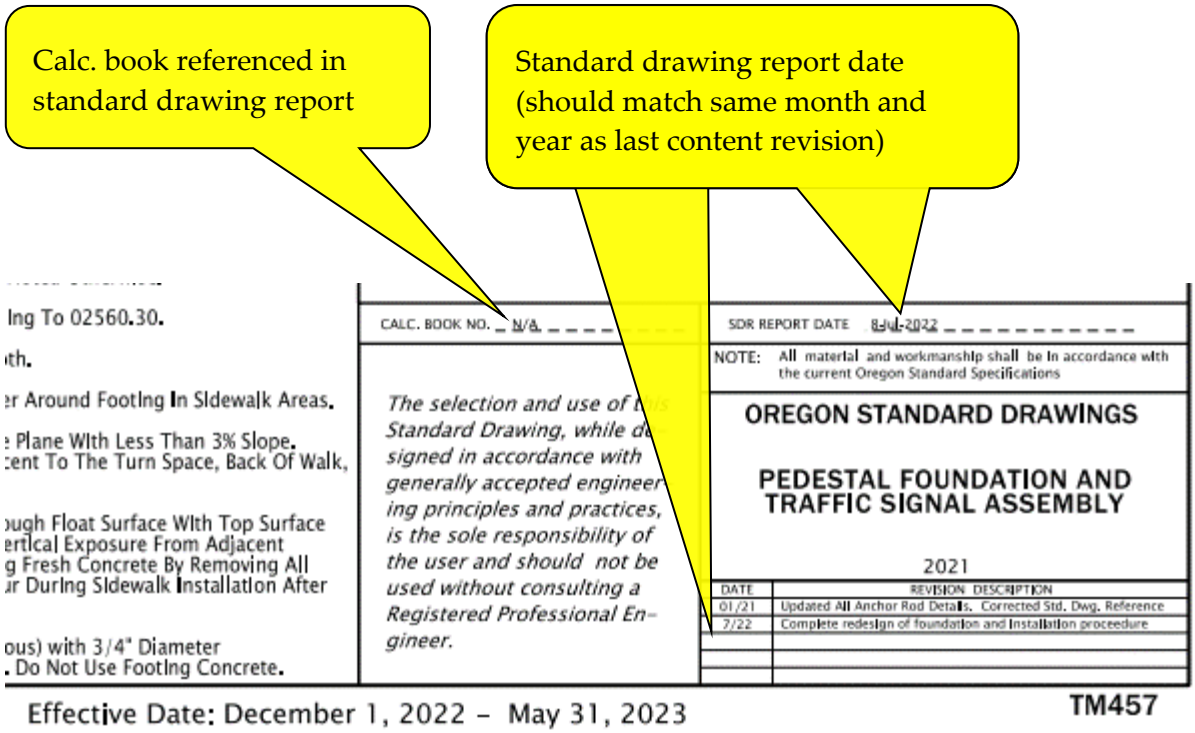
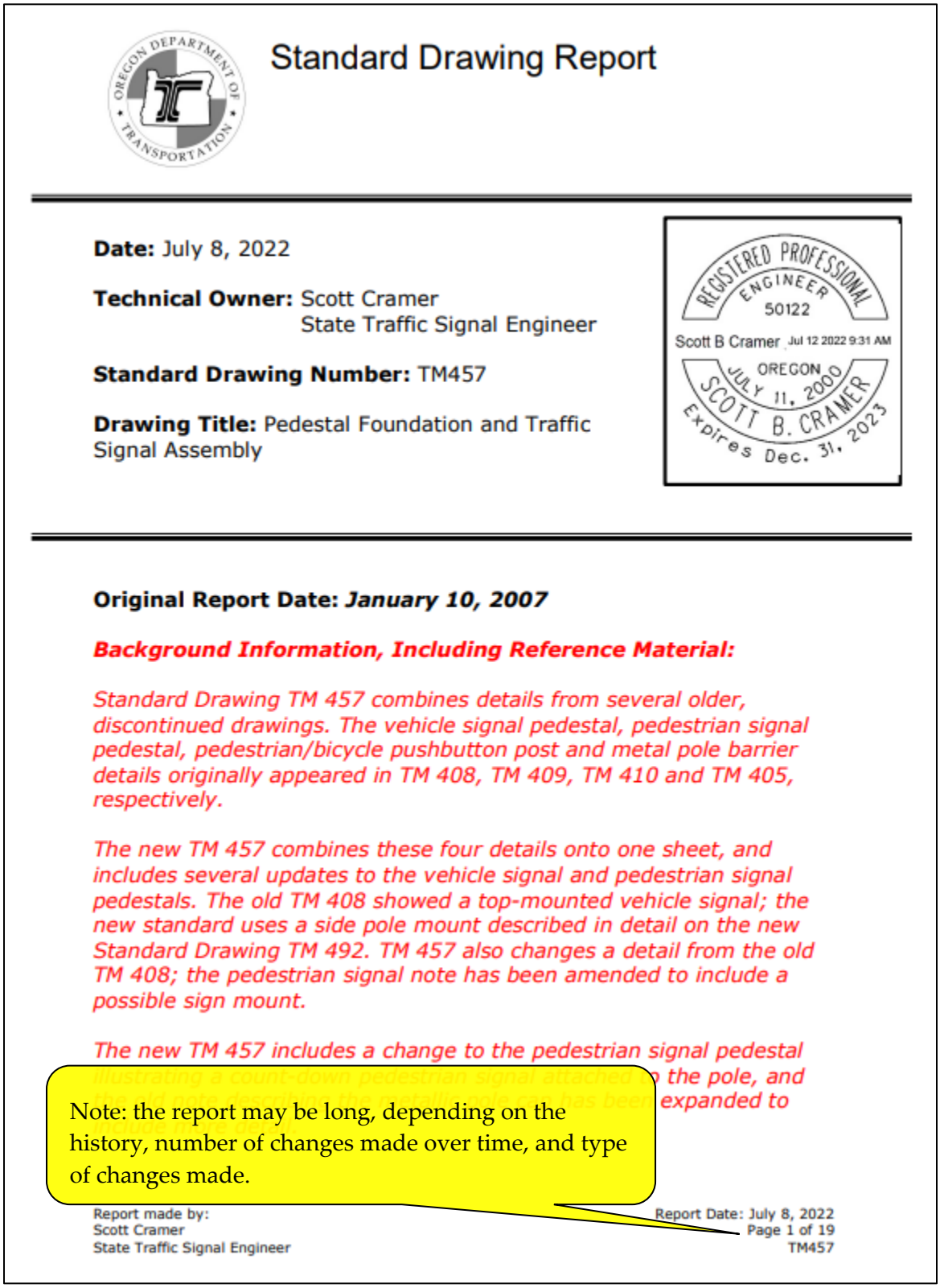


Figure 18-4 | Baseline Report Example



Standard Drawing Report

Date: July 8, 2022

Technical Owner: Scott Cramer
State Traffic Signal Engineer

Standard Drawing Number: TM457

Drawing Title: Pedestal Foundation and Traffic Signal Assembly

REGISTERED PROFESSIONAL ENGINEER
50122
Scott B Cramer Jul 12 2022 9:31 AM
OREGON
JULY 11, 2000
SCOTT B. CRAMER
Expires Dec. 31, 2023

Original Report Date: ***January 10, 2007***

Background Information, Including Reference Material:

Standard Drawing TM 457 combines details from several older, discontinued drawings. The vehicle signal pedestal, pedestrian signal pedestal, pedestrian/bicycle pushbutton post and metal pole barrier details originally appeared in TM 408, TM 409, TM 410 and TM 405, respectively.

The new TM 457 combines these four details onto one sheet, and includes several updates to the vehicle signal and pedestrian signal pedestals. The old TM 408 showed a top-mounted vehicle signal; the new standard uses a side pole mount described in detail on the new Standard Drawing TM 492. TM 457 also changes a detail from the old TM 408; the pedestrian signal note has been amended to include a possible sign mount.

The new TM 457 includes a change to the pedestrian signal pedestal illustrating a count-down pedestrian signal attached to the pole, and the old pole description, the metallic pole cap has been expanded to

Note: the report may be long, depending on the history, number of changes made over time, and type of changes made.

Report made by:
Scott Cramer
State Traffic Signal Engineer

Report Date: July 8, 2022
Page 1 of 19
TM457

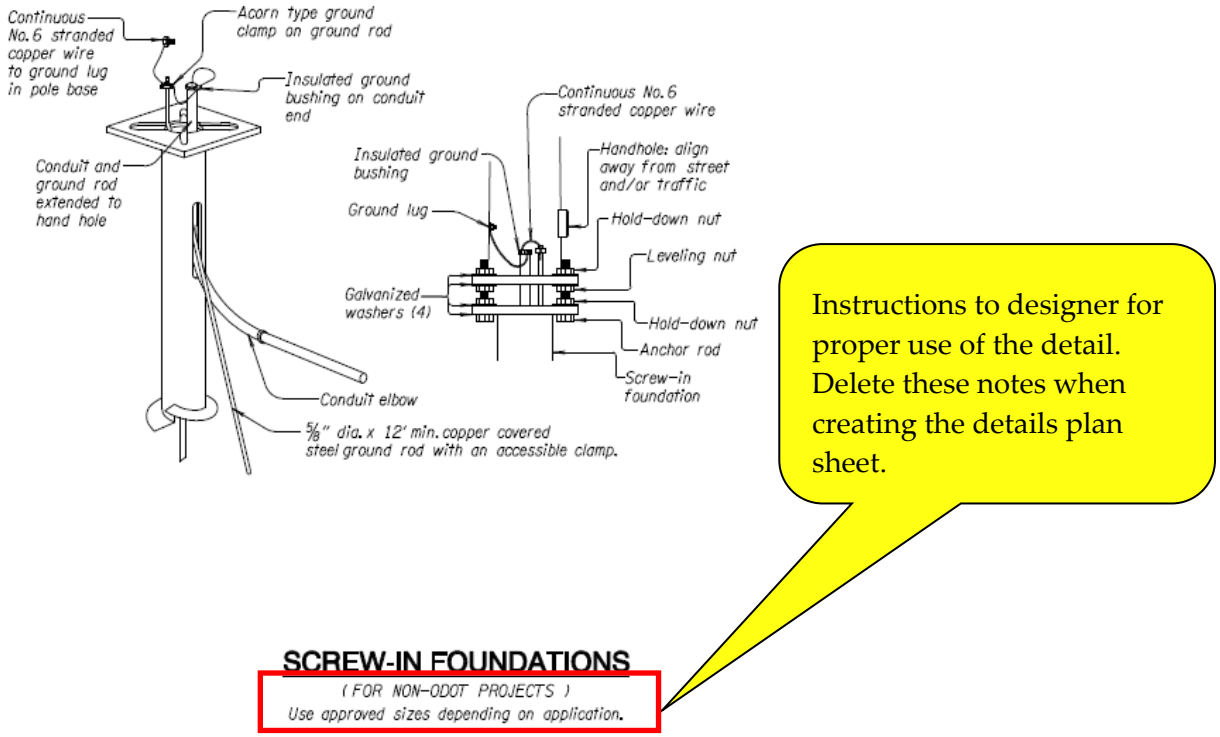
18.2 Standard Details

Standard details typically contain construction installation information that:

- Is used infrequently,
- Is used on non-state highway roadways,
- Requires modification based on the project specific location, and/or
- Is brand new/unproven technology that needs refinement prior to becoming a standard drawing.

Standard details are used by the designer to create a project specific details plan sheet that will be included in the project contract plans set and stamped by the engineer of record. The standard details can and should be modified by the designer to fit the unique, project specific requirements. Often there are notes to the designer in the standard detail containing further information/instruction on the appropriate use and modification of the detail. See Figure 18-5. Do not include these notes to the designer on the details plan sheet. Unlike the standard drawing report required for standard drawings, there is no formal report produced for standard details.

Figure 18-5 | Standard Detail – Notes to the Designer



Standard details are maintained and updated by the traffic engineering section and can be updated at any time, so the designer should always download a copy from the website to ensure the most up-to-date detail. The standard details from DET4400 to DET4499 are used for signal design.

19 Specifications, Bid Items, & Cost Estimate

Two separate documents are needed to complete the specifications for a project:

- The Oregon Standard Specifications for Construction; and
- Project specific special provisions.

The Oregon Standard Specifications for Construction is also known as just the standard specifications and is a published book. Therefore, it remains static until the next publication which occurs approx. every 3 to 5 years. In contrast to the standard specifications, the special provisions add, modify, and/or delete portions of the standard specifications based on project specific needs. Special provision boiler plates are used to create the project specific special provisions.

The Oregon Standard Specifications for Construction and special provision boiler plates are available online.

NOTE: Always download new copies of the special provision boiler plates for each project since modifications to the special provisions can occur at any time.

The following is a list of specifications directly related to traffic signals:

- 00227 - Temporary traffic signals and illumination
- 00921 – Major sign support drilled shafts (for mast arm poles with mast arms 60’ to 75’)
- 00950 – Removal of electrical systems
- 00960 – Common provisions for electrical systems
- 00962 – Metal illumination and traffic signal supports
- 00963 – Signal support drilled shafts (for mast arm pole with mast arms up to 55’)
- 00990 – Traffic signals

The following is a list of specifications indirectly related to traffic signals:

- 00440 – Commercial grade concrete
- 00442 – Controller low strength materials
- 00902 – Crosswalk closure supports
- 00970 – Highway illumination
- 02530 – Structural steel

Note that there may be references to other sections of the specifications not listed above. These references, while important, typically play a minor role in the overall specifications related to traffic signals.

19.1 Preparing the Special Provisions

Below is an outline of the step-by-step process required in the preparation of the special provisions for the project:

1. Determine which specifications are applicable to the project.
2. Download the current special provisions boiler plates of each applicable specification from the specification website.
3. Edit each special provision according to the project needs using Word with "track changes" turned on. If "track changes" is not used, review and future modifications become difficult.
    a. Instructions are provided in orange italic font within parentheses. For example: ***(Use the following subsection .42 when removed materials are to be stockpiled. Contact Region electrician for Region number, phone number, and all information regarding equipment to be salvaged. List materials and stockpile locations.)***
    b. The instructions shall be removed from the Special provisions, and will appear similar to what is shown below:
    ~~***(Use the following subsection .42 when removed materials are to be stockpiled. Contact Region electrician for Region number, phone number, and all information regarding equipment to be salvaged. List materials and stockpile locations.)***~~
    c. Edits are limited to the instructions provided. Anything other than what's contained in the current special provision boiler plate **REQUIRES** approval from the technical resource and state specifications engineer as per the instructions in the boiler plate.

The example below, according to the instruction set, is used on projects with loop splices. See Figure 19-1.

Figure 19-1 | Example: Special Provision Boiler Plate (Unaltered)

(Use the following subsection .40(a) on projects with loop splices.)

00990.40(a) General - In the paragraph that begins "Install wire between pole or…", replace the second sentence with the following:

Do not use junction boxes for splicing, except for loop wire splicing of loop wires to loop feeder cables.

For projects that will have loop splices, the instruction information in orange italics within parenthesis must be deleted. The special provision should look like Figure 19-2:

Figure 19-2 | Example: Special Provision Boiler Plate (Modified for Use on Project)

> ~~*(Use the following subsection .40(a) on projects with loop splices.)*~~
>
> **00990.40(a) General** - In the paragraph that begins "Install wire between pole or…", replace the second sentence with the following:
>
> Do not use junction boxes for splicing, except for loop wire splicing of loop wires to loop feeder cables.

For projects that do **NOT** have loop splices, the entire subsection must be deleted. The special provision should look like Figure 19-3:

Figure 19-3 | Example: Special Provision Boiler Plate (Deleted Text for Use on Project)

> ~~*(Use the following subsection .40(a) on projects with loop splices.)*~~
>
> ~~**00990.40(a) General** - In the paragraph that begins "Install wire between pole or…", replace the second sentence with the following:~~
>
> ~~Do not use junction boxes for splicing, except for loop wire splicing of loop wires to loop feeder cables.~~

The edits shown in Figure 19-2 and Figure 19-3 are simply following the instructions that are provided within the special provision boiler plate (information in orange italics within parenthesis) and therefore do not require additional review and approval from the technical resource and state specifications engineer.

If for some reason the current special provision doesn't meet the project needs, modifications that fall outside of the instructions within the special provision boiler plates may be proposed. Again, this requires approval from the technical resource and the state specifications engineer. The request for modifications may look something like Figure 19-4, where text has been added (shown in blue underline):

Figure 19-4 | Example: Special Provision Boiler Plate (Proposed Modification for Use on Project)

~~*(Use the following subsection .40(a) on projects with loop splices.)*~~

00990.40(a) General - In the paragraph that begins "Install wire between pole or…", replace the second sentence with the following:

Do not use junction boxes for splicing, except for loop wire splicing of loop wires to loop feeder cables and interconnect cable to interconnect cable.

It is important to note that the single line strikethrough for removal and signal line underline for additions are generated by the track changes feature in Word, not by changes in formatting.

Always use track changes when modifying the special provision boiler plates.

19.2 Review & Approval of the Special Provisions

Special provisions that have been created by making modifications according to the instructions that are provided within the special provision boiler plate (information in orange italics within parenthesis) do not require review and approval from the technical resource and state specifications engineer. However, the traffic engineering section will do a courtesy review if requested.

Special provisions that have modifications that fall outside of the instructions that are provided within the special provision boiler plate (e.g., revisions shown in Figure 19-4) require review and concurrence of the technical resource and the state specifications engineer.

19.3 Bid Items

Bid items are defined in the specifications and are the means by which the contract work is paid. The specifications define the title of bid item, the unit of measurement, and what work is included in the bid item. The following sections are used (depending on the scope of the project):

- 00227.90 contains the list for all temporary signal bid items
- 00902.90 contains the bid items for crosswalk closure supports
- 00921.90 – contains the list for all permanent signal pole foundation for mast arm poles with mast arms 60 to 75 feet (foundations are the only item that is not inclusive in the 00990.90 bid items)
- 00950.90 contains the list for removal of electrical systems
- 00990.90 contains the list for all permanent signal bid items
- 00963.90 contains the list for all permanent signal pole foundations for mast arm poles with mast arms up to 55 feet (foundations are the only item that is not inclusive in the 00990.90 bid items)

These bid item lists are explained in more detail in the following subsections and can be found on the specification website. The vast majority of project work should fit within these existing, standard bid items. If the standard bid item lists do not meet the needs of the project, contact the state traffic signal engineer for guidance. The solution may involve use of an existing standard bid item or creation of a new bid item. Use of a new, unique bid item requires approval of the state traffic signal engineer and the state specifications engineer.

When detailing design items on signal plan sheets that have the potential to also be detailed in other disciplines' plan sheets (e.g., signs, illumination, ITS), always coordinate with the other discipline to ensure the design item is only detailed (e.g., all information needed to fabricate and install) in one plan sheet, and not on the others. Other sheets may refer to the design item (e.g., see sheet X for installation information) if deemed useful. See chapter 21 for more information on detailing vs. referencing on plan sheets.

New, unique bid items are discouraged and require the approval of the state traffic signal engineer and state specifications engineer.

19.3.1 Permanent Signal Bid Items (00990.90)

The standard bid items available in the 00990.90 section of the specifications applies to permanent signal installations:

- TRAFFIC SIGNAL INSTALLATION – LUMP SUM
  Used for all new installations and for re-builds of existing signals. Includes the new permanent traffic signal, detector system, and removal of existing electrical features. Specifically includes what is shown on the signal plan sheet, detector plan sheet, and removal plan sheet. Excludes the interconnect system. Excludes mast arm pole foundations (See section 19.3.2 for foundation bid items).
- TRAFFIC SIGNAL MODIFICATIONS – LUMP SUM
  Used for existing installations where the traffic signal is modified. This includes the detection system. Excludes the interconnect system. Excludes mast arm pole foundations (See section 19.3.2 for foundation bid items).
- RAMP METER SIGNAL INSTALLATION – LUMP SUM
  Includes the new permanent ramp meter signal, detection system, and removal of existing features. Specifically includes what is shown on the ramp meter plan sheet and removal plan sheet. Excludes the interconnect system.
- FLASHING BEACON INSTALLATION – LUMP SUM
  Includes the new permanent flashing beacon and removal of existing features. Specifically includes what is shown on the flashing beacon plan sheet and removal plan sheet. This bid item also includes integrated speed feedback signs. Unintegrated speed feedback signs will use specification 00991 (and the associated bid items in 00991). See chapter 12 for more information on speed feedback signs.
- INTERCONNECT SYSTEM – LUMP SUM
  Includes the new or modifications to the existing interconnect system and removal of existing features. Specifically includes what is shown on the interconnect plan sheet and removal plan sheet.

All of the bid items above, except for the INTERCONNECT SYSTEM – LUMP SUM, are location specific. For example, if the project included three new traffic signals, three separate TRAFFIC SIGNAL INSTALLATION – LUMP SUM bid items would be used, one for each location. Each bid item contains a description of the location (typically labeled "mainline at side street") as shown:

US20 at Main St.

TRAFFIC SIGNAL INSTALLATION – LUMP SUM $125,000

US20 at 9th St.

TRAFFIC SIGNAL INSTALLATION – LUMP SUM $95,000

US20 at High St.

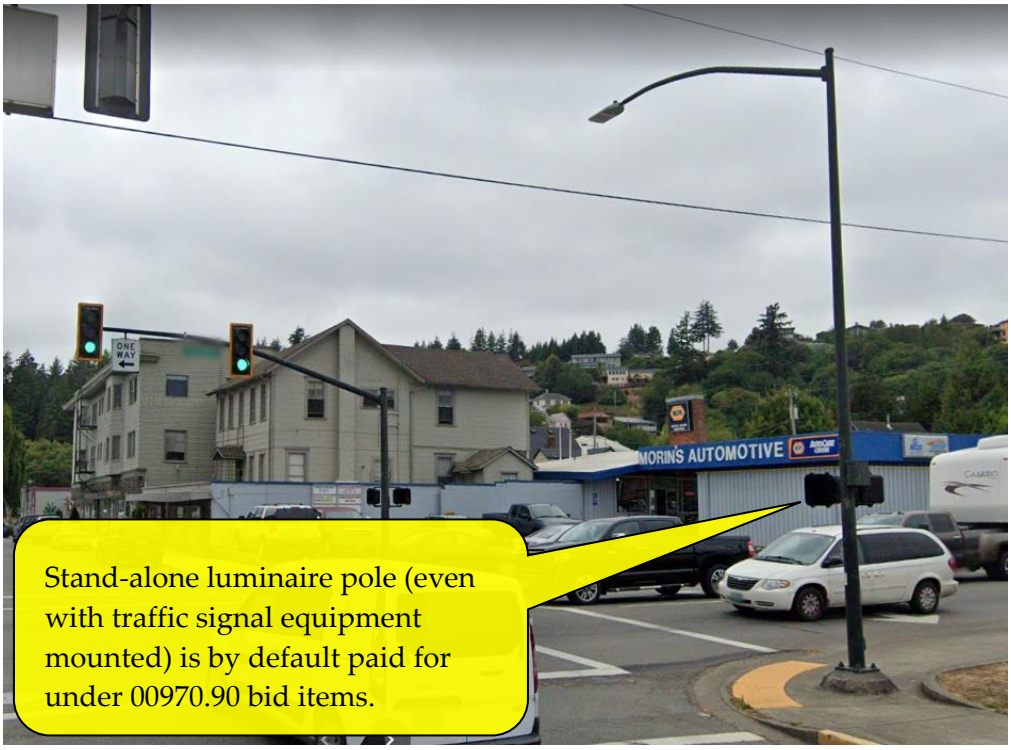
TRAFFIC SIGNAL INSTALLATION – LUMP SUM $140,000

It is also important to note that any items that are detailed on the signal plan sheets are paid for under the applicable traffic signal bid item. Any items that are referenced on the signal plan sheet are not paid for under the traffic signal bid items. A common example of this pertains to signs attached to signal equipment; if a sign is detailed on the signal plan sheet it is paid for under the traffic signal installation bid item which is lump sum. If the same sign is only referenced on the signal plan, but detailed on the signing plan sheet, it is paid for under the signing bid items (e.g., 00940, etc.). Note that crosswalk closure supports should now only be paid under 00902.90 (see section 0 for more info).

Verify that items detailed on the signal plan sheets are NOT detailed on other plan sheets (signing is a common item). See chapter 21 for more information on detailing vs. referencing on the plan sheets.

Stand-alone luminaire poles that are located at a signalized intersection (even in the rare case when they have traffic signal equipment mounted to them) are by default not included in the 00990.90 traffic signal lump sum bid item. The appropriate bid items listed 00970.90 should be used. See Figure 19-5 for example. However, depending on the scope of the project, modifying the default standard via the special provisions and including the stand-alone luminaire pole in the traffic signal lump sum bid item may be a good option (for example, if there is only one stand-alone luminaire pole on the project or there are no separate illumination plans).

Figure 19-5 | Example of Stand-Alone Luminaire Pole at Signalized Intersection (Not Included in the Traffic Signal Lump Sum Bid Item)



19.3.2 Permanent Signal Bid Items - Foundations (00921.90 & 00963.90)

Foundations for mast arm poles are excluded from the traffic signal lump sum bid items as per 00990.90. These foundations were intentionally separated from the lump sum bid item in approximately 2005 (when the new SM poles were designed) in order to track to the costs of the updated foundation design that resulted in a larger foundation and different installation method. There was concern that the new foundation installation would increase the cost of a traffic signal significantly, which over time has proven to not be the case. However, with the recent addition of mast arm poles that can accommodate 60 to 75 mast arms in 2020 (which have an even larger foundation) tracking the foundation costs of mast arm poles separately is still desired. At some point in the future, tracking these costs separately may no longer be desired and foundations may once again become part of the traffic signal lump sum bid items.

The standard bid items available in the 00963.90 section of the specifications applies to the foundations for permanent signal installations for mast arm poles with mast arms up to 55 feet.

- 36 INCH DIAMETER SIGNAL SUPPORT DRILLED SHAFT – FOOT
  Used for all standard foundations that require an "FD" minimum diameter of 36 inches as per standard drawing TM653 (see table in upper left corner of drawing).
- 42 INCH DIAMETER SIGNAL SUPPORT DRILLED SHAFT - FOOT
  Used for all standard foundations that require an "FD" minimum diameter of 42 inches as per standard drawing TM653 (see table in upper left corner of drawing).

The standard bid items available in the 00921.90 section of the specification applies to foundations for permanent signal installations for mast arm poles with mast arms 60 to 75 feet.

- 54 INCH DIAMETER SIGN SUPPORT DRILLED SHAFT FOUNDATION – FOOT Used for all standard foundations for as per standard drawing TM655 (use design no. 6 on TM628)

If the project has a non-standard foundation, work with the structural designer to determine the correct "FD" minimum diameter and which bid item to use. Use of an "FD" minimum diameter that is not 36" or 42" is very rare and should be avoided if possible.

This is the only signal bid item where a quantity is measured for payment and is not location specific. For the entire project, add up the foundation depths for all 36 inch "FD" minimum diameter foundations. Do the same for all 42 inch "FD" minimum diameter foundations and for all 54 inch sign support drilled shaft foundations on the project.

19.3.3 Removal of Electrical Systems Bid Items (00950.90)

The standard bid items available in the 00950.90 section of the specifications applies to removal of traffic signal equipment:

- INCIDENTAL TO INSTALLATION BID ITEM - If the removal work meets the criteria for "method A", which occurs when existing electrical systems are removed and replaced with new electrical systems, no separate bid item for removal is used. The removal work is inclusive to the new electrical system bid item (e.g., TRAFFIC SIGNAL INSTALLATION – LUMP SUM).
- REMOVAL OF ELECTRICAL SYSTEMS – LUMP SUM
  By definition in the specifications, this bid item is used when the removal work meets the criteria for "method B", which occurs when existing electrical systems are removed and are not replaced with new electrical systems. This bid item is location specific. See section 19.3.1 for more information on location specific bid items.

19.3.4 Temporary Signal Bid Items (00227.90)

The standard bid items available in the 00227.95 section of the specifications applies to temporary signal installations:

- TEMPORARY TRAFFIC SIGNAL – LUMP SUM
  By definition in the specification, this bid item includes all required materials called for by the plans and specifications. This includes all temporary appurtenances shown on the temporary signal plan sheet, the temporary detector plan sheet, the temporary interconnect plan sheet, etc. This bid item is location specific. See section 19.3.1 for more information on location specific bid items.
- PORTABLE TRAFFIC SIGNAL – EACH
  This bid item is normally used by the traffic control plans designer, not the signal designer. See chapter 11 for more information on portable traffic signals and their use in projects.
- TEMPORARY FLASHING BEACONS – EACH
  By definition in the specification, this bid item includes all required materials called for by the plans and specifications. This includes all temporary appurtenances shown on the temporary flashing beacon plan sheet.

19.3.5 Crosswalk Closure Support Bid Item (00902.90)

The standard bid item available in the 00902.90 section of the specifications applies to crosswalk closure supports:

- CROSSWALK CLOSURE SUPPORTS – EACH
  Crosswalk closures supports use to have two different methods for payment (as part of the lump sum traffic signal bid item and each) since the majority of these signs were installed at traffic signals. Since the ADA settlement agreement, the use of these signs at unsignalized intersections has greatly increased. To avoid payment confusion at unsignalized and signalized intersections on a project, the option to include these signs in the traffic signal lump sum bid item was removed. Coordinate with the sign designer to ensure the correct number of signs and who will be responsible for stamping this specification.

19.4 Letter of Public Interest Finding (LPIF)

Letters of public interest finding (LPIF) are required to document why it is in the public's interest to not follow a code of federal regulation (CFR) or Oregon statue requirement.

FHWA requires competition not only for the award of a construction contract, but also competition for the various materials and processes involved in the work. Whenever competition for materials or processes is eliminated, an LPIF is required.

General examples of materials or processes that require an LPIF are:

- Agency supplied materials
- Salvaged materials
- Work performed by agency forces

Typical traffic signal items that require an LPIF are:

- ITS equipment (processed by the ITS unit – Doug Spencer, typically agency furnished by price agreement contract)
- ATC controller (agency furnished, by price agreement contract)
- Salvaged equipment (common items are poles, controller cabinet, and radar/video detection). Note: salvaged equipment is intended to be re-used only by maintenance forces for emergency repairs or for replacement of equipment in-kind. It is not intended to be used on future projects with federal funding.

When salvaging equipment, a salvage cost estimate is required as per the LPIF process. The salvage cost for an item will be highest value of the two salvage cost estimate equations. See Figure 19-6. Salvage cost estimate examples for the most common items are shown in Figure 19-7.

Additional guidance and instructions for developing and processing LPIFs can be found in the LPIF Guidance Document on the project control office website. LPIF examples and templates are also included on the website. You can also request LPIF examples for traffic signal specific items from the state traffic signal engineer.

NOTE: The LPIF needs to be submitted and approved at least two weeks prior to PS&E submission. LPIF's should be submitted as early as possible. They are not always approved. The project schedule could be impacted if changes to the plans are needed due to the LPIF not being approved.

Figure 19-6 | Salvage Cost Estimate Equations

Salvage Cost Estimate Equations For each savaged item, calculate and use the highest value of the 2 equations	
Depreciated Value Based on Service Life	Salvage Cost Estimate 1 $= \frac{\text{Service Life}^{(a)} - \text{Item Age}^{(b)}}{\text{Service Life}^{(a)}} \times \text{Cost of New Item}^{(c)} \times \text{Depreciation Factor}^{(d)}$
Scrap Value Based on Material Recycling	Salvage Cost Estimate $2^{(e)} = \text{Quantity of item}^{(f)} \times \text{Scrap Cost Per Quantity}^{(g)}$

a: Use the following values (Contact the state traffic engineer for service life information of other items):
* 50 yrs for a large pole or steel structure
* 10 yrs for a controller cabinet
* 5 yrs for radar
* 3 yrs for video detection

If the item age is greater than or equal to the service life, equation 1= $0

b: Use as-built plans or maintenance history to determine the item age

c: Use recent project cost data or signal cost estimating tools to determine the cost of a new item

d: Use the following depreciation factors:
* 0.03 for 1st generation standard (e.g. truss arm, custom cabinet, radar/video model no longer sold, etc.)
* 0.05 for 2nd generation standard (e.g., curved mast arm, 336 cabinet, etc.)
* 0.10 for 3rd generation standard (e.g., 4-bolt base pole, 332 cabinet, etc.)
* 0.30 for current standard (e.g. 8-bolt base pole, 332S cabinet, etc.)

e: Equation 2 is typically applicable for large poles (steel scrap value). All other traffic signal items that are commonly salvaged are of a material type or quantity that is not economical to seek scrap value.

f: Use industry standard for recycling material (e.g. pounds of steel)

g: Use recent industry data

Figure 19-7 | Salvage Cost Estimate Examples

Most Common Salvaged Item	Given Conditions	Salvage Cost Estimate Calculations Bold Value = Salvage Cost Used in LPIF (highest value of the 2 equations)
Large poles (mast arm, strain pole)	• New SM5L pole cost = $32,000 • Pole age = 19 yrs • Current standard, 8-bolt pole base = DF of 0.30 • lbs of steel in SM5L = 4,900 • Material recycling rate = $0.08 per lb	Equation 1 = ((50-19)/50) x 32,000 x 0.30 **Equation 1= $5,952** Equation 2 = 4,900 x 0.08 Equation 2 = $392
Controller Cabinet	• New cabinet cost = $21,800 • Cabinet age = 7 yrs • Current standard, 332S = DF of 0.30	Equation 1 = (10-7)/10 x 21,800 x 0.30 **Equation 1 = $1,962** Equation 2 = N/A (material content and quantity is insignificant)
Radar Detection	• New detector cost = $8,800 • Detector age = 6 yrs • Model no longer sold = DF of 0.03	**Equation 1 = $0** (item age is greater than service life) Equation 2 = N/A (material content and quantity is insignificant)
Video Detection	• New detector cost = $6,000 • Detector age = 1 yrs • 3rd generation standard = DF of 0.10	Equation 1 = (3-1)/3 x 6,000 x 0.10 **Equation 1 = $400** Equation 2 = N/A (material content and quantity is insignificant)

When the salvage cost equations = $0, the item should typically not be salvaged. However, there can still be good reasons to salvage a $0 item that the equations do not take into account, such as needing the item for research purposes, or needing the item on-hand to allow a quick emergency fix response (some items have an unacceptably long procurement time for an emergency response). Contact the state traffic signal engineer when the salvage cost equations = $0 to discuss reasons and options.

19.5 Cost Estimate

Once the appropriate bid items are chosen, a cost estimate must be completed for each bid item. The bid item estimates should be based on historical data, available industry data, manufacturer quotes, and project specific research.

For ODOT signal designers, an excel spreadsheet (typically updated yearly by the traffic engineering section) can be downloaded from the signal specs share drive to assist in cost estimating. The file name will appear as "Signals2022-1.xls", with the date in the file name changing to reflect the current year and the number after the date changing to reflect the version if multiple changes are made during the same year.

ODOT internal estimating tools cannot be given to external staff.

19.5.1 Anticipated Items

Anticipated items are used to provide a funding mechanism for non-biddable elements of work that may be needed to complete a project. Anticipated items should not be used for items of work that can be competitively bid (e.g., unfinished or incomplete design work). Anticipated items are included with the cost estimate.

For signal work the following items require an anticipated item:

- Power hook-up (when installing a BMCL, BMC, or SC & MS). This should include conduit, trenching, and wiring from the power source to the traffic signal service cabinet. Coordinate with the region utility specialist to determine a reasonable cost estimate.
- Anything that is on price agreement, such as communication gear and ATC controllers.

20 Cabinet Print

The cabinet print is a schematic representation of the components that are inside the controller cabinet. This schematic is used mainly by TSSU, region electrical crew, and region signal timers.

A hard copy of the cabinet print is required to be in the controller cabinet at all times.

20.1 When is a Cabinet Print Required?

A cabinet print is required for all new installations that require a controller cabinet (e.g., a traffic signal, ramp meter, fire signal, TRAWS, etc.), the first stage for temporary signals, and any existing installations that have a controller cabinet that will require a change (addition, deletion, or modification) to the components or wire terminations inside the controller cabinet. To determine or verify how the design work will affect the existing controller cabinet components or wire terminations, work with TSSU, region traffic, and/or the electrical crew.

It is critical to field verify existing controller cabinet conditions to ensure the proposed design will work and any necessary controller cabinet modifications are identified and shown on the new cabinet print. If this is not done during the design phase, expensive and time consuming issues may arise during construction.

Cabinet prints must be accurate for proper maintenance and timing of the intersection.

20.2 Responsibilities For Creating a Cabinet Print

The signal designer is responsible for creating the initial cabinet print(s). The initial cabinet print should be submitted at DAP, when the basic signal equipment layout and normal phase rotation are known. It is critical that the signal timer has adequate time to review and comment on the detector unit placement and zones (shown on sheet 7) as early as possible in the design process. The cabinet print should be revised as necessary during the design phase based on comments received before the equipment arrives at TSSU for testing (during construction).

The traffic engineering section is responsible for creating the final version of the cabinet print from the red-line as-builts provided by TSSU after installation.

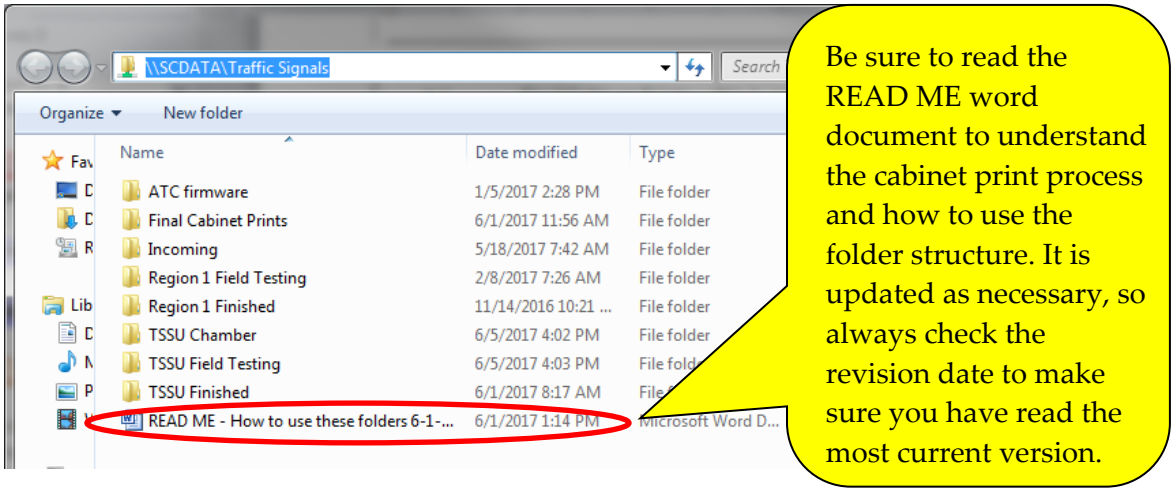
TSSU or region 1 electrical/tech is responsible for reviewing the whole existing cabinet print and reporting any errors, omissions, or modifications needed as part of their regular inspection duties. Anyone using an existing cabinet print should also report any errors or omissions they find. To report, send a red-lined copy of the cabinet print to the traffic engineering section. The traffic engineering section is responsible for updating the final version of the cabinet print.

A cabinet print reflects the conditions shown in the sealed plan sheets and therefore does NOT require a P.E. stamp.

20.3 Procedure for Producing Cabinet Prints

An internal ODOT server folder is used to process the various stages of the cabinet print (from start to final version). Within this server folder there are subfolders which are used to maintain an orderly and clear process for all staff that are involved in the creation, use, and QA/QC of the cabinet print. This process is explained in detail in the READ ME word document on the server folder. See Figure 20-1. Non-ODOT designers do not have access to this folder and should work directly with the state traffic signal engineer when providing cabinet print files.

Figure 20-1 | SCdata Traffic Signals Internal Server Folder for Cabinet Prints



Key information for the signal designer:

1. The cabinet print files (both DGN and PDF) are required in the appropriate INCOMING subfolder **at DAP**. This allows the region signal timer an adequate timeline to review and comment on the non-invasive detection unit and zone placement that are now only shown in the cabinet print (detection zones are no longer shown in the contract plans. See chapter 6 for more information). The signal designer should also address all comments received on cabinet print before the equipment arrives at TSSU (this is typically 2 to 6 months after the project plans are approved. However, a fast-track project may reduce that time to 4 to 8 weeks). Non-ODOT designers should e-mail the files to the state traffic signal engineer who will then place the files in the server folder. Plan accordingly, as failure to produce the cabinet prints in a timely manner may impact the design and construction schedule.
2. The signal designer must contact the region signal timer and request they place the signal timing files within the appropriate INCOMING subfolder. The same time frame described above applies.

If modifications to the cabinet print do NOT match the conditions shown on the most current, sealed plan sheet(s) for the intersection, a new plan sheet is required (as-built).

20.4 Creating the Cabinet Print

Each intersection should have its own cabinet print file. The file name should begin with the TSSU ID number and abbreviated intersection name using the highway route number and cross street, for example "04023_99W_LewisburgRd".

The cabinet prints are created in microstation. There are 10 different types of cabinet print base files available on the traffic signal standards website (click on "microstation cabinet prints") depending on what type of cabinet is used. Select the correct base file for each intersection on the project:

- 332S cabinet print
- 332S SDLC cabinet print
- 332 cabinet print
- 332 SDLC cabinet print
- 336S cabinet print
- 334 ramp meter cabinet print
- 334 count (ATR) cabinet print
- 334 SDLC cabinet print
- 334 TRAWS cabinet print
- 334 TRAWS SDLC cabinet print

An excel "detector configuration" file for each cabinet is also required to complete the input file (page 2) and the detection drawing (page 7). The signal timer is responsible for filling out the information correctly in the excel file and the signal designer will import that information into the microstation file. These excel files and additional information is found at the website mentioned above for base files.

The signal designer should also look in the FINAL CABINET PRINTS folder for existing information before starting a new cabinet print file. A copy of the existing file might be able to be used and modified for the project if the modifications are very minor AND the overall print format/intersection drawing/phase rotation diagrams are in the current format and correct. However, creating a new cabinet print file is required in all other circumstances, such as for a new traffic signal or when replacing an existing cabinet with different style cabinet (e.g., replacing a 332 with a 332S). For signal designers outside of ODOT, contact the traffic engineering section to obtain existing cabinet print information.

When in doubt, create a new cabinet print file when any modifications are needed. The base files on the website are constantly being updated which usually makes it easier/better to use them vs. manipulating the existing file. Just transfer the relevant existing cabinet print information into the new file (which is not very time consuming).

In the microstation base files, the areas that can be modified are typically shown in red. They are populated with the standard phase layout. There are different levels that can be turned on or off depending on the equipment that is installed. Make sure to read the additional instructions for using the DGN files on the website. The typical areas that require modification include:

- The title block identifying information (e.g., intersection name, city, hwy, MP, TSSU ID number, date and revision remarks)
- The input file (front view and side view)
- The input and output file (front view and back view)
- The intersection drawing and the intersection detection drawing

The cabinet print needs to show what is actually used and its intended function. If an area is unused, it should be blank. The other information contained in the cabinet print shows standard electrical schematics that apply to each type of cabinet and are generally not modified.

Cabinet prints are formatted for printing on 11x17 paper.

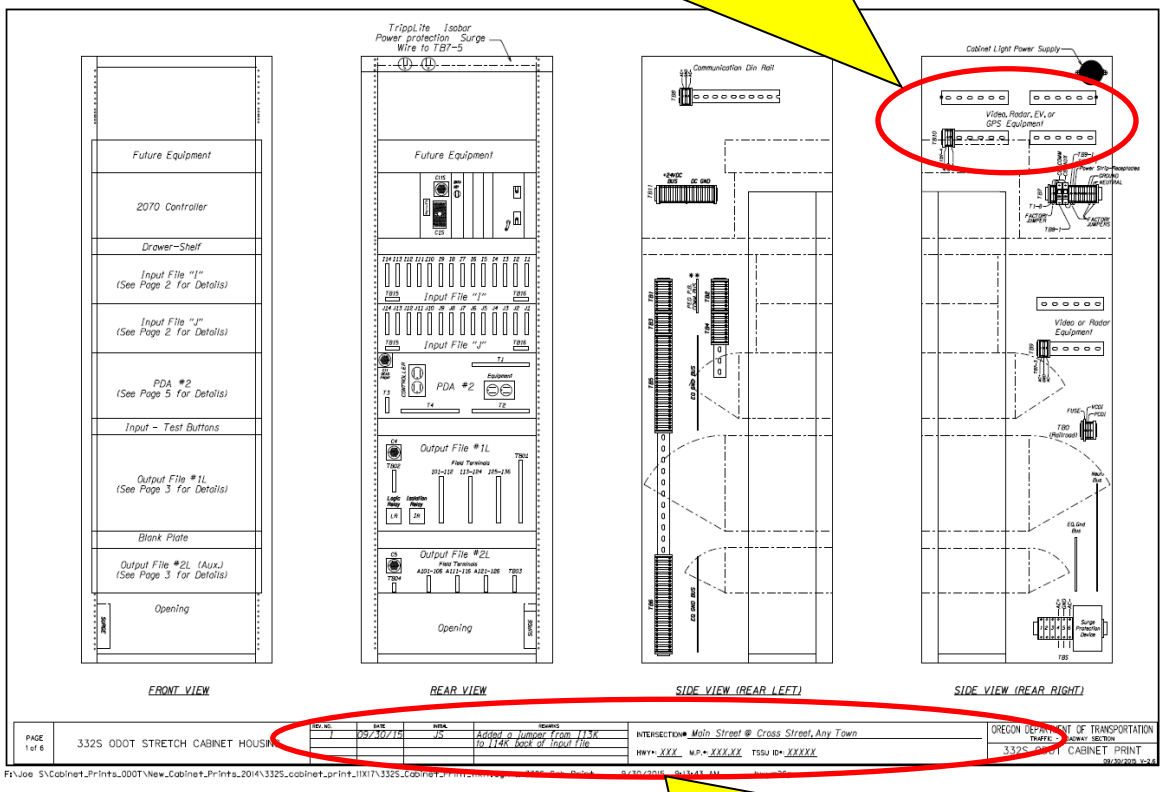
NOTE! All figures in this manual show a 332S cabinet with a C11 connector. The cabinet print layout for the 332 without a C11 connector, 336, and 334 cabinet will be slightly different, but all contain similar elements. The basic information in this manual can be used in conjunction with the appropriate base file.

20.5 332S Cabinet Print (Page 1 – Cabinet Layout)

Page 1 of the 332S cabinet print shows the front, rear, and both side views of the cabinet. There is not a lot to modify on this sheet, but certain levels and/or references will need to be turned-on or off to show the correct site-specific equipment, (e.g., communication equipment, battery back-up, etc.). See Figure 20-2.

Figure 20-2 | 332S Cabinet Print (page 1)

Various equipment on (different levels) can be turned on and off based on site specifics (video detection, communication equipment, etc.). Generally, the info on these levels does not need to be further modified.



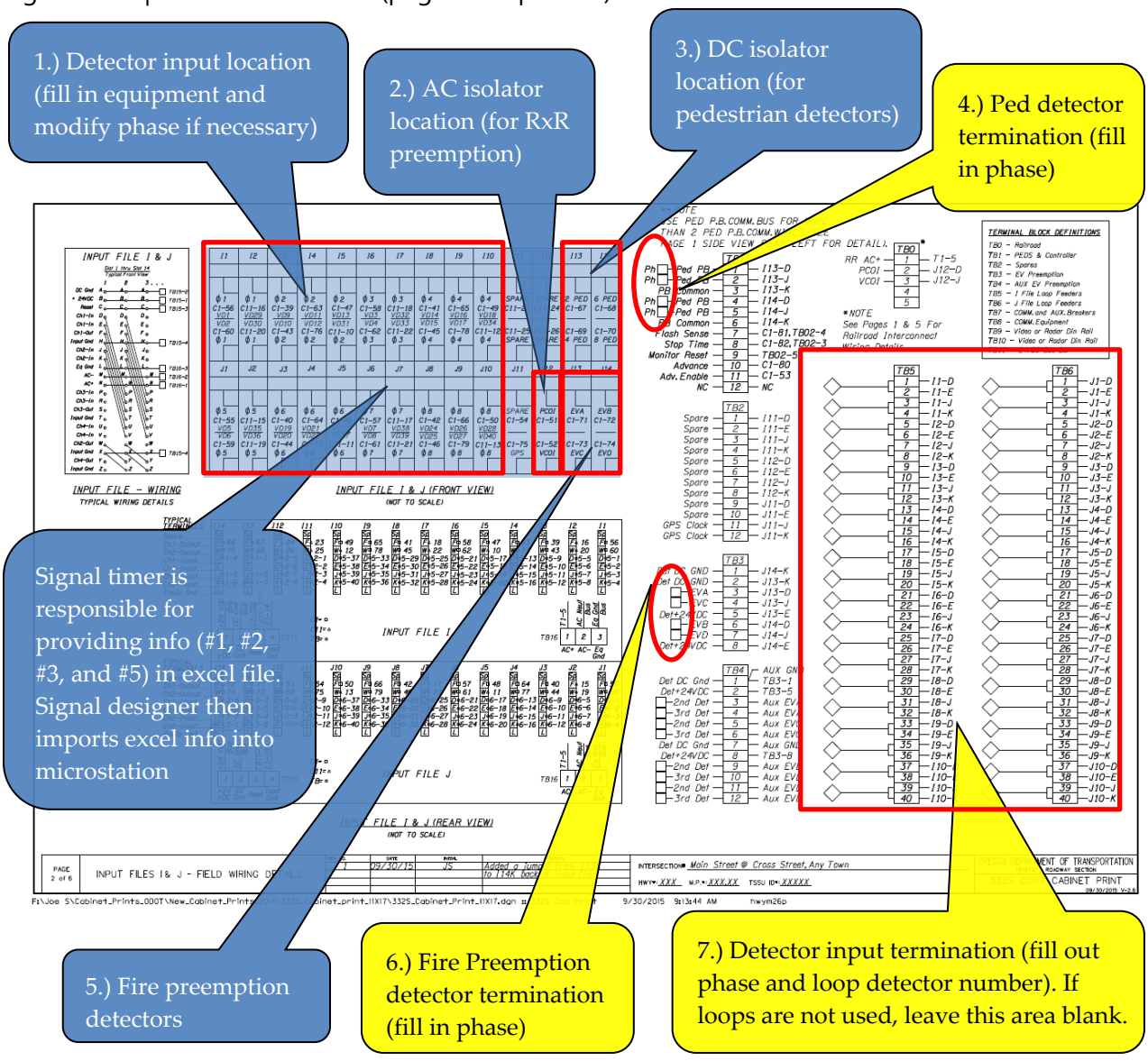
Title block area needs to be filled out as directed.

Include the project key number (if one exists) as part of the "remarks". This helps tie the revisions made to the project work and make it easier to find related plan sheets in the future.

20.6 332S Cabinet Print (Page 2 – Input File)

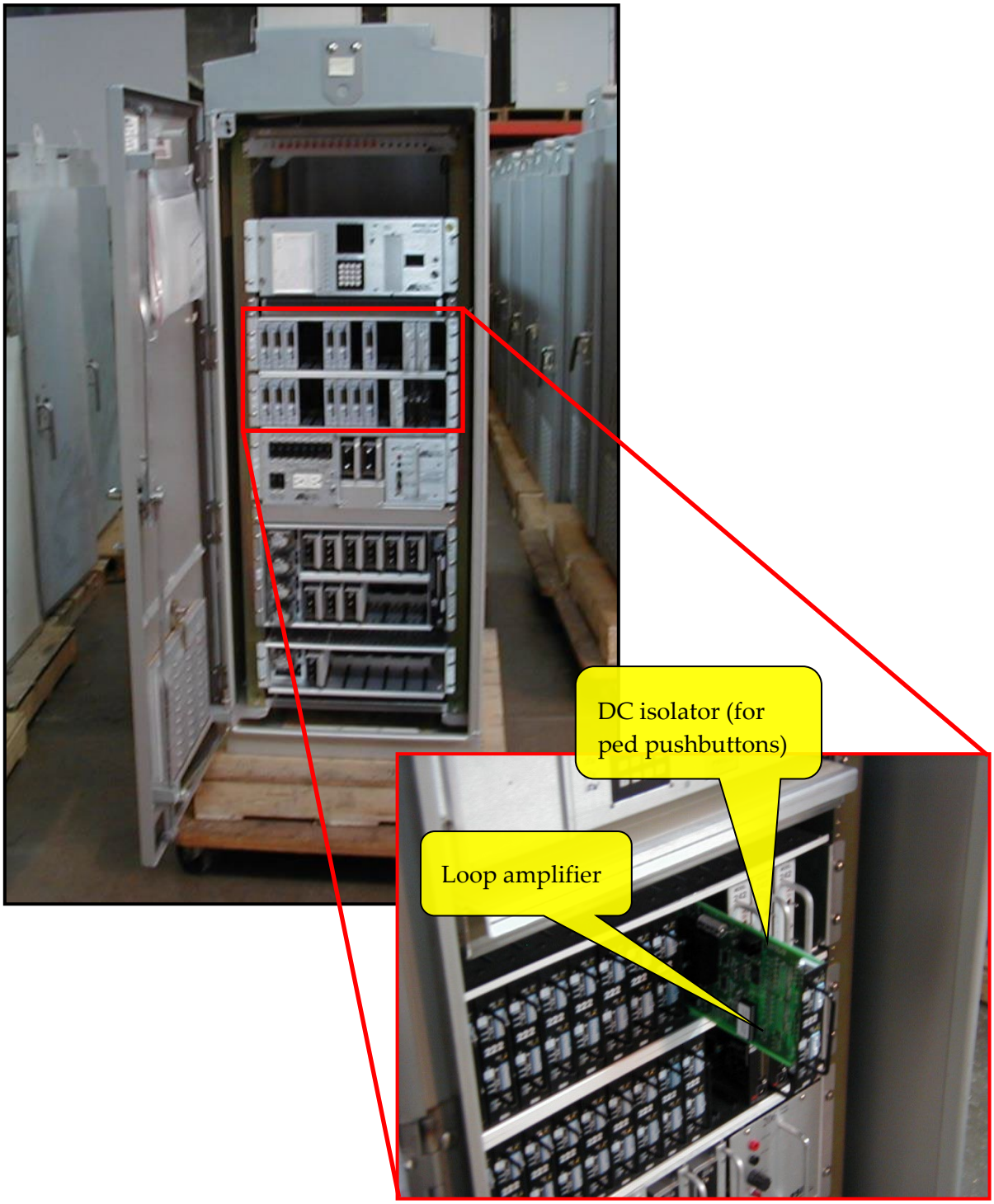
Page 2 of the 332S cabinet print shows the input file. This sheet requires filling in the information for all the input file equipment used. The signal timer is responsible for filling out the majority of the input file information in the detection configuration excel file which is then imported into the microstation cabinet print by the signal designer. See instructions for signal timers and designers for additional info. The basic input equipment (e.g., loop amplifiers, video rack cards, radar rack cards, DC isolators, AC isolators, fire preemption, etc.) that needs to be filled in is shown in Figure 20-3, with the signal timer's responsibility shown shaded in blue. Each bubble note in Figure 20-3 is numbered and described in more detail in the next sections. **Important additional information about the input file is in section 20.6.8.**

Figure 20-3 | 332S Cabinet Print (page 2 – Input File)



For reference, Figure 20-4 shows the actual front view of the input file in a 332 cabinet (which is very similar to the 332S).

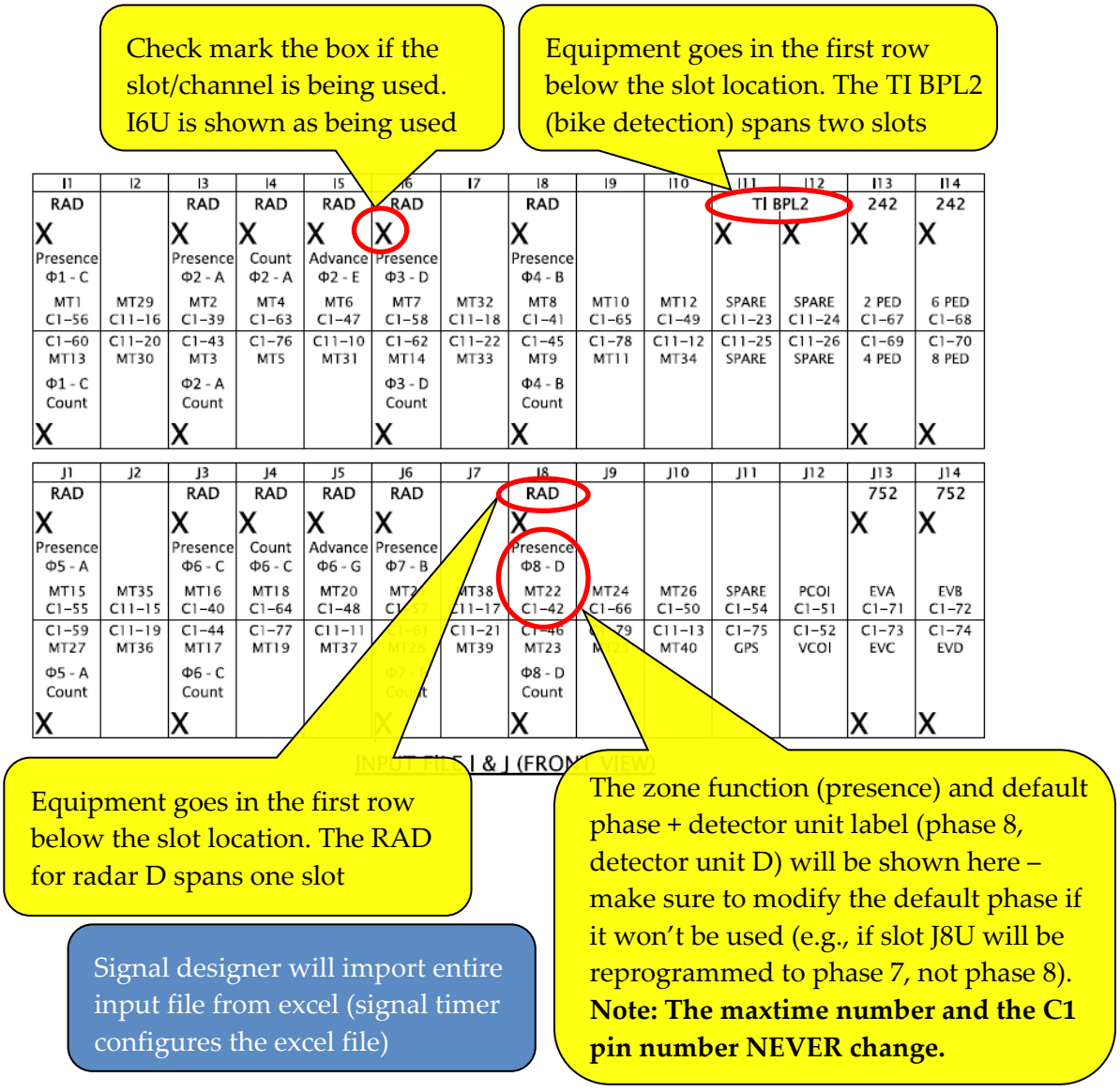
Figure 20-4 | 332 Cabinet – Input File (Front View) Actual View



20.6.1 Detector Input Location (Signal Timer Responsibility – Use Excel File)

Detector input location spans slots one to slot ten with the possibility of slot eleven and twelve of the "I" file used as needed (Note: the 332 cabinet spans only slots one to nine). When SDLC connection is used, slots 1 thru 10, I11, and I12 will be blank. When SDLC is not used, detection equipment will be placed in the input file (for loops, video, radar, etc.). The example shown in Figure 20-5 below shows where the signal timer will fill in the information (using the detector configuration excel file which automates the majority of items shown below).

Figure 20-5 | 332S Cabinet – Vehicle Detector Equipment



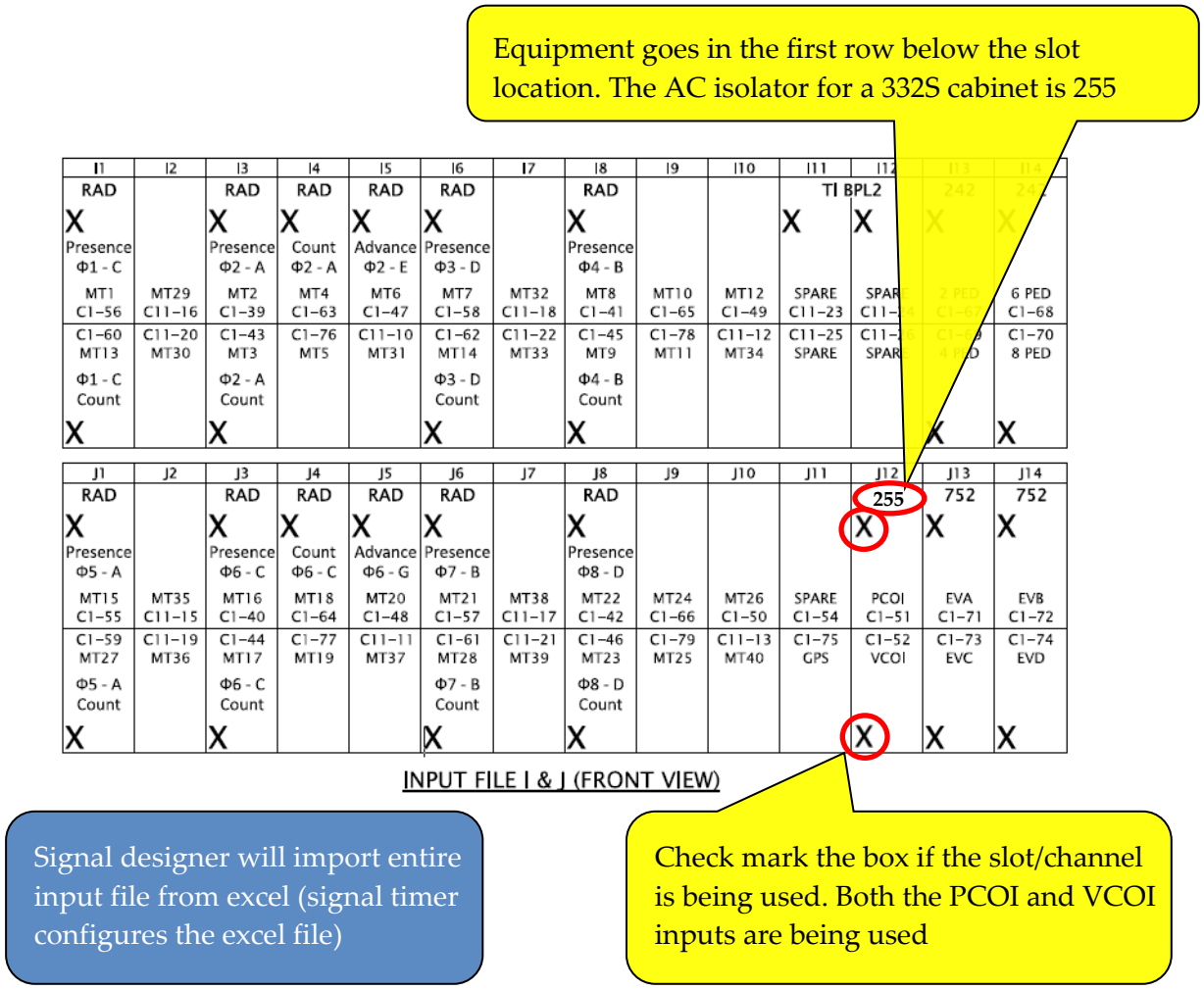
Equipment used in the detector input location is listed below, based on the allowed drop down list in the excel worksheet. For equipment that is not listed below (e.g., not on the drop down list in the excel worksheet) contact state traffic signal engineer, region signal timer, or TSSU to determine correct equipment to show in the input file.

- RAD = Radar equipment
- VIP = Video image processor
- 4 I/O = 4 channel input/output module for video camera
- 2 I/O = 2 channel input/output module for video camera
- VRCM: video equipment
- 222 = Loop detector amplifier

20.6.2 AC Isolator Location (Signal Timer Responsibility – Use Excel File)

AC isolators are located in slot J12 with J12U for the PCOI input and J12L for the VCOI input. This location is used for railroad preemption. The equipment module number is 255 (NOTE: a 252 is used in 332 cabinets and it is located in slot J11). The example shown in Figure 20-6 below shows where you fill in the equipment.

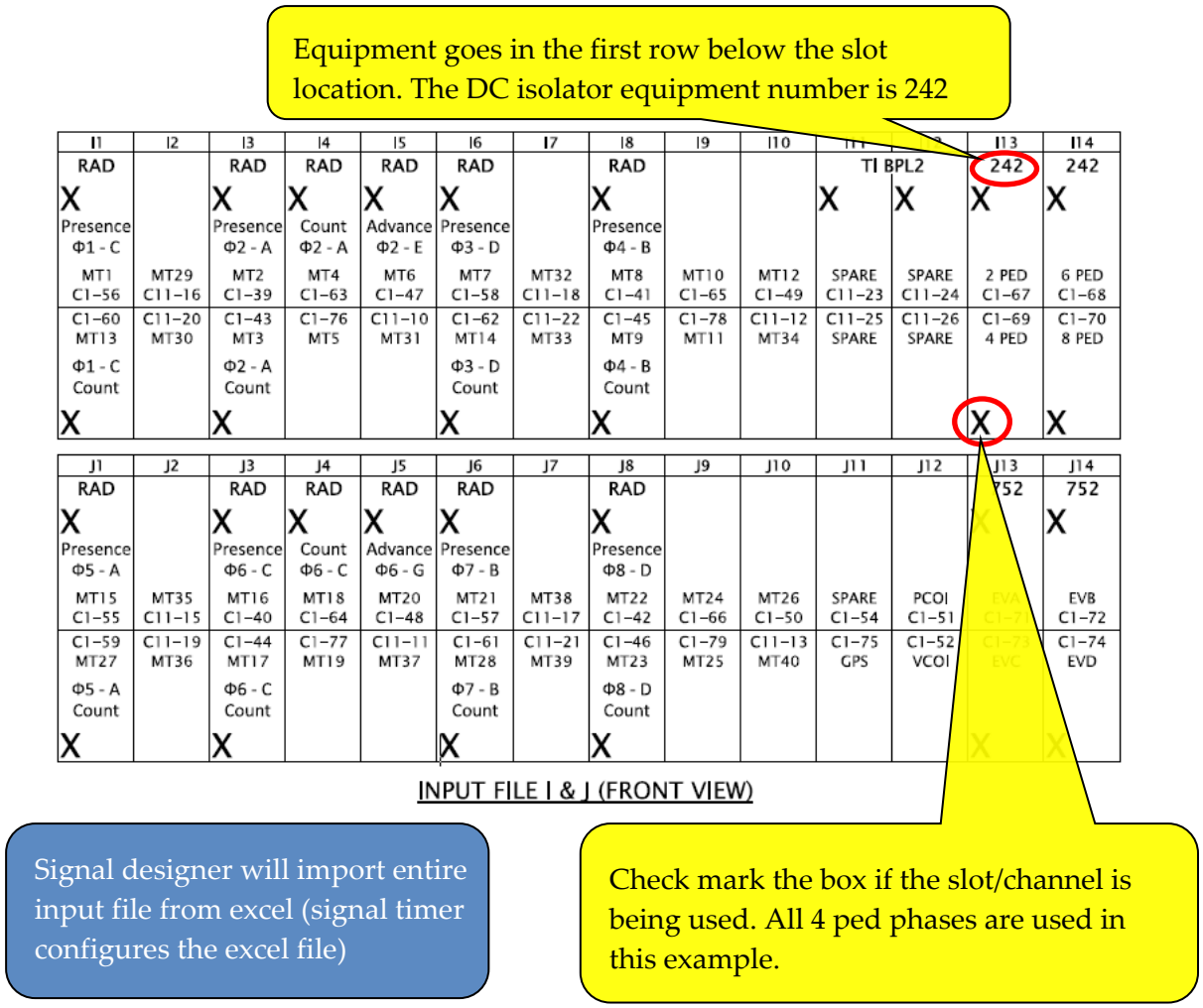
Figure 20-6 | 332S Cabinet – AC Isolator Equipment



20.6.3 DC Isolator Location (Signal Timer Responsibility – Use Excel File)

DC isolators are located in slots I13 and I14 and is used for pushbutton detection (Note: the 332 cabinet location is slots I12 and I13). The standard phasing is shown below in Figure 20-7. The equipment module number is 242.

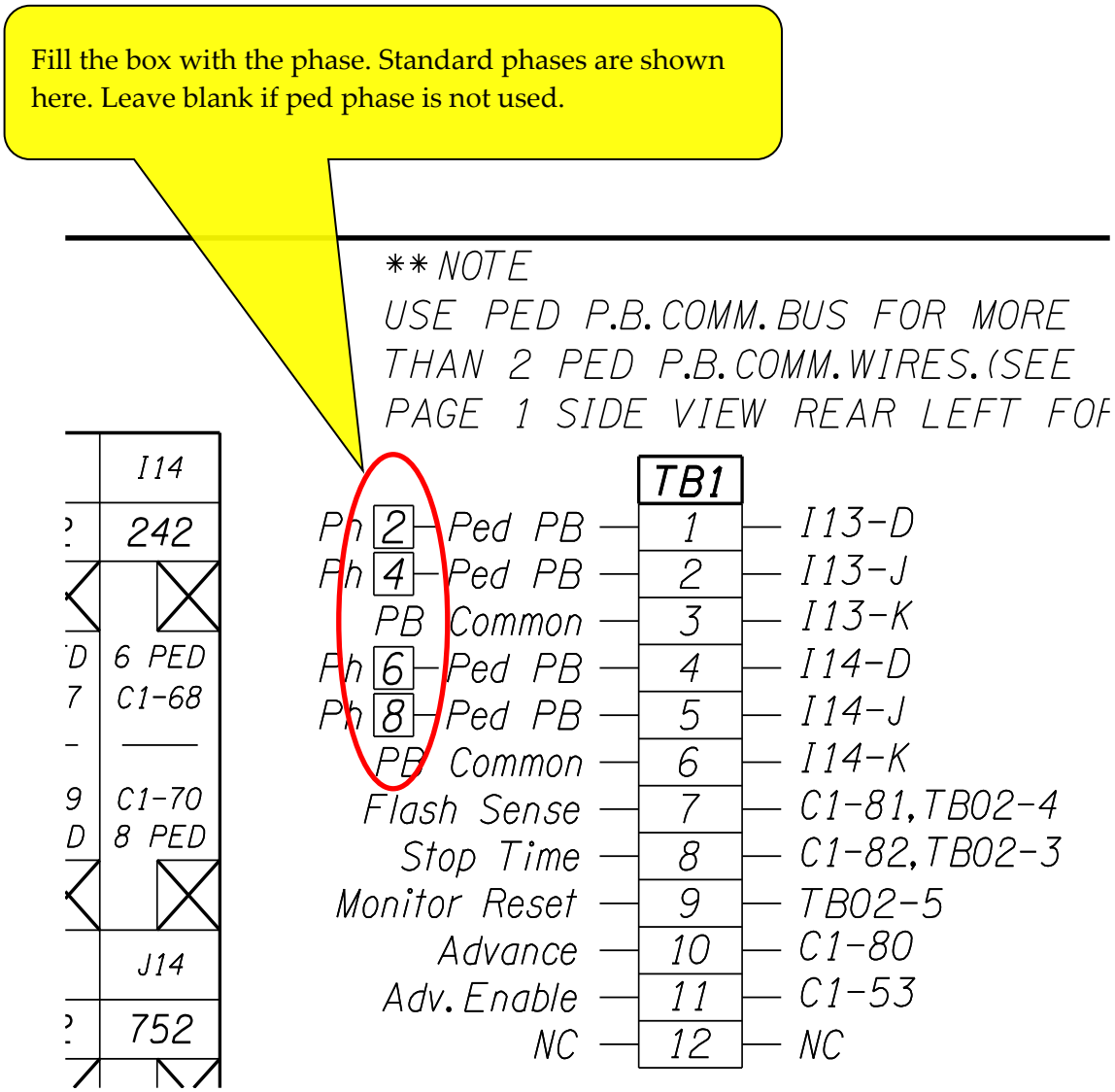
Figure 20-7 | 332S Cabinet – DC Isolator Equipment



20.6.4 Pedestrian Detector Termination

Figure 20-8 shows the terminal block where the pedestrian detectors are wired. Fill in the phase for the pedestrian pushbuttons being used.

Figure 20-8 | 332S Cabinet – Pedestrian Detector Termination

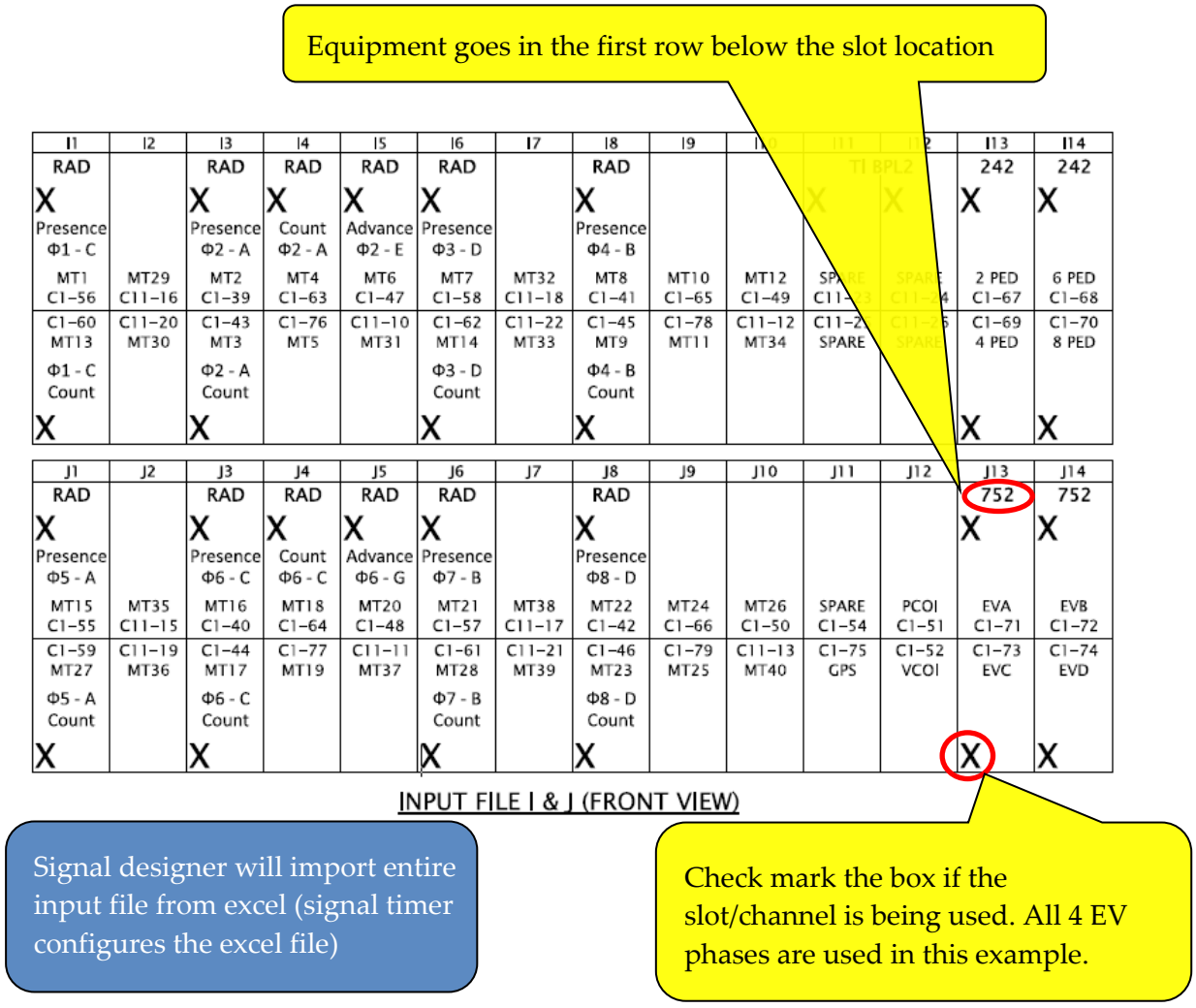


20.6.5 Fire Preemption Detectors (Signal Timer Responsibility – Use Excel File)

Fire preemption detector equipment is located in slots J13 and J14 and provides the input for fire preemption (Note: the 332 cabinet location is slots J12 and J13). See Figure 20-9. The equipment modules for fire preemption detectors are:

- 752 = Opticom phase selector (legacy, not used for new installations)
- 2140 = Tomar Stobecom II O.S.P.
- 762 = Opticom phase selector (2 phase selector)
- 764 = Opticom phase selector (4 phase selector, covers two slots)

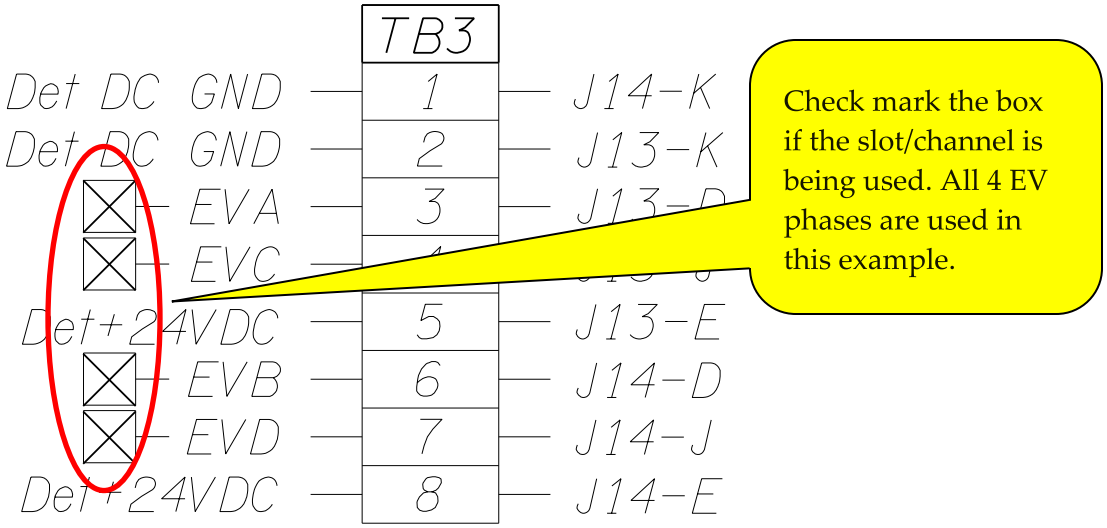
Figure 20-9 | 332S Cabinet – Fire Preemption Detector Equipment



20.6.6 Fire Preemption Detection Termination

Figure 20-10 shows the terminal block where the fire preemption is wired. Mark the check box if the EV channel is being used.

Figure 20-10 | 332S Cabinet – Fire Preemption Detector Termination



20.6.7 Detector Input Termination

Vehicle detection is wired to terminal block TB5 and TB6. In a 332S cabinet, this location should remain blank when using video, radar or SDLC as shown in Figure 20-11 below (display the proper models as per the microstation base file instructions). Loop detection is the only type of detection that requires entering info and is shown in Figure 20-12.

Figure 20-11 | 332S Cabinet – Detector Input Termination for Video, Radar, or SDLC

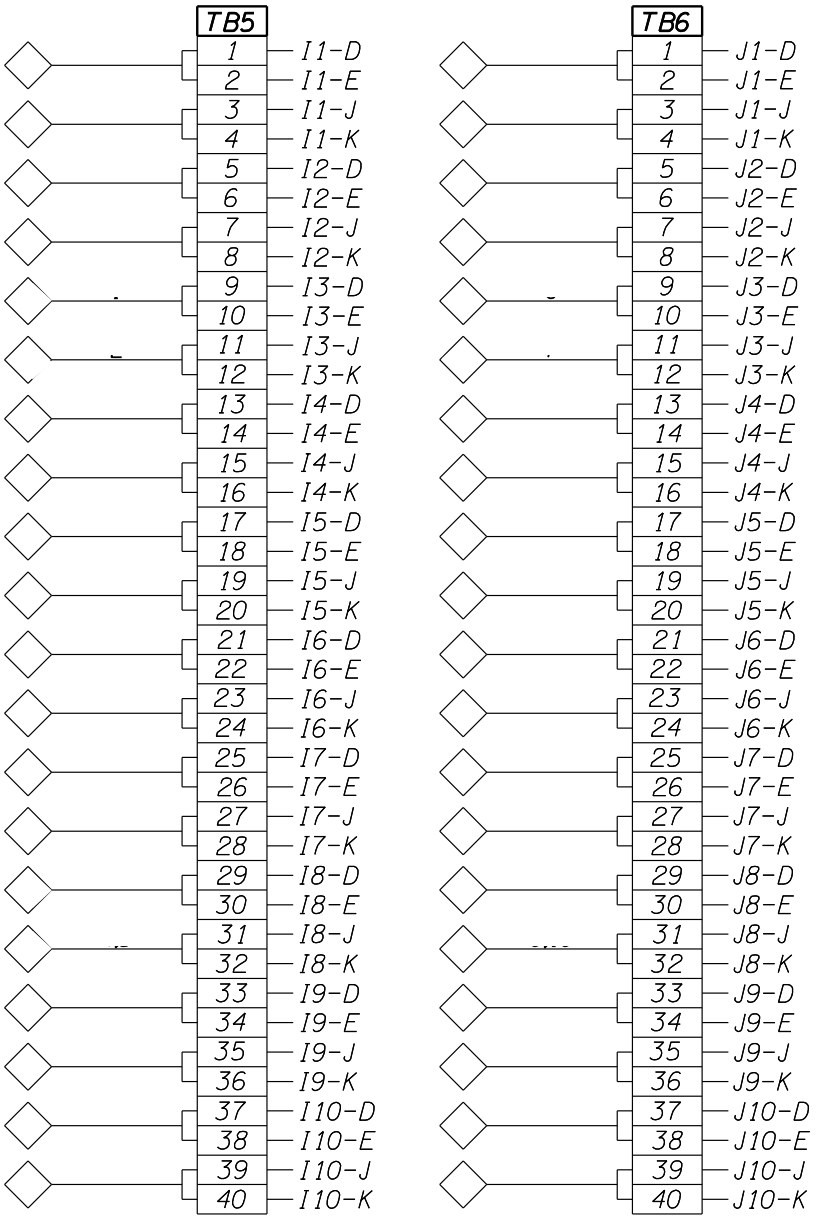
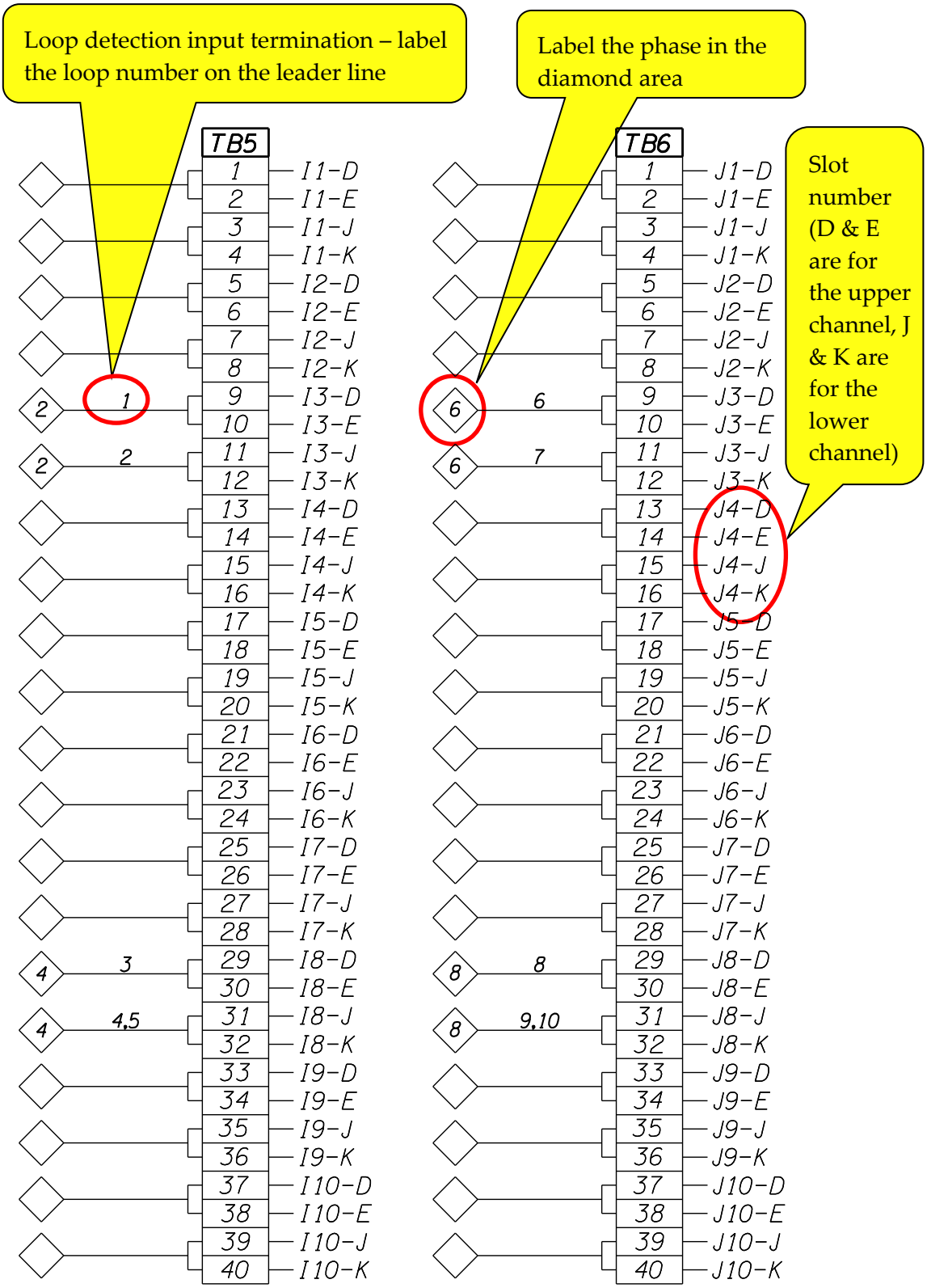


Figure 20-12 | 332S Cabinet – Detector Input Termination for Loops



20.6.8 Additional Information about the Input File

332 Cabinet Without a C11 Connector

28 vehicle inputs using 9 slots and 2 input files that is wired to accommodate:

- 2 vehicle detection inputs to the controller for each odd numbered phase
- 5 vehicle detection inputs to the controller for each even numbered phase
- 4 pedestrian detection inputs (Slot I12 and I13)
- 4 emergency preemption inputs (Slot J12 and J13)
- 2 railroad preemption inputs (Slot J11: indirect via 4 C1 pins using a 252 AC Isolator)
- 0 spares

Each input file slot has (2) channels associated with it, the upper and the lower. The slot may have one or two controller inputs wired to it. Slots 1, 4, 5, and 8 have one controller input. Slots 2, 3, 6, 7, 9, 12, and 13 have two controller inputs. Slot 10, I11 and 14 have no inputs and are not used (e.g., no C1 pin).

If a viewcom module is used, it will go in slot I10 and I11.

332S Cabinet With a C11 Connector

40 vehicle inputs using 10 slots and 2 input files that is wired to accommodate:

- 4 vehicle detection inputs to the controller for each odd numbered phase
- 6 vehicle detection inputs to the controller for each even numbered phase
- 4 pedestrian detection inputs (Slot I13 and I14)
- 4 emergency preemption inputs (Slot J13 and J14)
- 2 railroad preemption inputs (Slot J12: direct via inverting a 255 AC isolator)
- 1 GPS (J11L)
- 5 spares (Slot I11U, I11L, J11U, J12U, and J12L)

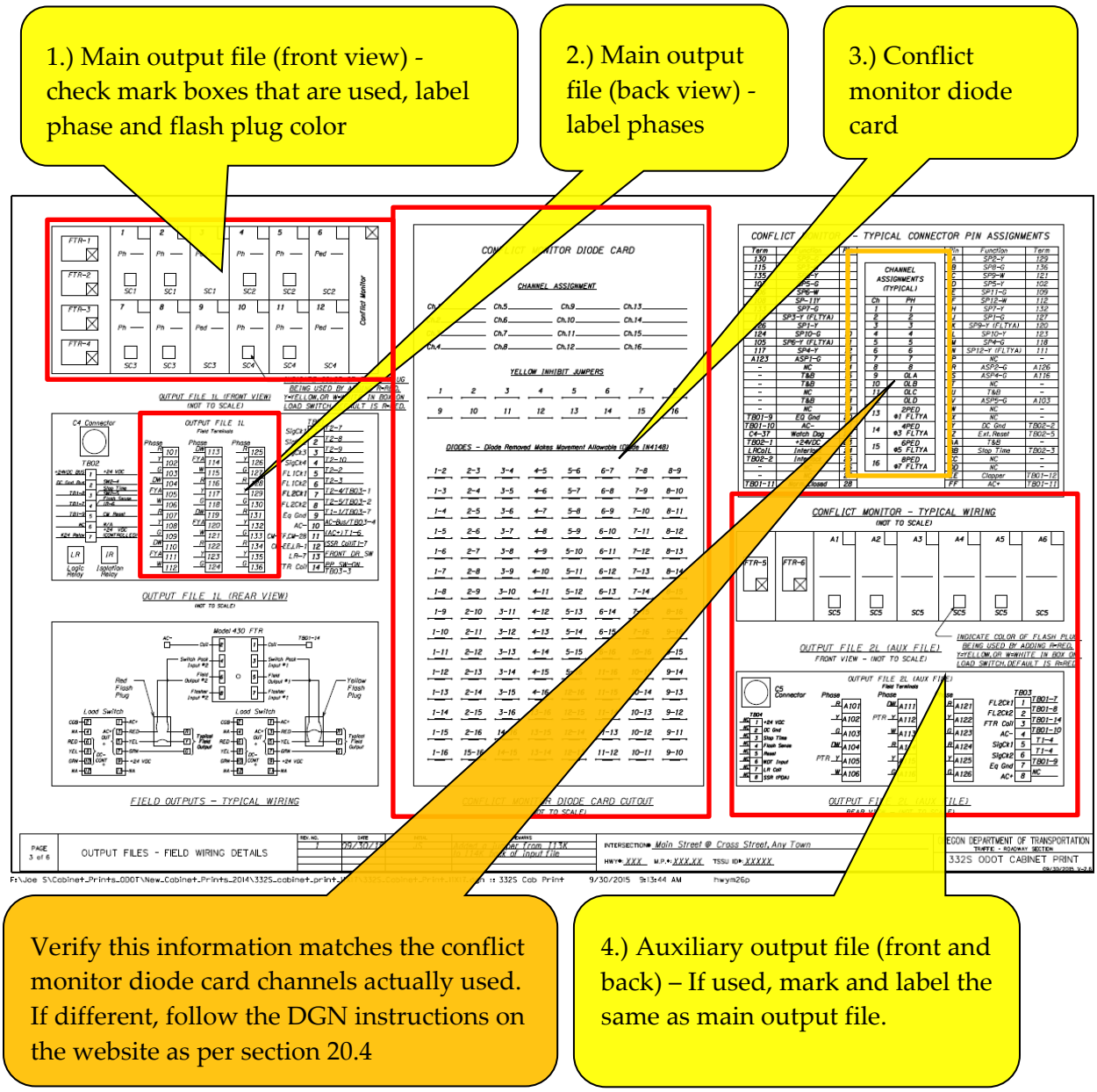
Each input file slot has (2) channels associated with it, the upper and the lower. All slots have two controller inputs wired to it (assigned to the C1 or C11 connector).

If a viewcom module is used, it will go in slot I11 and I12. The C11 pins need to be disconnected for the viewcom module to function.

20.7 332S Cabinet Print (Page 3 – Output File)

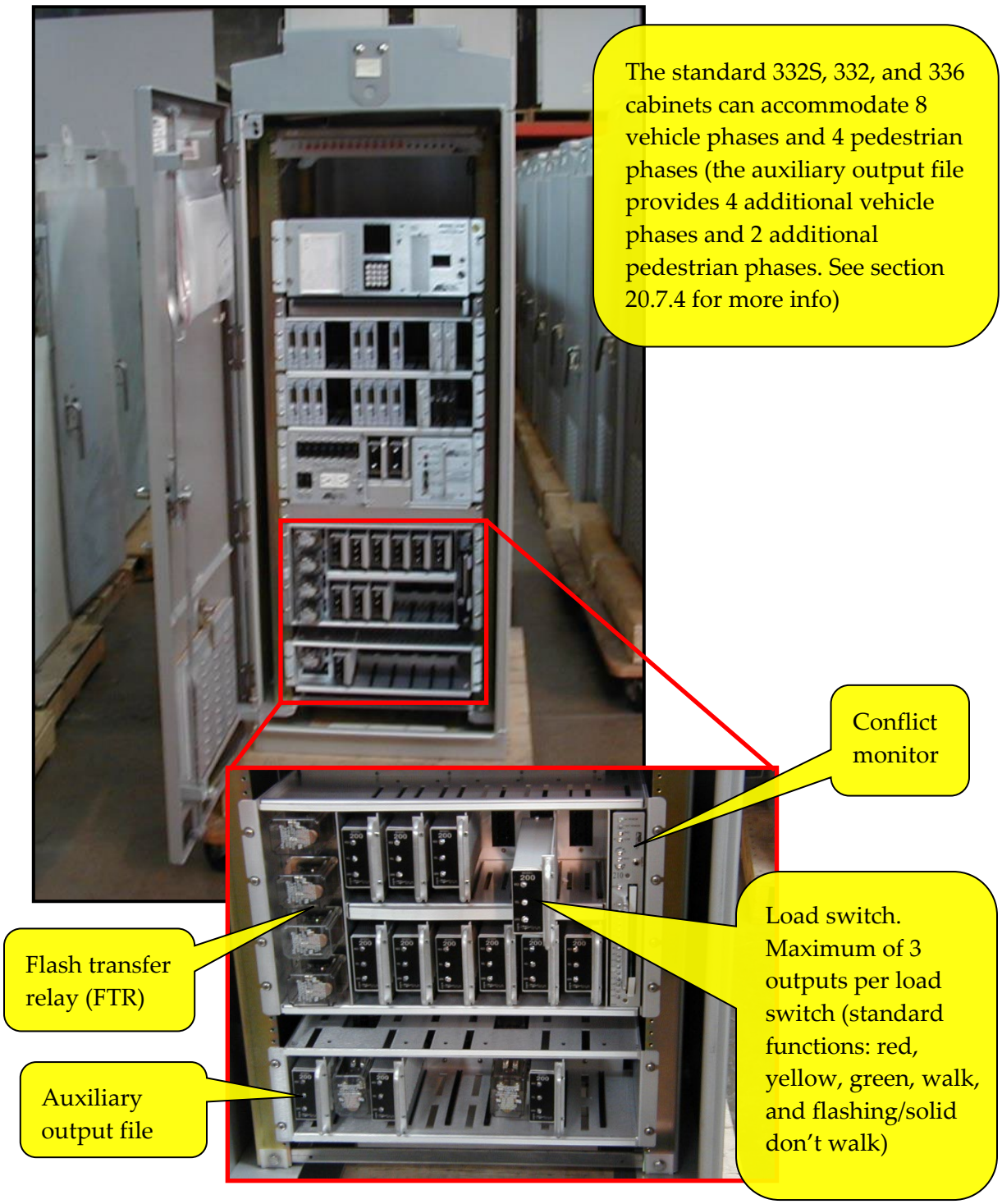
Page 3 of the 332S cabinet print shows the output file and conflict monitor. This sheet requires filling in the information for all the output equipment used. The basic output equipment (e.g., load switches, flash transfer relays, flash plugs, etc.) that needs to be filled in is shown in Figure 20-13. Each bubble note in Figure 20-13 is numbered and described in more detail in the next sections. **Important additional information about the output file is in section 20.7.5.**

Figure 20-13 | 332S Cabinet Print (Page 3 – Output File)



For reference, Figure 20-14 shows the actual front view of the output file in a 332 cabinet (which is very similar to the 332S).

Figure 20-14 | 332 Cabinet – Output File (Front View) Actual View



20.7.1 Main Output File (Front View):

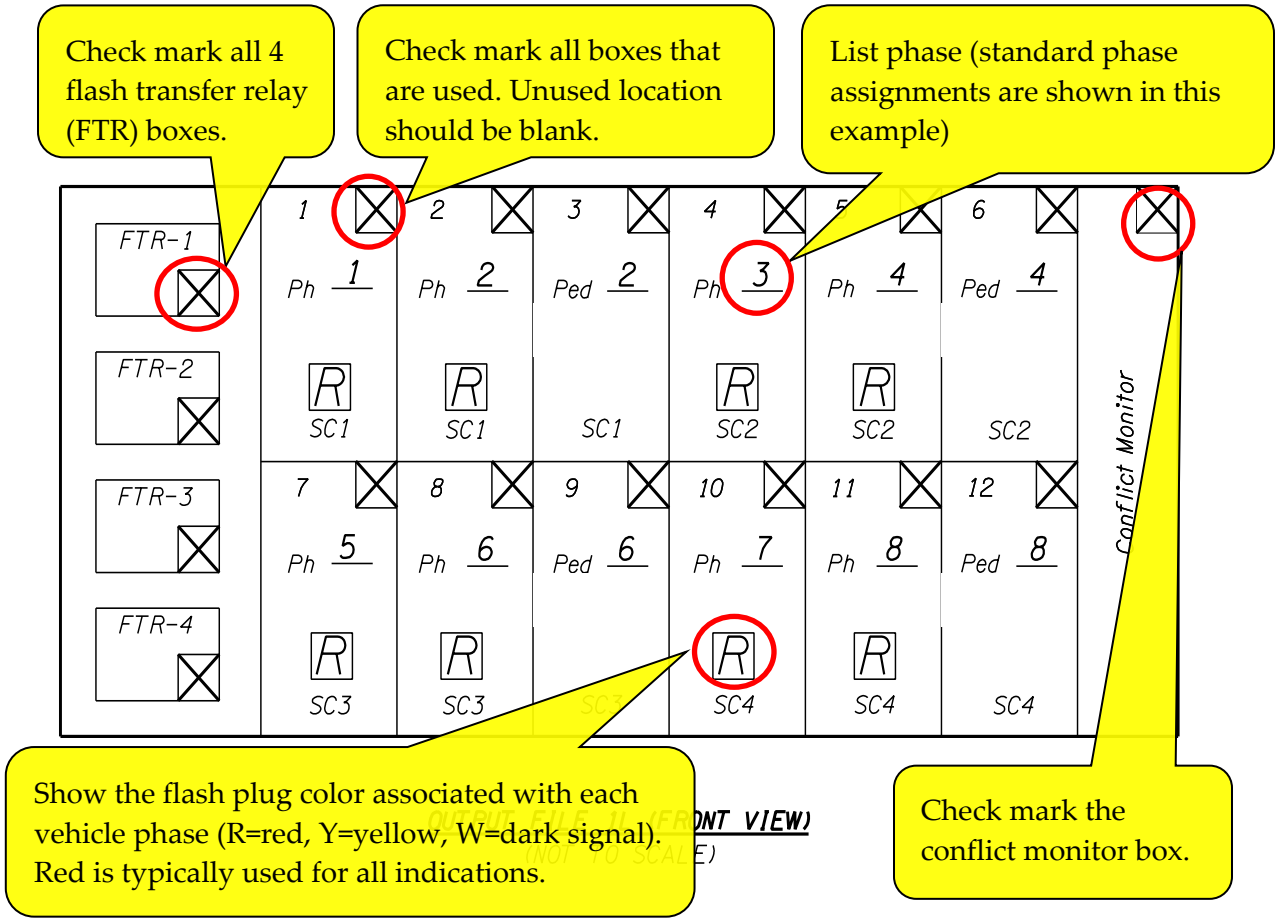
The main output file (front view) shows the load switches that are used to power the field indications (vehicle signals: red, yellow, green and pedestrian signals: walk, flashing don't walk). Other types of powered indications, such as PTR signs or advance flashing beacons may be wired to a load switch. Dummy phases do not have a field output (not wired to any load switches) and only exist in controller to allow for proper phase rotation. Do not show dummy phases in the output file. Each load switch that corresponds to a vehicle phase will have a flash plug (red, yellow, or white).

The flash transfer relays (FTR) are used to switch power from the load switches to the flasher units during cabinet flash. All four flash transfer relays should be included.

The conflict monitor checks the green indications, flashing yellow arrow and walk indications (and a few other items, such as voltage, connection to the controller, etc.) and causes the signal to go into cabinet flash if any conflicting indications come up together.

See Figure 20-15 for an example.

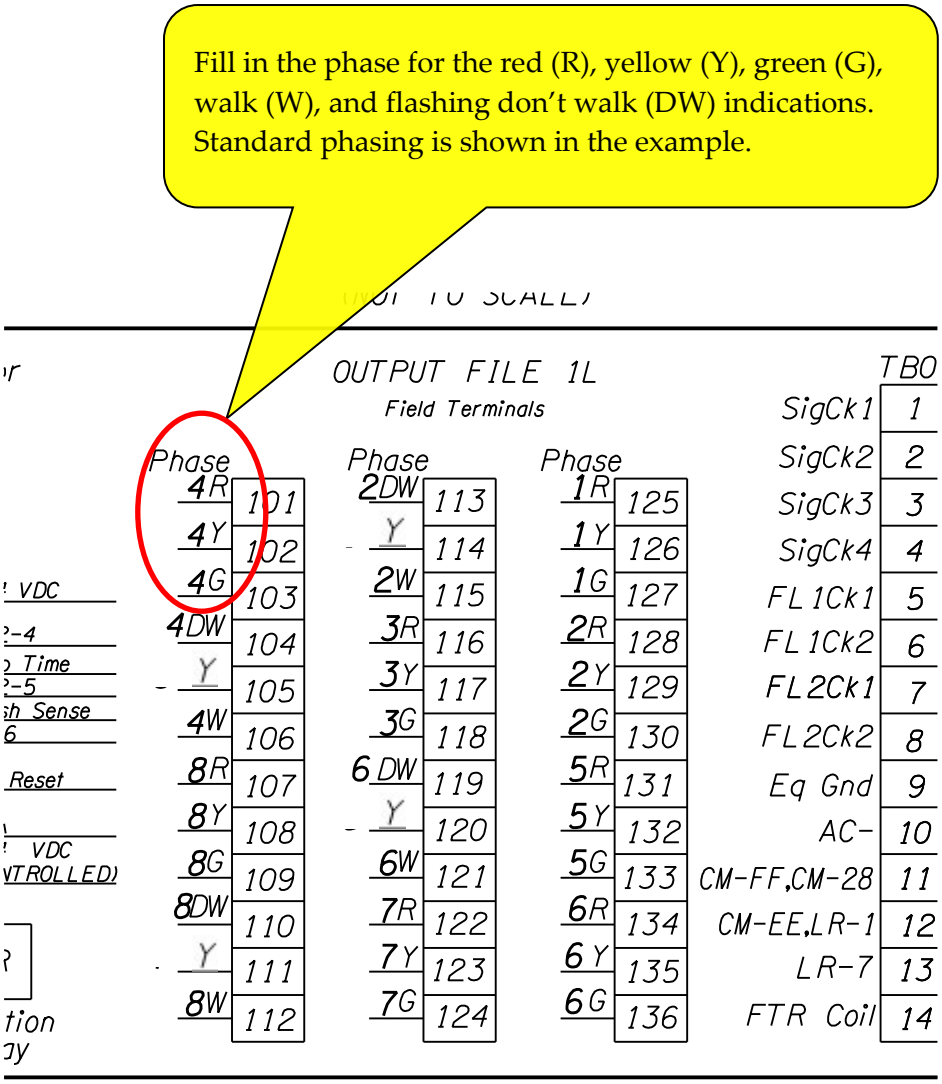
Figure 20-15 | 332S Cabinet – Main Output File (Front View)



20.7.2 Main Output File (Back View)

Figure 20-16 shows the terminal blocks for the output file. Fill in the phases being used.

Figure 20-16 | 332S Cabinet – Main Output File (Back View)

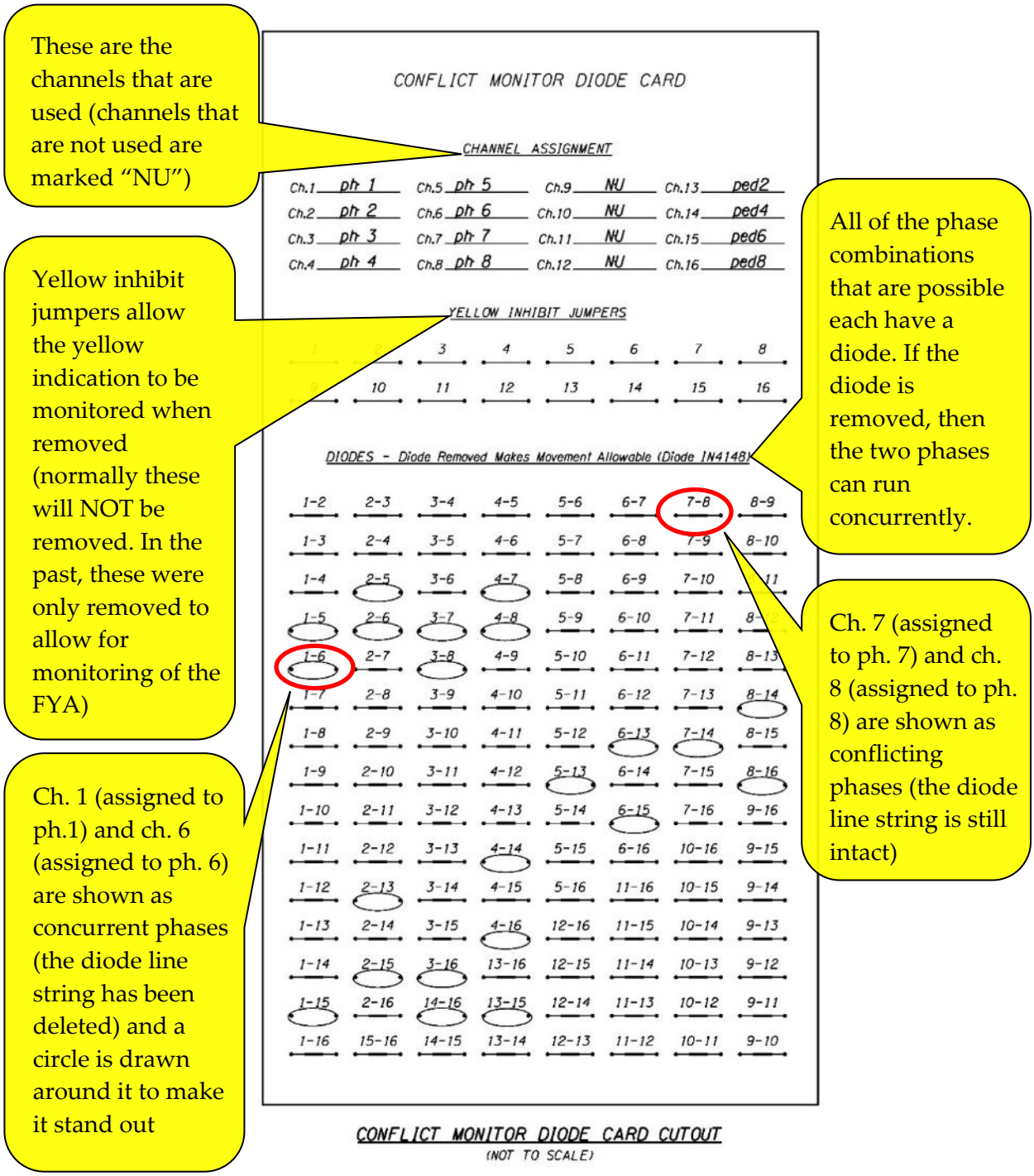


20.7.3 Conflict Monitor Diode Card

The signal designer will complete the conflict monitor diode card. It will be reviewed and approved by TSSU and/or the traffic engineering section. By default, the conflict monitor is configured such that ALL phases are conflicting (all diodes are intact). The diodes for non-

conflicting phases will be removed, leaving the diodes for conflicting phases intact. Only the phases that are actually used will determine the monitor configuration (e.g., if phase 3 and 7 are not used, those diodes will remain intact, even though phase 3 and phase 7 are typically non-conflicting phases). See Figure 20-17 for an example.

Figure 20-17 | 332S Cabinet – Conflict Monitor Diode Card



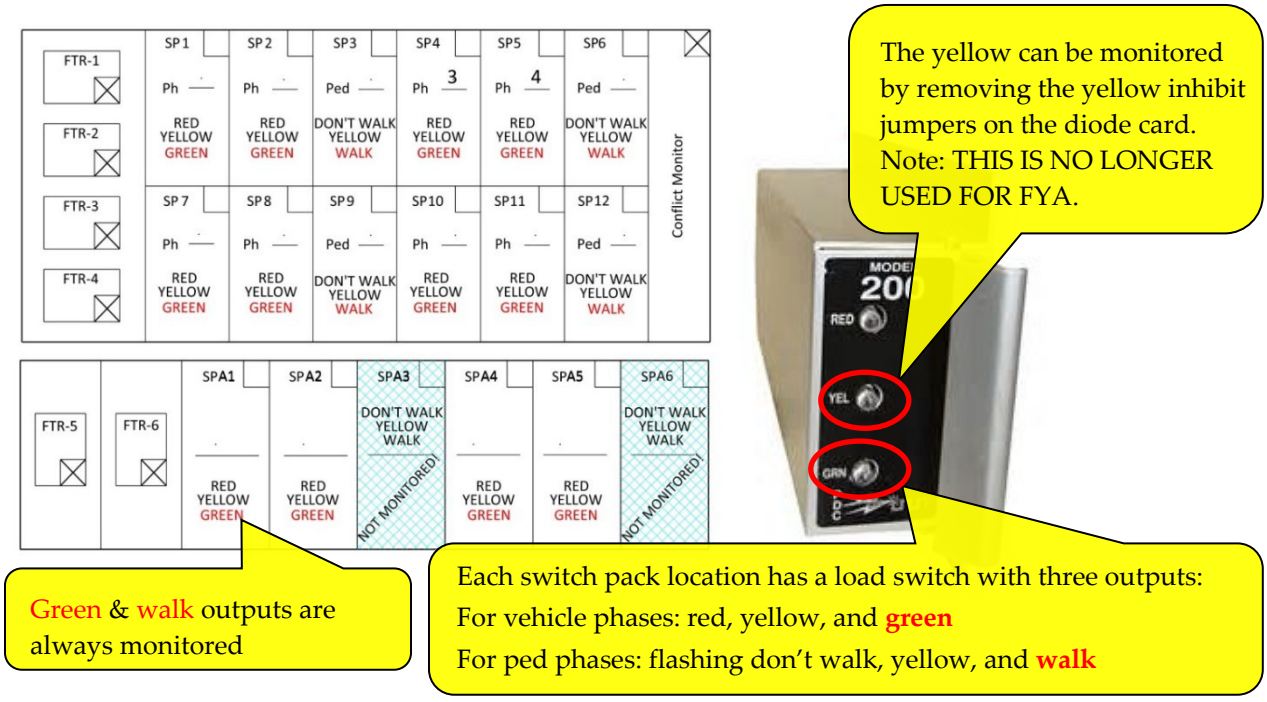
Outputs That Are Monitored

All green, walk and flashing yellow arrow outputs for each phase shall be monitored by the conflict monitor. These are critical indications for each phase because they inform the driver or pedestrian when it is OK to enter or precede through the intersection. Monitoring these outputs for conflict ensures that a driver or pedestrian will never be incorrectly informed when it is OK to enter the intersection.

The green and walk outputs are always wired to the conflict monitor by the manufacturer as per the Standard Specification for Microcomputer Signal Controller. See Figure 20-18 with the monitored channels shown in red. **ANY OUTPUT ASSIGNED TO ONE OF THESE LOCATIONS WILL BE MONITORED. Do NOT reassign an output that shouldn't be monitored to one of these locations.**

The yellow indication can be monitored by removing the yellow inhibit jumpers on the diode card (note: this was used in the past for monitoring flashing yellow arrows), but it does NOT operate independently of the green indication on the same load switch. For example, if ped phase 2 yellow is monitored by removing the yellow inhibit jumpers, it will have the exact same conflicts as ped phase 2 walk. This can be advantageous for monitoring the flashing yellow arrow, as the opposing pedestrian phase typically has the same conflicts (e.g., ped phase 2 walk has the same conflicts as ph. 1 flashing yellow arrow), but widespread use of negative ped phasing, overlaps, and type 3LCF signal heads resulted in problems when monitoring the FYA via the yellow indication. Therefore, this method is no longer allowed. See section 20.13.1 for more info.

Figure 20-18 | Monitored Outputs



Not all outputs require conflict monitoring as they are not as critical to eliminating the crash potential associated with being incorrectly informed. For example, the yellow and red outputs for each phase inform the driver or pedestrian that they must stop. If a driver is shown one of these indications erroneously, the action the driver is informed to take (stop) should not result in a crash with a conflicting vehicle that has been informed by a green indication.

Outputs that are NOT monitored include:

- Red outputs
- Yellow outputs
- Flashing don't walk outputs
- PTR sign outputs*
- Fire signal confirmation indication outputs* (Note: this refers to legacy installations that have not been updated to the current standard, as these are no longer allowed for new construction. As per chapter 17, the new standard requires tattletale lights which are not assigned to an output and are directly wired to the RED signal indication.)

*It is important to note that PTR sign output and fire signal confirmation indication outputs always require an output reassignment (as they do not have a standard output location). Do NOT reassign these outputs to a load switch location that is monitored (see Figure 20-18).

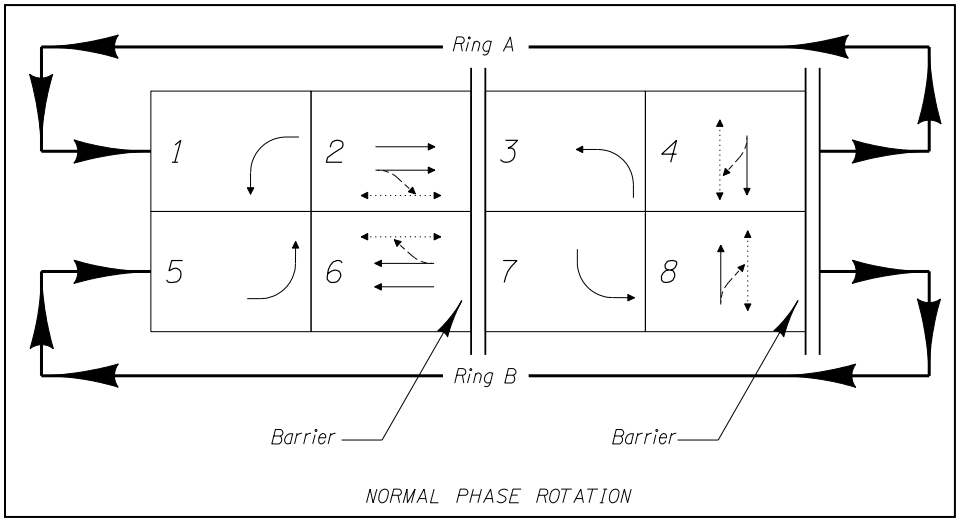
The conflict monitor also monitors other critical aspects of the how the traffic signal is functioning (watchdog, voltages, etc.) as per the Standard Specification for Microcomputer Signal Controller. Unlike the diode card, these aspects do NOT require a custom configuration for each intersection.

Rules for Standard Signal Timing Configurations

When using a standard ring and barrier configuration (see Figure 20-19 and chapter 3 for more information on ring and barrier configuration), the following rules apply:

- An active phase is defined as a movement whose green, walk, or flashing yellow arrow intervals are being timed by the controller.
- Only ONE active phase per ring at a time
- A phase can be active with the phase vertically opposite or diagonal from it as long as it exists on the same side of the barrier. These are called compatible phases (e.g., phase 1 and phase 5, phase 1 and phase 6)
- Both rings must cross the barrier at the same time

Figure 20-19 | Standard 8 Phase Ring and Barrier Diagram



When using overlap phases the following rules apply:

- An overlap phase may be assigned with any phase or number of phases. These are called the parent phase(s).
- An overlap phase will be permitted by every phase compatible with the assigned parent phase. For example, if Figure 20-19 had an OLA = phase 2, then OLA will also be permitted with ped phase 2, phase 5, phase 6, ped phase 6.
- Any phase can have a pedestrian phase assigned to it, limited by the available outputs from the controller.

When using flashing yellow arrow the following rules apply (for additional background information see section 20.13.1):

- The flashing yellow arrow signal head type shall be a type 3LCF
- Phase 1 FYA/YA = Channel 9
    - RED arrow terminated on ph. 1 RED
    - FYA/solid YELLOW arrow terminated on OLA GREEN
    - GREEN arrow terminated on ph. 1 GREEN
- Phase 3 FYA/YA = Channel 10
    - RED arrow terminated on ph. 3 RED
    - FYA/solid YELLOW arrow terminated on OLB GREEN
    - GREEN arrow terminated on ph. 3 GREEN
- Phase 5 FYA/YA = Channel 11
    - RED arrow terminated on ph. 5 RED
    - FYA/solid YELLOW arrow terminated on OLC GREEN
    - GREEN arrow terminated on ph. 5 GREEN
- Phase 7 FYA/YA = Channel 12
    - RED arrow terminated on ph. 7 RED
    - FYA/solid YELLOW arrow terminated on OLD GREEN
    - GREEN arrow terminated on ph. 7 GREEN

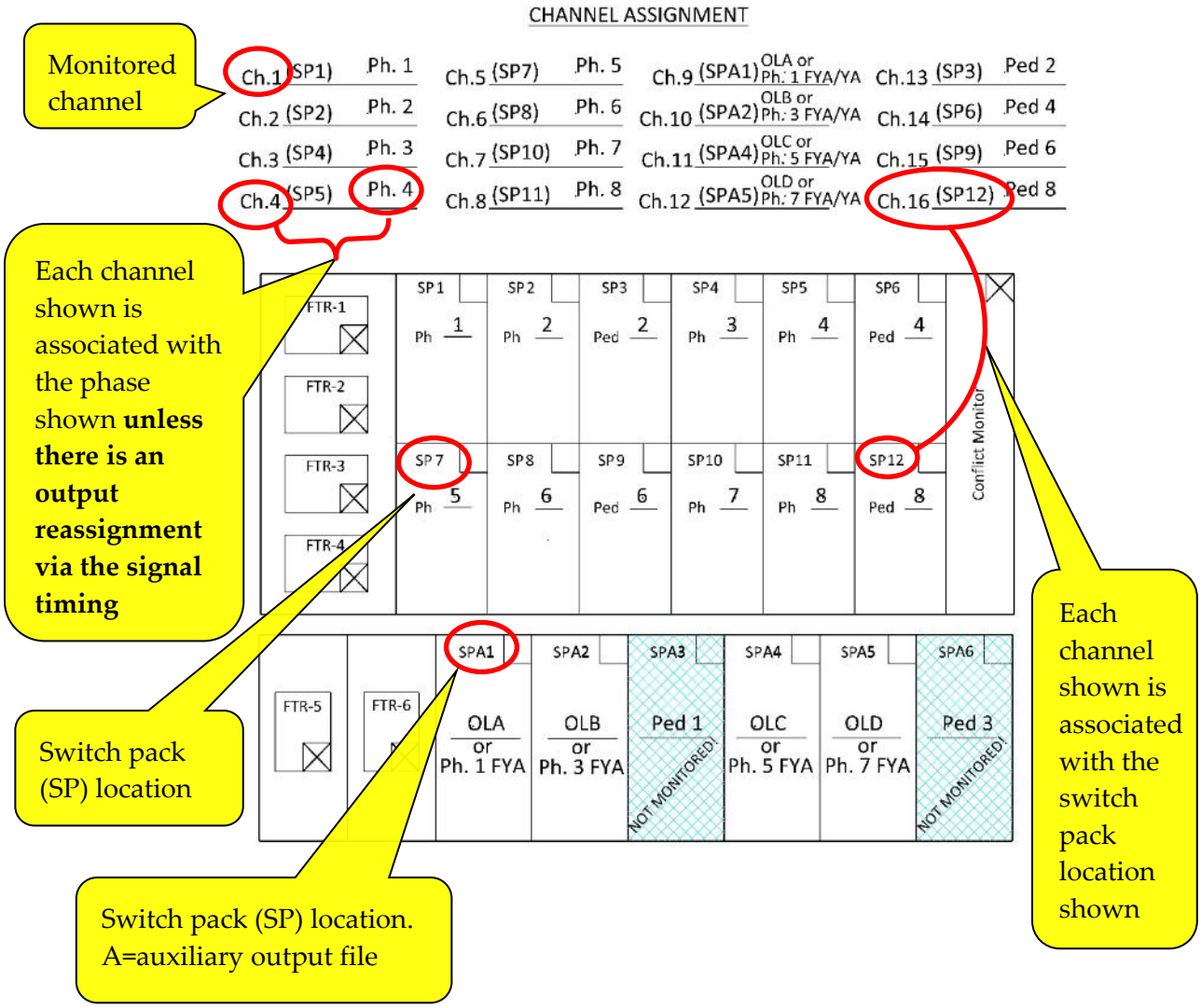
Note: Each FYA/YA phase (for a left or right turn) and each overlap phase green indication require termination on a separate overlap green location (OLA through OLD) for proper conflict monitoring. This limits the total number of FYA/YA phases and overlap phases combined at an intersection to four. See section 20.7.5 for more info on the limitations.

See "channel assignments – output reassignment order of priority for FYA/YA phases & overlap phases" in this section for info on properly assigning ch. 9 through ch. 12 when the intersection has a combination of FYA/YA and overlap phases.

Channel Assignment - Standard

On a standard model 210 conflict monitor, there are 16 channels that can be monitored. Each active phase (green, walk, or flashing yellow arrow) shall be assigned to a channel on the conflict monitor. The standard channel and phase assignment is shown in Figure 20-20. Switch packs A3 and A6 are NOT wired to the conflict monitor. Each monitored channel is ALWAYS directly wired to the switch pack location as shown in Figure 20-20. For example, channel 1 (regardless of what phase channel 1 is associated with) is ALWAYS wired to switch pack 1. Each channel is associated with the phase shown in Figure 20-20, unless there are output reassignments (done via the signal software).

Figure 20-20 | Standard Channel Assignment



Channel Assignment – Output Reassignments

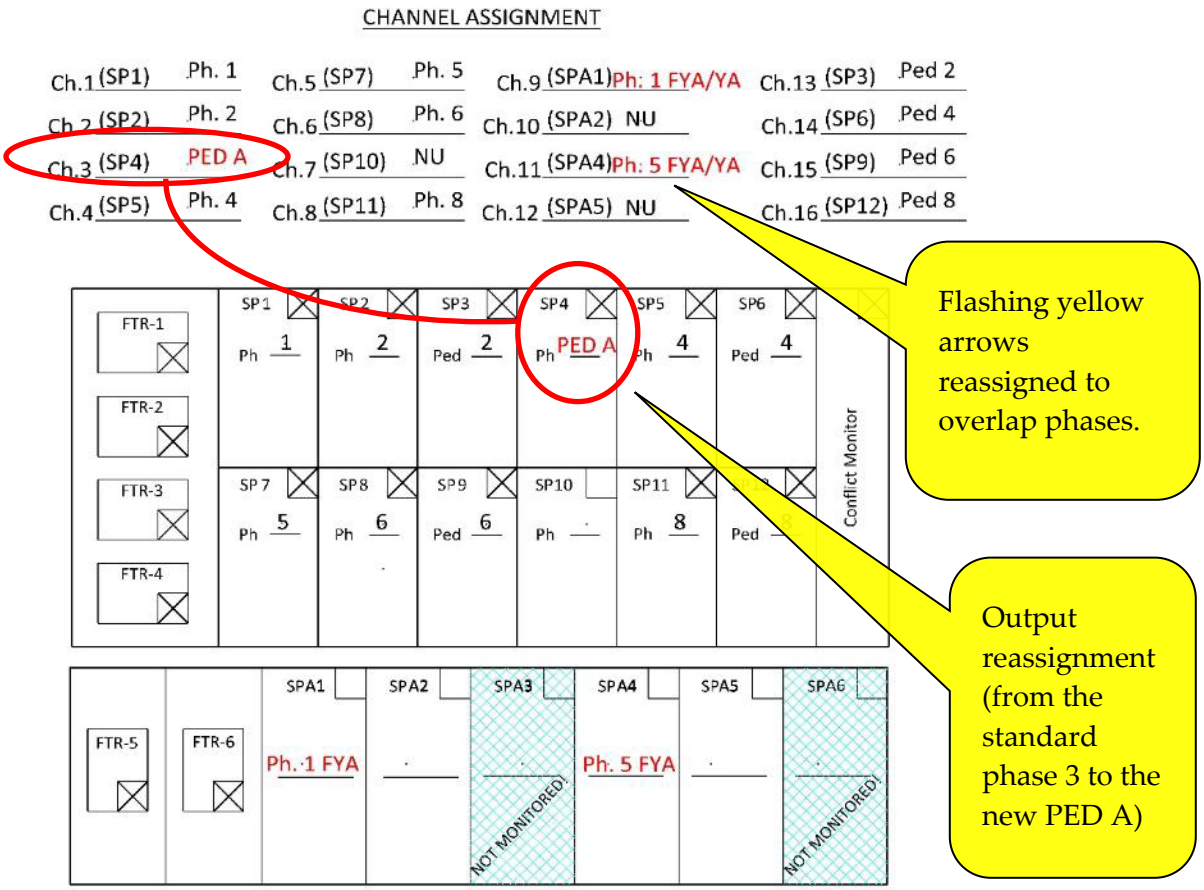
There are cases where it is necessary to reassign the output because a standard designation does not exist in the output file, such as:

- An odd numbered ped phase
- A ped overlap phase
- A flashing yellow arrow

In the past, output reassignments for vehicle overlap phases were commonly done to avoid installing an auxiliary output file. Auxiliary output files are now installed standard in 332S cabinets, so this practice is no longer required for new installations.

Output reassignments are done via the signal timing software. **Always verify with the signal timer any output reassignments.** Figure 20-21 shows an example where the channel 3 switch pack location SP4 has been reassigned to ped A. Flashing yellow arrows have been reassigned to the unused overlap phase switch packs.

Figure 20-21 | Channel Assignment – Output Reassignments

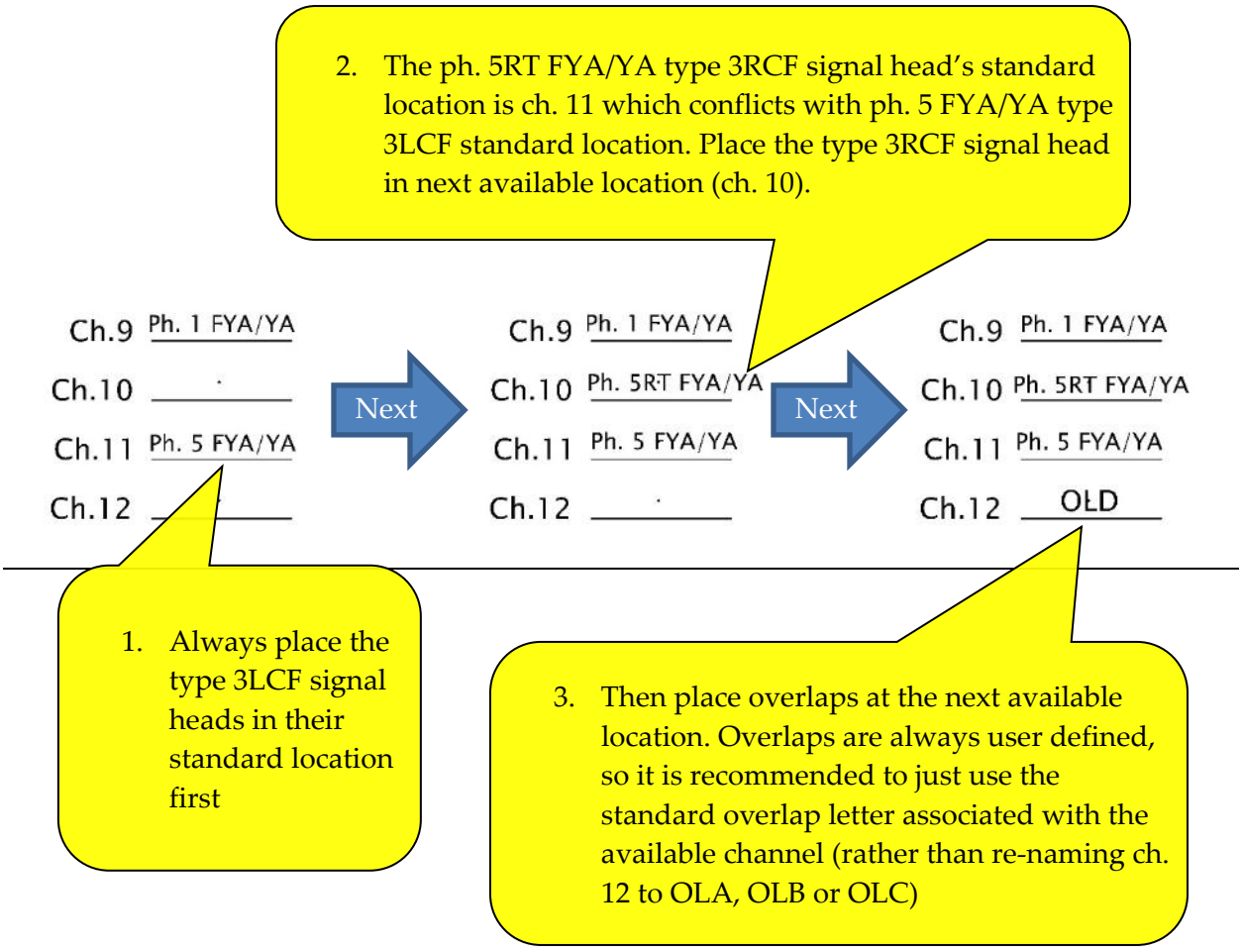


Channel Assignment – Output Reassignment Order of Priority for FYA/YA phases & Overlap Phases

If there is a combination of left-turn flashing yellow arrows, right-turn flashing yellow arrows, and overlap phases at the same intersection, use the following order of priority to rearrange the auxiliary outputs (ch. 9 through ch. 12) when the standard switch pack locations for the type 3LCF signal heads, type 3RCF signal heads, and overlap signal heads conflict. See Figure 20-22:

1. Place the type 3LCF signal head outputs first in their standard output locations.
2. Next, place the type 3RCF signal head outputs in their standard output locations if possible. If not possible due to a conflict with a type 3LCF signal head output, place the type 3RCF signal head outputs in the next available unused overlap switch pack locations.
3. Next, place the overlap signal head outputs in the next available unused overlap switch pack locations.

Figure 20-22 | Order of Priority for Standard Placement of Type 3LCF Signal Heads, Type 3RCF Signal Heads, and Overlap Signal Heads in the Auxiliary Output File



Determining Compatible Phases for the Diode Card

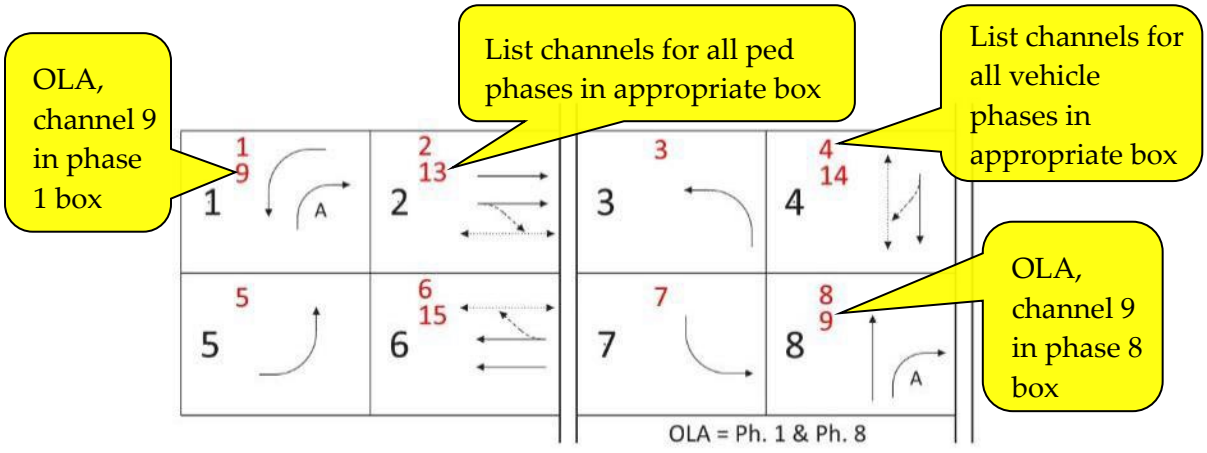
There are 3 basic steps to determine compatible phases as shown in Figure 20-23 thru Figure 20-25. Collect all information about the intersection that will be needed in order to determine the compatible phases, such as:

- Vehicle phases in use
- Pedestrian phases in use
- Parent phase assignments of overlaps
- Exclusive phase assignments
- Output reassignments from signal timing
- Load switches in use (note: dummy phases are not wired to load switches and therefore are not listed in the conflict monitor channel assignment)
- Existing cabinets: verify cabinet is wired as per standard with TSSU

Figure 20-23 | Basic Step 1 of 3: Determining Compatible Phases for the Diode Card



Figure 20-24 | Basic Step 2 of 3: Determining Compatible Phases for the Diode Card

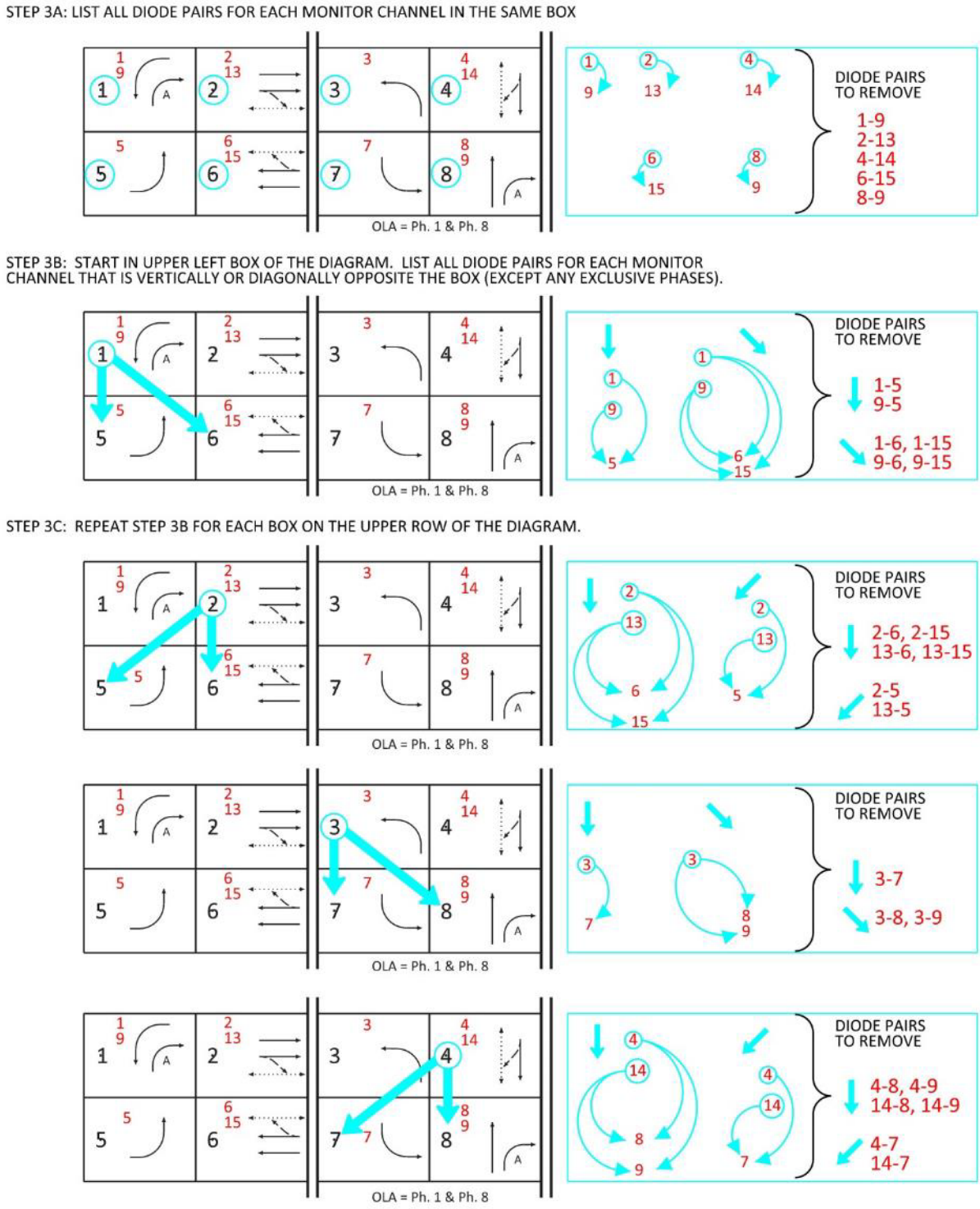


Write the monitor channels in the ring and barrier diagram for:

- Each vehicle phase used
- Each pedestrian phase used
- Each parent phase assigned to an overlap. For example, if OLA = ph. 1 and ph. 8, and OLA is assigned to channel 9, then write 9 in the phase 1 box and 9 in the phase 8 box of the ring and barrier diagram.

PAY CLOSE ATTENTION TO OUTPUTS THAT HAVE BEEN REASSIGNED

Figure 20-25 | Basic Step 3 of 3: Determining Compatible Phases for the Diode Card



Step 3 determines the compatible phases (diode pairs that need to be removed). This procedure will ensure that all correct diodes are removed. Duplicate diode pairs for phases with overlaps can occur. This is OK, since a diode can only be removed once.

When an intersection has a type 3LCF signal head for PPLT **AND** has any overlap phases, the conflict monitor diode configuration shall be determined by using the standard ring and barrier diagram method (shown on the previous page) **PLUS a separate ring and barrier diagram showing only the overlap green movements (vehicle and pedestrian) and the solid yellow left turn arrow of the type 3LCF signal head.** See Figure 20-26.

Figure 20-26 | Determining Compatible Phases – FYA (Type 3LCF Signal Head) and Overlap Phases

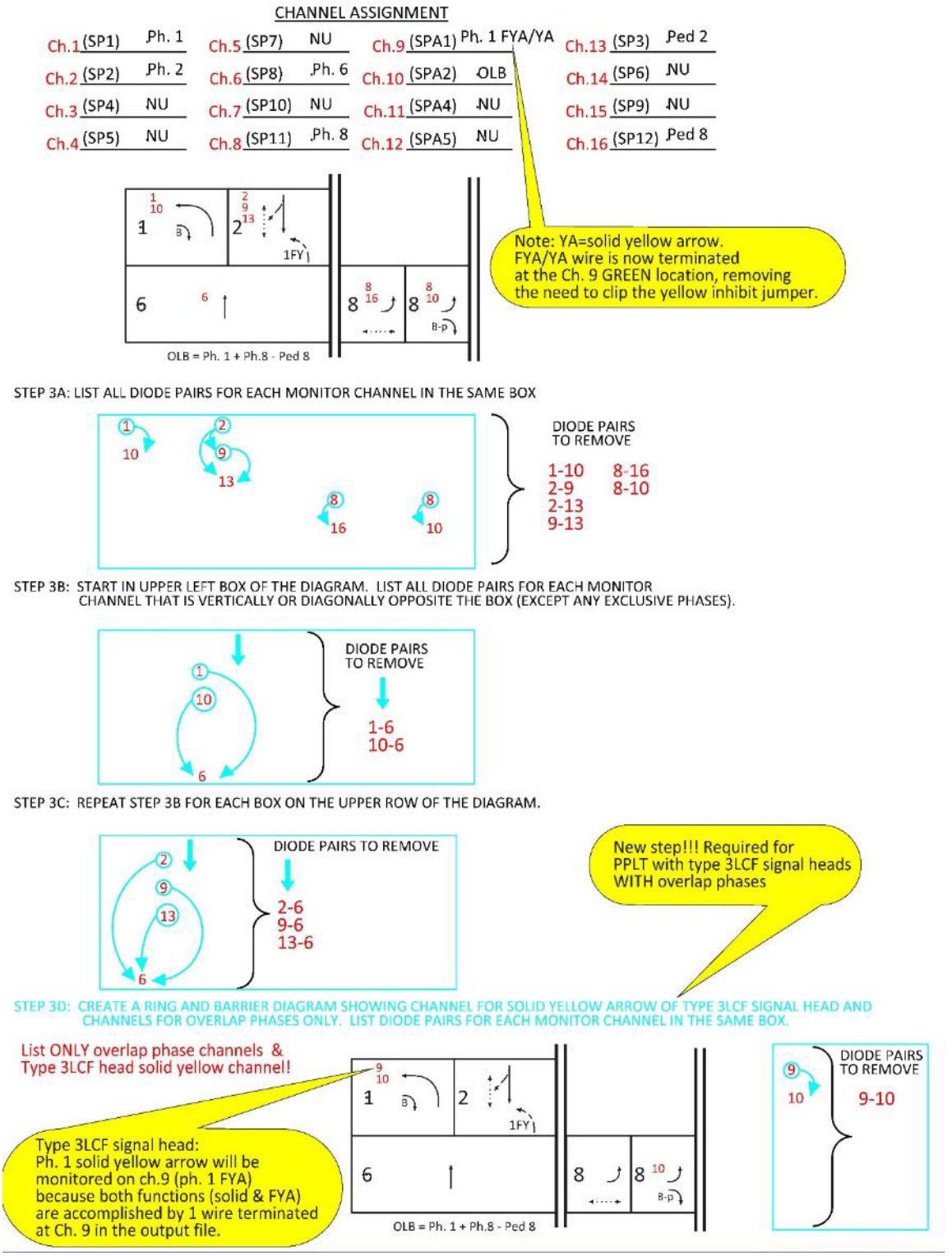
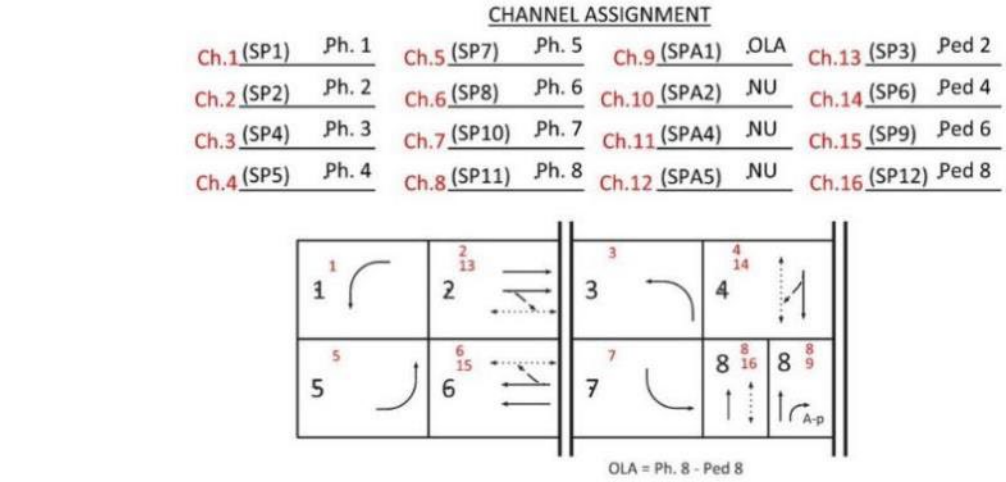
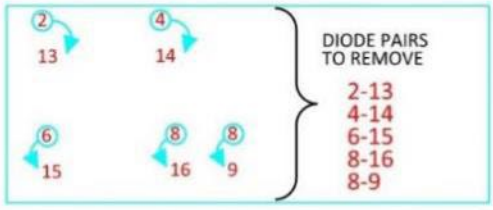


Figure 20-27 thru Figure 20-30 show common examples of determining compatible phases.

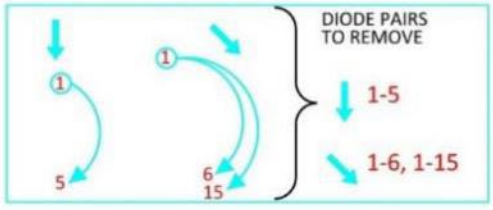
Figure 20-27 | Determining Compatible Phases – Example 1: Negative Ped Overlap



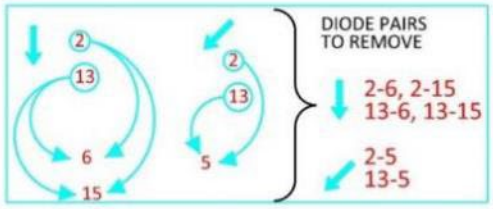
STEP 3A: LIST ALL DIODE PAIRS FOR EACH MONITOR CHANNEL IN THE SAME BOX

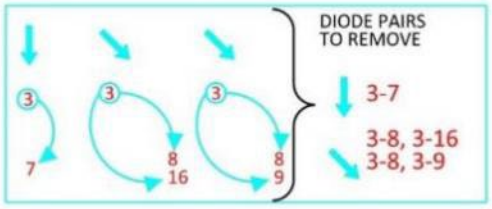


STEP 3B: START IN UPPER LEFT BOX OF THE DIAGRAM. LIST ALL DIODE PAIRS FOR EACH MONITOR CHANNEL THAT IS VERTICALLY OR DIAGONALLY OPPOSITE THE BOX (EXCEPT ANY EXCLUSIVE PHASES).



STEP 3C: REPEAT STEP 3B FOR EACH BOX ON THE UPPER ROW OF THE DIAGRAM.





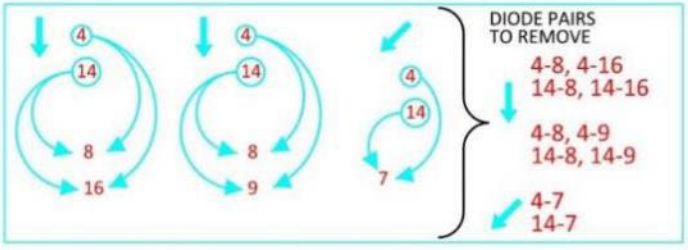


Figure 20-28 | Determining Compatible Phases – Example 2: Flashing Yellow Arrow (OLD METHOD – DO NOT USE PED YELLOW FOR NEW FYA INSTALLATIONS. SEE Figure 20-26 INSTEAD)

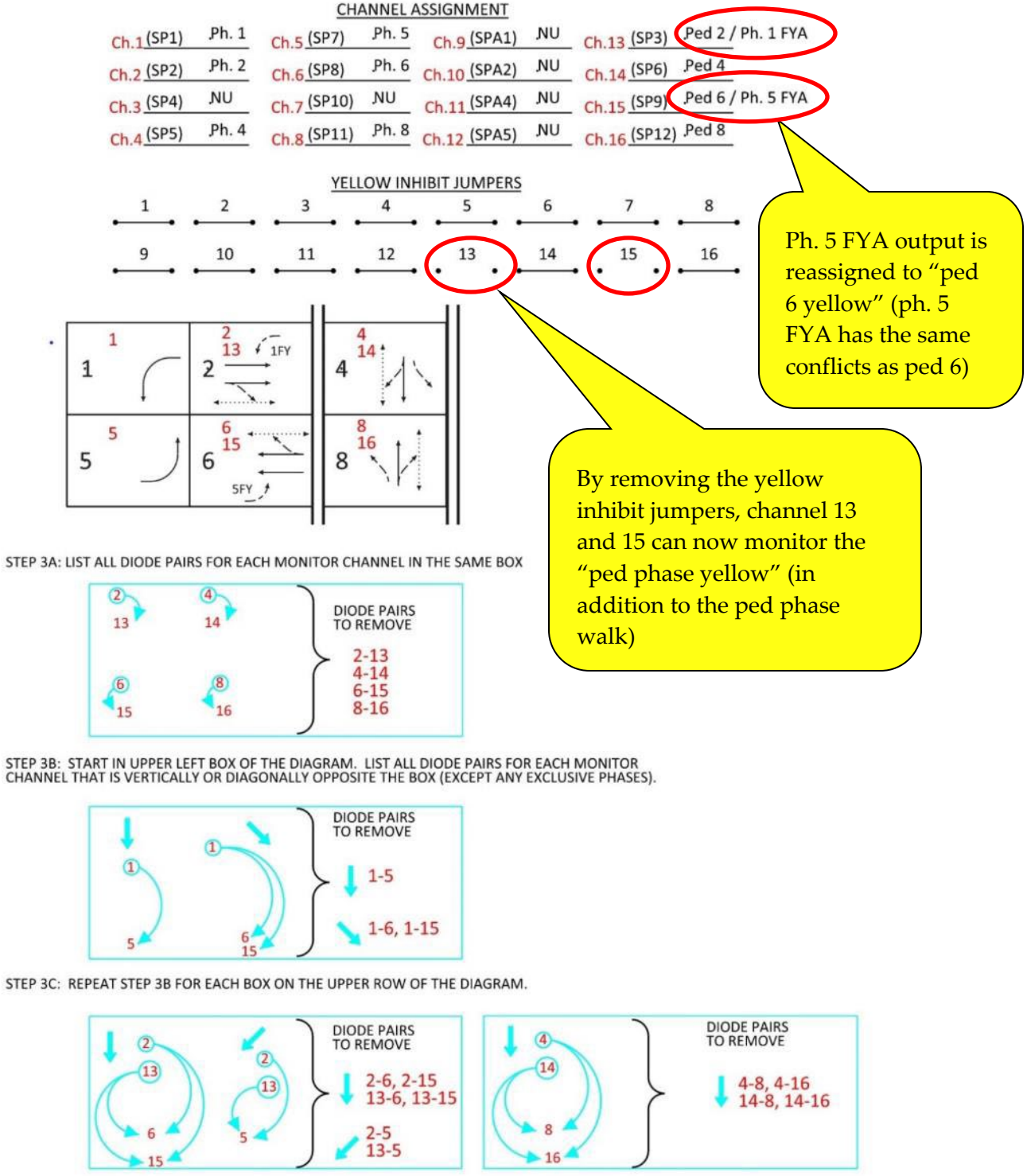


Figure 20-29 | Determining Compatible Phases – Example 3: Exclusive Phases

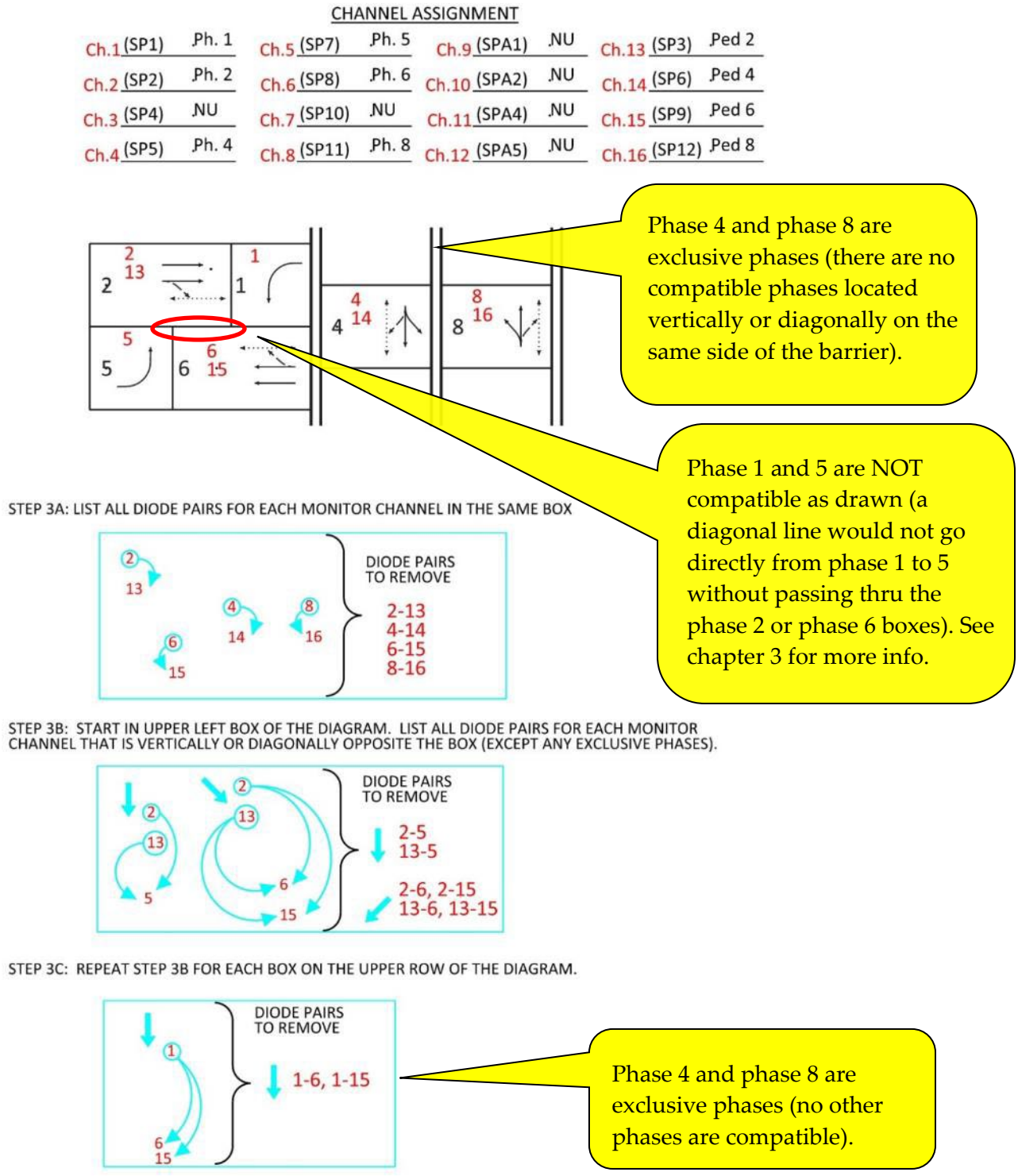
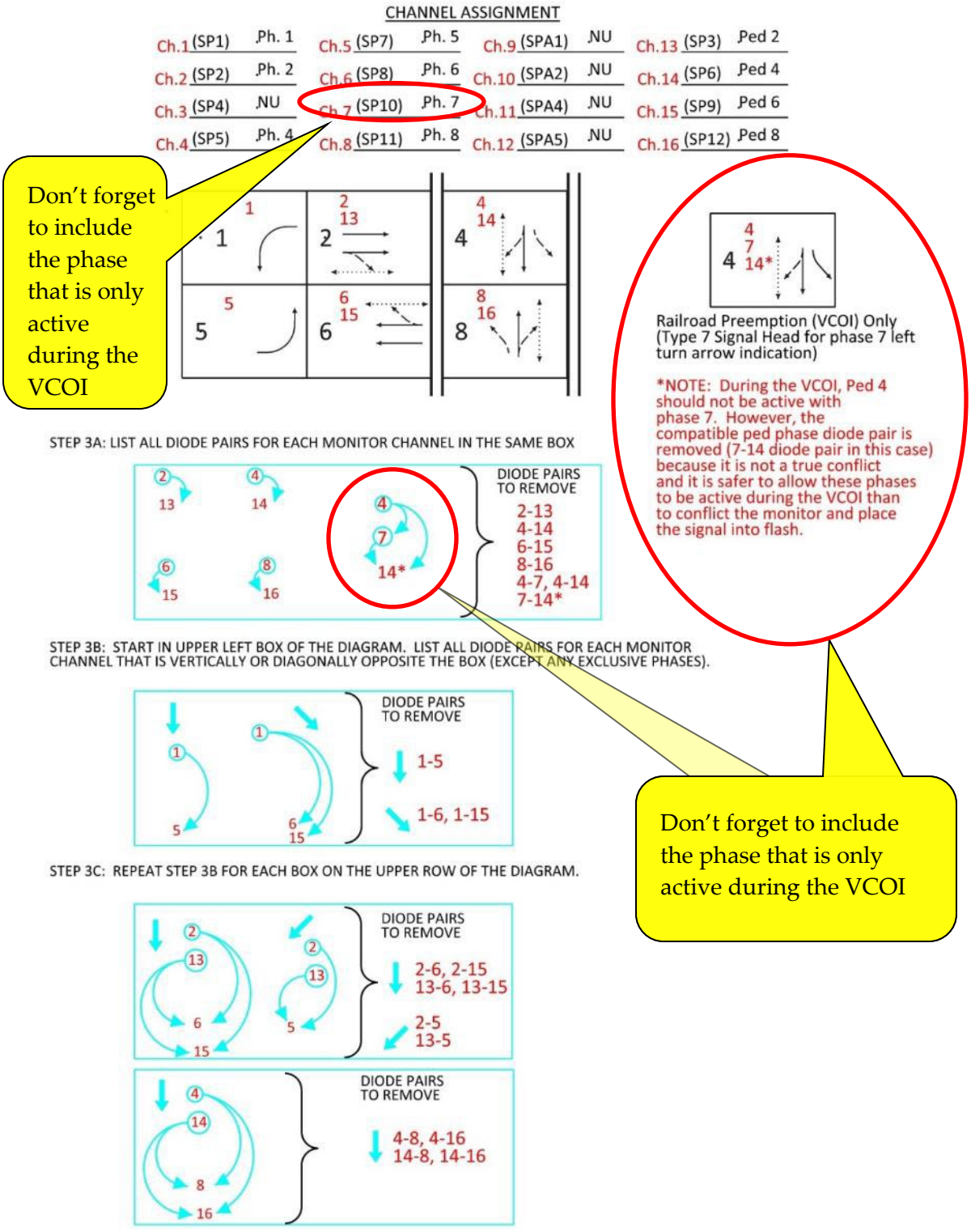


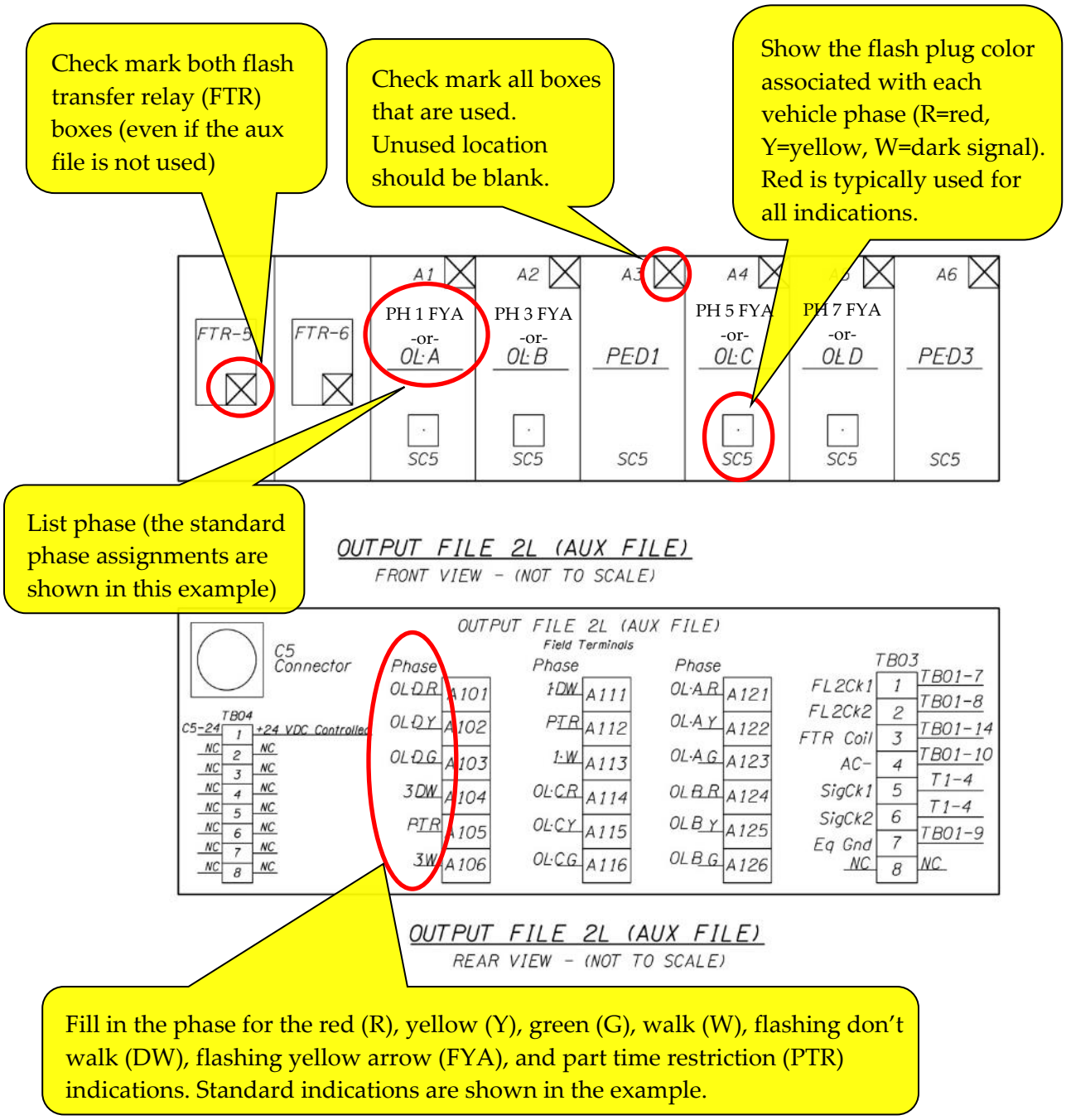
Figure 20-30 | Determining Compatible Phases – Example 4: Railroad Preemption Type 7 Signal Head



20.7.4 Auxiliary Output File (Front and Back View)

The auxiliary output file location comes standard in 332S cabinets (optional in 332 cabinets) and provides additional outputs if more are needed. Unused locations should be left blank. It is filled out the same way as the main output file. See Figure 20-31.

Figure 20-31 | 332S - Auxiliary Output File (Front and Back View)



20.7.5 Additional Information for the Output File

- The standard 332S (and 332 and 336) cabinets can accommodate 8 vehicle phases and 4 pedestrian phases (a total of 12 load switches). An additional 4 vehicle phase and 2 pedestrian phases (a total of 6 additional load switches) are available if needed in the auxiliary output file of the 332S and 332 cabinet (The auxiliary output file comes standard in the 332S cabinet and is optional in the 332 cabinet). There is a standard phase layout for the output file. However, most intersection software programs allow the flexibility to assign any phase, pedestrian phase, overlap or special use output to any output location in the output files.
- Sixteen (of the 18 total) load switches are conflict monitored. The load switches in the auxiliary file slot A3 and A6 are not monitored.
- Pedestrian output locations will always be in load switch location 3, 6, 9, and 12 of the main output file and A3 and A6 of an auxiliary output file. The reason for this is that the flash power is not routed to these load switch locations, which allows the pedestrian signal indications to remain dark while the signal is operating in emergency flash mode. Vehicle signal indication should not be reassigned to these slots as they should not remain dark in flashing mode.
- PTR signs should terminate on the phase 1 ped yellow output of the auxiliary output file, switch pack location A3. Note: in the past, PTR signs for rail preemption (the typical installation) were normally terminated on the phase 4 ped yellow output (or any other unused ped yellow output if the phase 4 ped didn't exist) to avoid installation of an auxiliary file.
- The conflict monitor is limited to a total of 16 channels which limits the number of phases that can used at an intersection. The flashing yellow arrow indication (for a protected/permitted left turn phase) is assigned to the channels normally reserved for overlap phases. As such, the number of protected/permitted left turn phases and vehicle overlap phases at an intersection will be limited to a combined total of four. For example, typical maximum combinations an intersection can have:
    - PPLT for phases 1, 3, 5, and 7 with NO overlap phases
    - Four overlap phases with NO PPLT
    - PPLT for phases 1 and 5 with two overlap phases
    - PPLT for phases 3 and 7 with two overlap phases

  Exceptions to combined total of four may be acceptable in the rare circumstance where there is an unused vehicle phase output that an overlap phase can be reassigned to (channels 1 thru 8). The flashing yellow arrow indications should only be wired to channels 9 thru 12 as shown in Figure 20-20.

  Assigning flashing yellow arrow to pedestrian yellow outputs will no longer be allowed as it can result in problematic conflict monitoring when used in conjunction with overlaps, negative ped phasing and type 3LCF signal heads. See Section 20.13.1 for additional background/reference info.

- Flash plugs are used with the output file to enable the correct indication to flash while the signal is operating in emergency flash mode (e.g., cabinet flash). Red flash plugs enable the red indication to flash, and yellow flash plugs enable the yellow indication to flash. White flash plugs shall be used to bypass the flash power if a standard vehicle phase output (switch pack locations 1, 2, 4, 5, 7, 8, 10, 11, A1, A2, A4, and A5) has been reassigned to a pedestrian phase so that the reassigned pedestrian indications will remain dark while the signal is operating in emergency flash mode. The default standard is to use red flash plugs for all load switch locations that serve vehicle phases; standard pedestrian phase load switch locations do not use flash plugs and are already wired to bypass the flash power. If something other than default standard red flash plugs are used, it shall be noted on the switch pack location as "Y" (for yellow) or "W" (for no-flash).

20.7.6 Output File & Conflict Monitor Configuration for PHBs

Pedestrian hybrid beacons (PHBs) require a unique output file and conflict monitoring set-up. See Figure 20-32 for a single stage ped crossing and Figure 20-33 for a two-stage ped crossing.

Figure 20-32 | PHB Output File and Conflict Monitor Configuration – Single Stage Ped Crossing

PHB: 1 Crossing Output File & Conflict Monitor Configuration

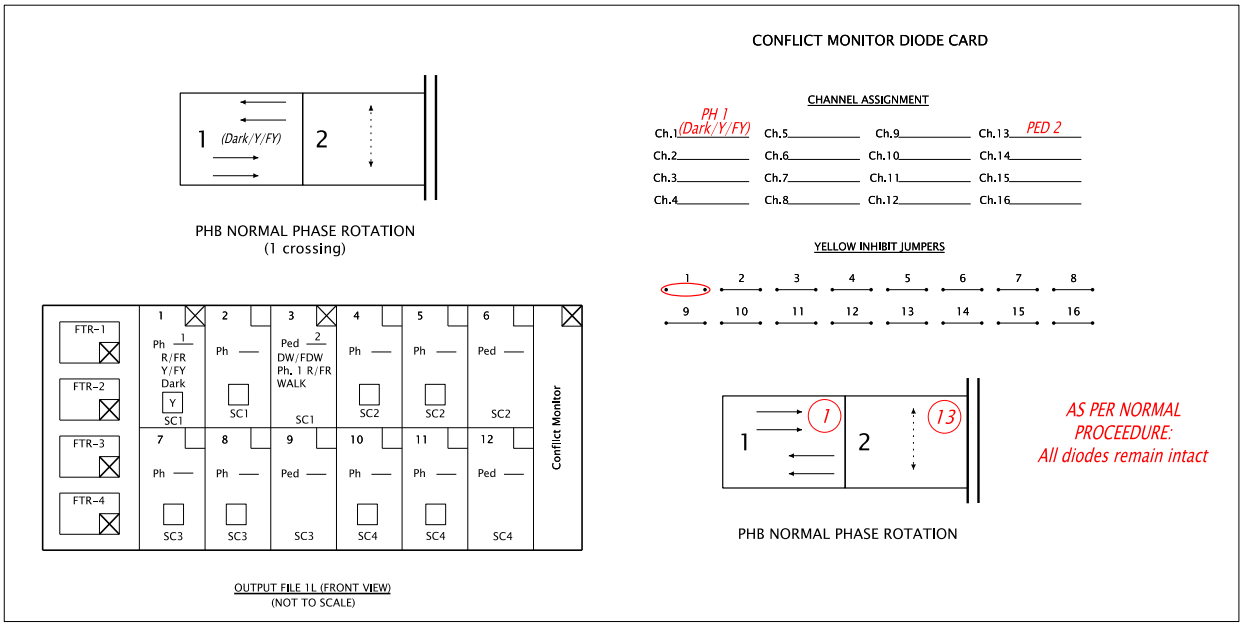
As per normal convention, we monitor
1.vehicular green (which = DARK in this case),
2.vehicular flashing yellow (Solid yellow is same output in this case)
3. ped walk

As per normal convention, vehicular red, flashing red and Ped Flashing DONT WALK are unmonitored

In the event of a conflict, the cabinet shall flash YELLOW

Basic Software Logic:
If both Ph. 1 Red outputs are OFF, Turn ON output Dummy Ph. 1 DARK.

HARDWARE: NEED A FAKE LOAD ON DUMMY OUTPUTS (20W Load Resistor)



SEQUENCE OF OPERATIONS

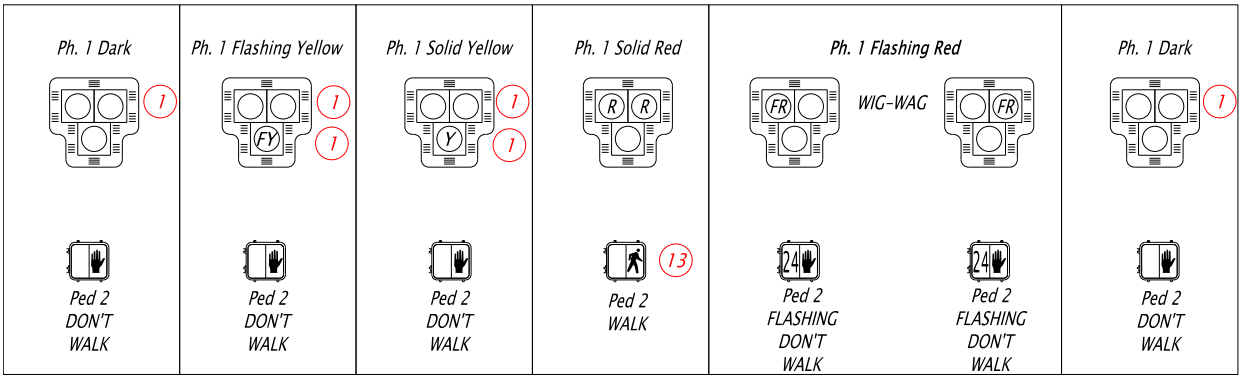


Figure 20-33 | PHB Output File and Conflict Monitor Configuration – Two-Stage Ped Crossing

PHB: 2 Crossings Output File & Conflict Monitor Configuration

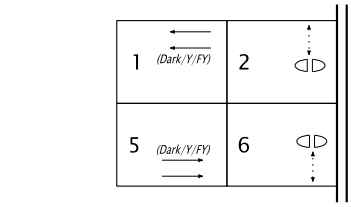
As per normal convention, we monitor
1.vehicular green (which = DARK in this case),
2.vehicular flashing yellow (Solid yellow is same output in this case)
3. ped walk

As per normal convention, vehicular red, flashing red and
Ped Flashing DONT WALK are unmonitored

In the event of a conflict, the cabinet shall flash YELLOW

Basic Software Logic:
If both Ph. 1 Red outputs are OFF, Turn ON output Dummy Ph. 1 DARK.
If both Ph. 5 Red outputs are OFF, Turn ON output Dummy Ph. 5 DARK.

HARDWARE: NEED A FAKE LOAD ON DUMMY OUTPUTS (20W Load Resistor)



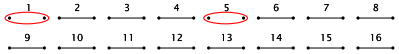
PHB NORMAL PHASE ROTATION

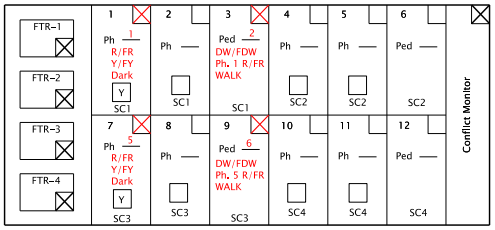
CONFLICT MONITOR DIODE CARD

CHANNEL ASSIGNMENT

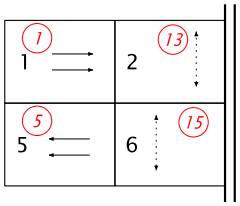
Ch.1 PH 1 (Dark/Y/FY)	Ch.5 PH 5 (Dark/Y/FY)	Ch.9	Ch.13 PED 2
Ch.2	Ch.6	Ch.10	Ch.14
Ch.3	Ch.7	Ch.11	Ch.15 PED 6
Ch.4	Ch.8	Ch.12	Ch.16

YELLOW INHIBIT JUMPERS





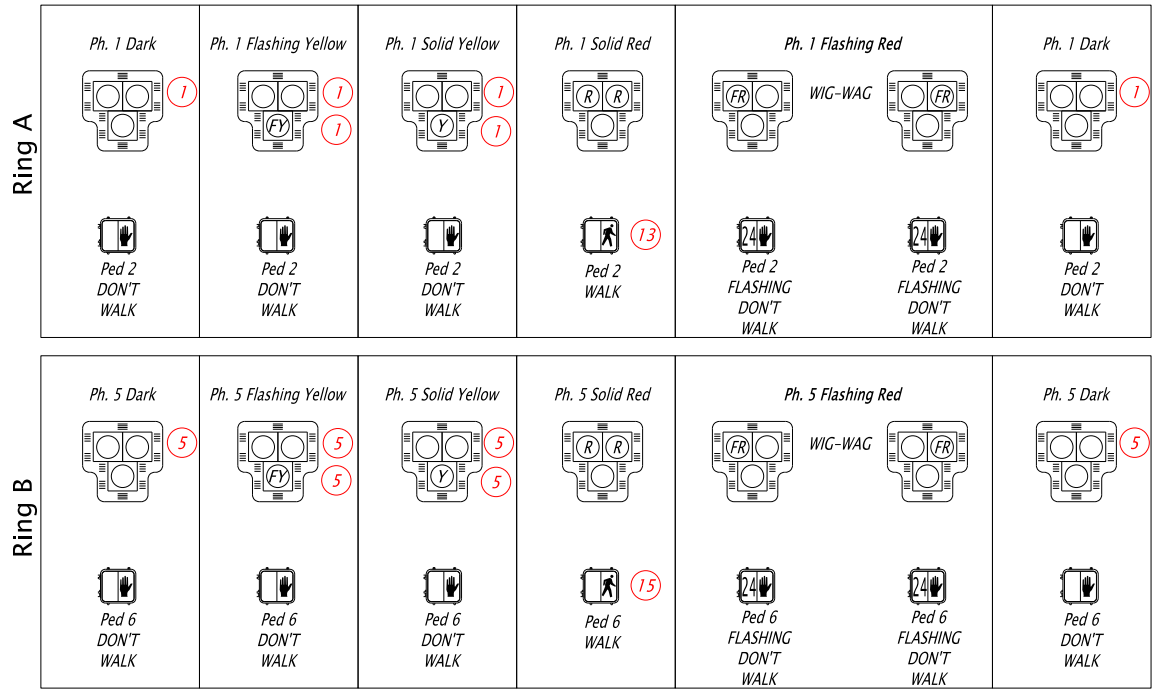
OUTPUT FILE 1L (FRONT VIEW)
(NOT TO SCALE)



PHB NORMAL PHASE ROTATION

AS PER NORMAL PROCEEDURE, CLIP DIODES:
1-5
1-15
5-13
13-15

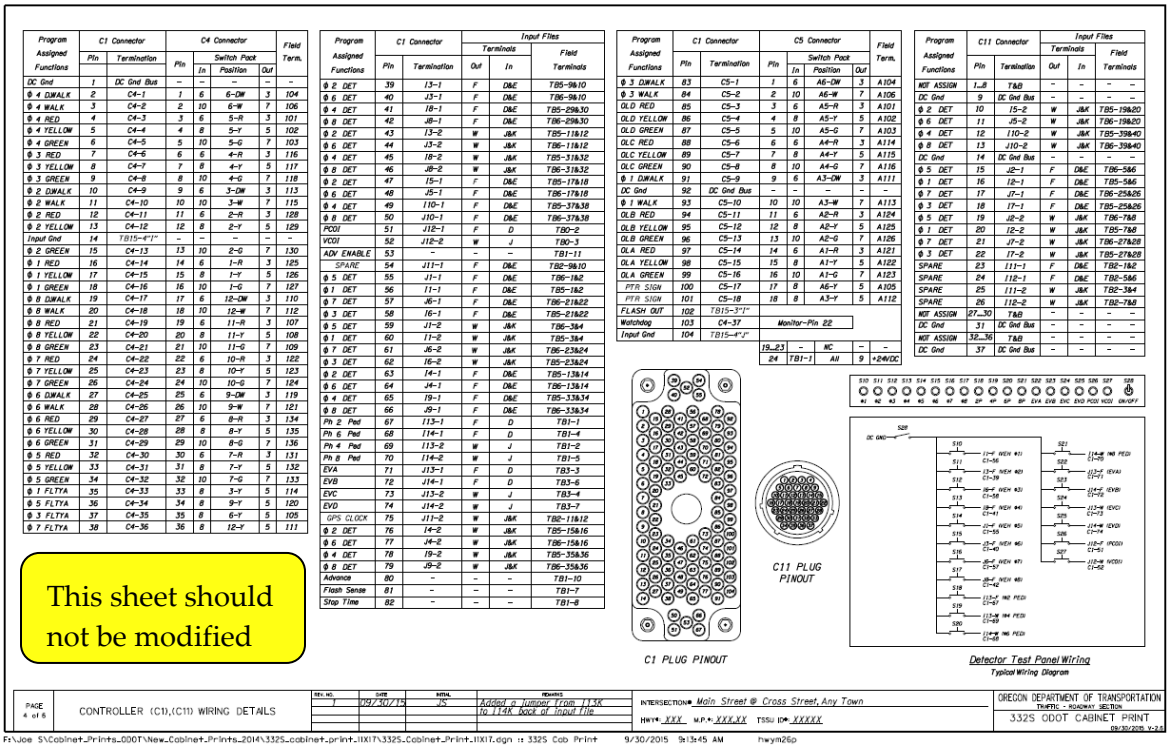
SEQUENCE OF OPERATIONS



20.8 332S Cabinet Print (Page 4 – C1 Pin Assignments & Test Switch)

Page 4 of the cabinet print shows the C1 pin assignments and test switch details. This sheet generally doesn't require any modification. See Figure 20-34.

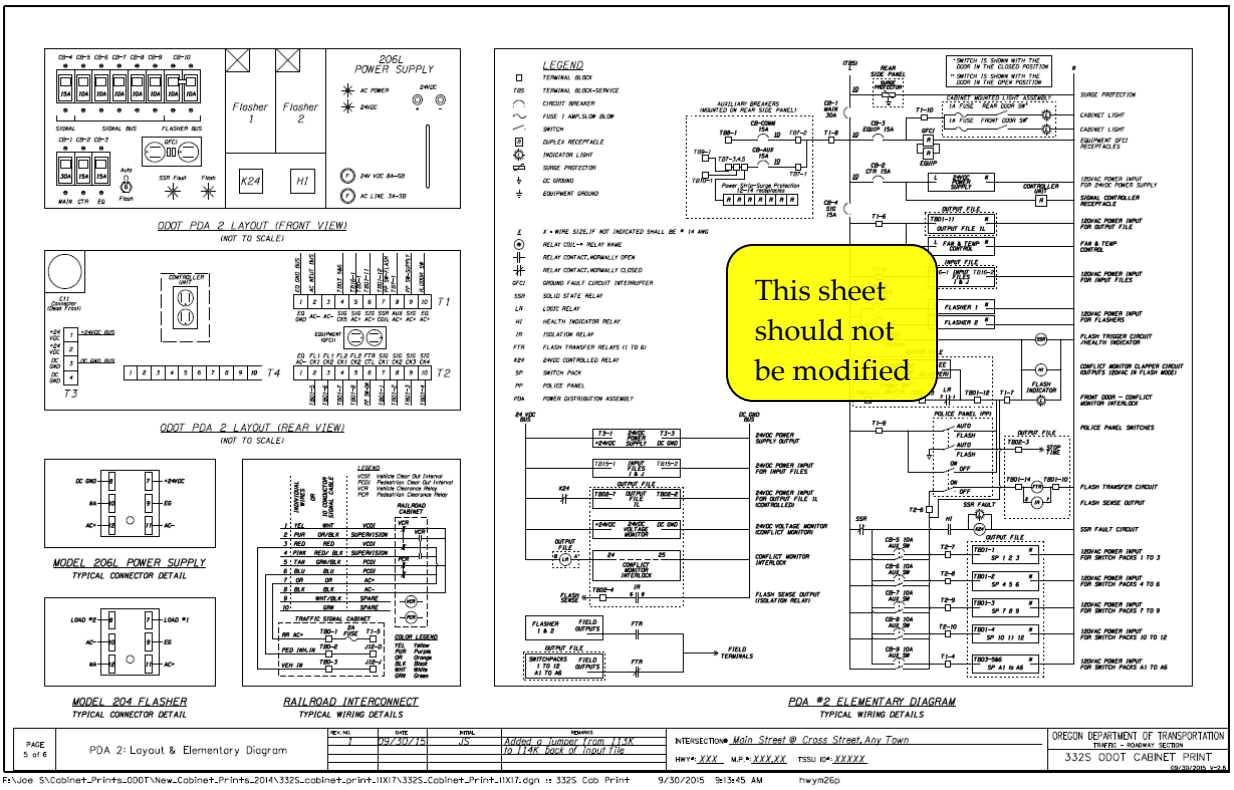
Figure 20-34 | 332S Cabinet Print (Page 4 – C1 Pin Assignments & Test Switch)



20.9 332S Cabinet Print (Page 5 – Electrical Diagrams)

Page 5 of the cabinet print shows the electrical diagram details. This sheet generally doesn't require any modification. See Figure 20-35.

Figure 20-35 | 332S Cabinet Print (Page 5 – Electrical Diagrams)



20.10 332S Cabinet Print (Page 6 – Intersection Drawing)

Page 6 of the cabinet print shows the intersection drawing. The intent of the intersection drawing is to provide a simplified illustration of critical signal equipment and operations to allow the field tech to quickly determine the orientation and location of equipment during routine maintenance and troubleshooting. It may seem redundant to provide an intersection drawing as part of the cabinet print given the contract plan sheet(s) contain the same (plus additional) info, but it is very valuable to highlight only the relevant maintenance information on a single sheet (or two sheets if necessary) for efficient fieldwork. THIS SHEET NO LONGER SHOWS DETECTION INFO. THIS INFORMATION IS NOW SHOWN ON SHEET 7.

The intersection drawing is created from the design file and is copied (not referenced) into the cabinet print file. This is to allow for easy future modification and archiving of the cabinet print file without reference files.

The intersection drawing should include the following. See Figure 20-36 to Figure 20-38:

- Plan view of intersection. This is typically the same orientation as plan sheet, with the mainline parallel to long edge of the page (17" side). It should also match orientation of the plan view shown on page 7 of cabinet print.
- North arrow
- Street names
- Operation items:
    - Lanes and lane use arrows
    - Phasing, labeled in each lane
    - Crosswalks, labeled in each crosswalk
    - Phase rotation diagram (ring and barrier style required. Note: older cabinet prints not using a standard ring and barrier diagram shall be updated)
    - Fire preemption diagram
- Equipment:
    - Signal poles with mast arms/span wires
    - Pedestals
    - Other poles that contain signal equipment controlled by the cabinet (e.g., a remote fire preemption unit, advance flashing beacons, etc.)
    - Signal heads and pedestrian heads
    - Emergency preemption devices, labeled per device
    - Controller cabinet, labeled
    - Communications gear located on TB8, TB9, or TB10
- Railroad items (see Figure 20-37):
    - Railroad controller cabinet, labeled
    - Railroad tracks, labeled
    - PTR signs, labeled per device
- Reference to all relevant contract plan sheets related to the intersection
- List of intersections that are interconnected

The intersection drawing should be simple, uncluttered and easy to read. To achieve this, do NOT include the following:

- Detection information (now shown separately on sheet 7)
- Right-of-way lines
- Conduit
- Utilities
- Stationing
- Bubble notes & legend

The scale of all features shown on the intersection drawing is flexible to maximize readability while still containing all the information needed. TSSU and region electricians may request modifications to what is included or not included on the intersection drawing depending on the intersection complexity, uniqueness, or staff preference. In general, modifications are allowed, but are reviewed and informally approved by traffic engineering section.

Figure 20-36 | 332S Cabinet Print (Page 6 – Intersection Drawing) Example 1

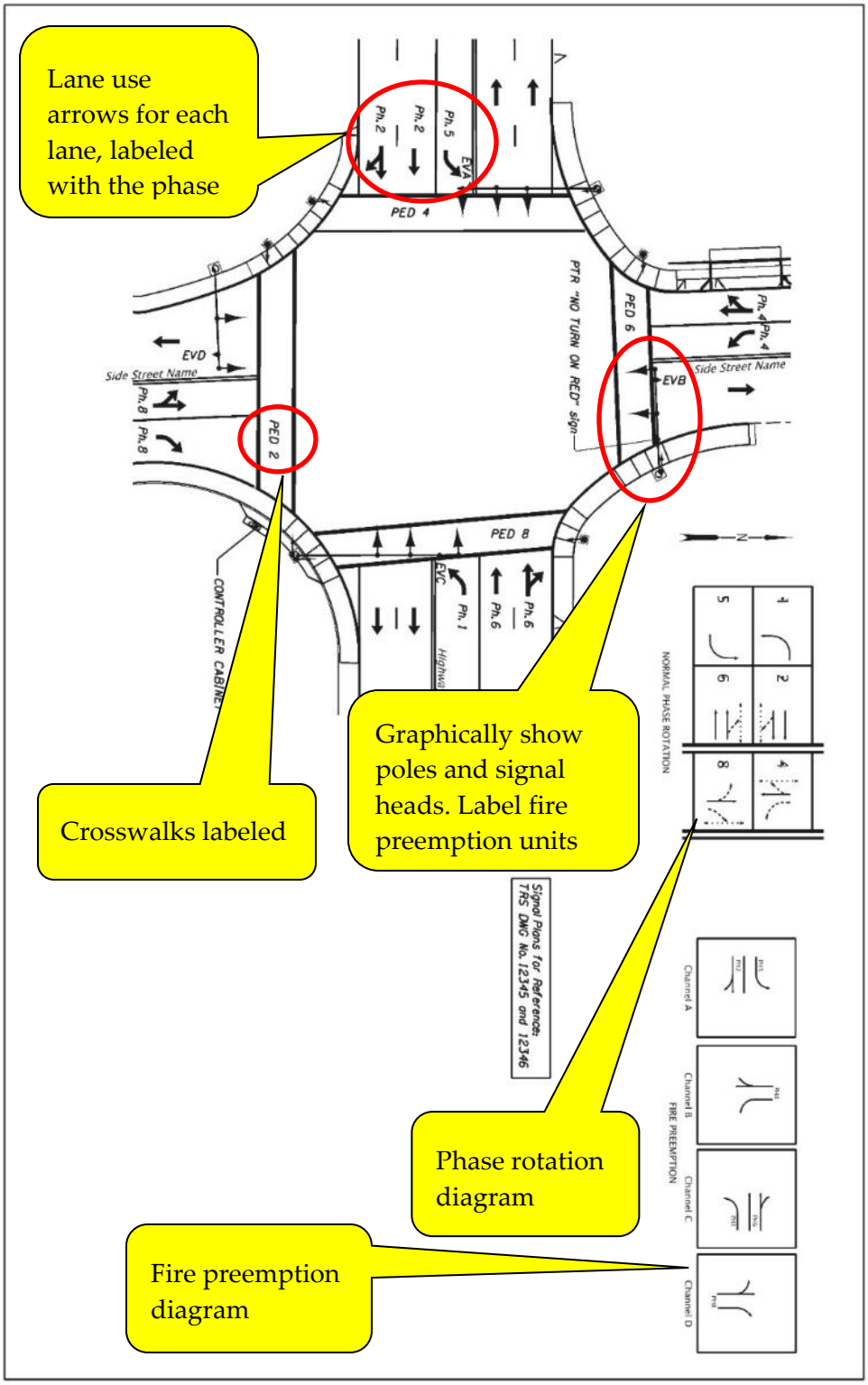


Figure 20-37 | 332S Cabinet Print (Page 6 – Intersection Drawing) Example 2

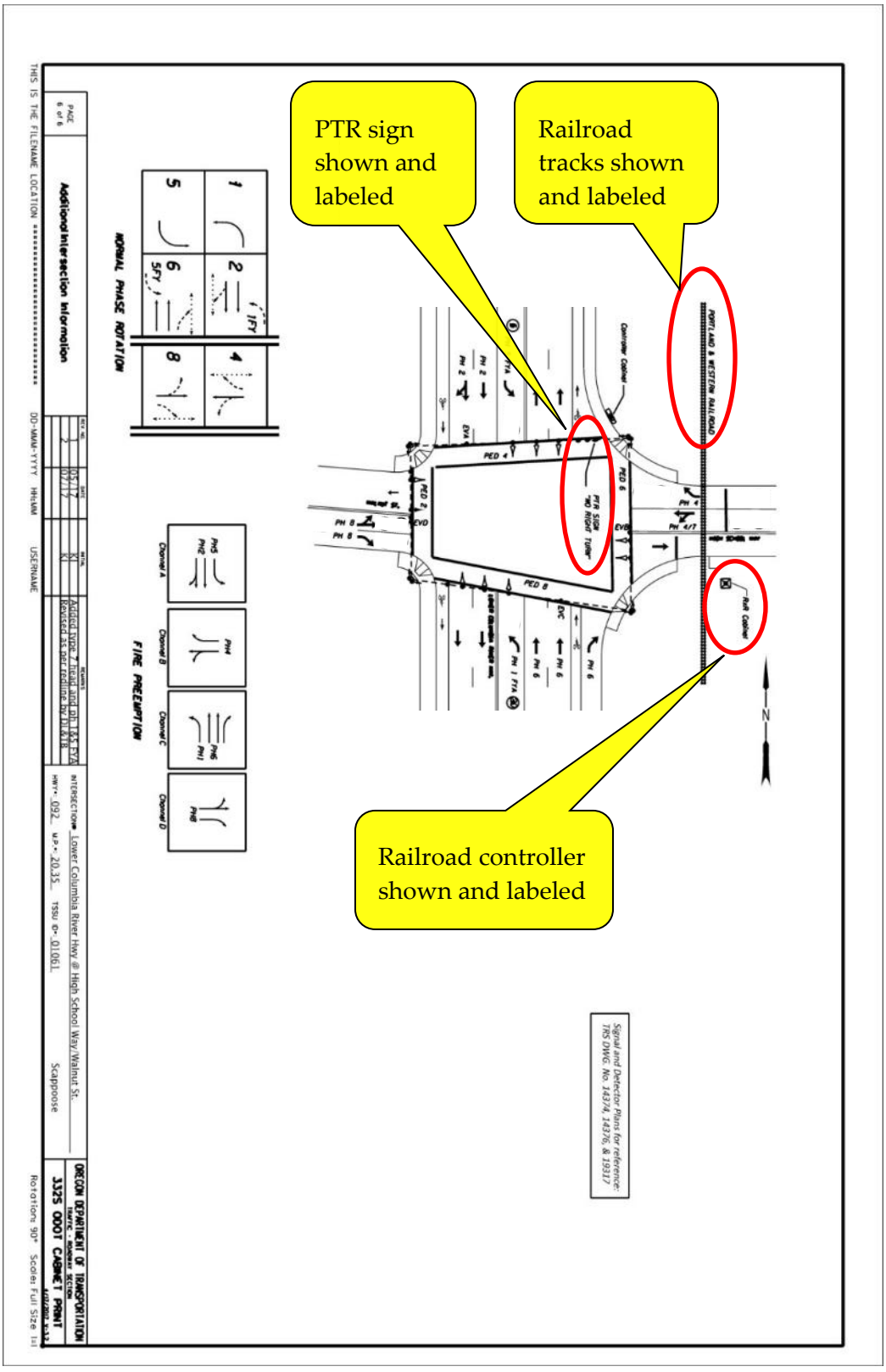
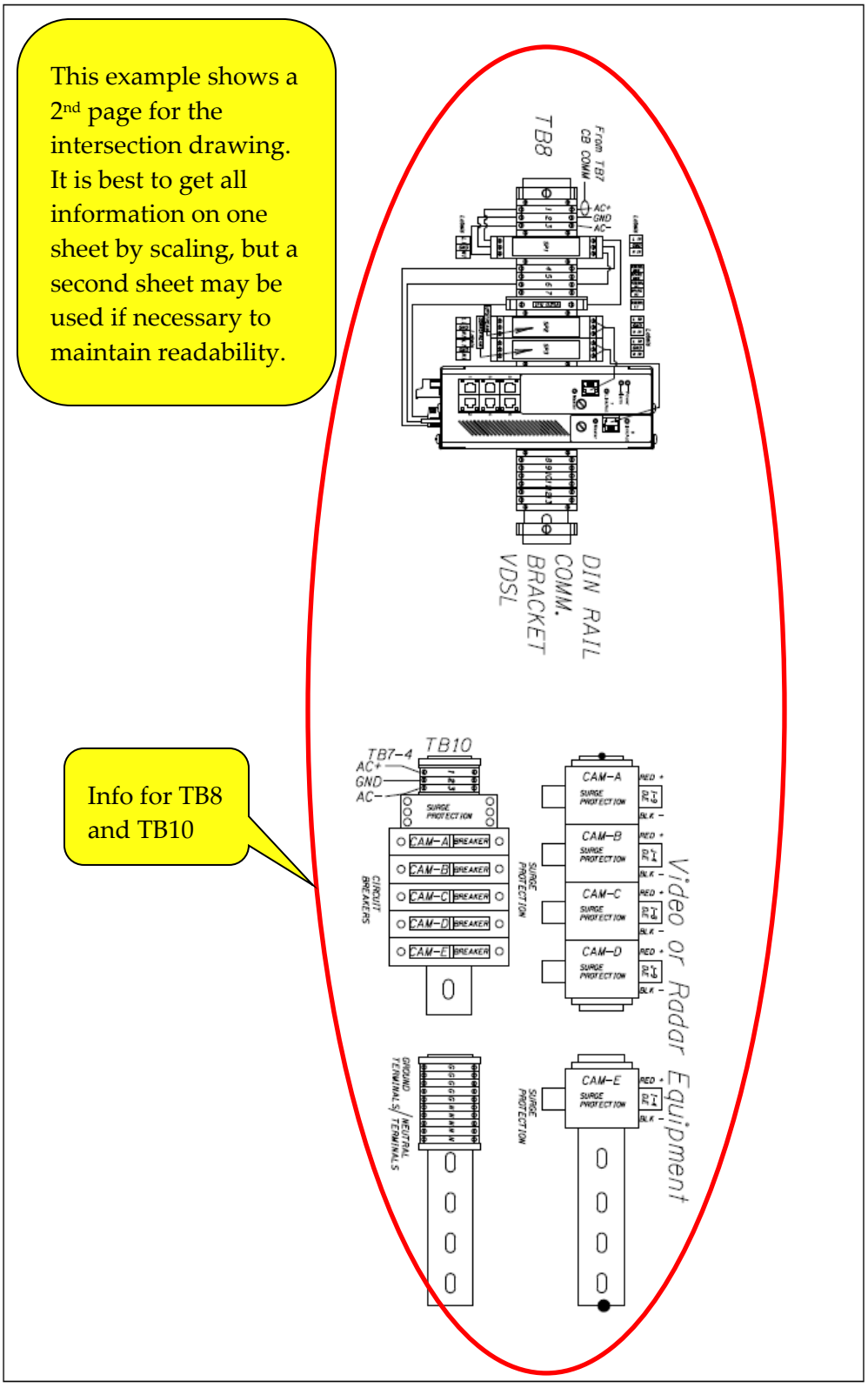


Figure 20-38 | 332S Cabinet Print (Page 6 – Intersection Drawing) Example 3



20.11 332S Cabinet Print (Page 7 – Detection Drawing)

Page 7 of the cabinet print shows the detection drawing. The intent of the detection drawing is to provide a general illustration of detection units, coverage areas, and/or zones and software detection configuration information to allow efficient maintenance and troubleshooting. Showing the detection info on a separate sheet from the intersection drawing helps with readability and field workflow.

The detection drawing is created from the design file and is copied (not referenced) into the cabinet print file. This is to allow for easy future modification and archiving of the cabinet print file without having reference files.

The detection drawing should include the following. See Figure 20-39 to Figure 20-40:

- Plan view of intersection. This is typically the same orientation as plan sheet, with the mainline parallel to long edge of the page (17" side). It should also match orientation of the plan view shown on page 6 of cabinet print.
- North arrow
- Street names
- Note on detection zones (one for if zones are shown, one for if they are not)
- Function legend
- Operation items:
    - Lanes and lane use arrows
    - Near-side radar coverage area (cone shape), labeled
    - Passive pedestrian detection zones, labeled
    - Detection zones, not labeled – ONLY IF REQUESTED BY THE SIGNAL TIMER!
    - Import excel file of detector configuration from signal timer. See Instructions for Signal Timers and Designers for additional information.
- Equipment:
    - Signal poles with mast arms/span wires or pedestals where detector units are mounted
    - Detector units, labeled
    - Controller cabinet, labeled
    - Loops with loop numbers (for advance loops only indicate the distance from stop line)
- Railroad items:
    - Railroad tracks

The detection drawing should be simple, uncluttered and easy to read. To achieve this, do NOT include the following:

- Information shown on the intersection drawing on page 6
- Right-of-way lines
- Conduit
- Utilities
- Stationing
- Bubble notes & legend

The scale of all features shown on the intersection drawing is flexible to maximize readability while still containing all the information needed. TSSU and region electricians may request modifications to what is included or not included on the detection drawing depending on the intersection complexity, uniqueness, or staff preference. In general, modifications are allowed, but are reviewed and informally approved by traffic engineering section.

Figure 20-39 | 332S Cabinet Print (Page 7 – Detection Drawing) Example 1

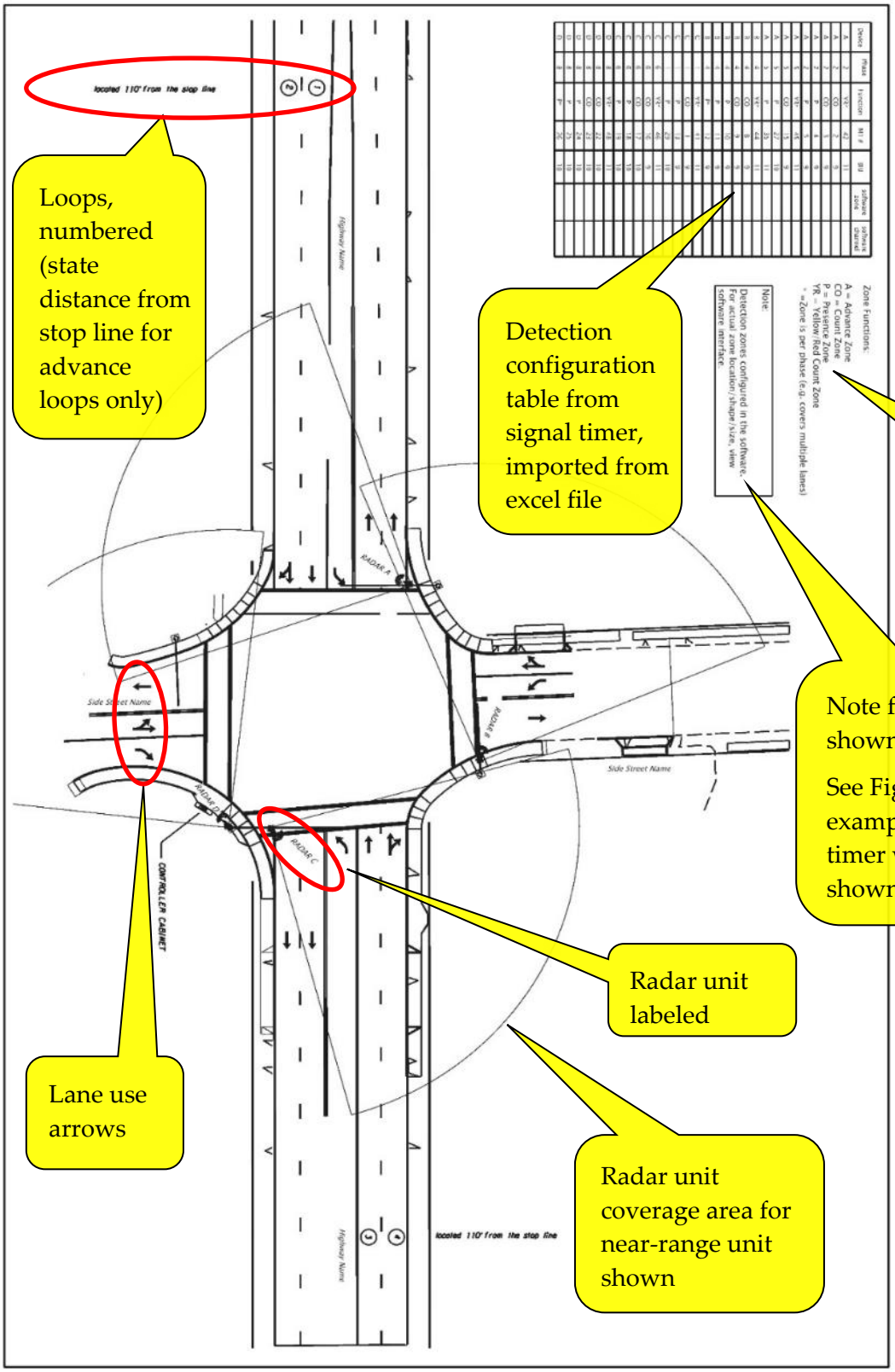
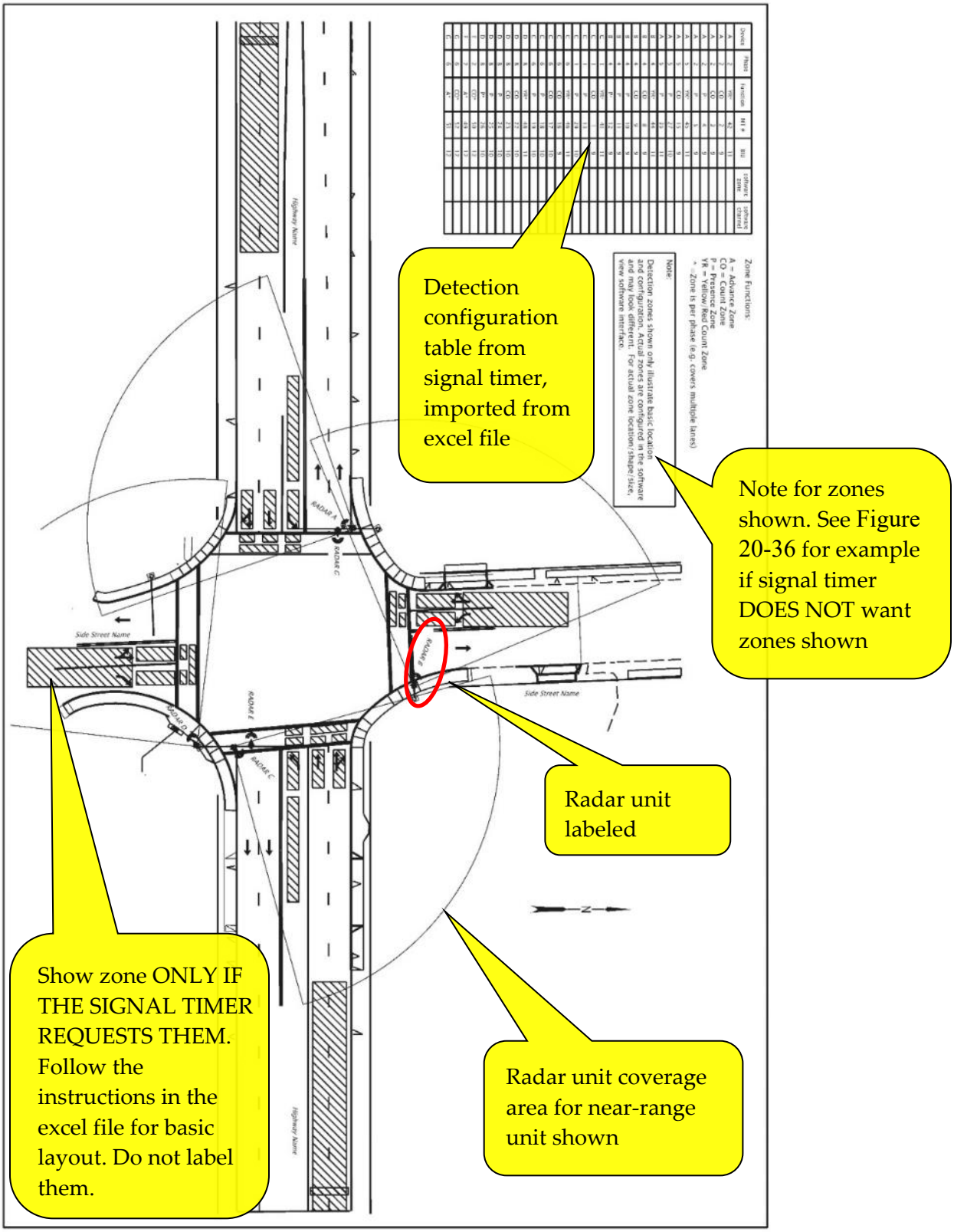


Figure 20-40 | 332S Cabinet Print (Page 7 – Detection Drawing) Example 2



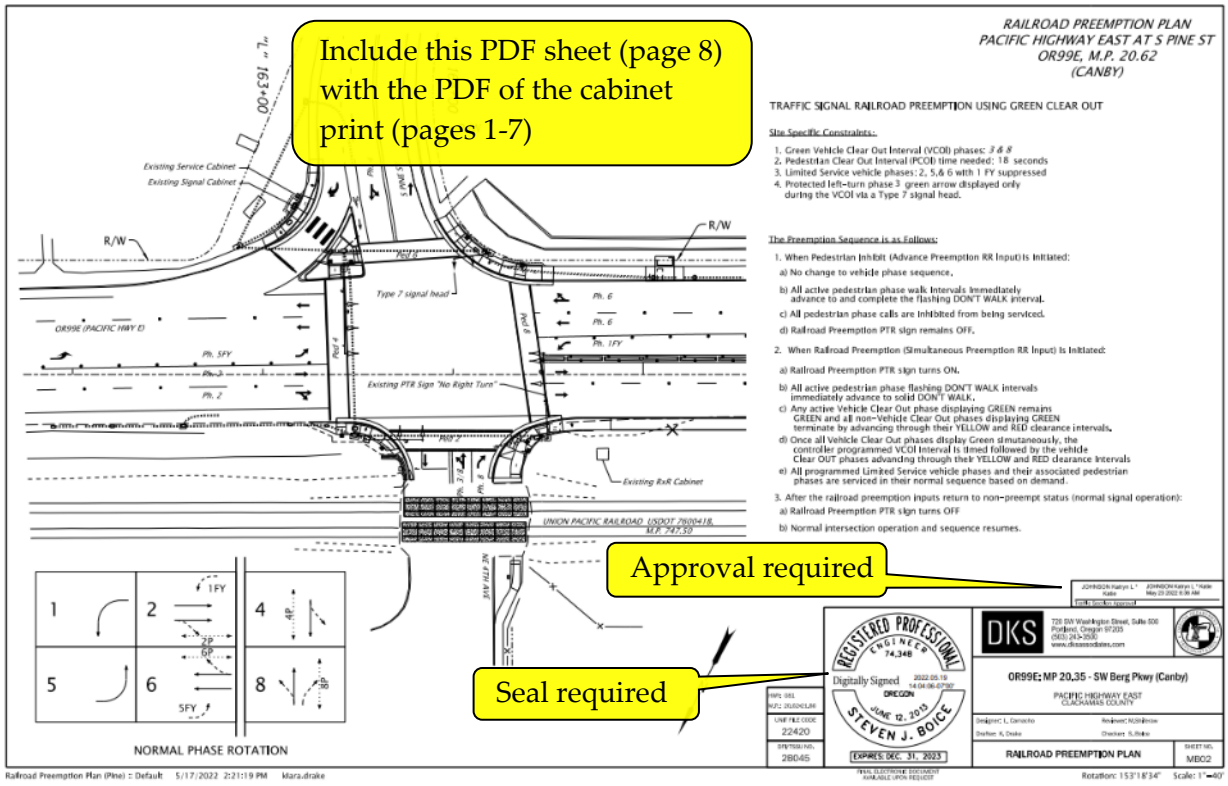
20.12 332S Cabinet Print (Page 8 – Railroad Preemption Plan Sheet)

Page 8 is only included for traffic signals that are interconnected to a railroad crossing. Page 8 of the cabinet print is NOT contained within the microstation cabinet print file as described in section 20.4. It will instead be a separate PDF page of the sealed and approved railroad preemption plan sheet that is required as per chapter 16 for the crossing order. Combine the cabinet print PDF (pages 1 through 7) with the sealed and approved railroad preemption plan sheet PDF (page 8) via adobe. See Figure 20-41. Combining the sealed and approved railroad preemption plan sheet PDF to the cabinet print PDF incorrectly will result in breaking the digital signatures and show up as a blank spot. To avoid this, the following process should be used:

1. Open the PDF of the sealed railroad preemption plan sheet, the digital signature should be visible and can also be verified.
2. Go to "print" and set the printer to "Microsoft print to PDF" to make a copy and save the new PDF file. The signature should still be visible in the new file, but it is no longer an actual digital signature (it is basically a photocopy of the digital signature).
3. The new PDF file can now be combined with the cabinet print PDF into a single electronic document.

The railroad preemption plan sheet is required to be sealed and approved, so if any changes are needed to it in the future, follow the process and guidance described in chapter 16. Updating the railroad preemption plan sheet for the cabinet print may or may not require a rail crossing order (e.g., also documenting the updated preemption plan sheet in a crossing order) as per the decision by the ODOT commerce and compliance division. Contact the state traffic signal engineer for assistance in getting this process started.

Figure 20-41 | 332S Cabinet Print (Page 8 – Railroad Preemption Plan Sheet) Example



The railroad preemption plan sheet provides important information that signal timers, TSSU, and electricians should know for properly maintaining and operating the traffic signal. It is also helpful for the signal designer to use when completing the cabinet print. The following is a list of rail interconnected specific items to remember to detail in the cabinet print:

- Type 7 signal head – show a load switch in the appropriate location in the output file and label it "RxR grn clear-out only"
- Include the type 7 signal head phase in the conflict monitor diode information as per Figure 20-30
- PTR signs – show a load switch in the appropriate location in the aux. output file and label it "RxR PTR"
- Include the AC isolator in the appropriate location in the input file (252 model for 332 cabinets and 255 model for 332s cabinets)

20.13 Background/Reference Information

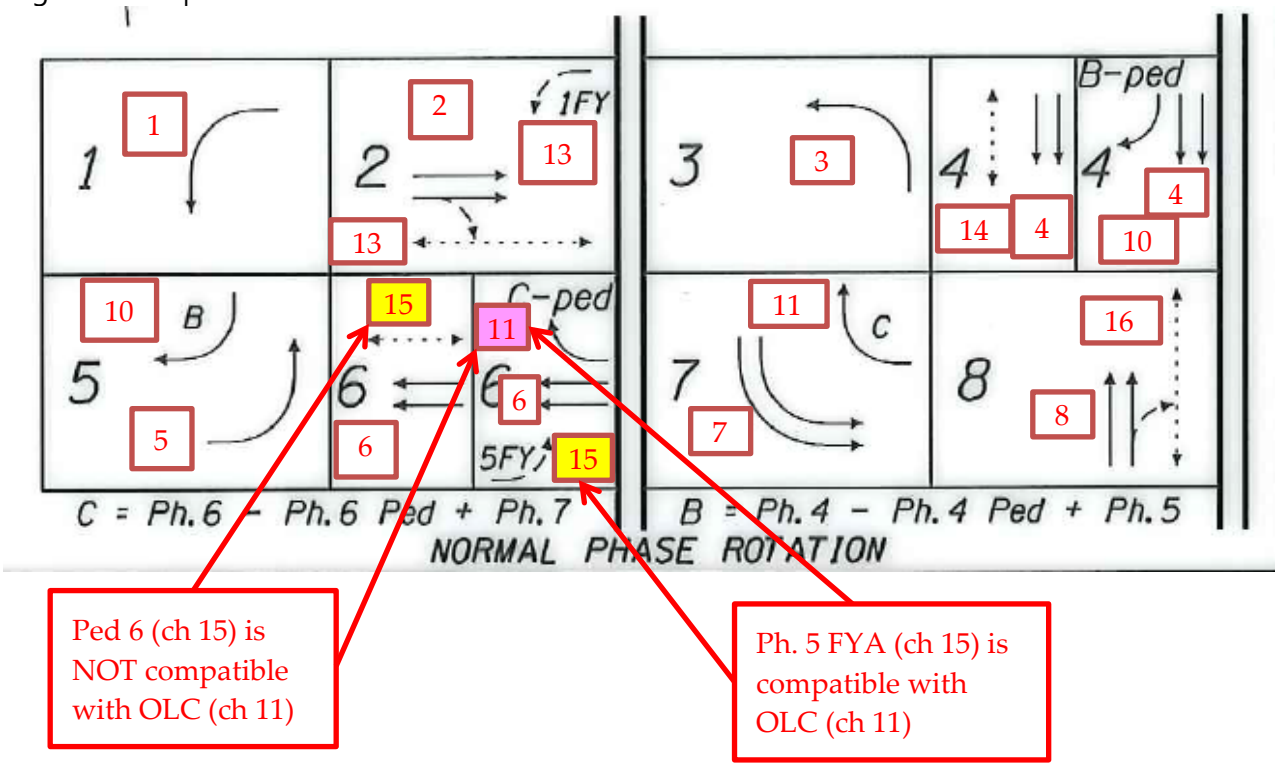
This section contains more in-depth information to aid in understanding guidance presented in this chapter.

20.13.1 Flashing Yellow Arrow and Conflict Monitoring

Two problems with using pedestrian yellow outputs for FYA were identified when troubleshooting several signals that went into cabinet flash after installing negative ped overlap phases and/or type 3LCF signal heads. The results of this investigation led to changing the FYA output and conflict monitoring standard from ped yellow with yellow inhibit jumpers to overlap green (ch. 9 thru 12).

Problem 1: Using a ped yellow output for the FYA will not work if the FYA has different conflicts than the ped walk. For example, Figure 20-42 shows that OLC is not compatible with ped 6 which would require conflict monitor diode 11-15 to remain intact. However, OLC is compatible with ph. 5 FYA which would require conflict monitor diode 11-15 to be removed. If diode 11-15 remains intact, the signal will go into cabinet flash when OLC and phase 5 FYA are served together, resulting in signal phasing that will fail every cycle. If diode 11-5 is removed, the signal will NOT go into cabinet flash if OLC and ped 6 are served together, resulting in unsafe operation.

Figure 20-42 | Problem 1: FYA and WALK Phase Have Different Conflicts



CONFLICT MONITOR DIODE CARD

CHANNEL ASSIGNMENT

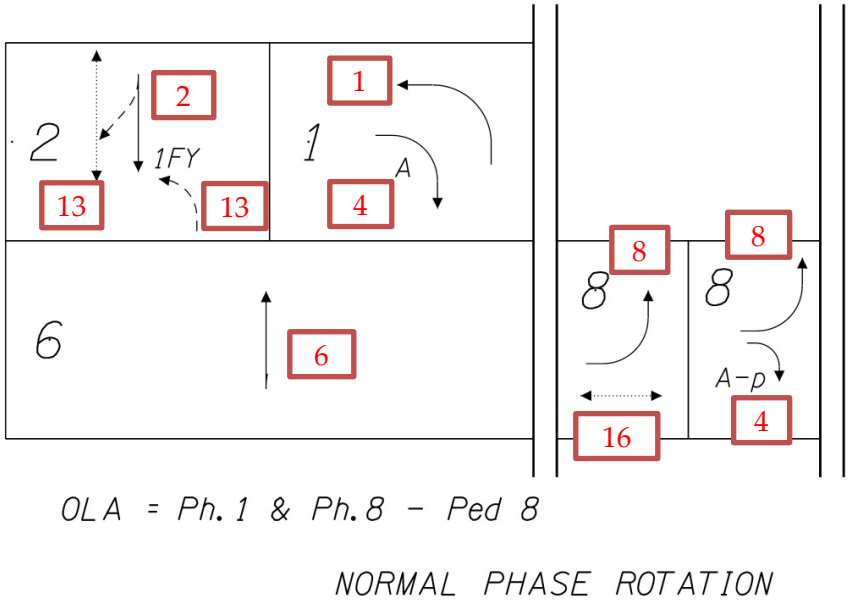
Ch.1 Ph. 1	Ch.5 Ph. 5	Ch.9	Ch.13 Ped2/1FYA
Ch.2 Ph. 2	Ch.6 Ph. 6	Ch.10 OLB	Ch.14 Ped4
Ch.3 Ph. 3	Ch.7 Ph. 7	Ch.11 OLC	Ch.15 Ped6/5FYA
Ch.4 Ph. 4	Ch.8 Ph. 8	Ch.12	Ch.16 Ped8

YELLOW INHIBIT JUMPERS

1	2	3	4	5	6	7	8
9	10	11	12	13	14 (X)	15	16 (X)

Problem 2: Using a ped yellow output for the FYA will not work with a type 3LCF signal head and overlap phase. The type 3LCF signal head uses only one wire terminated at the yellow indication which will provide both the solid yellow and the flashing yellow function. The solid yellow will be monitored because the FYA is required to be monitored and both functions are driven by the same wire/output in the controller cabinet. The solid yellow has different conflicts than the FYA which will cause the signal to go into cabinet flash when the complementary overlap phase stays green while the protected left turn phase is solid yellow. For example, Figure 20-43 shows the conflict monitor channel assignment and Figure 20-44 shows where this phasing sequence creates a conflict monitoring problem with the solid yellow and overlap phase.

Figure 20-43 | Problem 2: FYA and Solid Yellow Have Different Conflicts – Conflict Monitor Channel Assignment



CONFLICT MONITOR DIODE CARD

CHANNEL ASSIGNMENT

Ch.1 Ph. 1	Ch.5	Ch.9	Ch.13 Ped2/1FYA
Ch.2 Ph. 2	Ch.6 Ph. 6	Ch.10	Ch.14
Ch.3	Ch.7	Ch.11	Ch.15
Ch.4 OLA	Ch.8 Ph. 8	Ch.12	Ch.16 Ped8

YELLOW INHIBIT JUMPERS

1	2	3	4	5	6	7	8
9	10	11	12	13 (X)	14	15	16

Figure 20-44 | Problem 2: FYA and Solid Yellow Have Different Conflicts – Phasing Sequence

For a 3-wire system, solid yellow is monitored with the FYA

For a 3-wire system, solid yellow is monitored with the FYA

Phase	Indication color, sequence going from left to right								
1	-	-	-	-	G 1	Y 13	R	R	-
1 FYA	FYA 13	FYA 13	Y 13	R	-	-	-	-	FYA 13
2	G	G	Y	R	R	R	R	R	G
Ped 2	W	FDW	DW	DW	DW	DW	DW	DW	W
6	G	G	G	G	G	Y	R	R	G
8	R	R	R	R	R	R	G	Y	R
Ped 8	DW	DW	DW	DW	DW	DW	DW	DW	DW
OLA	R	R	R	R	G 4	G 4	G 4	Y	R

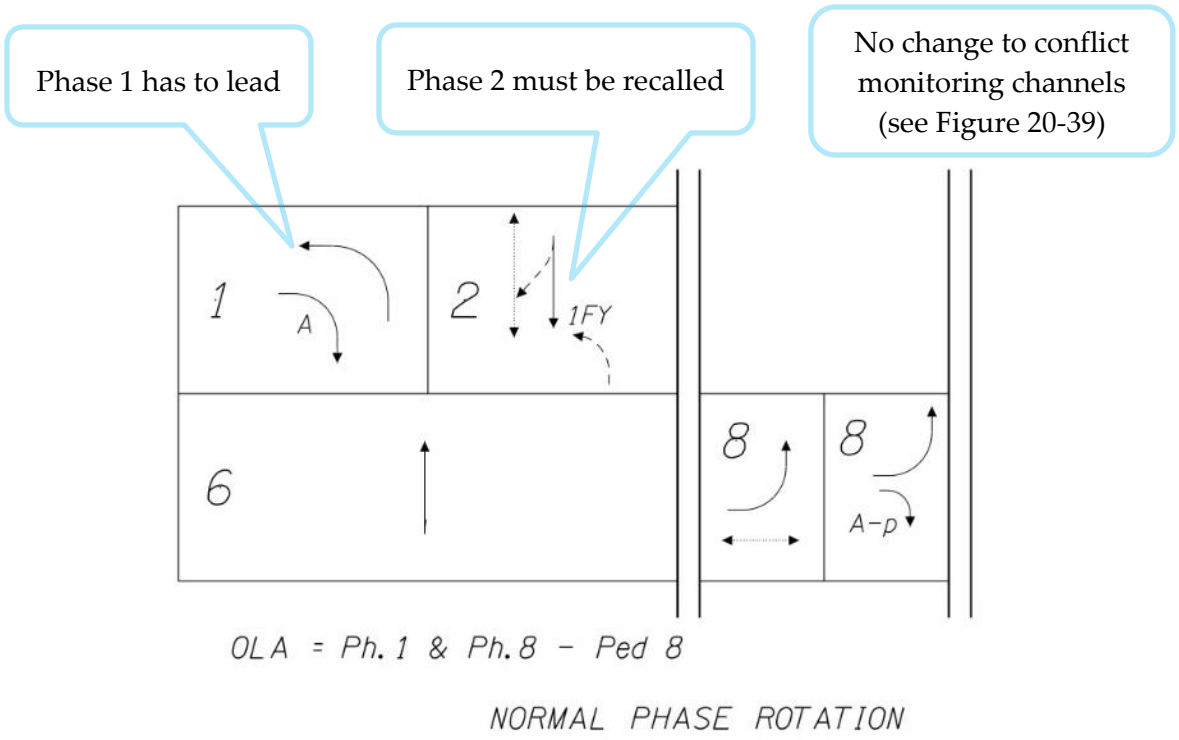
In this column, diode 4-13 would need to be removed (compatible phases). However, OLA (ch 4) and ped 2 (ch 13) are conflicting phases requiring diode 4-13 to remain intact.

If diode 4-13 is removed, the signal will NOT go into cabinet flash if OLA (ch 4) and ped 2 (ch 13) are served together, resulting in unsafe operation. If diode 4-13 remains intact, the signal will go into cabinet flash when OLA remains green when phase 1 is followed by phase 8.

Various solutions to these two problems, listed below, were thoroughly vetted by traffic engineering section, TSSU, region traffic and local agency staff:

- **Do not monitor the flashing yellow arrow:** Several local agencies do not monitor the flashing yellow arrow because the software controlling the flashing yellow arrow sequence has a high level of reliability and there are a limited number of conflicts that can be monitored using the standard conflict monitoring equipment. On the same principle, ODOT does not monitor the flashing don't walk portion of the pedestrian phase (only the walk phase is monitored). However, ODOT has a long standing history of requiring monitoring of the flashing yellow arrow as it provides the same function as a circular green indication for a permissive left turn and we monitor all green indications. At this point in time, this option was dismissed due to the importance of ensuring the flashing yellow arrow does not run concurrent to any conflicting phase.
- **Restrict signal phasing options:** Allow the overlap phase and remove the FYA or allow the FYA and remove the overlap phase. One of the original benefits of the standard conflict monitoring using pedestrian yellow outputs for FYA was to "free-up" the overlap channels (ch 9 thru 12) for use. In the past, when overlap phases used type 2 programmed signal heads or closed conflicting pedestrian crossings, those "available" channels could be used without a conflict monitoring problem. This changed when overlap phases started to use type 3R signal heads and negative ped phasing, basically making those previously "available" overlap channels unusable if pedestrian yellow outputs were being used for FYA. Restricting the desired operation at the intersection was also met with widely varying opinions about what phases are truly needed. This option was dismissed because agreement could not be reached that prioritizing the conflict monitoring standard (ped yellow FYA monitoring) over desired operations (when operational analysis indicates certain phases are not needed for acceptable V/C and queue lengths) was a viable solution and an original benefit of using ped yellow monitoring was negated.
- **Problem 2 only – use a type 6L signal head (separate wire and termination for solid yellow and flashing yellow):** This option allows the solid yellow indication to be unmonitored. This option was dismissed because ODOT is moving away from using type 6L signal heads for new PPLT installations. The type 3LCF signal head has many advantages over the type 6L signal head, such as reduced structural loading, less wiring, reducing the number of signal head types for maintenance to stock, and far easier ability to retro-fit existing installations.
- **Problem 2 only - Restrict signal phasing to ensure overlap phase green and solid yellow are never served together:** By restricting the sequencing of the left turn phase (lead/lag) and recalling other phases, the solid yellow and overlap green will always terminate at the same time. See Figure 20-45 for example. This option was dismissed due to being overly complicated to determine the correct sequencing and because changing from a left turn phase from leading to lagging shouldn't require a change to the conflict monitor.

Figure 20-45 | Problem 2 Potential Solution: Restricted Signal Phasing Sequence



Phase	Indication color, sequence going from left to right									
1	G [1]	Y [13]	R	-	-	-	-	-	-	G [1]
1 FYA	-	-	-	FYA [13]	Y [13]	R	R	R	R	-
2	R	R	G	G	Y	R	R	R	R	R
Ped 2	DW	DW	W [13]	FDW	DW	DW	DW	DW	DW	DW
6	G	G	G	G	Y	R	R	R	R	G
8	R	R	R	R	R	G	G	G	Y	R
Ped 8	DW	DW	DW	DW	DW	W	FDW	DW	DW	DW
OLA	G [4]	Y	R	R	R	R	R	G [4]	G [4]	G [4]

Phase 1 solid yellow will never be on with OLA green because phase 1 is always followed by phase 2, which will terminate OLA green and phase 1 green at the same time.

Phase 1 solid yellow will never be on with OLA green

21 Contract Plan Development & Drafting

21.1 General

This chapter contains information about drafting standards, nomenclature, and MicroStation tools specific to creating contract plan sheets for traffic signal work. General information (that is not specific to traffic signal work) is contained in the ODOT CAD Manual, ODOT Roadway CAD Manual, or the ODOT Contract Plans Development Guide and includes the following topics:

1. Seed files
2. Using separate files for design work and for plan sheet detailing work (allows for proper use of annotation scale)
    a. Setting up the signal base map file
    b. Setting up the signal plan sheet file
3. File naming conventions
4. Use of files in ProjectWise
5. Title block
6. Digital signatures
7. Order of plan sheet disciplines in the contract plans
8. Numbering the contract plan sheets according to the discipline specific series letter (this is different from the unique TRS drawing number/unit file code that is assigned by traffic engineering section as per chapter 2.)
9. Using print organizer

General information about MicroStation workspace and workflows can be found in the ODOT Engineering Applications Support Team (EAST Team) MicroStation Users Guide:

1. Discipline ribbon workflow and standard symbologies
2. Using annotation scale
3. Using models in your design files
4. Setting up the signal plan sheet files for printing (allows for proper use of the print organizer)

This chapter assumes the user is comfortable using the MicroStation platform and is moderately proficient in its use. Parts of this chapter will also be of value to AutoCAD users.

21.2 General Drafting Requirements

The following bullet points list the basic requirements for plans submitted to ODOT. This includes projects to be let and administered by ODOT as well as projects produced for ODOT by cities, counties, or private developers.

- Plans must be legible, in black and white, and meet all design and drafting criteria in this manual and the ODOT CAD Manual, ODOT Roadway CAD Manual, or the ODOT Contract Plans Development Guide.
    - Features/text/bubble notes shall not be obscured.
    - Levels/features that aren't necessary for the work and only add clutter to the plan sheet shall not be visible.
- Plans must be drafted and submitted in MicroStation Connect format. AutoCAD files are not acceptable.
- Plans must be submitted an 11x17 PDF for plan review submittals.
- Final plans must be submitted in an 11x17 PDF with each sheet digitally signed by the engineer of record. See chapter 2 for more information.
- Final plans must be approved and digitally signed by ODOT traffic signal standards. See chapter 2 for more information.

Uniformity for drafting is very important as it creates a language that is used to efficiently communicate. Uniformity of drafting leads to less errors and quick comprehension. It also helps custom notes and unique work stand-out better. However, it is understood that drafting style will vary slightly from drafter to drafter, and this will result in subtle differences in how the plan sheets look and convey information. This is normal and acceptable as long as the drafter is in substantial conformance of this chapter and the plans are clean, legible, and easy to follow. The state traffic signal engineer will make comments on any drafting issues that require correction during the design approval process.

21.3 General Plan Sheet Content Requirements

All traffic signal work shall be **shown and detailed** on the proper traffic signal plan sheets of the M series in the contract plans set. The M series has been designated as the traffic signal discipline as per the ODOT CAD Manual. Other disciplines are assigned different letters which are alphabetically arranged in the contract plan set (e.g., workzone plans are assigned to the E series, therefore workzone plan sheets will always precede traffic signal plan sheets).

Traffic signal work may be **shown and referenced** on other discipline plan sheets but shall only be **shown and detailed** on the M series plan sheets. Other discipline's work may be **shown and referenced** on the M series plan sheets but shall not be **shown and detailed** on the M series plan sheets. Always coordinate with the other discipline's designer when referencing work. See Figure 21-1 and Figure 21-2 for examples. Showing and detailing the work for each discipline on the proper plan sheet is very important for the following reasons:

- All contractors working on the project have an expectation of where to look to find the proper information. This results in increased efficiency and less risk of work being missed (e.g., contractors that perform traffic signal work know to look in the M series plan sheets. They do not expect to find this type of work in other discipline's plan sheets).
- Payment for the work performed needs to be very clear. When traffic signal work is shown and detailed on another discipline's plan sheet (or vise-versa) it introduces confusion on which bid item should be used and makes contract administration more difficult. It can also result in higher bid items prices (e.g., contractor covers the payment of that work in multiple incorrect bid items instead of using the correct bid item).
- The engineer of record (EOR) should only be stamping plan sheets detailing work that is within their expertise. When the detailed work is outside of EOR's area of expertise, they may not be aware of all applicable policies/guidelines/procedures associated with the work which can result in incomplete plan sheet detail and poor construction support.
- Archiving the work is important for future maintenance and design needs. When traffic signal work is shown and detailed on another discipline's plan sheet (or vise-versa) it will not be properly archived and accessible to those that will need it in the future (e.g., roadway plans are archived via the V-file number and traffic signal plans are archived via the unit file code. Staff doing the archiving work do not look at plan sheet contents and will not archive in both locations). Unless someone has past knowledge that some traffic signal work was shown on a different discipline's plan sheet, it will be virtually impossible to efficiently search and find that information in another discipline's archive system.

If the scope of work and number of plan sheets in the contract plan set is extremely limited (e.g., project has only 1 to 2 plans sheets total), combining the work of multiple disciplines (showing and detailing) on a single plan sheet may be allowed at the discretion of the state traffic signal

engineer. Even on projects this small, though it may feel excessive to produce discipline specific plan sheets, it immensely helps with contract administration and archiving.

Figure 21-1 | Work Shown and Detailed Example

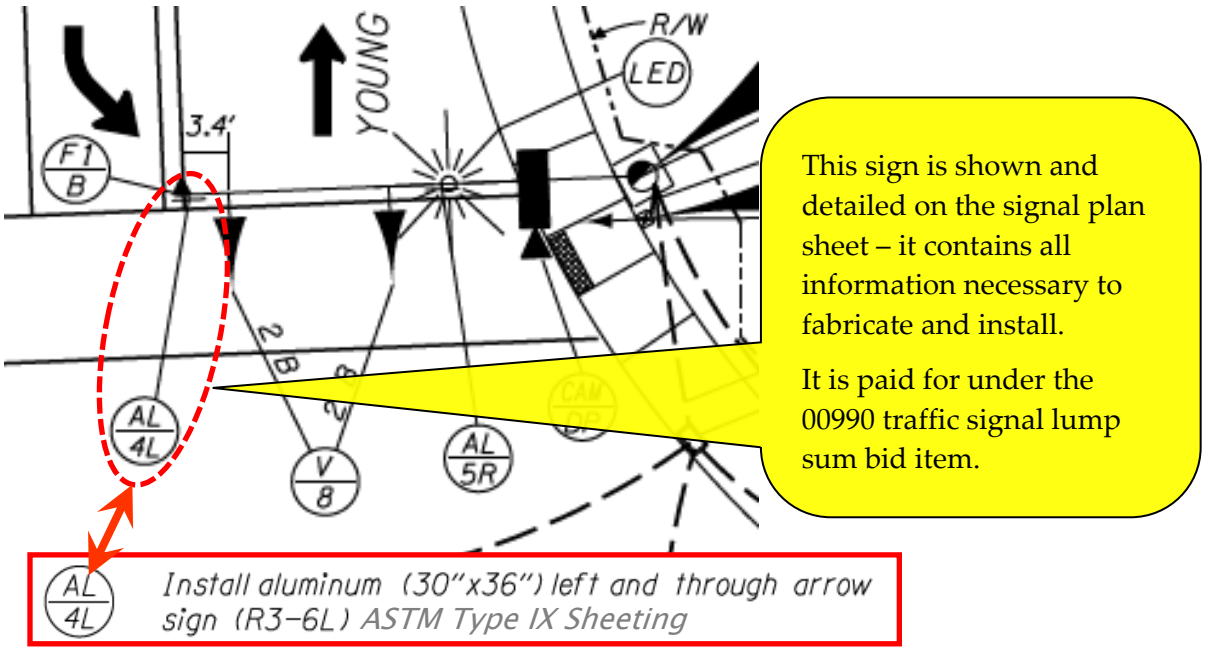
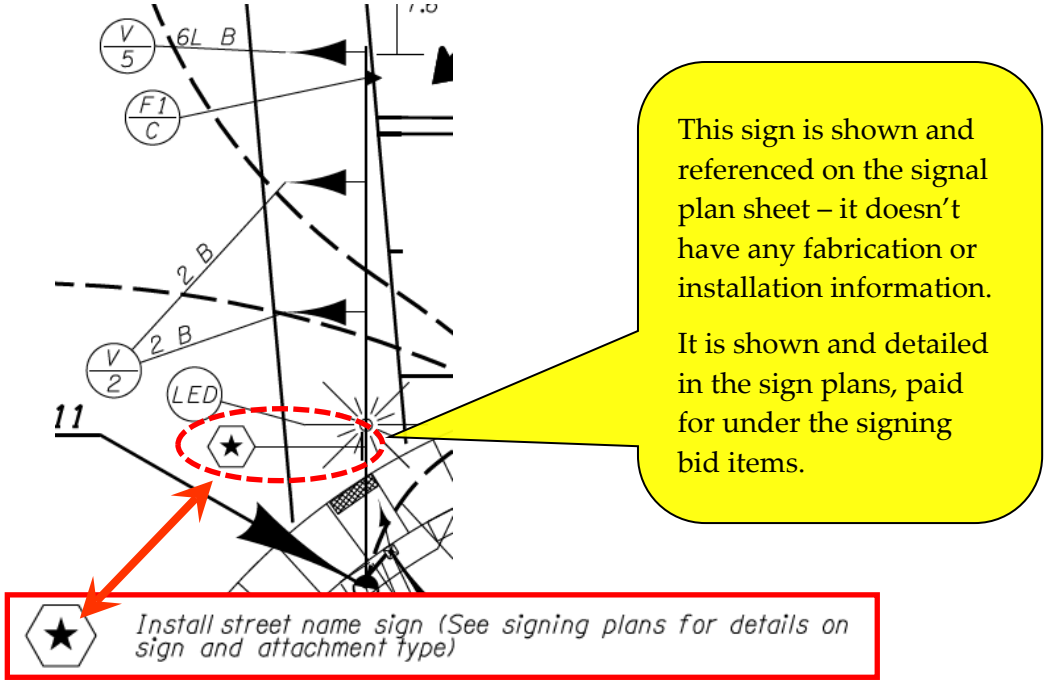


Figure 21-2 | Work Shown and Referenced Example



21.4 MicroStation Traffic Signal Workflow

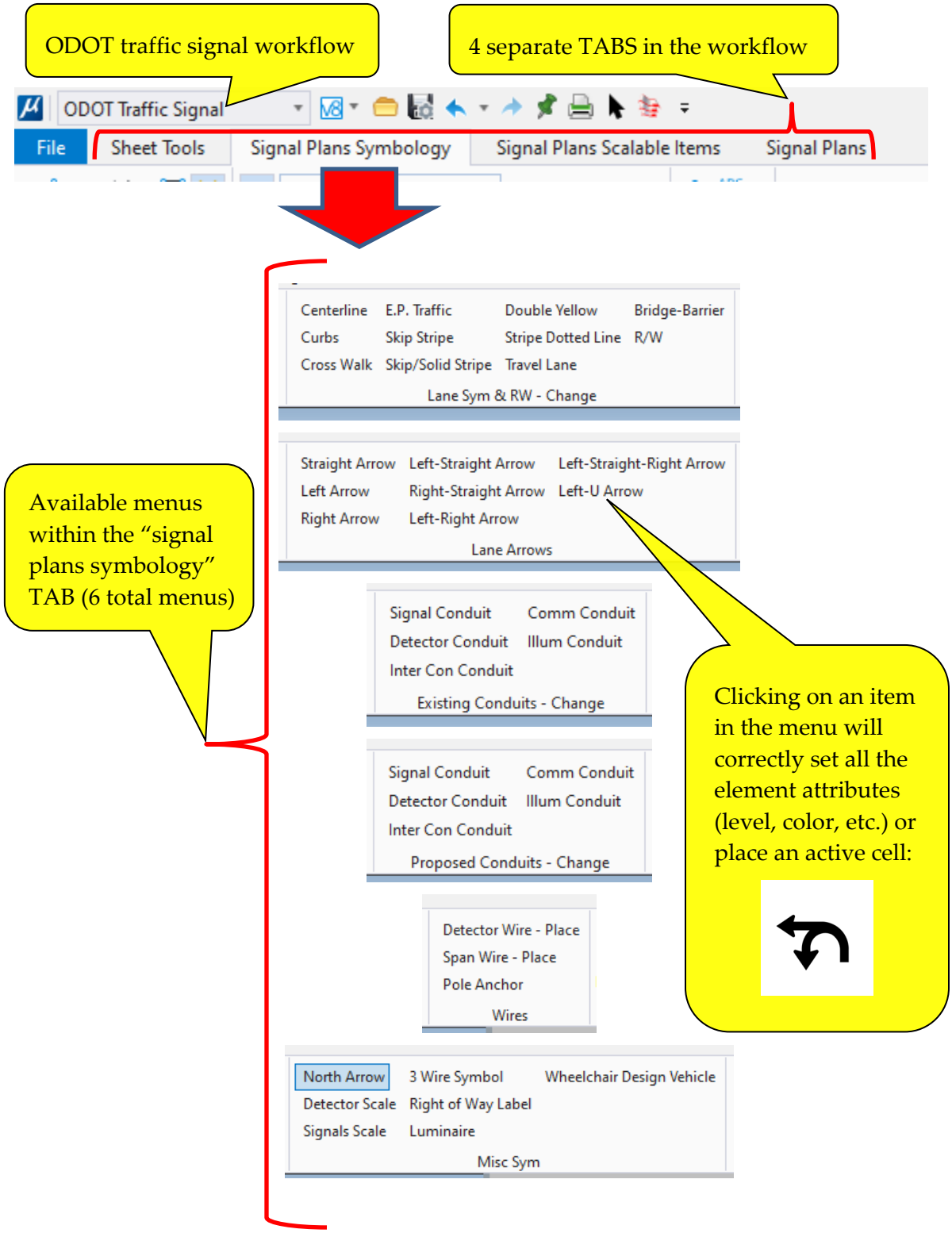
The MicroStation workspace has a workflow for each specific engineering discipline. The traffic signal workflow contains the typical features and symbology that are used on traffic signal plans (e.g., scale, line weight, line style, color, level, wording of notes, font, etc.) and greatly reduces the need to create custom symbology/notes.

The symbology and scaleable features in the workflow are all labeled according to what they are and how they should be used. They have been created to work with the annotation scale of the plan sheets and/or the actual dimensions of the feature when placed at a scale of 1:1. Critical features that may affect right-of-way, affect placement of other features, and/or require very precise placement display the actual dimensions (e.g., pole and pedestal foundations, mast arm lengths, wheelchair design vehicle, junction boxes, etc.). Non-critical features do not display the actual size but instead provide good visibility of the feature at the plan sheet scale used (e.g., conduits, signal heads, pedestrian heads, etc.).

The traffic signal plans shall use the standard symbology contained within the traffic signal workflow. General information about the MicroStation workspace and how to access them is contained in section 21.1. See Figure 21-3 for how the traffic signal workflow is configured. In the situations where custom symbology/notes may be needed, contact the state traffic signal engineer for guidance.

Updates to the workflow may occur at any time, typically due to changes to standards, correcting errors/oversights, and making improvements for the drafter and/or plan reader. Updates should be automatic for ODOT personnel when opening MicroStation and the user should also get an e-mail from the ODOT EAST team summarizing the updates. For non-ODOT personnel, it the user's responsibility to ensure the workspace is the latest version before and during design of all signal projects.

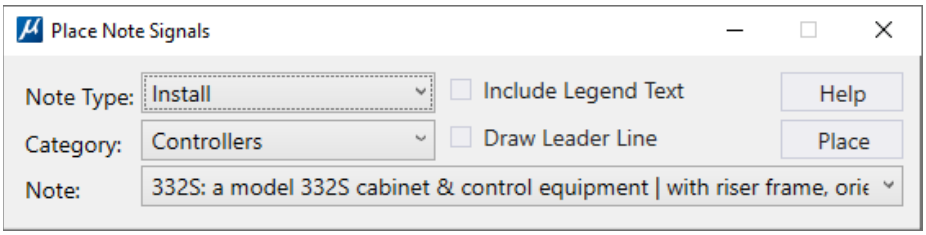
Figure 21-3 | MicroStation Traffic Signal Workflow



The workflow contains a bubble note "place note signals" tool that contains all the standard bubble notes and makes placing them for the legend and in plan sheets quick and easy. See Figure 21-4. It can be found in either workflow detailed below:

- "ODOT" workflow
  - "Bubble Note Tools"
    - "Signals"
- "ODOT Traffic Signal" workflow
  - "sheet tools"
    - "notes & symbols"
      - "signal note tool"

Figure 21-4 | Bubble Note "Place Note Signals" Tool



A list of the standard bubble notes contained in the MicroStation workspace is provided at the end of this chapter for easy reference when creating and reviewing plan sheets.

Custom or modified bubble notes may be necessary if the bubble notes in the "place note signals" tool do not adequately or clearly address unique site-specific needs. For example, the EX/1 bubble note for the power source, "retain and protect existing power pole (power source)" is found only under the category "poles" because that is the most typical location for the power source. However, the power source could be ground mounted and not on a pole. In this case, the EX/1 bubble note should still be used, but the accompanying legend text should be modified to reflect the site-specific condition as follows, "retain and protect existing power cabinet (power source)".

The workflow should contain all the standard drafting elements discussed in this chapter. If items are missing or not working/displaying correctly, or something should be added, contact the traffic engineering section so it can be fixed. Your feedback is important to maintain the workflow.

Custom/modified bubble notes and symbology should be avoided but is sometimes necessary on a project. Work with the state traffic signal engineer. If the custom/modified feature has the potential for wider use or improves upon the existing element, it will likely be included in a future update to the MicroStation workspace.

21.5 Grooming Reference Files

Each referenced base map file (e.g., roadway, striping, etc.) should be groomed. This is done because signal plan sheets are produced at a different scale and must emphasize different design features than plan sheets produced for other disciplines. Grooming includes turning off any levels with extraneous information/features not needed for the signal design and modifying the design features to conform to the traffic signal drafting standards as per the MicroStation workflow. Common elements that require grooming include:

- Turning off levels:
  - Signs
  - Landscaping, trees and brush
  - Buildings
  - Pavement markings for lane use
- Modifying design features to traffic signal drafting standard symbology:
  - Curbs
  - Crosswalks
  - Centerline
  - Various lane lines (e.g., converting striping line styles with raised pavement markers to striping line styles without raised pavement markers).
  - Edge of travel lanes/edge of pavement
  - R/W lines
  - Survey symbols of existing features (e.g., junction boxes, poles, conduit, etc.)

Grooming reference files and incorporating them into the traffic signal plan sheets can be done in various ways. Regardless of the method used, it is critical that the signal designer uses the correct reference files and monitors the reference files for changes throughout the design process. Good communication with the designer that is responsible for each reference file is key.

21.6 Projects Without Reference Files/Survey Data

Small scale projects that don't involve any roadway construction (such as state force work) may not have any survey data or other reference files. When a project won't have any reference files, the plan view features of the intersection (lane lines, edge of pavement, curbs, ramps, lane lines, etc.) will need to be created from the most current data available. This can include google earth images, original plans, or as-built plans (from FileNet) that are brought into MicroStation and then re-traced using the MicroStation workflow. This method requires the information to be field verified to ensure it is accurate. Another option for getting the necessary existing features includes requesting a base map from the data collected by the ODOT mobile lidar. Lidar data is collected on all state highways on a reoccurring schedule. Contact the geometronics unit: remote sensing and UAS program surveyor for assistance in getting a base map from lidar data. This method provides more accurate information, but it can take a little longer to get and could be slightly out-of-date (depending on when the lidar data was collected).

21.7 Traffic Signal Style Drafting – Basic Layout and Information

The following subsections provide guidance on the drafting style for basic layout and information that is shown on the M series for a typical project.

21.7.1 Plan Sheet Titles, Size, and Scale

All final contract plans are printed to an 11x17 PDF. Scales of each plan sheet title are shown in Figure 21-5.

Figure 21-5 | Plan Sheet Title Scale

Scale	Signal Plan Sheet Title
20:1	Signal Plan (may also be at 30:1 if necessary) *
	Temporary Signal Plan (may also be at 30:1 if necessary) *
	Railroad Preemption Plan
	Flashing Beacon Plan
	Fire Signal Plan
	Pedestrian Signal Plan
	Red Light Enforcement Plan
	Existing Utilities (may also be at 40:1 if necessary) *
	Automatic Traffic Recorder Plan
40:1	Detector Plan
	Temporary Detector Plan
	Ramp Meter Plan
	Temporary Ramp Meter Plan (may also be at 30:1 or 20:1 if necessary) *
	Removal Plan
80:1	Interconnect Plan
100:1	Legend
	Details
	Miscellaneous

*Occasionally, it may be necessary to use a modified scale to get acceptable clarity of the work/features or to avoid creating multiple sheets or awkward break lines. If the scale MUST be modified, always use the largest scale possible to maximize the legibility of the finished plan sheet.

21.7.2 Order of Traffic Signal Plan Sheets

The plan sheet titles shown in the previous subsection are always arranged in a specific order in the contract plans. See Figure 21-6 for the basic order.

Figure 21-6 | Basic Order of Traffic Signal Plan Sheets

1	Legend
2	Removal Plan
3	Temporary Signal Plan or Temporary Ramp Meter Plan
4	Temporary Detector Plan
5	Signal Plan, or Ramp Meter Plan, or Flashing Beacon Plan, or Fire Signal Plan, or Pedestrian Signal Plan, or Red Light Enforcement Plan (insert the type of plan you are designing here)
6	Detector Plan
7	Existing Utilities
8	Interconnect Plan
9	Details (one or more sheets)

When multiple intersections or multiple types of installation are on a project, the plans shall be arranged so the that the signal plan sheets follow the same order as the roadway plan sheets. Roadway stationing should be followed if available. If stationing is not available, follow milepoints from lowest to highest. See Figure 21-7 for an example of arranging multiple intersections/installations.

Figure 21-7 | Multiple Intersections/Installations Order of Traffic Signal Plan Sheets Example

1	Legend	All intersections
2	Removal Plan	1st intersection
3	Temporary Signal Plan	
4	Signal Plan	
5	Detector Plan	
6	Existing Utilities	
7	Removal Plan	2nd intersection
8	Fire Signal Plan	
9	Existing Utilities	
10	Flashing Beacon Plan	3rd intersection
11	Existing Utilities	
13	Interconnect Plan(s)	All intersections
14	Details (pole entrance chart)	
15	Details (miscellaneous)	

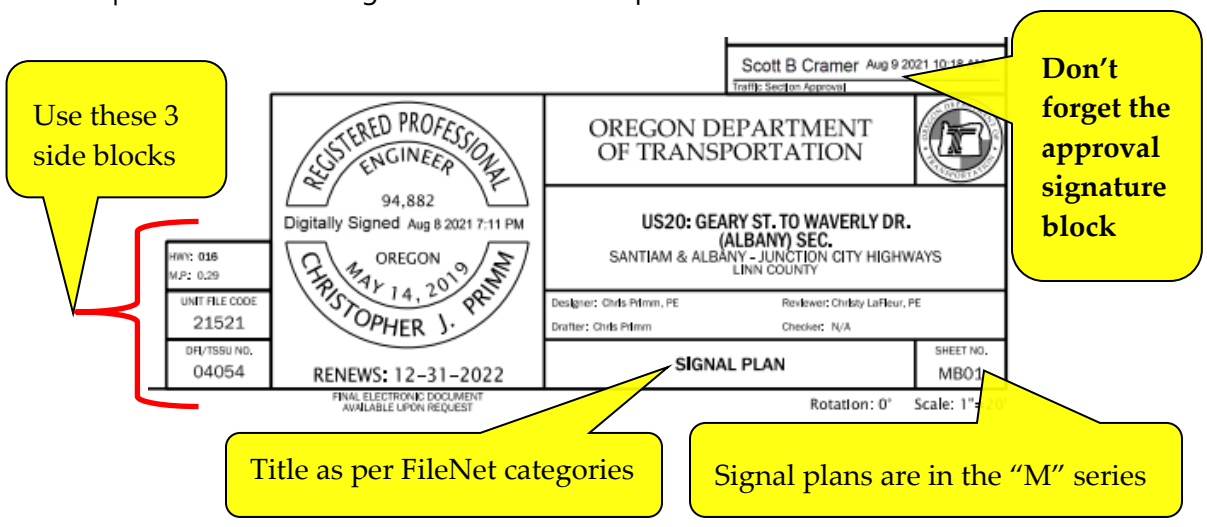
21.7.3 Title Block - Traffic Signal Specific Information

Use the standard title block and standard floating boxes (additional information and how to access them is contained in Section 21.1) and fill out the traffic signal specific information according to following list. See Figure 21-8 for an example of a completed title block.

- Hwy and MP: Input the ODOT hwy number (NOT ROUTE NUMBER) and milepoint of the intersection. This can be found in TransGIS or in the operational approval.
- Unit file code: Input the unique plan sheet number assigned by the traffic engineering section. See chapter 2 for more info.
- TSSU No.: Input the identification number of controller cabinet/asset. See chapter 2 for more info.
- **Traffic section approval signature block.** Place this standard title block add-on adjacent to the title block.
- Fill out the "designer", "reviewer", and "drafter" ("checker" is typically N/A or blank)
- Input the sheet number for the contract plan set (will be in the M series for traffic signals). See section 21.1 for more information on discipline specific sheet numbering.
- Input the title of the sheet. It shall be as per the designated categories listed in FileNet:

  - Automated Traffic Recorder Plan
  - Details
  - Detector Plan
  - Existing Utilities
  - Fire Signal Plan
  - Flashing Beacon Plan
  - Interconnect Plan
  - Legend
  - Miscellaneous
  - Pedestrian Signal Plan
  - Railroad Preemption Plan
  - Ramp Meter Plan
  - Red Light Enforcement Plan
  - Removal Plan
  - Signal Plan
  - Temporary Detector Plan
  - Temporary Ramp Meter Plan
  - Temporary Signal Plan

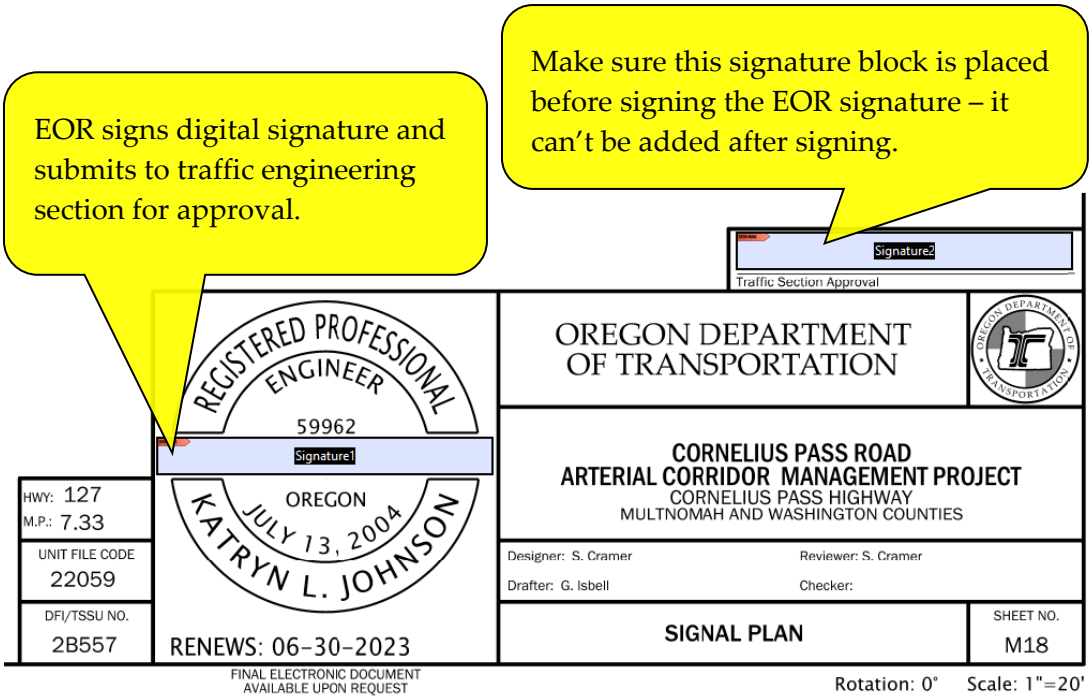
Figure 21-8 | Standard Traffic Signal Title Block Example



21.7.4 Digital Signatures

Digital signature blocks for both the EOR and traffic engineering section approval are required and placed on the PDF file when ready to finalize the plan sheet. See Figure 21-9.

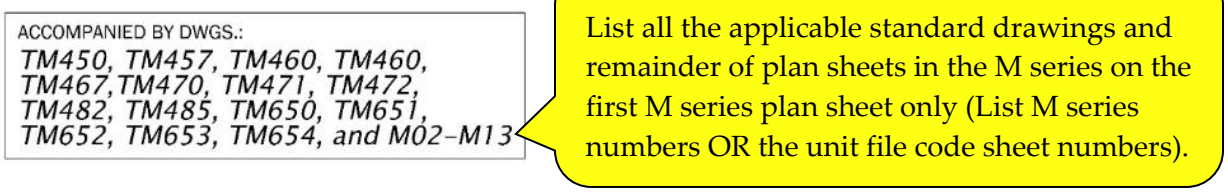
Figure 21-9 | Digital Signature Blocks on Plan Sheets



21.7.5 Accompanied by Dwgs. Box

The first plan sheet of the M series shall have the "Accompanied by Dwgs." Box (plan sheet title block floating boxes in the ODOT CAD Manual) placed near the title block. It shall list all applicable standard drawings needed for the M series, typically drawings in the TM400 series and TM600 series. Occasionally the TM200 series or RD series are necessary. It shall also list the remainder of plans sheets in the plan set (either the M series numbers, or the unit file code numbers is acceptable to list). See Figure 21-10.

Figure 21-10 | Accompanied by Dwgs. Box Example



21.7.6 Upper Right Corner Title Information

Each traffic signal plan sheet shall have at least four lines of intersection identifying information as shown in Figure 21-11. V-numbers are not used or shown on traffic signal plan sheets.

On certain plan sheets (e.g., the legend, details, and interconnect plan sheets), it will be necessary to modify the standard four lines of identifying information. For example, providing a range distance for the interconnect sheet(s) or adding multiple intersections to the legend sheet. See Figure 21-13 and Figure 21-12 for examples.

Figure 21-11 | Upper Right Corner Title Information Example

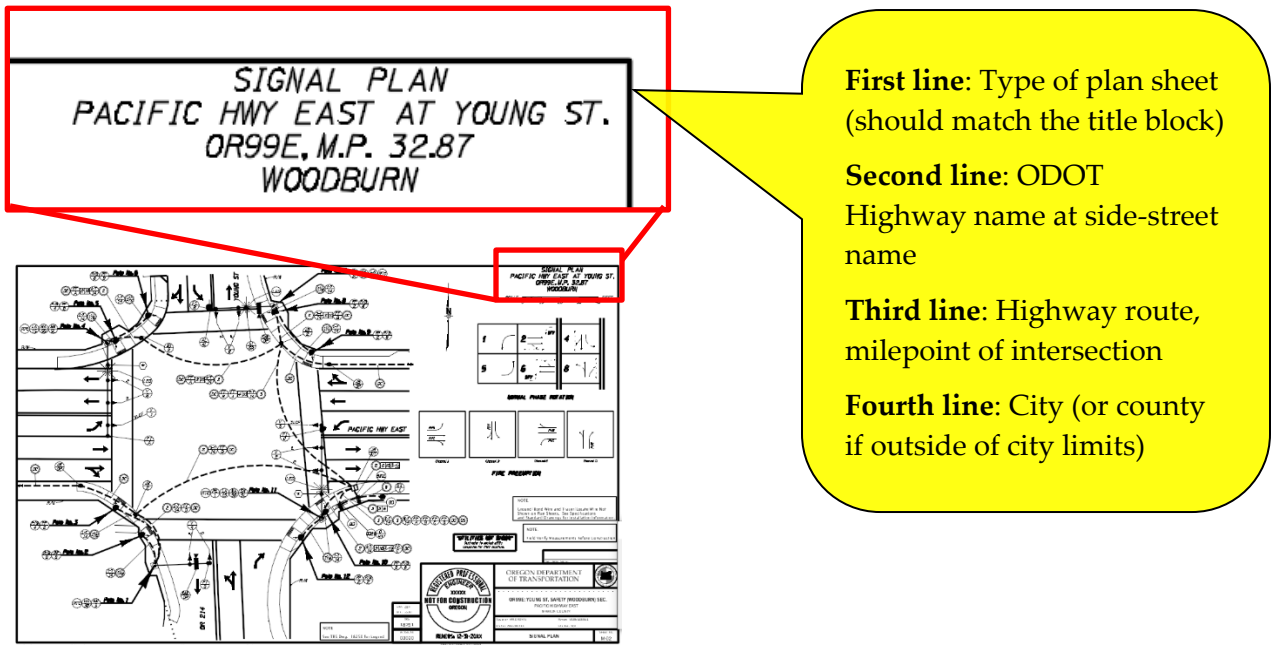


Figure 21-12 | Upper Right Corner Title Information – Modified for Interconnect Plan Sheet

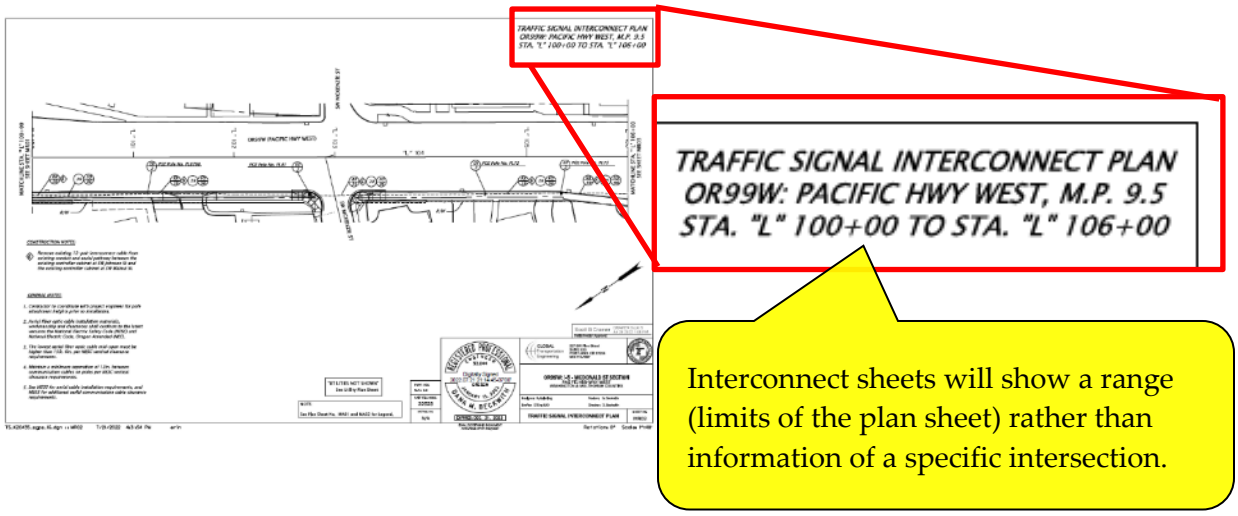
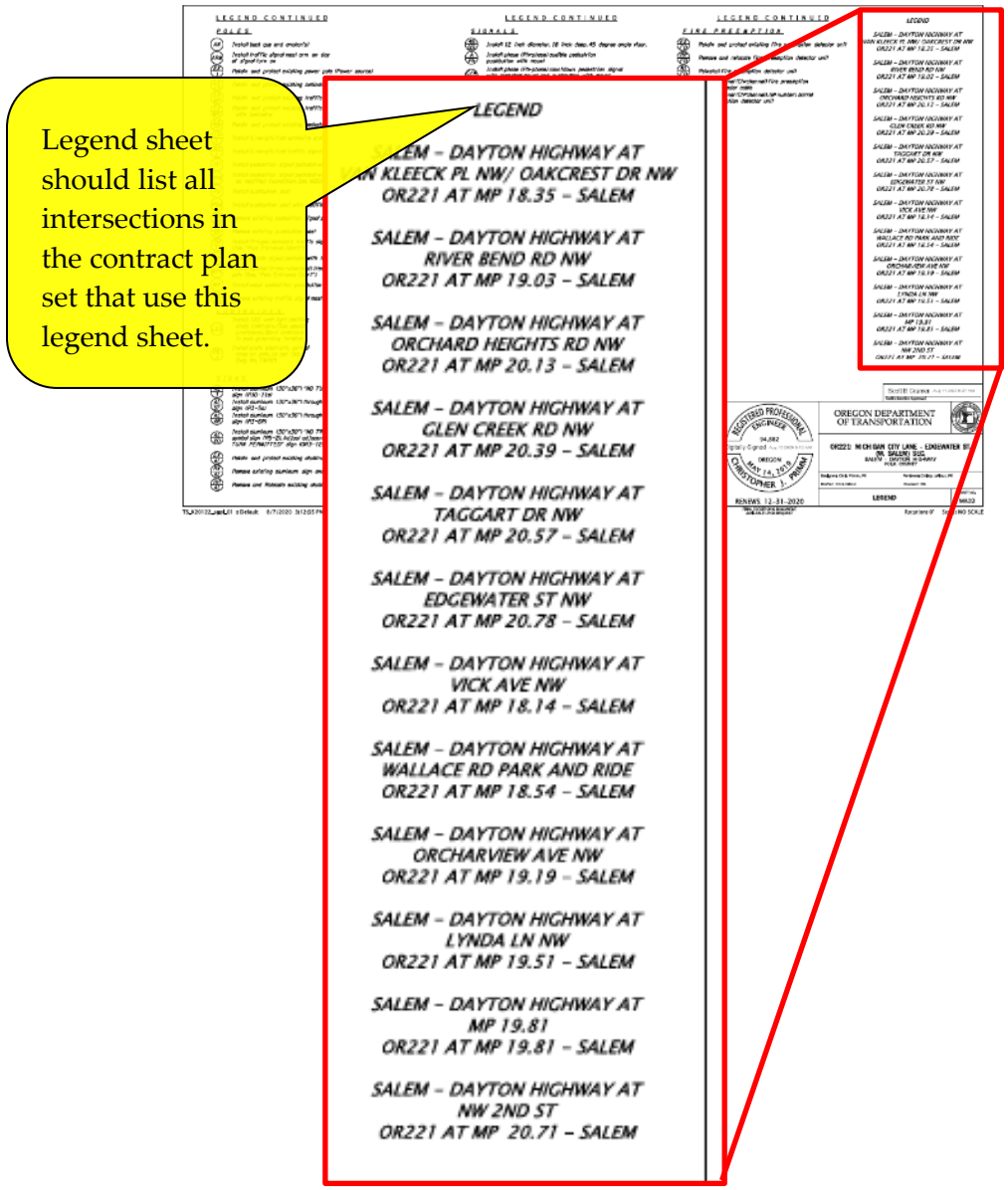


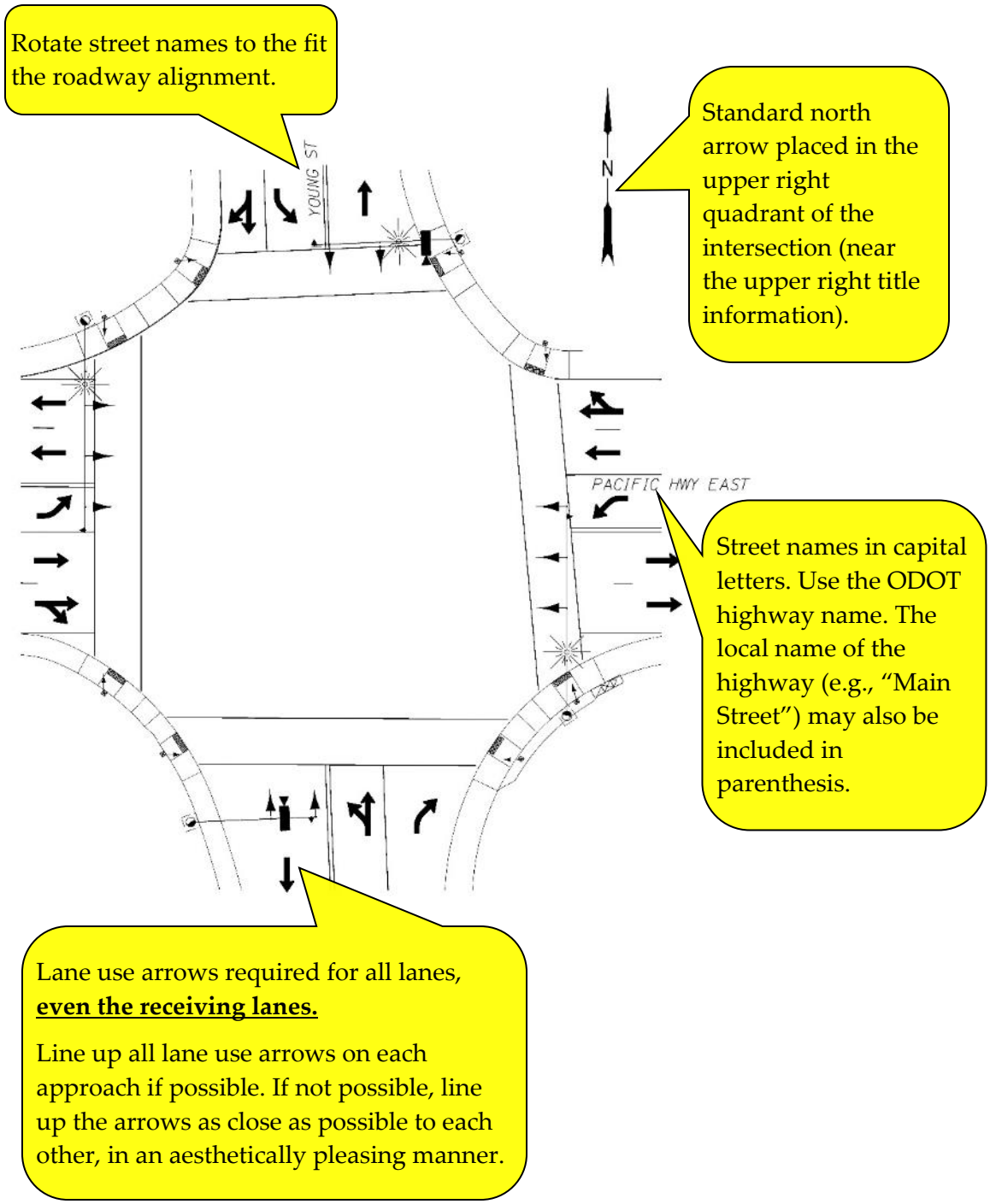
Figure 21-13 | Upper Right Corner Title Information – Modified for Legend Sheet



21.7.7 North Arrow, Street Names, & Lane Use Arrows

A north arrow, street name text, and lane use arrow shall be used as shown in Figure 21-14.

Figure 21-14 | Lane Use Arrow in All Lanes, Street Names, and North Arrow Example



21.7.8 Centerline Station or Scale Bar

The centerline alignment shall be shown with at least two stations labeled. See Figure 21-15. If an alignment is not present, use a scale bar instead. See Figure 21-16.

Figure 21-15 | Centerline Alignment with Two Stations Example

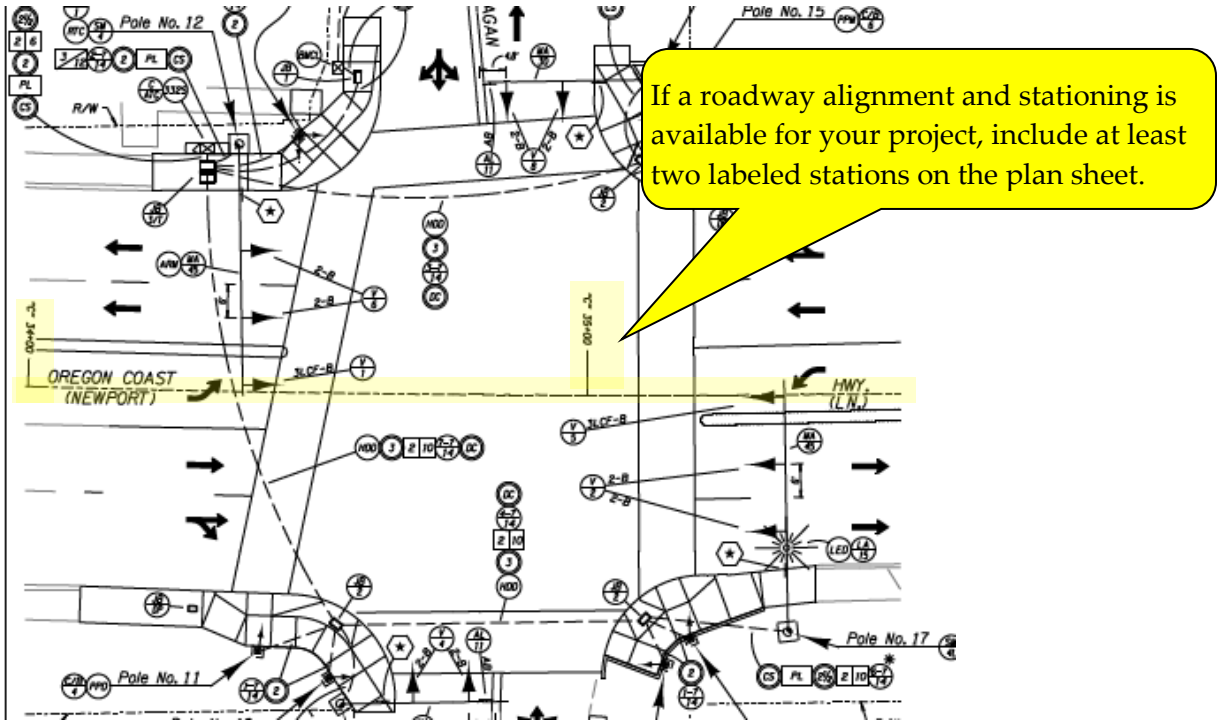
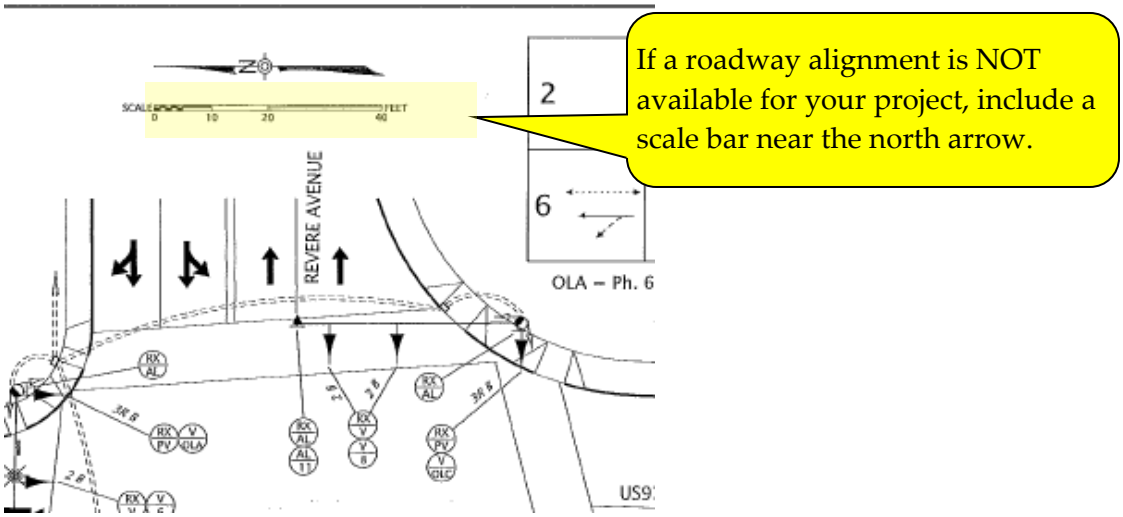


Figure 21-16 | Scale Bar Example



21.7.9 Right-of-Way

It is important to show and label the right-of-way lines, permanent and easements, on the plan sheets when the work involves installing new equipment that requires moving soil to ensure that all equipment is placed within right-of-way (e.g., mast arm poles, pedestals, service cabinet, controller cabinets, junction boxes, conduits, etc.). See Figure 21-17. In some cases, the right-of-way is beyond the plan sheet scale (e.g., interchange terminals) and should be noted as such on the plan sheets. See Figure 21-18.

Figure 21-17 | Right-of-Way Shown and Labeled

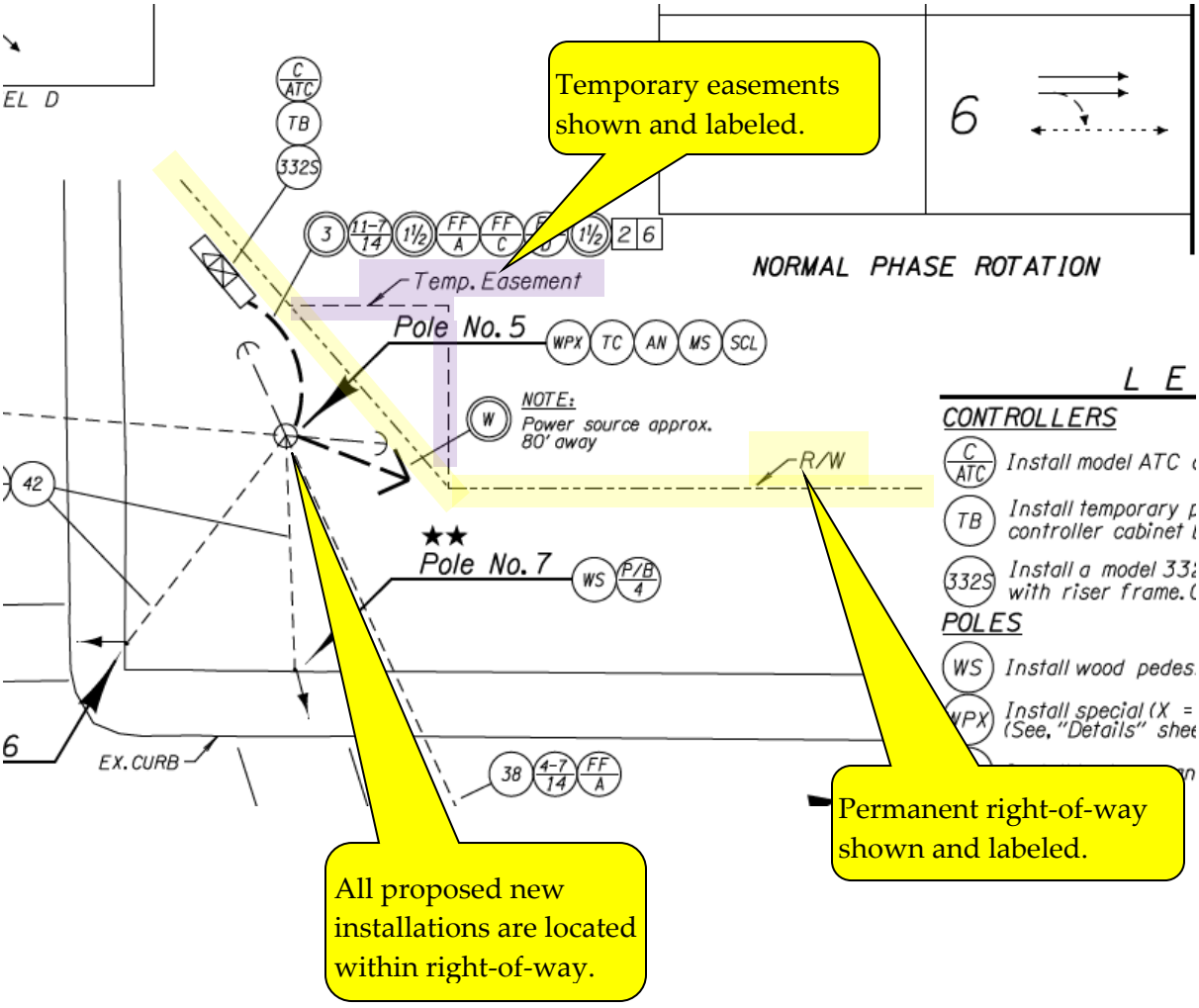
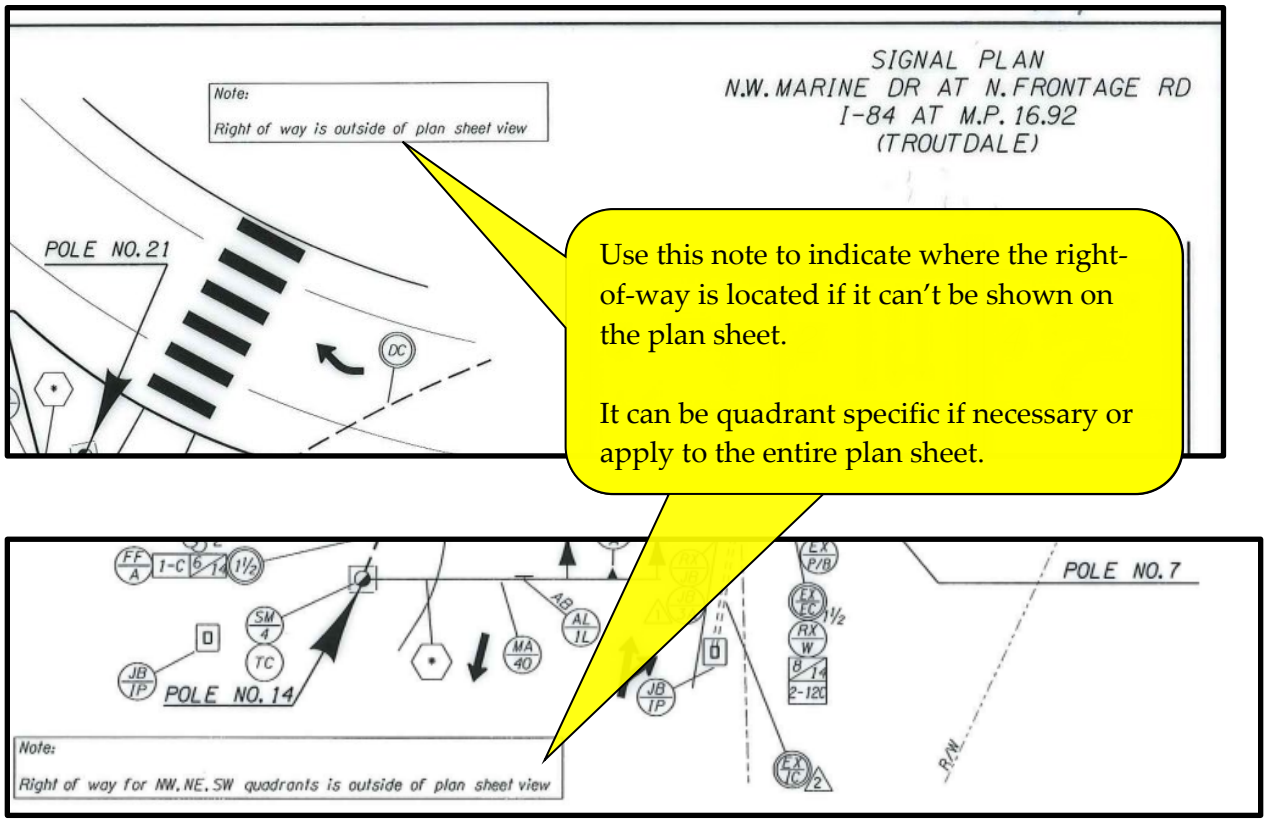


Figure 21-18 | Right-of-Way Outside of Plan Sheet View Note Examples



21.7.10 New Roadway & Pavement Markings

The new roadway (edge or pavement, curb, sidewalk, ramps, driveways, etc.) with new lane line striping, crosswalks, stop bars, and bike lane stencils shall be shown with the correct symbology for traffic signal plans as per the MicroStation workflow. Turn-off the levels for all other pavement markings.

Existing roadway/pavement marking feature symbology is typically not shown on the plan sheets for new signals or complete signal rebuilds. However, existing feature symbology with proper detailing may be necessary for certain projects to clearly show the intended work (e.g., partial signal modifications).

21.7.11 Break Lines and Match Lines

Break lines are typically required for detection plans (where loops are shown) and can be useful for other plan sheets (e.g., interconnect plan, railroad preemption plan, ramp meter plan, ATR plan, and removal plan) to keep all necessary information on one plan sheet at the proper scale or to reduce the number of plan sheets in the plan set. See Figure 21-19 and Figure 21-20 for examples.

Figure 21-19 | Break Line Example 1: Keep Info on One Page (Detector Plan Sheet)

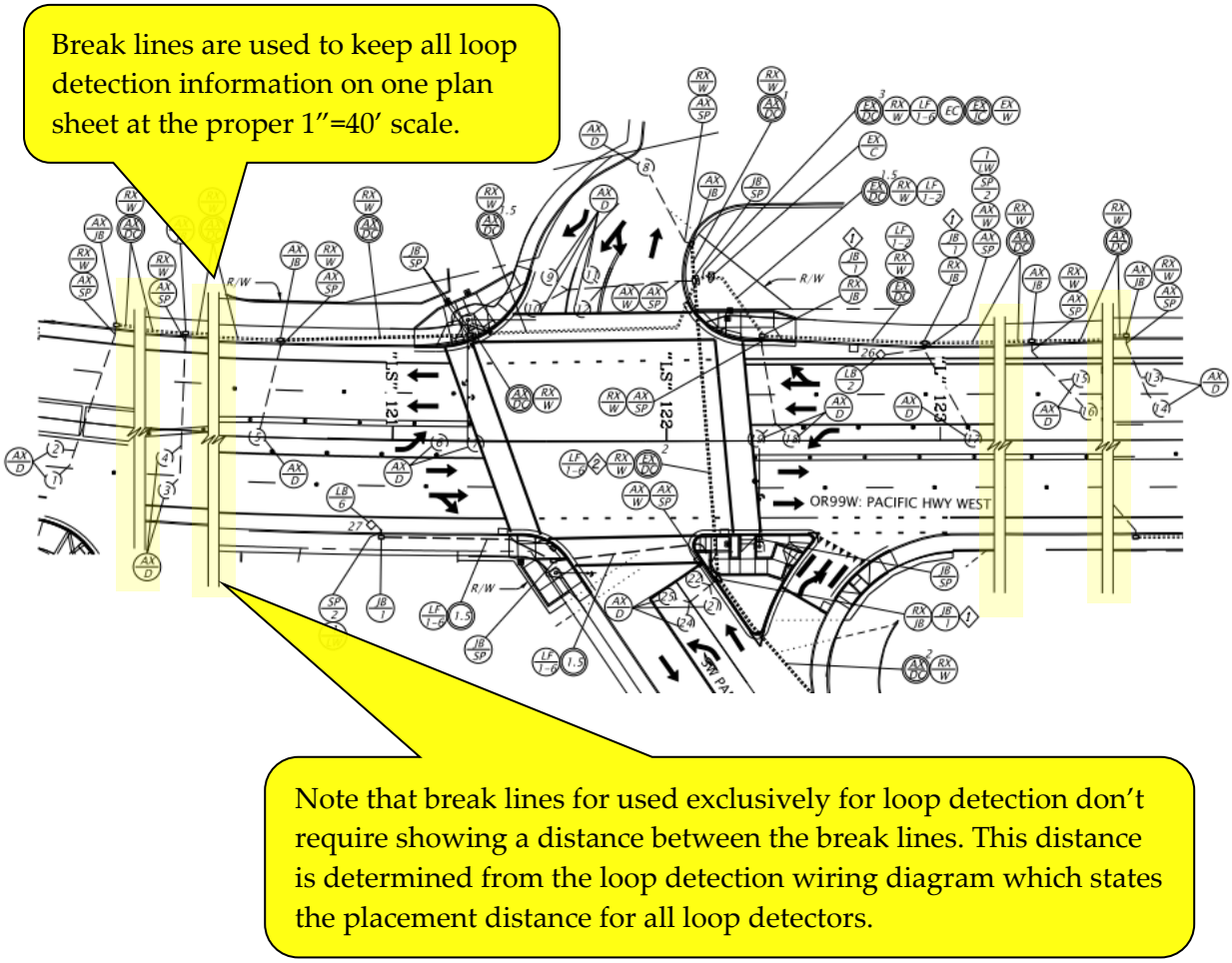
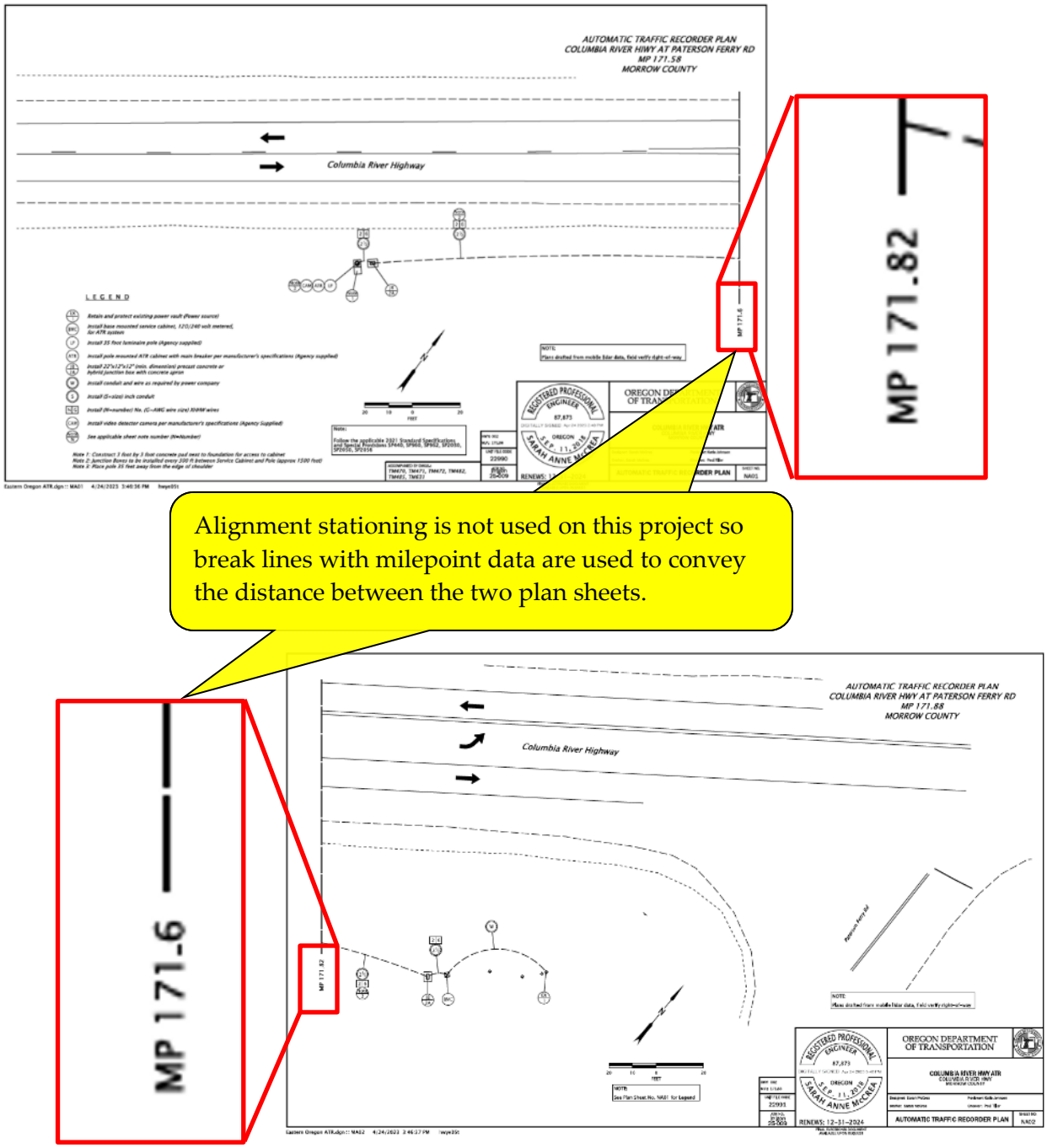
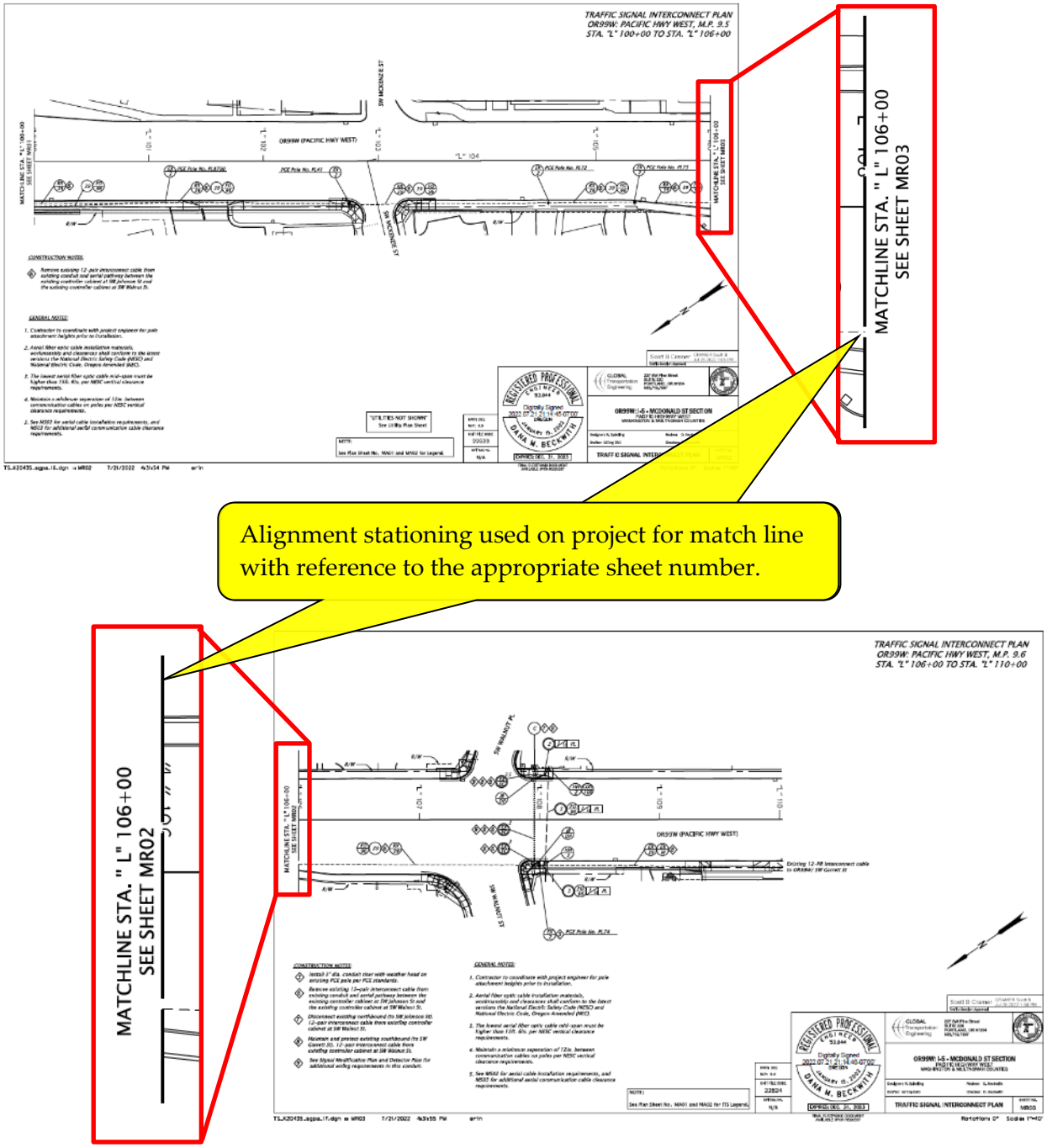


Figure 21-20 | Break Line Example 2: Reduce Number of Plan Sheets (ATR Plan Sheet)



Match lines are used for certain project alignment configurations (as per the guidance in the manuals listed in section 21.1) and to easily reference appropriate plan sheets. See Figure 21-21 for an example.

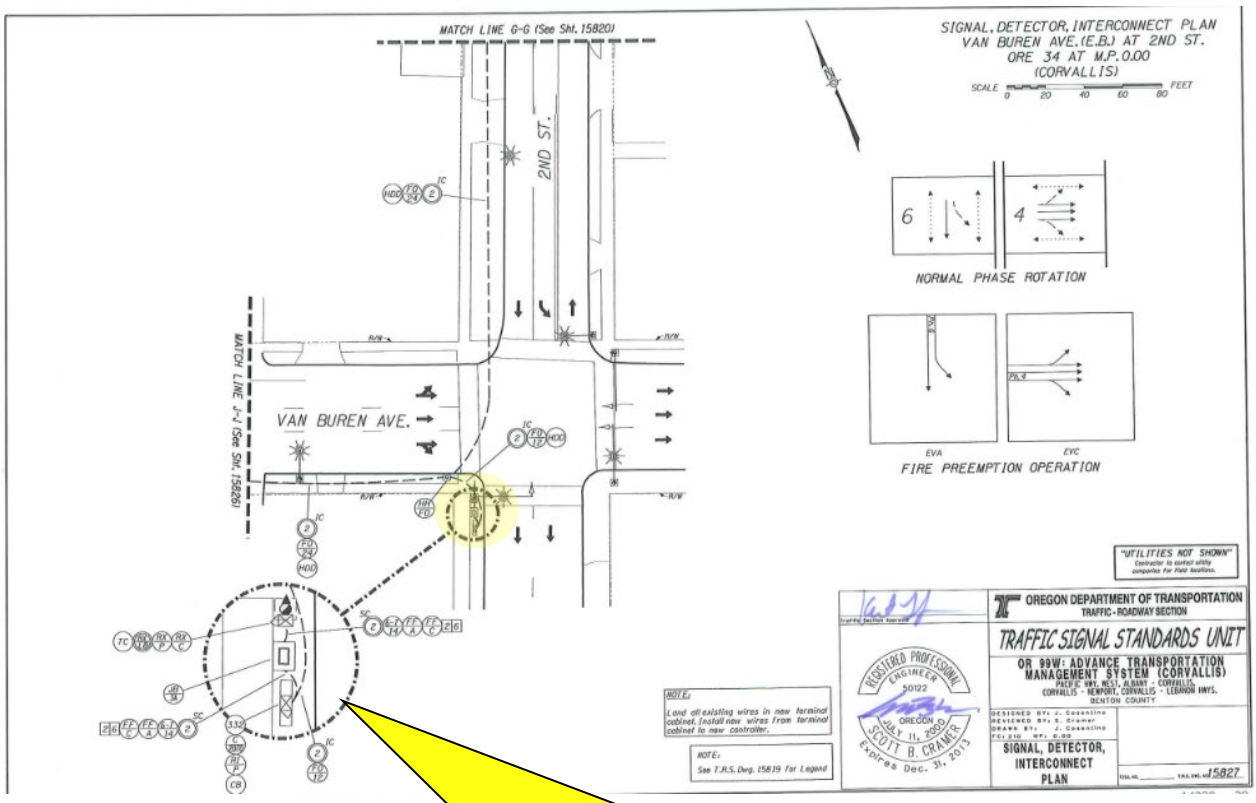
Figure 21-21 | Match Line Example



21.7.12 Blow-up Views

Occasionally it will be necessary to use a different scale for certain areas of work. These areas often have a lot of details in a small space which makes clearly showing the work a challenge at the standard plan sheet scale. If this is the case, use a blow-up view at an appropriate scale to clearly show the work. The blow-up view should be clearly labeled and shown on the same plan sheet if possible. See Figure 21-22. However, the blow-up view may also be placed on a separate plan sheet if there is not enough room to fit it on the same sheet. See Figure 21-23.

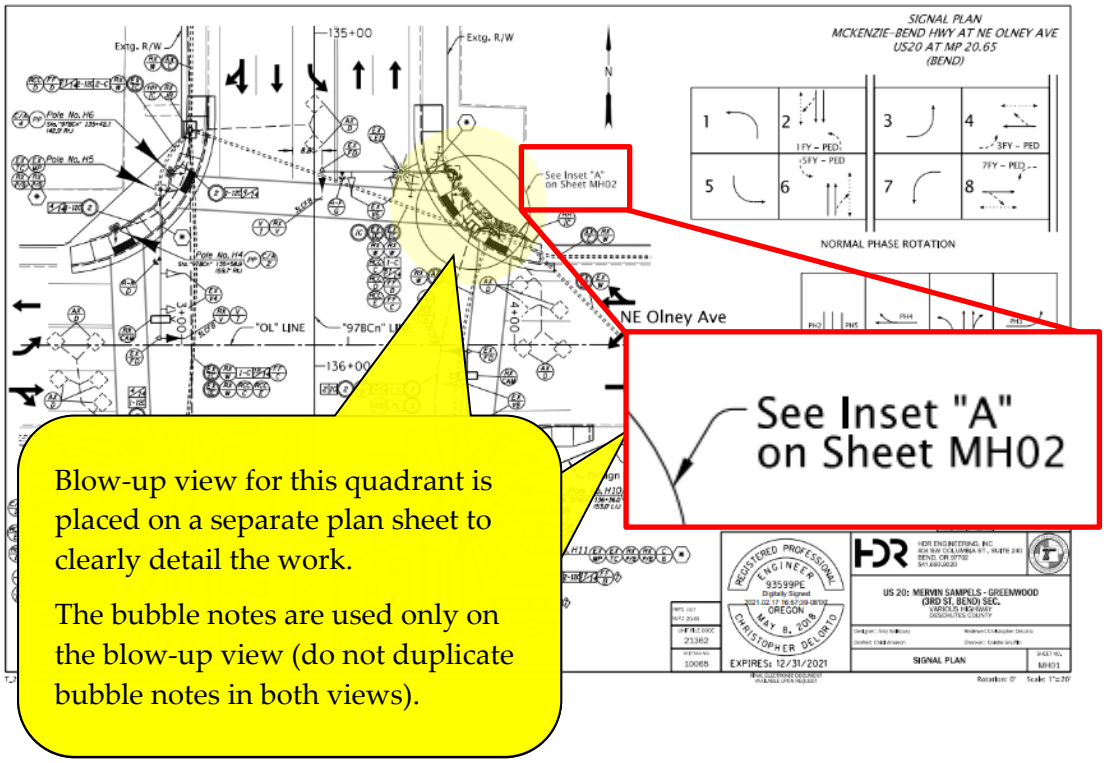
Figure 21-22 | Blow-up View Example 1 (Shown on Same Plan Sheet)

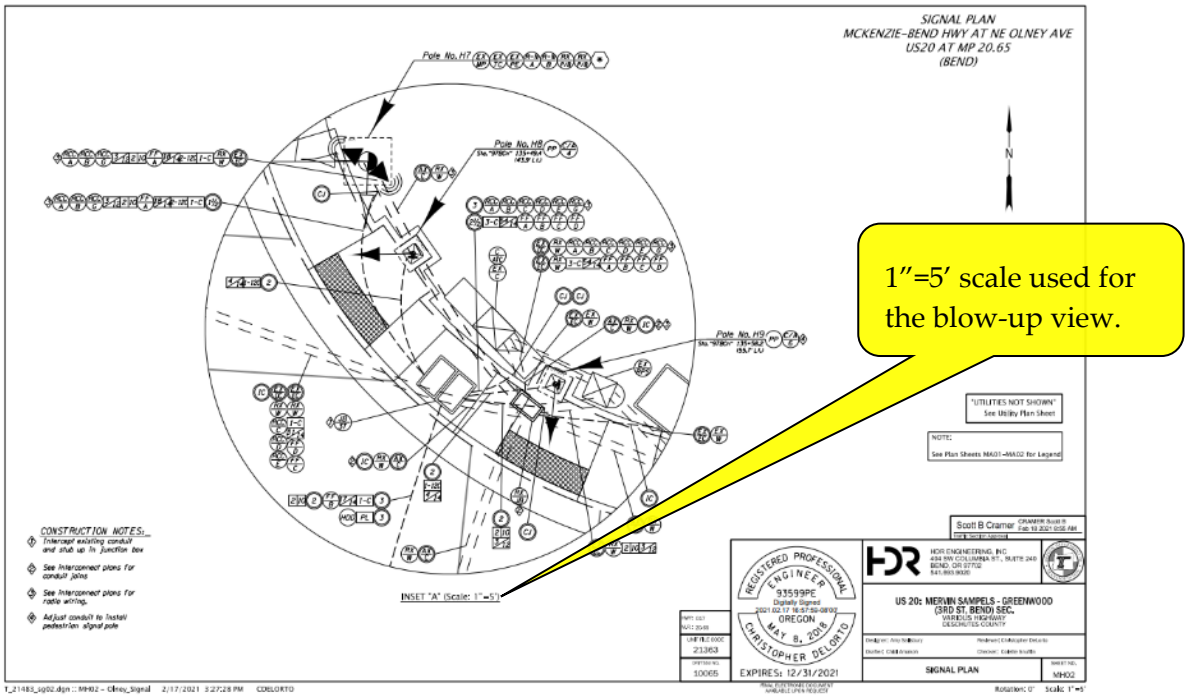


Blow-up view located on the same sheet.

The bubble notes are used only on the blow-up view (do not duplicate bubble notes in both views).

Figure 21-23 | Blow-up View Example 2 (Shown on a Separate Plan Sheet)

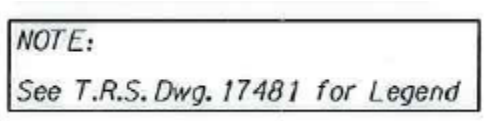




21.7.13 Cross References

Cross reference to other plan sheets as necessary using a text note box, such as the cross reference to the legend sheet. See Figure 21-24. Bubble note cross referencing is discussed in section 21.9.4.

Figure 21-24 | Cross Reference Text Note Box Example



21.8 Traffic Signal Style Drafting – Specific Design Features

The following subsections provide guidance on the drafting style for specific traffic signal design features that are shown on the M series for a typical project.

21.8.1 New vs. Existing Symbology

Certain features (e.g., conduit, signal heads, pedestrian signals, etc.) have slightly different symbology depending on if the feature is being installed new vs. if the feature is existing (retain and protect). In Figure 21-25 two examples of this are shown:

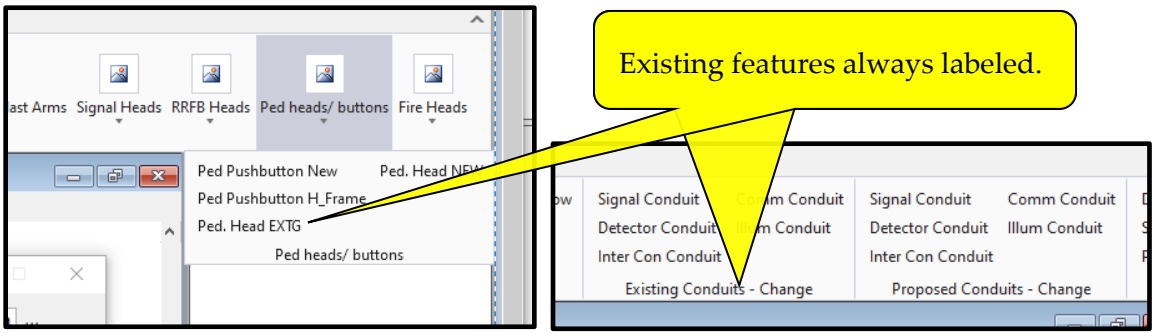
- A new signal head is shown as a solid arrow and an existing signal head is shown as a hollow arrow
- A new conduit is shown with a different line style than existing conduit

Figure 21-25 | Two Examples of Symbology for New vs. Existing

Feature	Proposed/New Symbology (Typically solid and/or bold)	Existing Symbology (Typically hollow and/or lighter)
Signal Head		
Conduit		

Not all features use a different symbology for existing (e.g., junction boxes, controller cabinets, etc.). When a feature does have a different symbology for new and existing, they will be together in the same area of the workflow with the existing feature always labeled “extg.” or “existing”. See Figure 21-26 for example.

Figure 21-26 | Existing Features Labeled in the Workflow

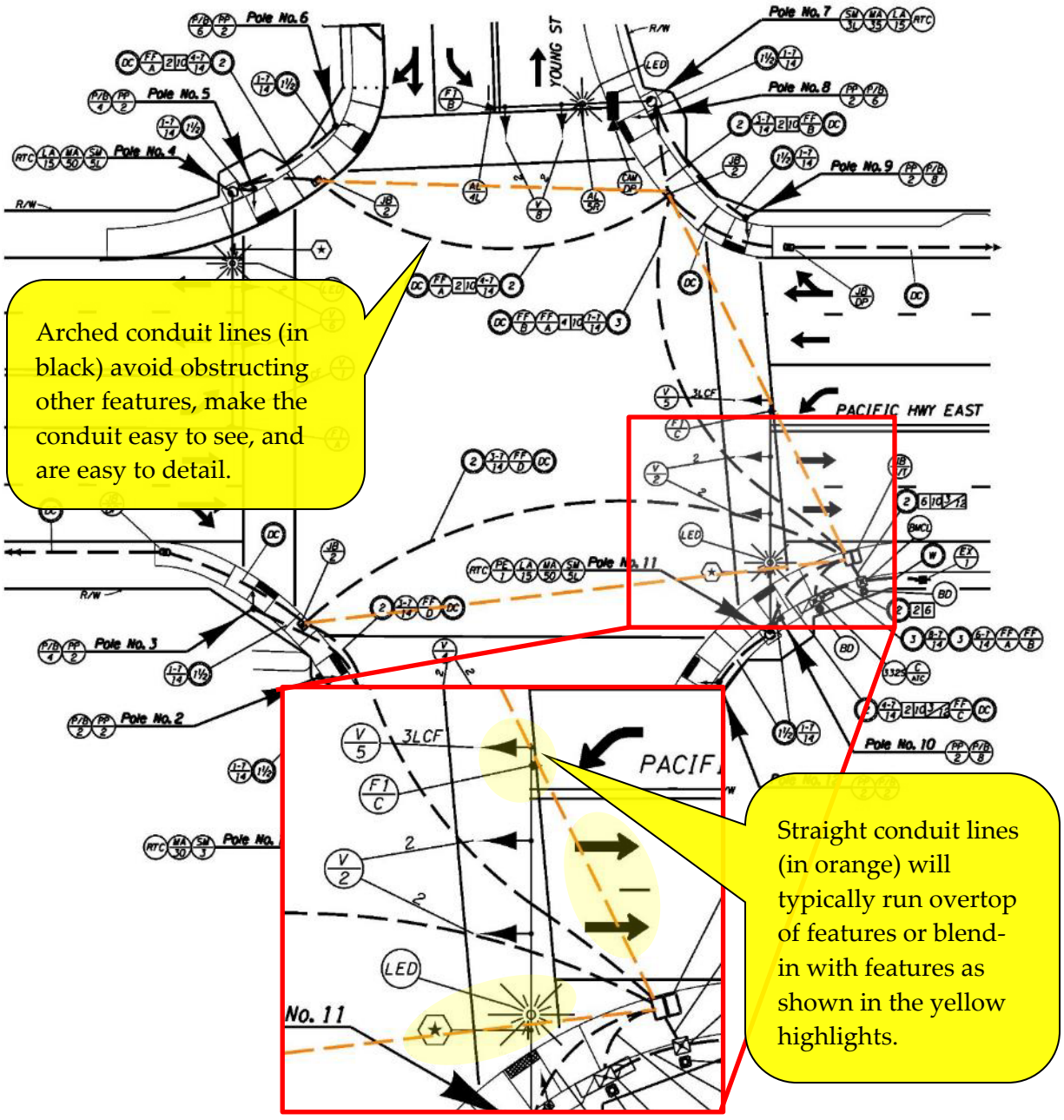


When detailing existing features, always verify if an existing symbology is applicable.

21.8.2 Showing Conduit Runs

It is important to show the conduit runs in a way that is readable and doesn't obscure or clutter other features. This is typically done by arching long conduit runs. The contractor will install the conduit as straight as possible between the beginning and ending point as per the standard drawing TM471 (which states that conduit runs shown on plans are for bidding purposes only and locations may be changed to avoid obstructions), but the arching makes the plan sheet much more readable. See Figure 21-27 for example.

Figure 21-27 | Arching Conduit Runs Example



21.8.3 Pole (and Pedestal) Numbering

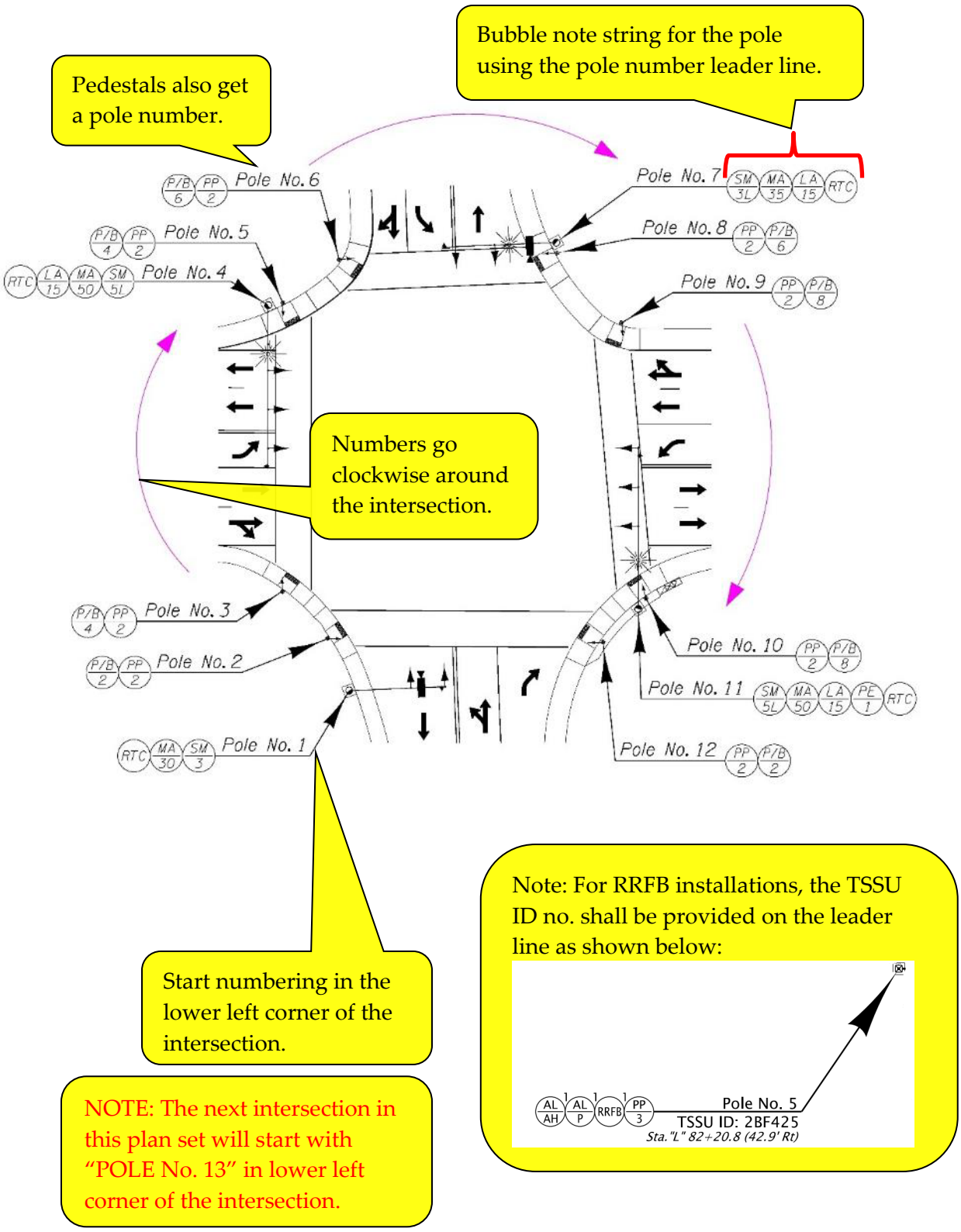
All poles and all pedestals (including all temporary) are numbered starting from the lower left corner of the intersection in a clockwise direction. Plans having poles at more than one intersection shall have the poles numbered consecutively starting with the first intersection shown in the plan set and ending with the last intersection shown in the plan set. It is important that each pole and pedestal in the plan set has a unique number as it lessens the chance for error. For example, if there is only one pole number 3 on the project, there is no confusion about what pole you are referencing. If there are three poles labeled number 3 in the same plan set (e.g., pole no. 3 at Main Ave. @ 1st St, pole no. 3 at Main Ave. @ 2nd St., and pole no. 3 at Main Ave. @ 3rd Street) extra info is needed to identify which pole is being referenced and design information for each of those poles can easily get mixed up. For this reason, using letters in conjunction with the number (e.g., 3A, 3B, 3C, etc.) should also be avoided, but may be used if a pole/pedestal needs to be added to the project **during the construction phase.** If a pole needs to be added late in the design phase, the poles should be re-numbered accordingly.

Only the existing poles and pedestals that have work on them (e.g., replacing signal heads or pedestrian pushbuttons) are required to be numbered as it is necessary to include information about the work on these poles in the pole entrance chart. However, existing poles and pedestals without work on them may also be numbered if it helps with clarity.

A large arrow with the pole number along the leader line is used for each pole and pedestal. For RRFB installations, the TSSU ID number shall be provided on the leader line. Additional information about the pole location can also be provided on the leader line as necessary (e.g., station and offset, reference to ADA curb ramp plan sheets, etc.), however, this information is typically not necessary to include as the signal design CADD files (which are coordinate correct) are used during the construction process to verify equipment location based on survey data. The leader line for the pole numbering should also be used for the bubble note string associated with the pole, rather than using a separate bubble note leader line.

See Figure 21-28 for an example of pole numbering and bubble note strings.

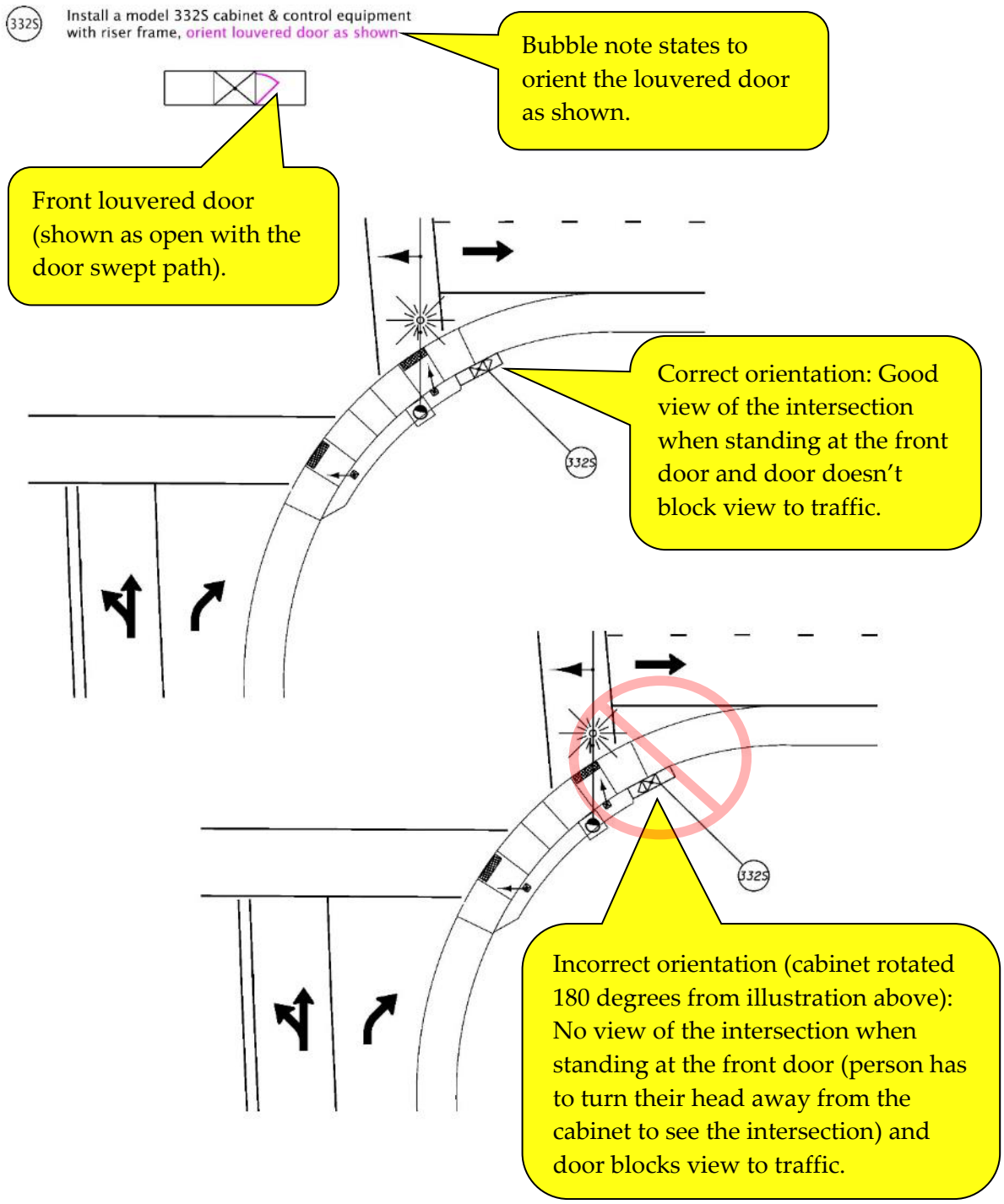
Figure 21-28 | Pole Numbering and Bubble Note Strings



21.8.4 Controller Cabinet Orientation

The controller cabinet symbology and associated bubble have a specific orientation that needs to be shown correctly on the plan sheets as per the guidance in chapter 5. See Figure 21-29.

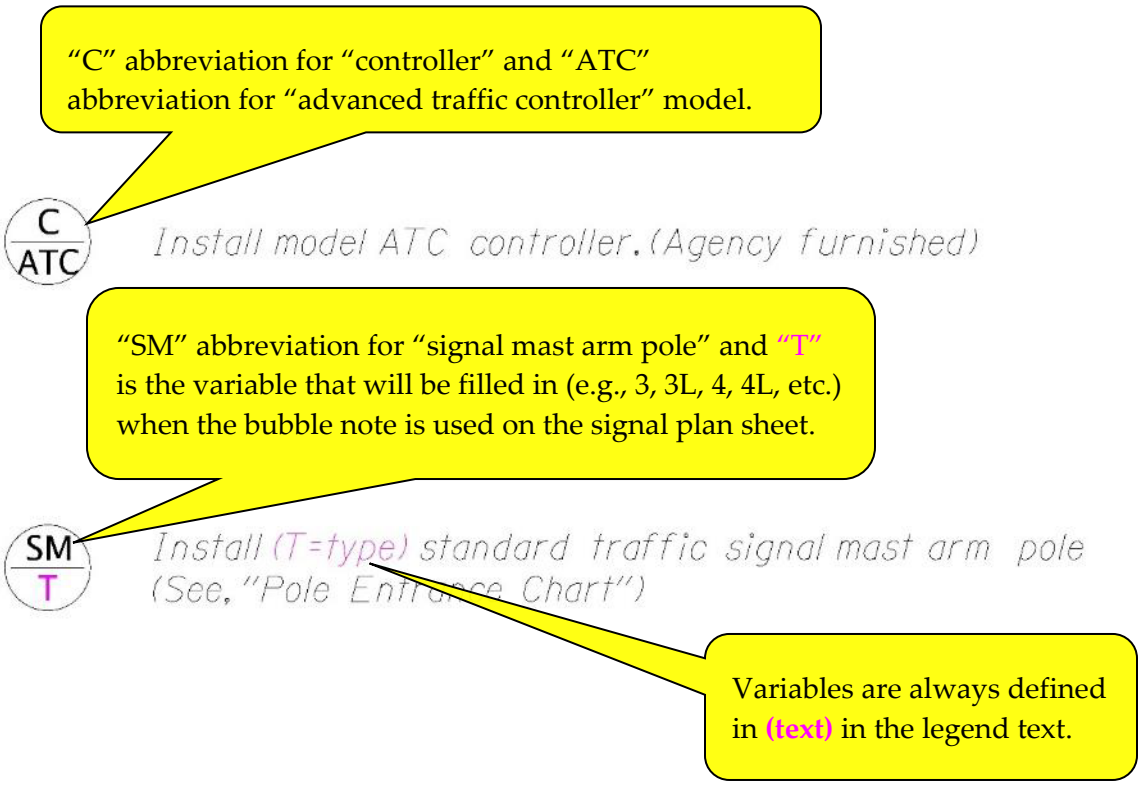
Figure 21-29 | Controller Cabinet Symbology



21.9 Bubble Notes

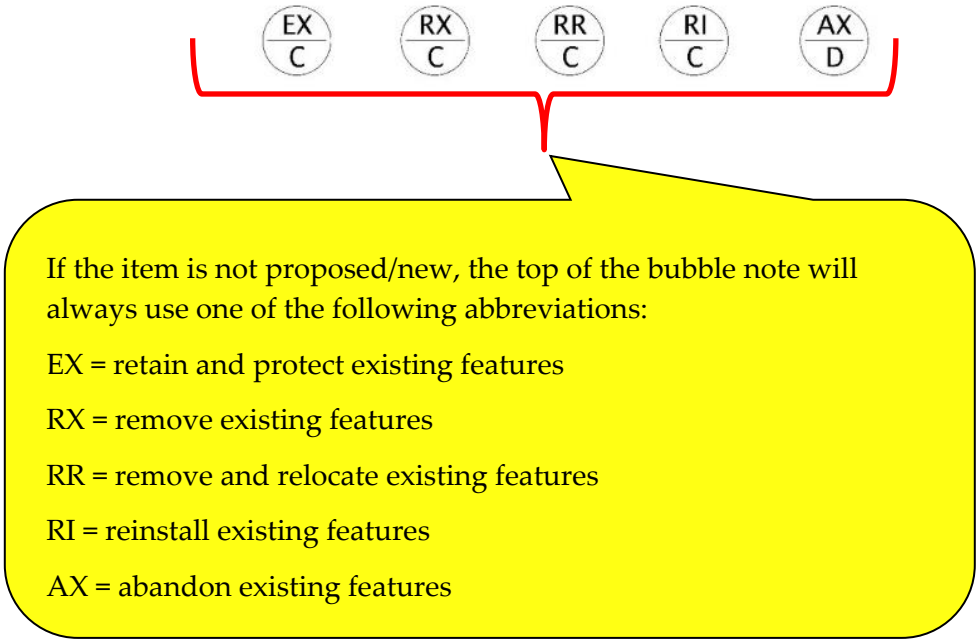
Bubble notes are used in conjunction with the standard drafting symbology to provide specific information about the work to be done. The bubble notes have been designed to be "intelligent" using abbreviations and variables, such that an experienced user will be able to read the signal plan sheets without much assistance from the bubble note legend text. See Figure 21-30 for basic bubble note structure of proposed/new items.

Figure 21-30 | Basic Bubble Note Structure for Proposed/New Features



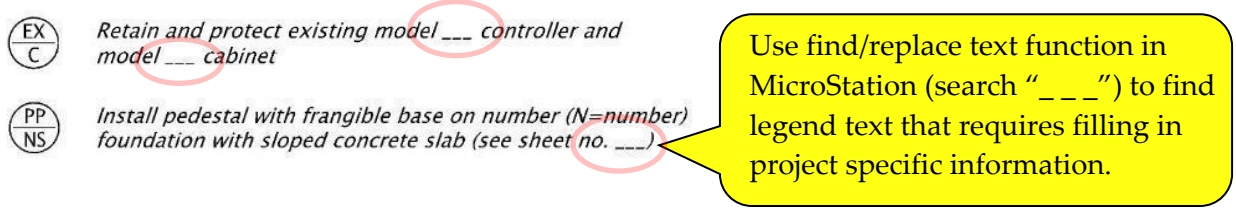
Bubble notes also have a specific structure when used for items that are not proposed/new, such as existing (retain and protect), remove, remove & relocate, reinstall, and abandon. See Figure 21-31. Note that these bubble note categories may only have a few standard options in the workflow. For example, the only standard abandon bubble notes are for loop detectors and conduits. This is intentional; typically, these are the only traffic signal features that have been deemed appropriate to abandon as per the design guidance contained within this manual.

Figure 21-31 | Basic Bubble Note Structure for Features that are not Proposed/New



Certain bubble notes have a location in the legend text that will need to be filled out. These are easily found by using the find/replace text function in MicroStation and searching for three underscores (no spaces): "_ _ _". See Figure 21-32.

Figure 21-32 | Bubble Note Text Examples That Requires Filling in Project Specific Information



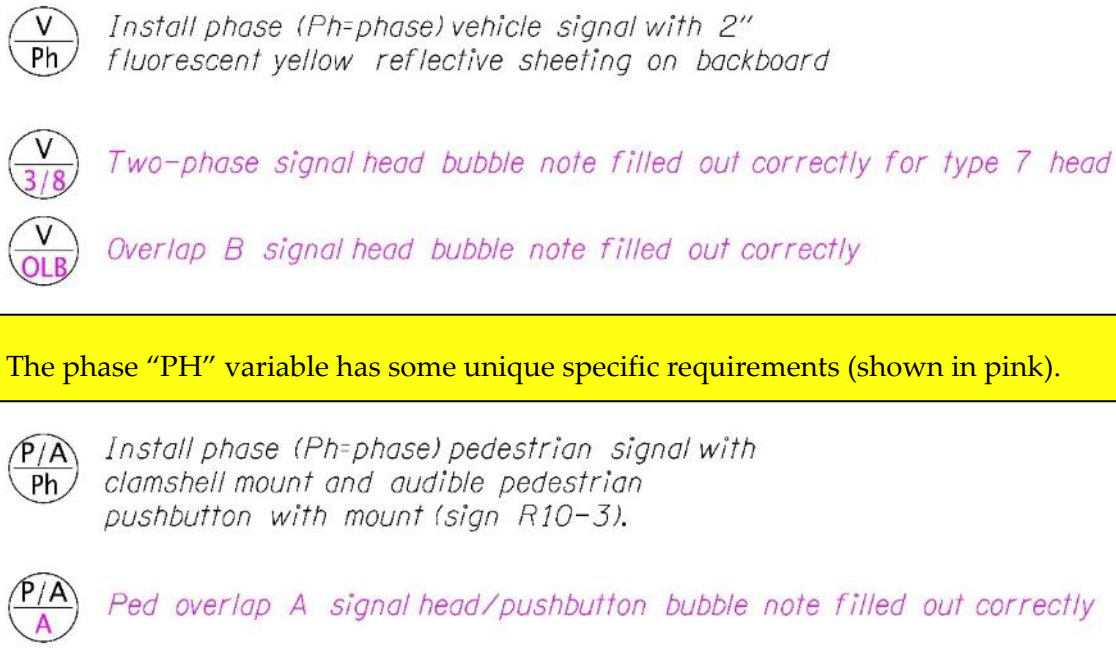
Only modify the standard bubble notes and legend text (found in the workflow) when absolutely necessary, as modifications can be easy for others to overlook. In cases where modification of a bubble note is necessary, using a brand-new custom note may be a better solution to highlight the unique work. The state traffic signal engineer will approve any custom bubble notes.

21.9.1 Filling Out Bubble Note Variable Correctly

For most bubble note variables, it is obvious how they should be filled out. However, the phase "PH" variable is not as intuitive, especially for complicated signal phasing. The following list provides guidance for properly filing out this variable for specific situations (see Figure 21-33):

- Two-phase vehicle signal heads (Type 4L, type 5, and type 7) require listing both phases in "V/PH" bubble note. Note: while flashing yellow arrow signal head types (Type 3LBF, 3LCF, 3RCF, and 6L) may technically be considered a two-phase signal head, only the protected left turn phase is listed in the bubble note.
- Overlap phases for vehicle signal heads shall use "OLA", "OLB", "OLC", etc. as the variable in the "V/PH" bubble note.
- Overlap phases of pedestrian signal heads/pushbuttons shall use "A", "B", "C", etc. as the variable in the pedestrian signal/pushbutton bubble note series.

Figure 21-33 | "PH" Phase Bubble Note Variable Examples

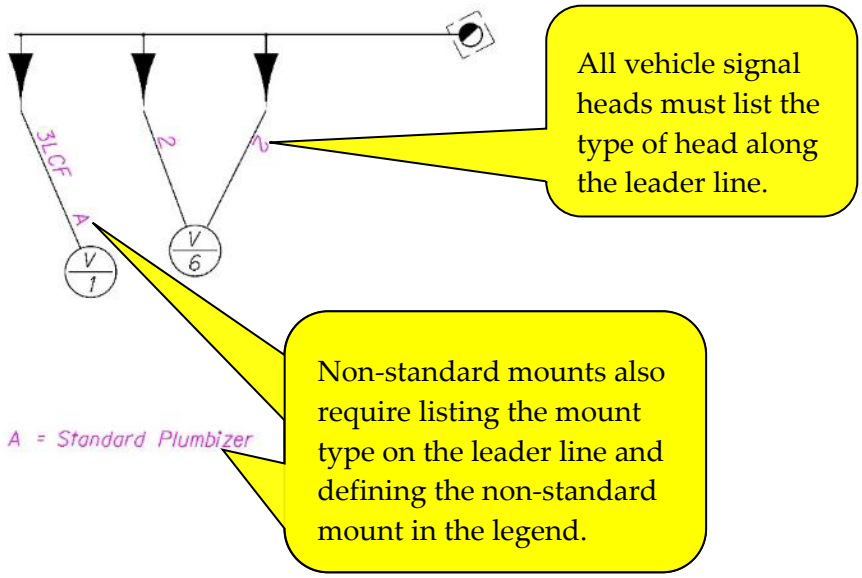


21.9.2 Leader Line Information

Certain bubble notes require providing additional information along the leader line. See the following list and Figure 21-34.

- The signal head type shall be placed on the leader line for the "V/PH" bubble note.
- If a non-standard mount is used for equipment on the signal pole, mast arm, or pedestal (e.g., standard plumbizer, elevator plumbizer, pipe bracket, etc.), the mount type shall be placed on the leader line of the appropriate bubble note. The non-standard mount abbreviation will need to be defined in the legend sheet. DO NOT list standard mounts on the leader line (e.g., spanwire hanger, vehicle signal bracket, sign bracket, clamshell, etc.).

Figure 21-34 | Standard Leader Line Information



Leader line information for equipment that will be removed and relocated (e.g., temporary traffic signal with several construction stages) can be very helpful and should be used if it adds clarity. See section 21.9.7 and Figure 21-41 for an example.

21.9.3 Creating and Reading Bubble Note Strings

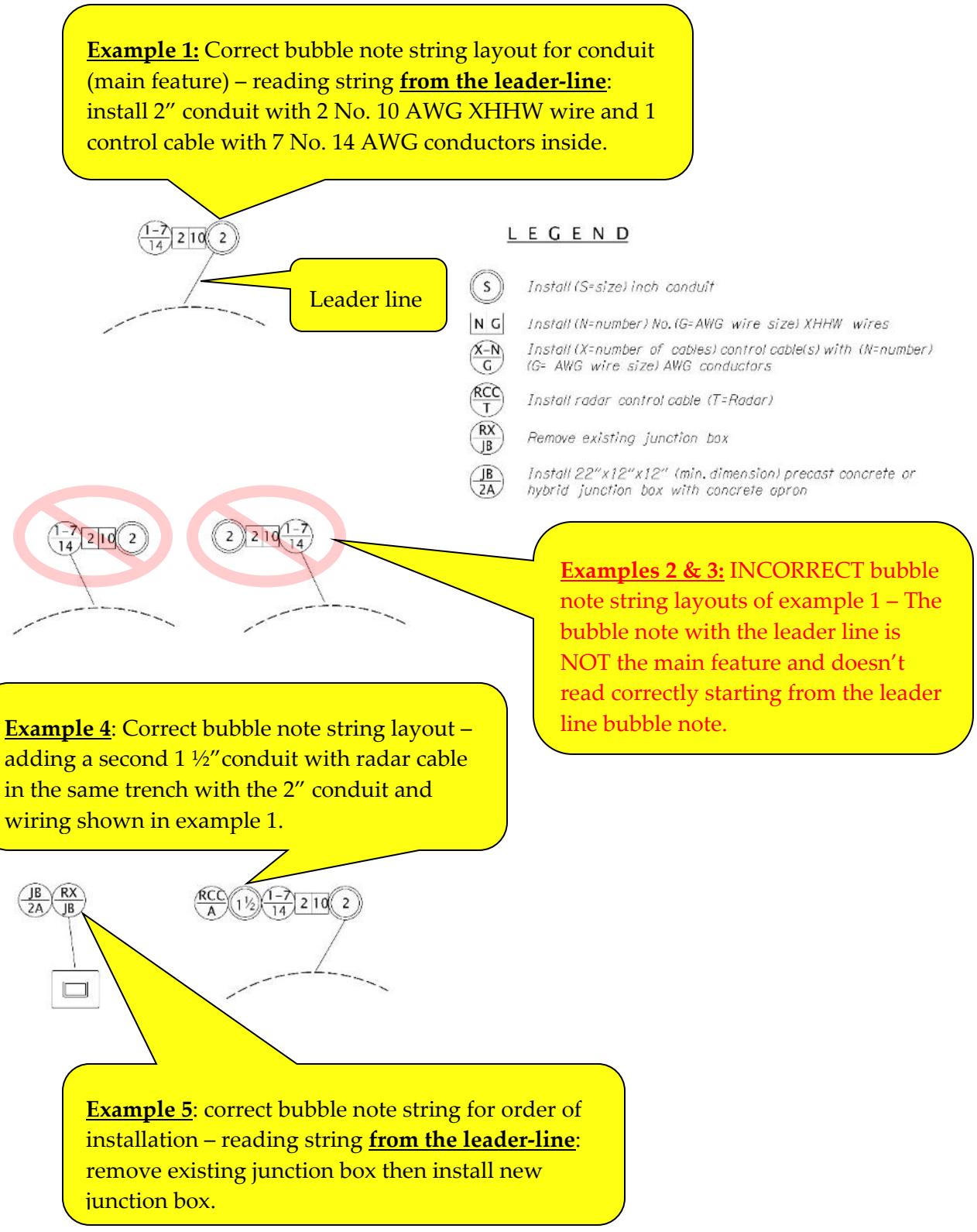
Bubble notes are placed with a leader line that points to the applicable feature. Certain features require multiple bubble notes, with each subsequent bubble note attached to the previous bubble note. This is called a bubble note string. The order of the bubble notes in the bubble string is also important and conveys information. The bubble note with the leader line attached to it is the starting bubble note and will identify the main feature and/or the order of installation. The subsequent bubble notes in the bubble note string will identify the other features either attached to or installed inside of the main feature and the logical order for installation. For example:

- The bubble note for a new conduit (main feature) will be followed by bubble notes for the wire/cables contained within that conduit. Additional conduits in the same trench are added on in the same manner (conduit note first, followed by notes for wires installed inside of that conduit)
- The bubble note for a mast arm pole (main feature) will be followed by the bubble notes for the mast arm, the pedestrian signal indications, recessed terminal cabinet, and luminaire arm that are attached to it.
- The bubble note for removal of a junction box (main feature) may be followed by the bubble note for installation of a new junction box to indicate the logical installation sequence.

Unlike reading text which starts from left and goes to right, when reading bubble note strings, always start **from** the leader line and read going towards the end of the bubble note string.

See Figure 21-35 for examples of creating and reading bubble note strings.

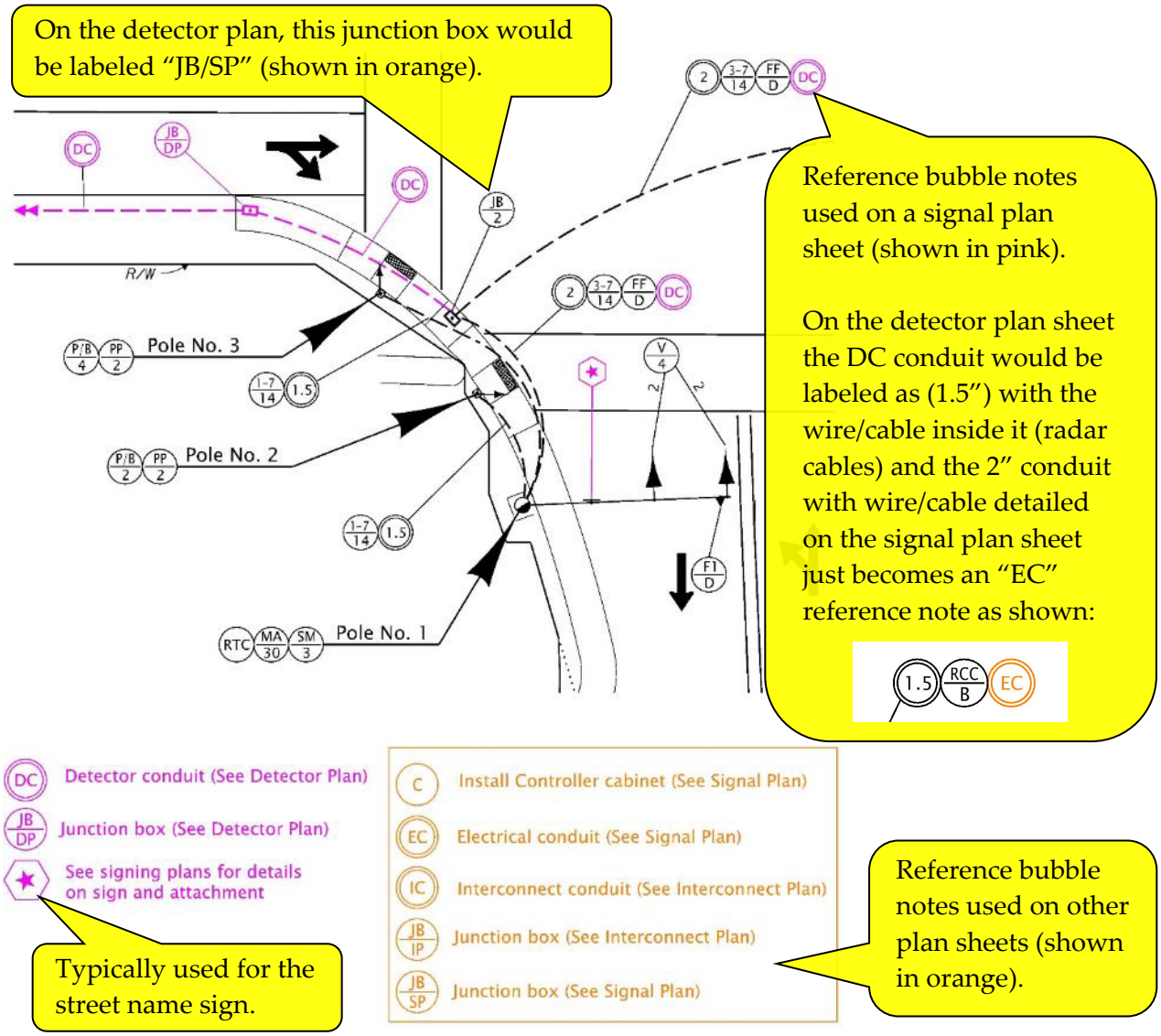
Figure 21-35 | Creating and Reading Bubble Note Strings



21.9.4 Reference Bubble Notes

Reference bubble notes are used in traffic signal plans as some of the features installed on one plan sheet will also be used or shown on another plan sheet (typically applies to conduits, junction boxes, controller cabinets, and certain signs). For example, junction boxes installed for the signal installation (on the signal plan) that are also used for the interconnect system (on the interconnect plan sheet). If the junction box on signal plan sheet uses an "install" note and that same junction box is also labeled with a "install" note on the interconnect plan sheet, it can get confusing how that one junction box is paid for (is it under the traffic signal bid item or the interconnect system bid item?) or if two separate junction boxes in the same area should be installed. Using reference bubble notes makes the design intent and payment very clear. See Figure 21-36 for example.

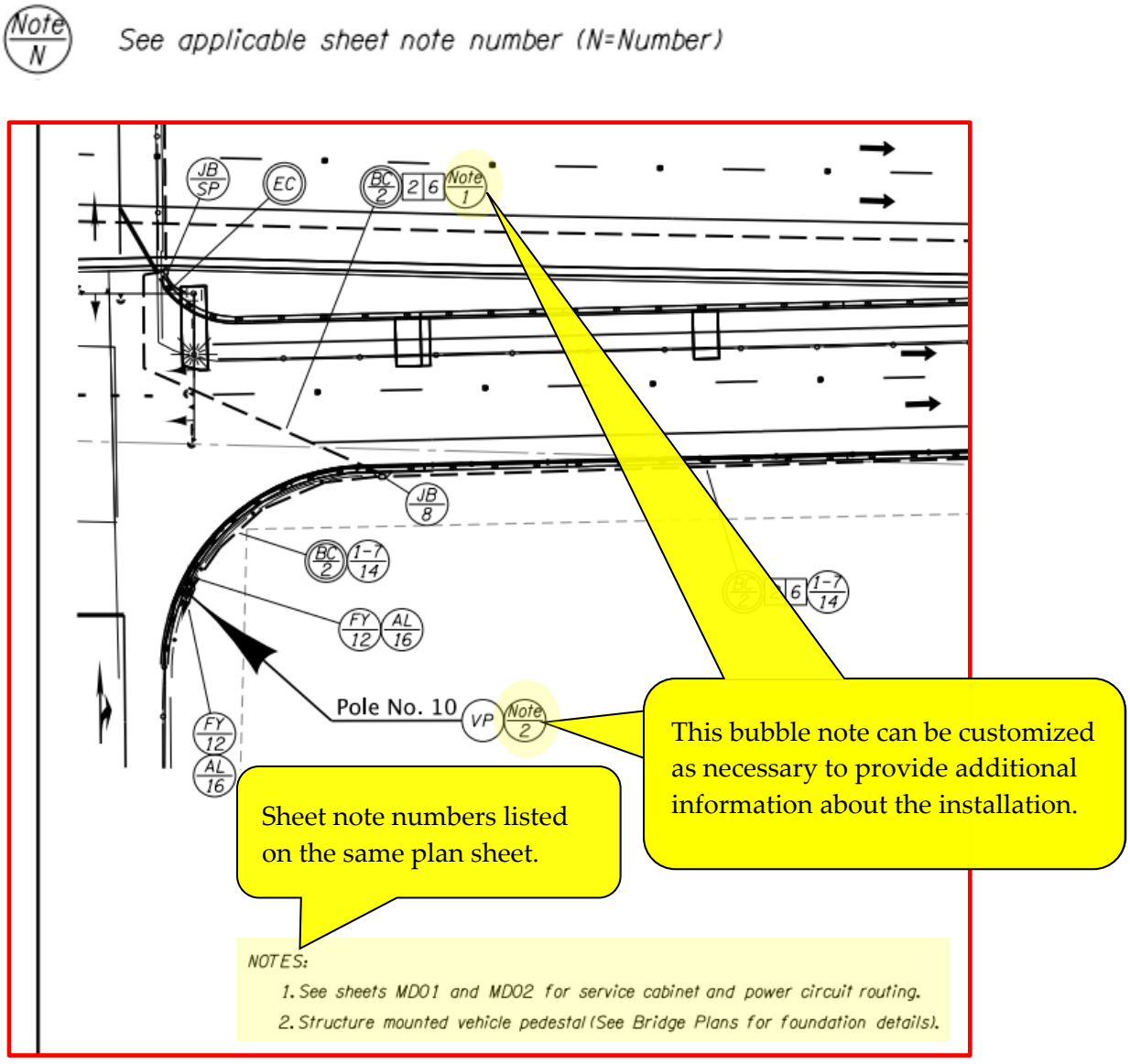
Figure 21-36 | Signal Plan Reference Bubble Note Example



21.9.5 Miscellaneous Customizable Bubble Note

When project specific information needs to be conveyed on a plan sheet, a miscellaneous customizable bubble note should be used. See Figure 21-37 for an example.

Figure 21-37 | Miscellaneous Customizable Bubble Note Example



21.9.6 Use of "EX" Bubble Notes

Plan sheets should only detail the work to be done and just show the symbology for the other signal equipment that is not impacted by the work. Place a reference to the prior plan sheets so that finding information on the signal equipment that is just shown symbolically is easier and it also makes it clear that any items not detailed on the plan sheet are to be retained and protected. See Figure 21-38 for example note referencing prior plan sheets. This simplifies the plan sheet and makes it much easier to see what work needs to be done. See Figure 21-39 for an example of properly detailed work and symbology for all other existing equipment.

Figure 21-38 | Referencing Prior Plan Sheets

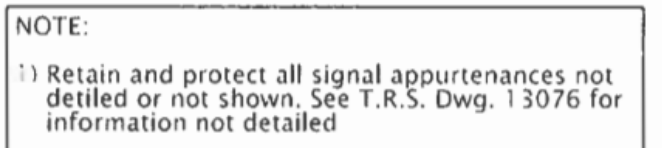
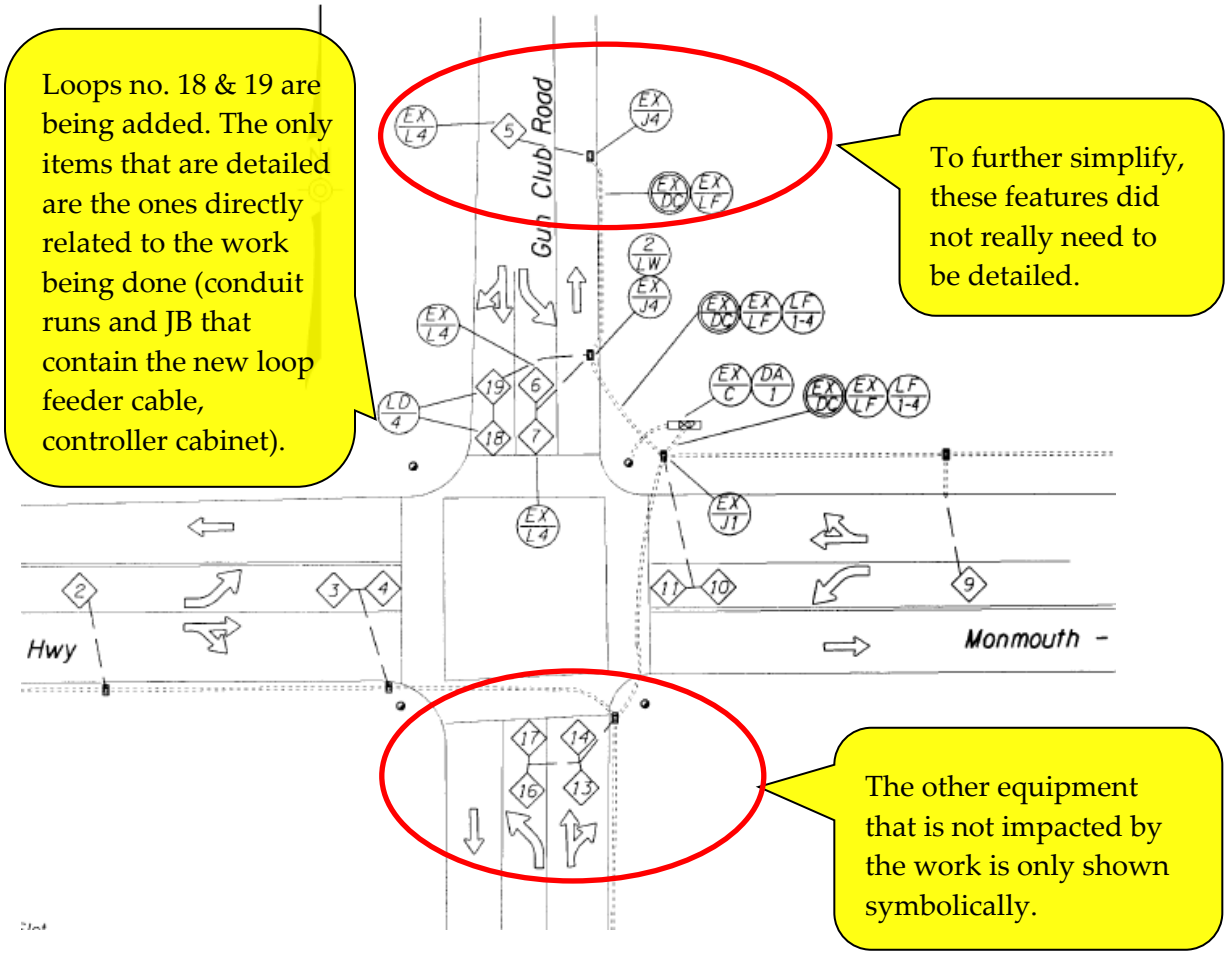
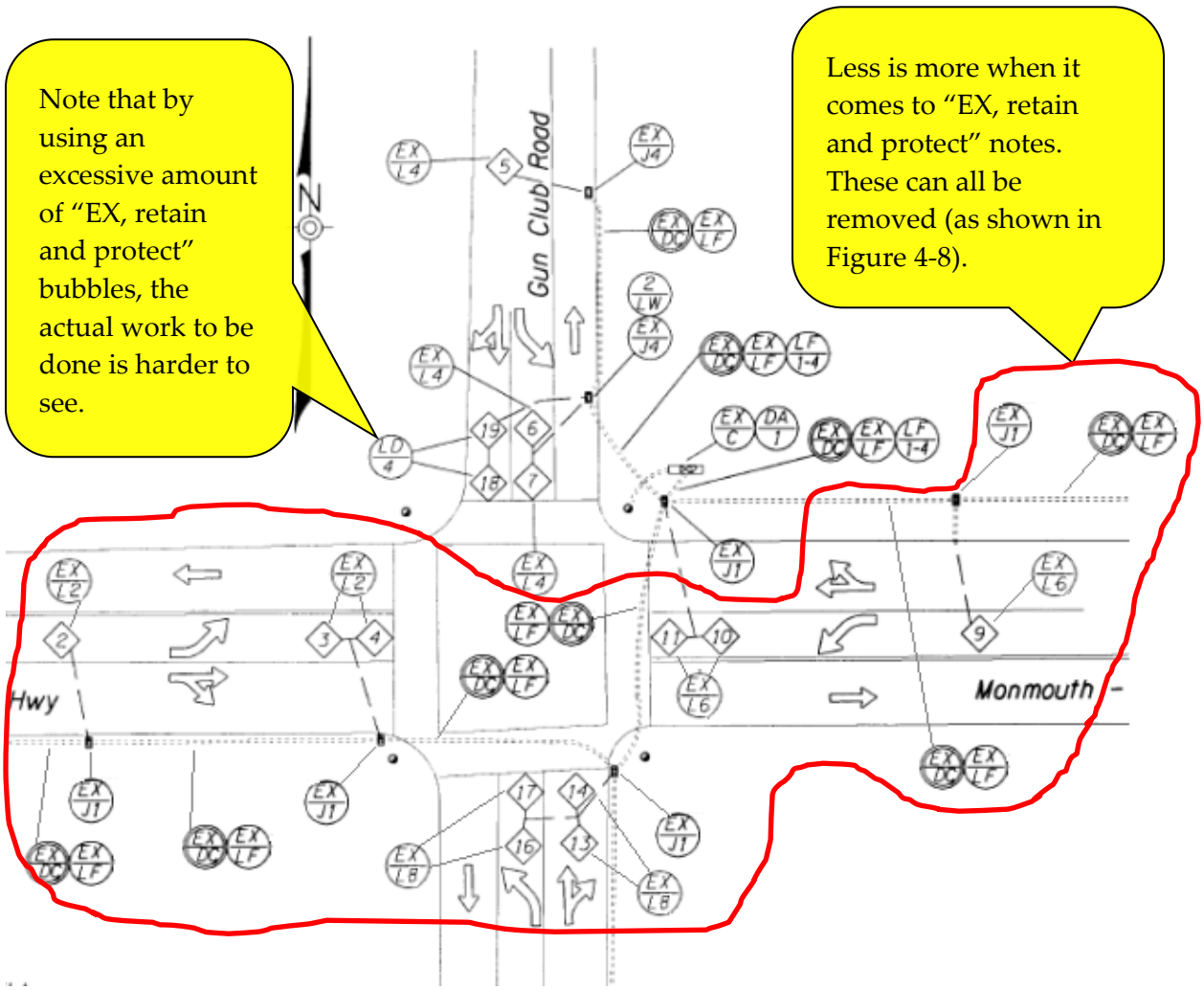


Figure 21-39 | Only Detailing Work to be Done (Preferred Method)



Avoid detailing any equipment that is not impacted by the work to be done (e.g., placing a large amount of "EX, retain and protect" bubble notes). This tends to add little value and instead clutters the drawing making it easier to miss what work needs to be done. See Figure 21-40 for an example of excessive use of "EX, retain and protect" bubble notes.

Figure 21-40 | Detailing Equipment Not Impacted by the Work (Avoid this Method)

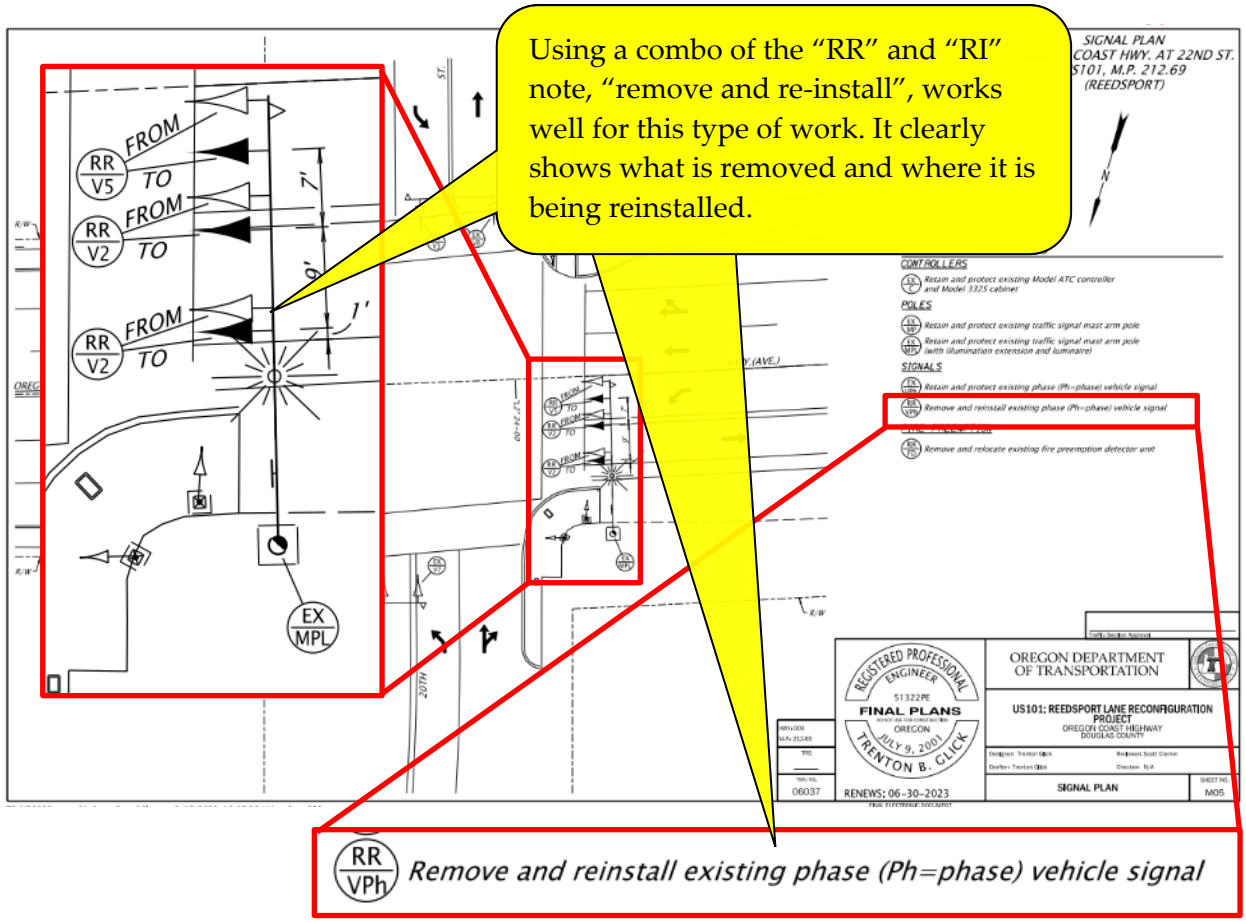


21.9.7 Use of "RX", "RR", and "RI" Bubble Notes

The remove & relocate and reinstall bubble notes are not frequently used as it is usually desirable and more cost effective to just remove the existing equipment and install all new equipment for a project. The equipment that was removed can still be salvaged if it is still in good condition and the electrical crew wants it. However, there will be cases where removing/relocating/reinstalling equipment makes the most sense (e.g., state force work and temporary signal work).

Note the remove and relocate bubble notes ("RR") or reinstall ("RI") may be combined into a "remove and reinstall" bubble note with use of "TO" and "FROM" on the leader line to show where the equipment is being removed *from* and where it is being reinstalled *to*. This works very well for certain types of work (e.g., adjusting signal head locations on the same mast arm) See Figure 21-41. If the equipment being removed is located too far away from where it will be reinstalled (or shown a different plan sheet), the standard "RR" and "RI" bubble notes are the only option.

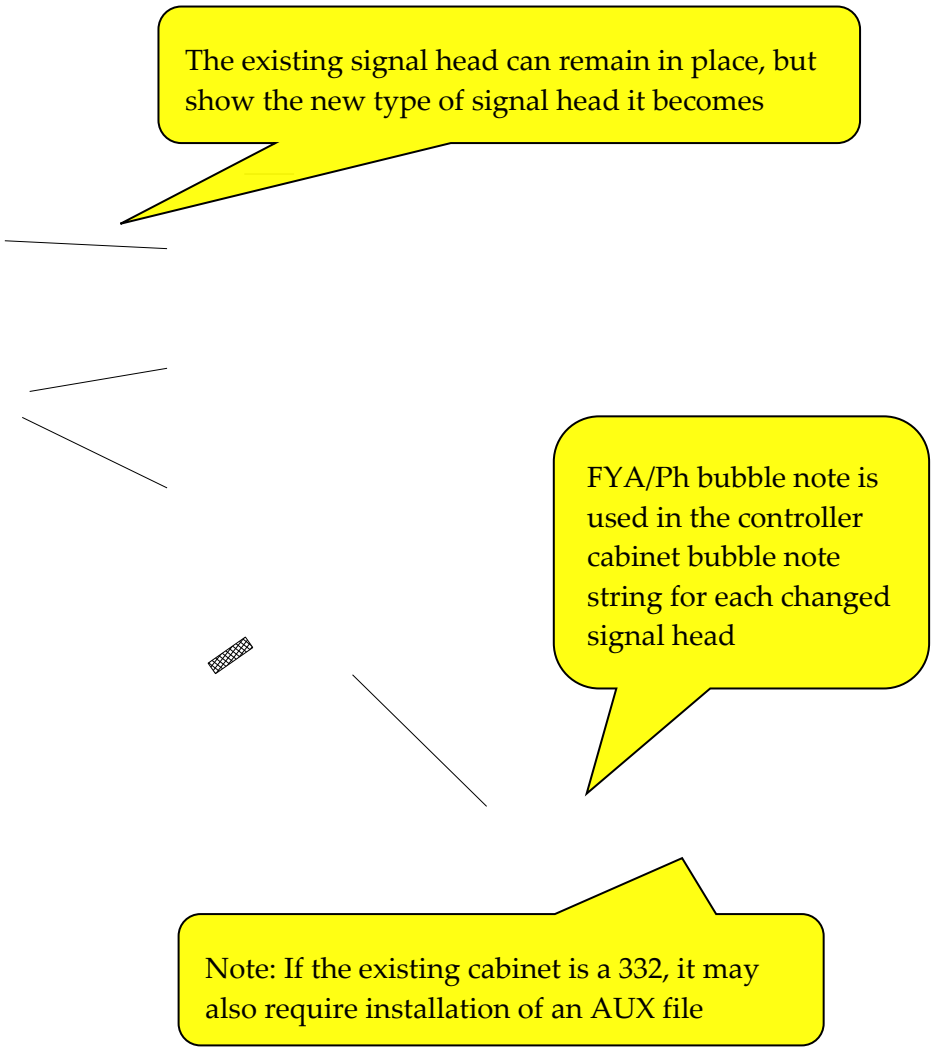
Figure 21-41 | Remove and Reinstall Combined Bubble Note



21.9.8 Updating Type 3L to Type 3LCF Signal Heads

When type 3L signal heads are converted to type 3LCF signal heads, there is a specific way to show this unique work on the signal plan sheet. See Figure 21-42.

Figure 21-42 | Updating Type 3L to Type 3LCF Signal Heads



21.10 Specific Plan Sheet Content Requirements

This section of the manual lists the required content and some good examples for each specific title of plan sheet. The state traffic signal engineer may allow exceptions based on a case-by-case basis.

21.10.1 Legend Plan Sheet

The legend plan sheet shall include the following:

- List all bubble notes that are used on the project. Projects that have a lot of bubble notes should be categorized under the correct sub-heading heading (e.g., "poles", "conduits", "controllers", etc.)
- Show all vehicle signal head types used on the project
- Show cross-reference to all other plan sheets in the signal plan set that are using this legend sheet via the upper right corner title information.
- Show all the applicable standard drawings (typ. TM400 series and TM600 series) that will be needed for the project in the "accompanied by" box in the MicroStation workspace. This box is only used once, always on the first sheet of M series (which is typically the legend sheet).

The legend plan sheet may also include other information as necessary (for example, the normal phase rotation diagram and fire preemption diagram if there is not enough room to place it on the signal plan sheet).

Note that a separate legend sheet may not be necessary if the legend information can fit on the actual plan sheet(s). This is advantageous for smaller scopes of work. It also makes reading the plan sheets a little easier as all necessary information is contained on a single plan sheet. A separate legend sheet is advantageous for large projects (only drafting one list of bubble notes vs. drafting multiple lists of bubble notes for each sheet) and may be the only option if space on the actual plan sheet(s) is tight. See Figure 21-43 for an example of a separate legend sheet and Figure 21-44 for an example of the legend information shown on the actual plan sheet.

Legend plan sheet specific MicroStation workflow items to aid in drafting:

- Sheet Tools → Legends 1 Column
- Sheet Tools → Legends 1 Column Cont.
- Sheet Tools → Legend 2 Column
- Sheet Tools → Accompanied By (box)
- Sheet Tools → Signal/Sign Mount Opt (heading list)
- Sheet Tools → Signal Note Tool (contains the legend sub-headings, signal head types, and all standard bubble notes)

Figure 21-43 | Legend Plan Sheet Example

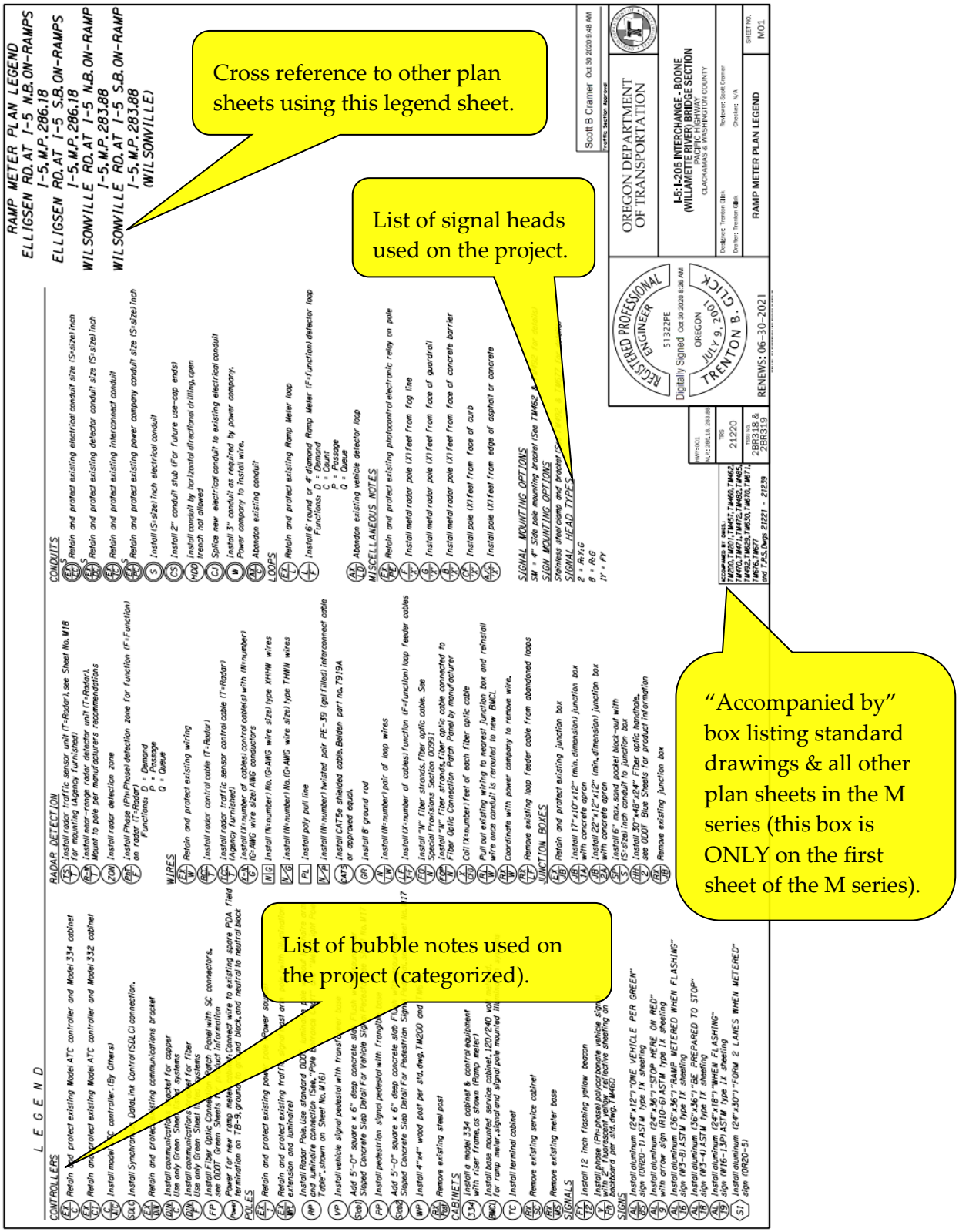
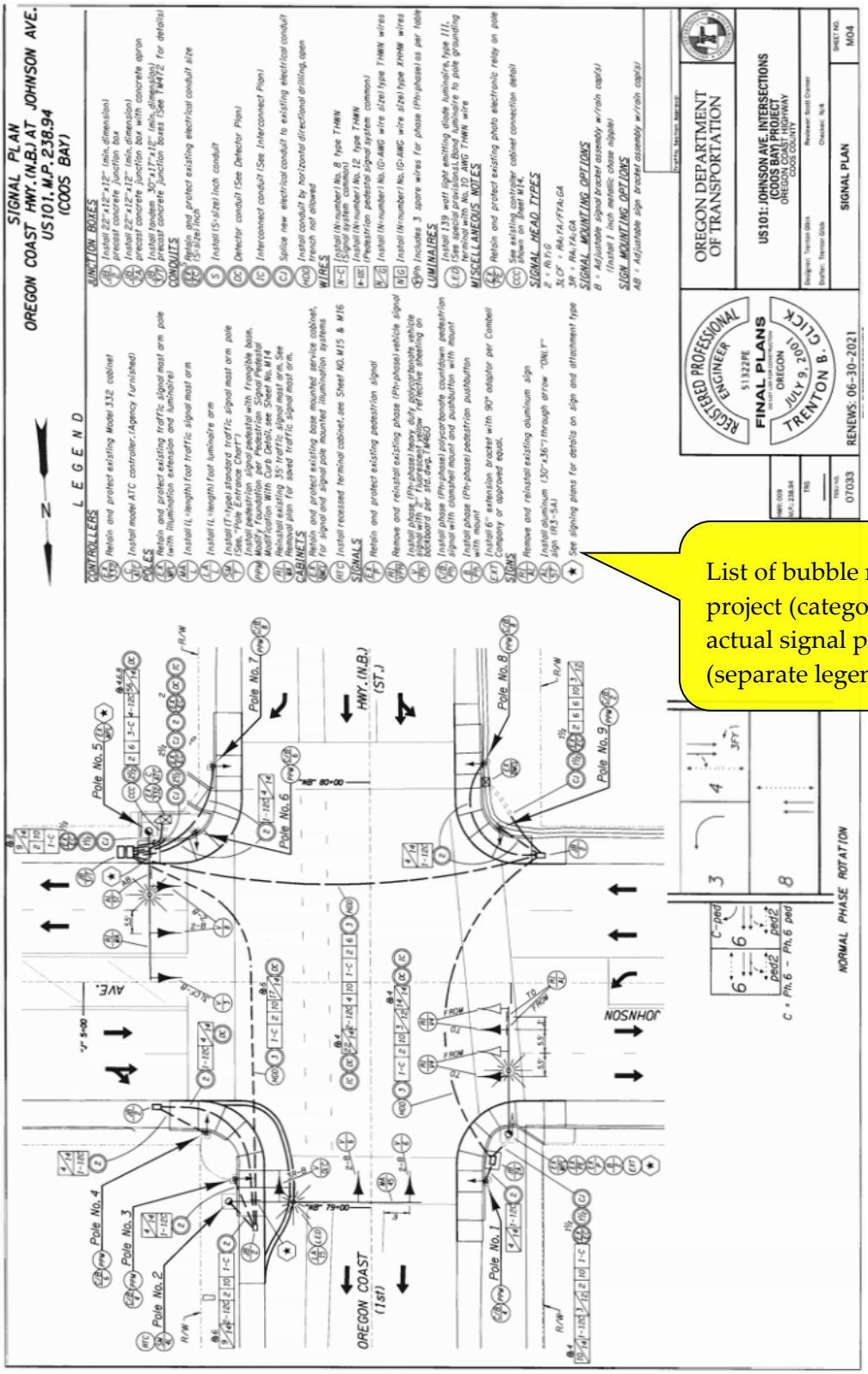


Figure 21-44 | Legend Information Shown on the Plan Sheet (No Separate Legend Sheet)



List of bubble notes used on the project (categorized) on the actual signal plan sheet (separate legend not necessary).

21.10.2 Removal Plan

The removal plan shall include the following:

- Existing feature symbology (e.g., poles, wires, vehicle signals, pedestrian signals, overhead signs, controller cabinet, service cabinet, etc.)
- Proper detailing: bubble note(s) with leader lines to each feature that is removed or abandoned under the 00950 removal bid items (see chapter 19).

If the project requires a *complete* removal/abandon of all appurtenances at a traffic signal, the removal plan may just show the standard removal note (modified as necessary) with the plan view symbology of the existing traffic signal symbology vs. using detailing out all of the existing equipment with "RX" and "AX" bubble notes. See Figure 21-45 for example of using the removal note. For some installations where it may not be clear what comprises the "entire system" to be removed or there are multiple systems that need to be removed at the same intersection, detailing with the appropriate "RX" and "AX" bubble notes may be more appropriate. See Figure 21-46.

A separate removal plan sheet may not be necessary if the information can be fit and be shown clearly on the actual plan sheet(s). This is generally advantageous for small or partial removal work. See Figure 21-47 for example of the removal information shown on the actual plan sheet.

Removal plan sheet specific MicroStation workflow items to aid in drafting:

- Sheet Tools → Remove Entire Signal (note)

Figure 21-45 | Removal Plan Example – Standard Removal Note for Entire Traffic Signal

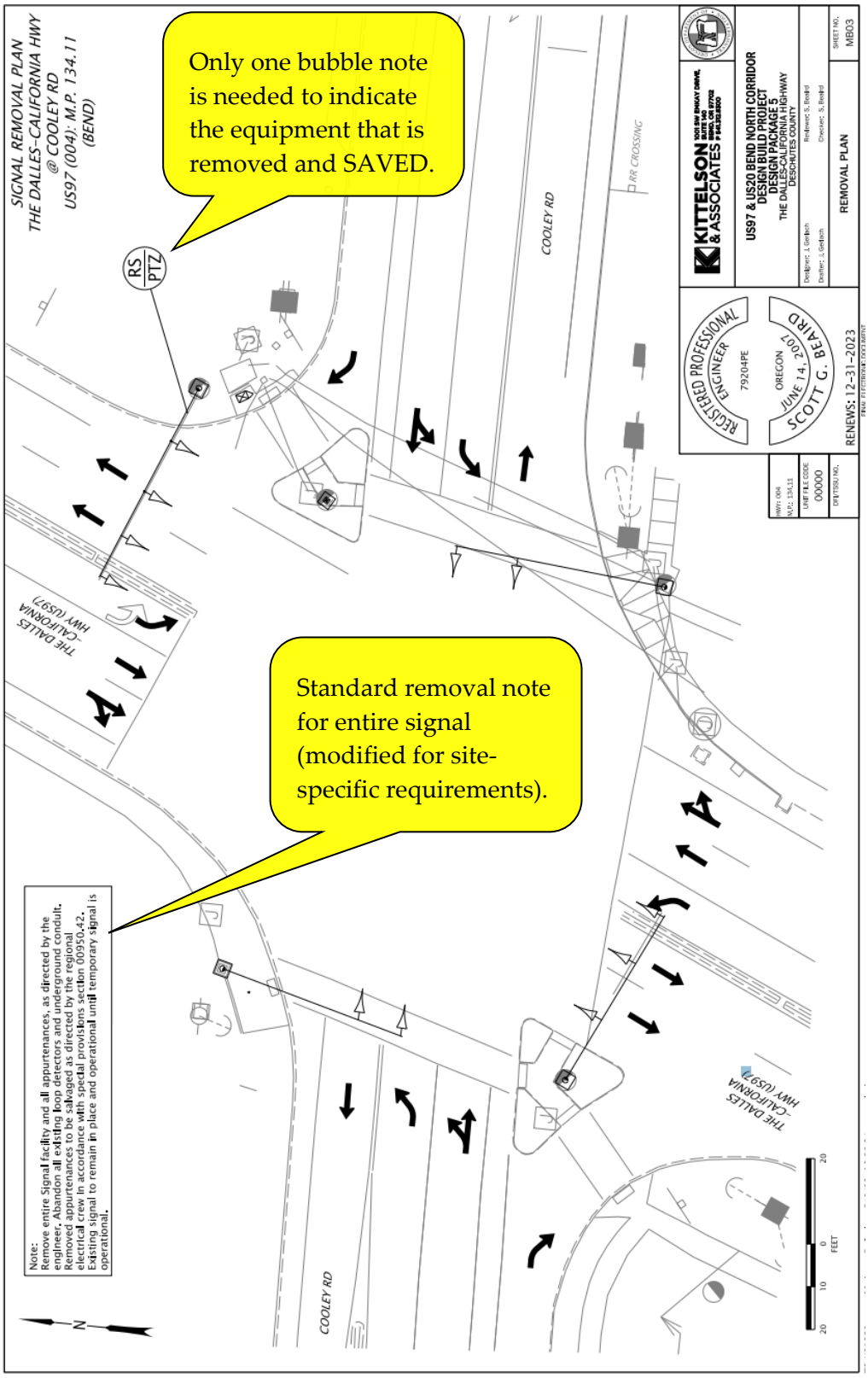
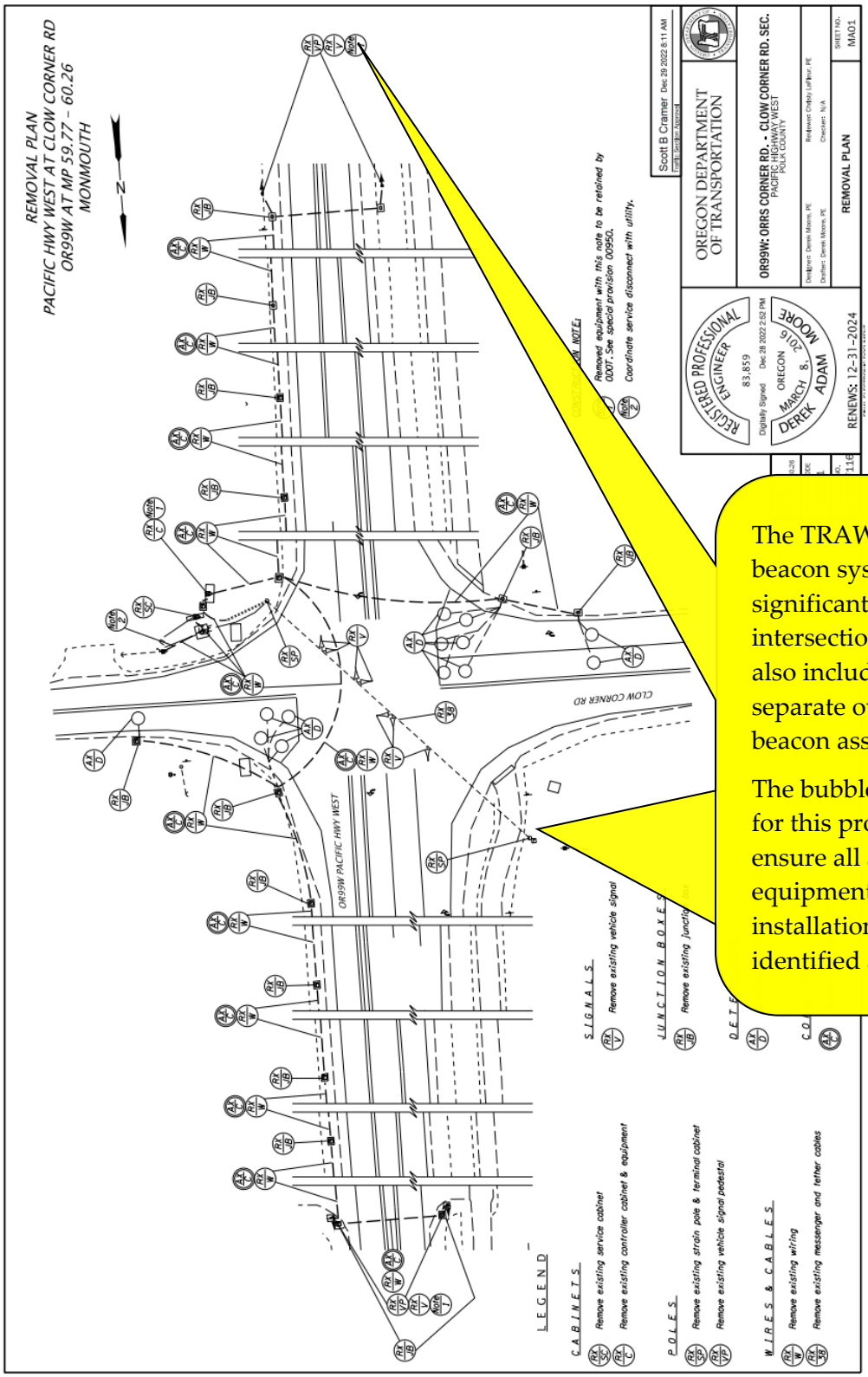


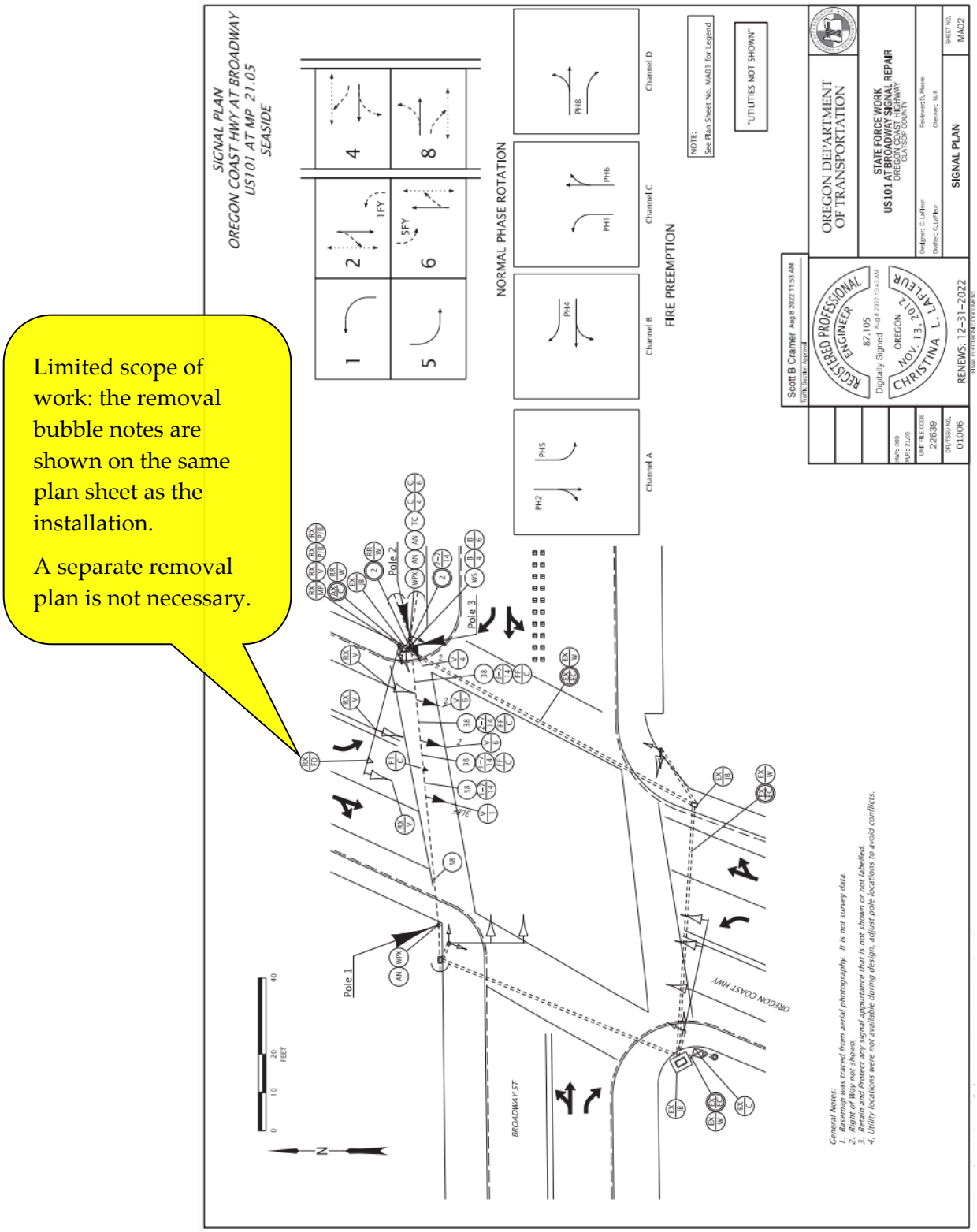
Figure 21-46 | Removal Plan Example – Detailing With "RX" and "AX" Bubble Notes



The TRAWS flashing beacon system extends significantly beyond the intersection and the project also includes removing a separate overhead flashing beacon assembly.

The bubble note detailing for this project helps ensure all associated equipment with BOTH installations is properly identified and addressed.

Figure 21-47 | No Separate Removal Plan - Removal Information Shown on the Installation Plan



21.10.3 Signal Plan

The signal plan shall include the following as applicable for the scope of work (see Figure 21-48 through Figure 21-50 for good examples):

- Normal phase rotation diagram (may be shown on the legend sheet if there is not enough room for it on the signal plan sheet)
- Fire preemption phase diagram (may be shown on the legend sheet if there is not enough room for it on the signal plan sheet)
- Proposed/new feature symbology:
    - Power source (existing or new)
    - Controller cabinet
    - Service cabinet
    - Mast arm poles and pedestals – labeled with pole numbers (See section 21.8.3)
    - Illumination equipment that is part of the traffic signal installation
    - Vehicle and pedestrian signal heads
    - Pedestrian pushbuttons
    - Signs mounted on mast arm/mast arm pole (e.g., street name signs, lane use signs, PTR signs)
    - Fire preemption devices
    - Crosswalk closed supports
    - Junction boxes, conduit, and wires/cables for the signal system
    - Non-invasive detection equipment and wires/cables (as per chapter 6). Detection zones are NOT shown on plan sheets (shown on cabinet print as per chapter 20)
    - Railroad specific: Railroad bungalow, junction boxes, conduit, and wiring (as per chapter 16)
- Proper detailing: bubble note(s) with leader lines to each feature that will be installed as part of the 00990 traffic signal bid items (See chapter 19).
- Use appropriate reference bubble notes:
    - "DC" and "IC" bubble notes reference detector and interconnect plans for conduit respectively
    - The hex star bubble note references signing plans for street name signs, crosswalk closure supports, etc.

Signal plan sheet specific MicroStation workflow items to aid in drafting:

- Sheet Tools → Pole Number Tx
- Sheet Tools → Pole Arrow
- Sheet Tools → Utilities Not Shown (text box)
- Sheet Tools → Legend Cross Ref (text box)
- Sheet Tools → Right of Way (text box)
- Signal Plans Symbology → Wheelchair Design Vehicle
- Signal Plans → Phase Rotation Dia
- Signal Plans → Fire Preemption

Figure 21-48 | Signal Plan Sheet Example 1 (New Signal)

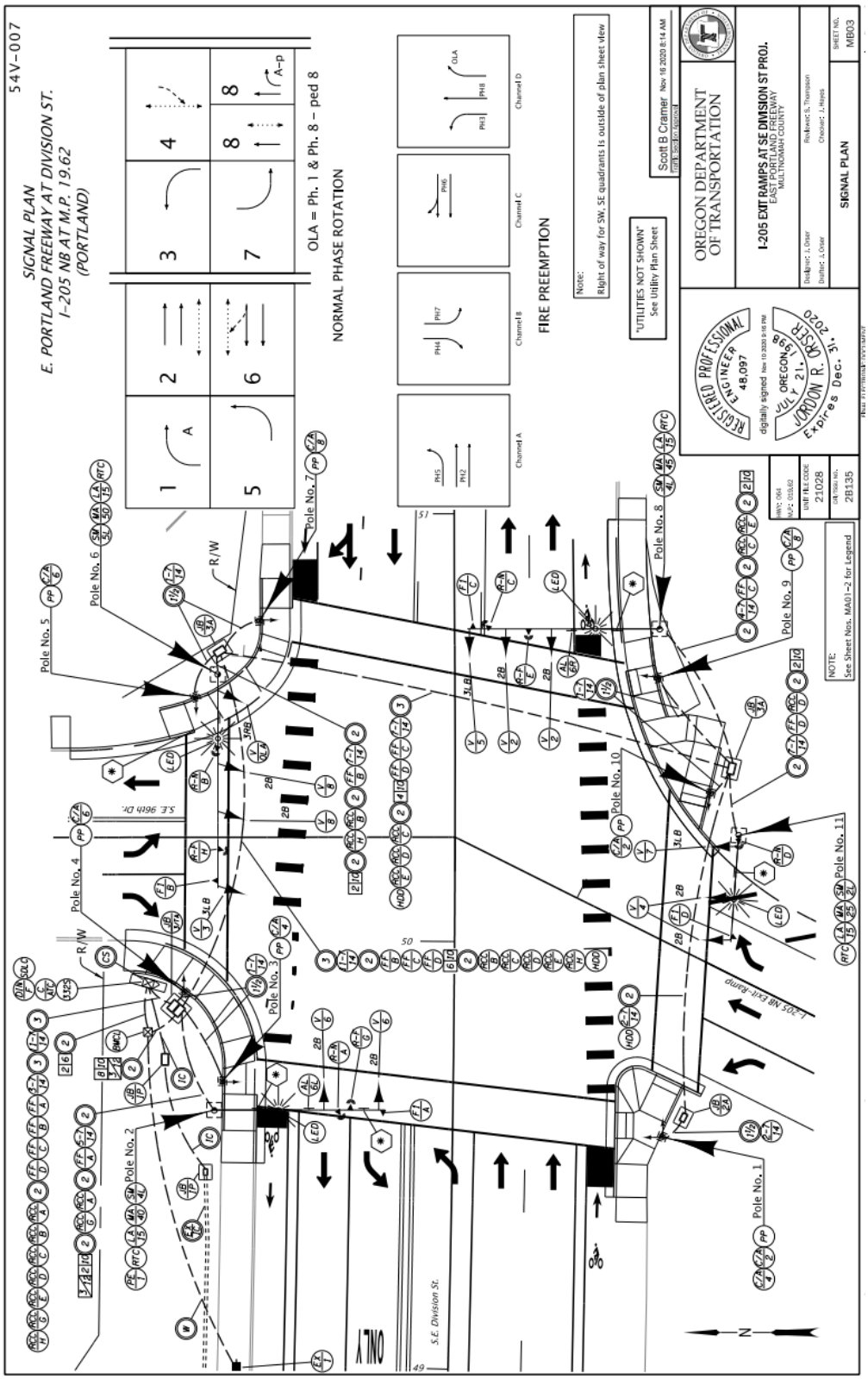


Figure 21-49 | Signal Plan Sheet Example 2 (New Signal)

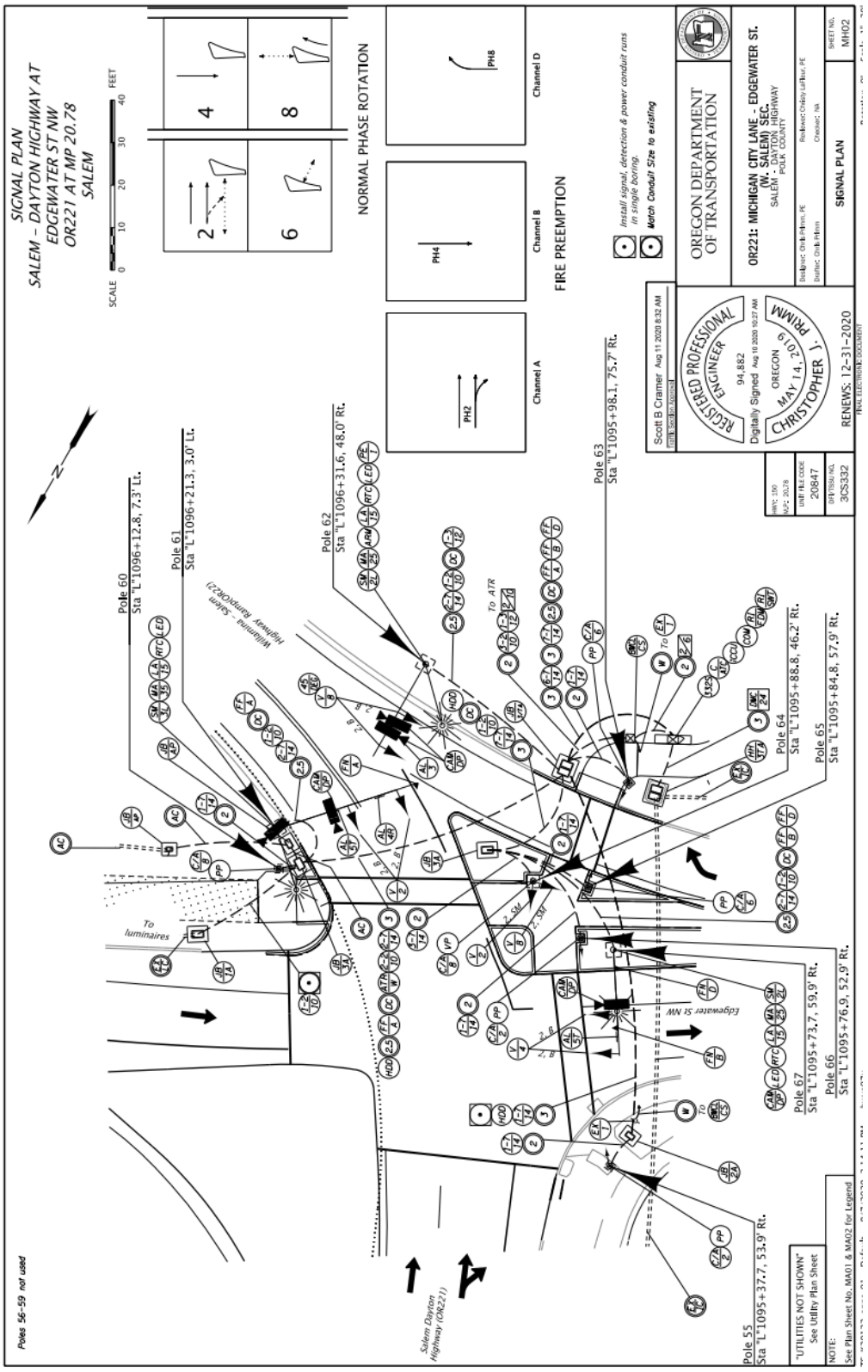
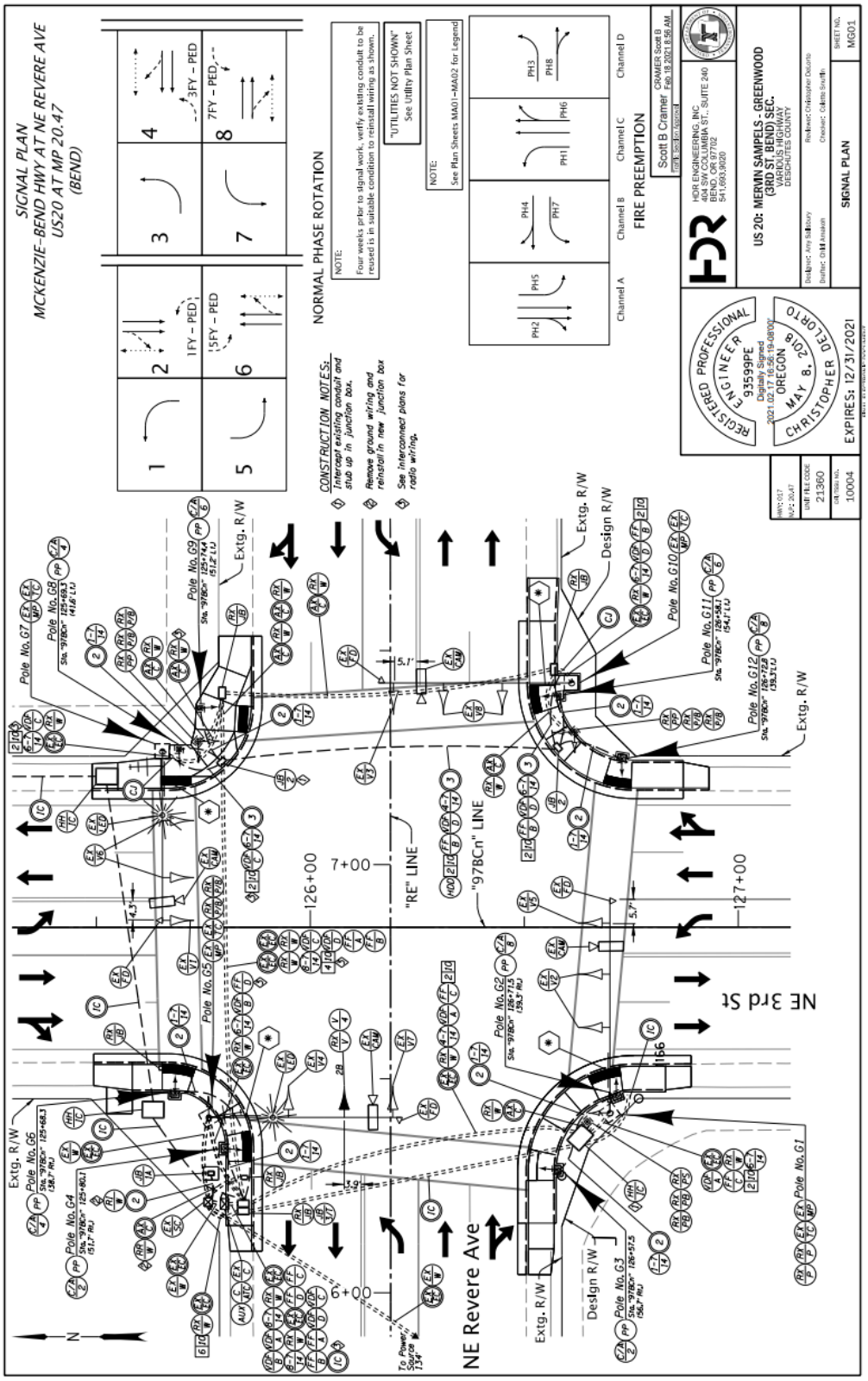


Figure 21-50 | Signal Plan Sheet Example 3 (Existing Signal Modification)



21.10.4 Detector Plan

The detector plan sheet is no longer necessary if the entire intersection has non-invasive detection as per chapter 6. 100% non-invasive detection will be shown on the signal plan sheet for new or completely rebuilt signals. If the project has any loop detection (typically not allowed for new construction) or the only work to be done is adding non-invasive detection to an existing signal, a detector plan sheet will be necessary, and it shall include the following as applicable for the scope of work (See Figure 21-51 through Figure 21-53 for good examples):

- Proposed/new feature symbology:
  - Loop detection – labeled with numbers.
  - Loop wire entrance
  - Junction boxes, conduit, and wires/cables for the loop detection system
  - Controller cabinet
- Loop detector wiring diagram, properly filled-out
- Non-invasive detection equipment and wires/cables (as per chapter 6). Detection zones are NOT shown on plan sheets (shown on cabinet print as per chapter 20).
- Use break lines to compress the plan into one plan sheet when possible.
- Proper detailing: bubble note(s) with leader lines to each feature that will be installed as part of the 00990 traffic signal bid items (See chapter 19).
- Use appropriate reference bubble notes:
  - "EC" and "IC" bubble notes reference signal and interconnect plans for conduit respectively
  - "C" bubble note references the signal plan for the controller
  - "JB/SP" bubble note references the signal plan for junction boxes

Detector plan sheet specific MicroStation workflow items to aid in drafting:

- Signal Plans → Loop Wiring Diagrams
- Sheet Tools → Break Line
- Sheet Tools → Rewire Loops (text box)

Figure 21-51 | Detector Plan Sheet Example 1 (New Loop Detection – Not Allowed for New Construction)

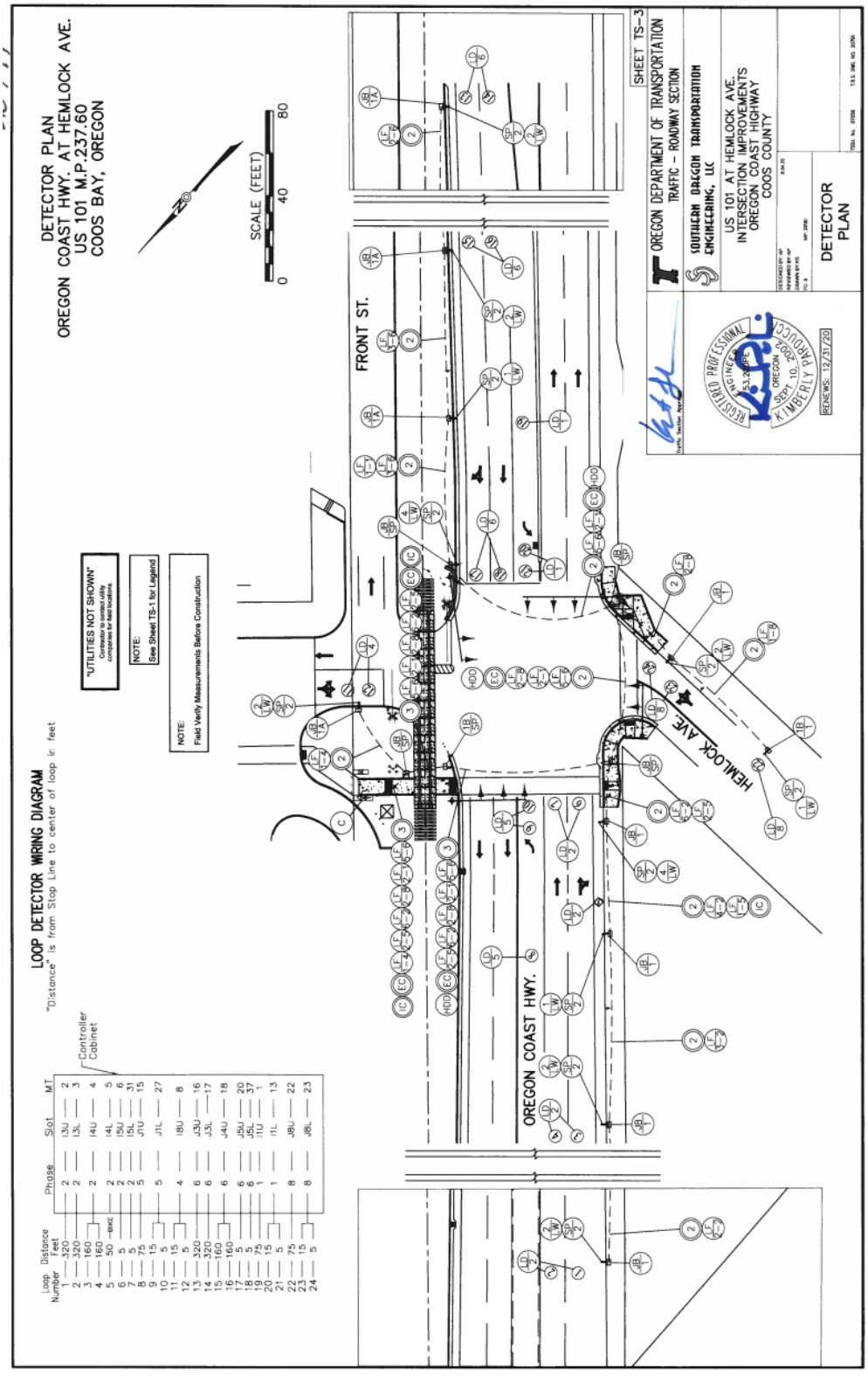


Figure 21-52 | Detector Plan Sheet Example 2 (Replacing Loop Detection at Existing Signal)

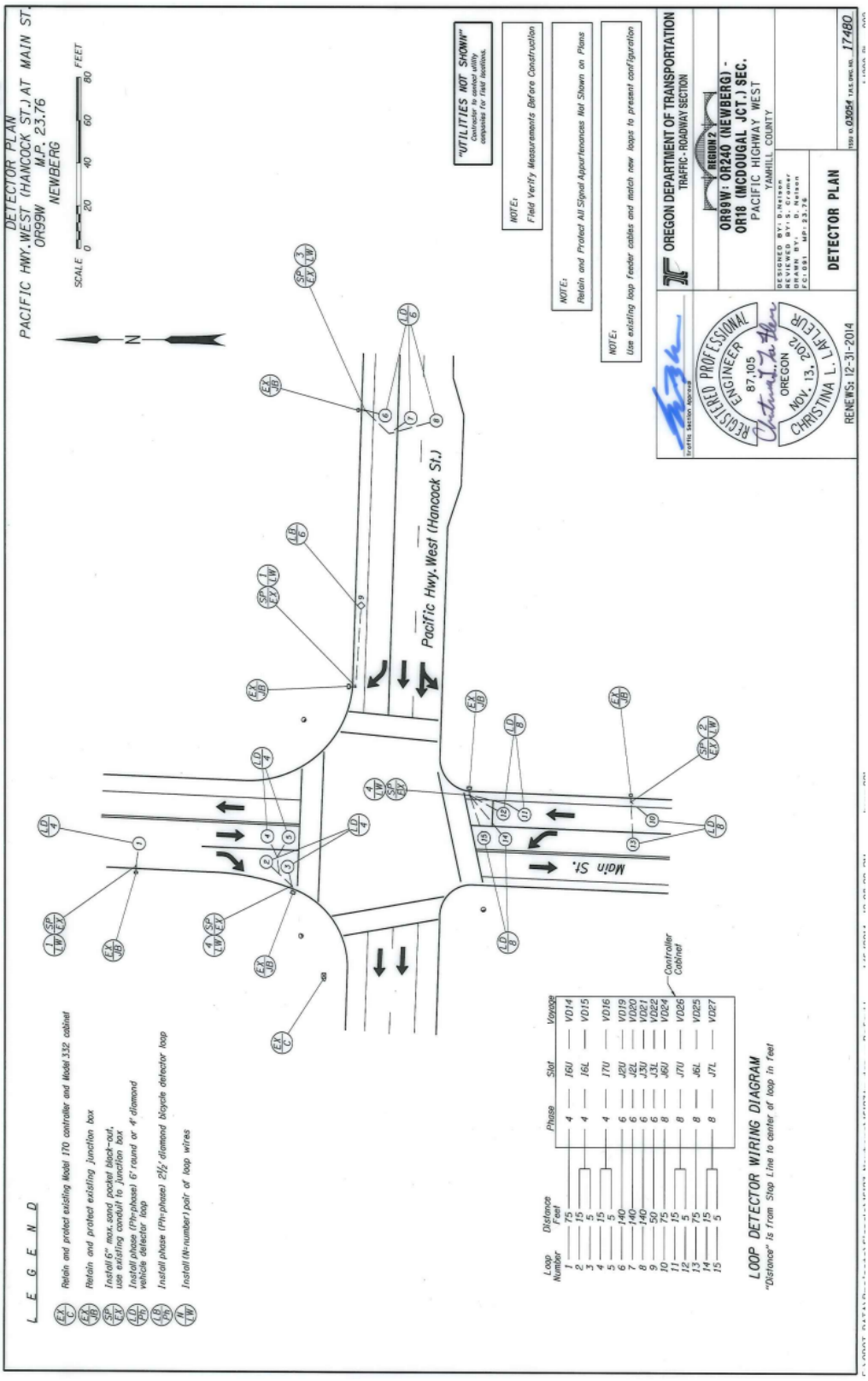
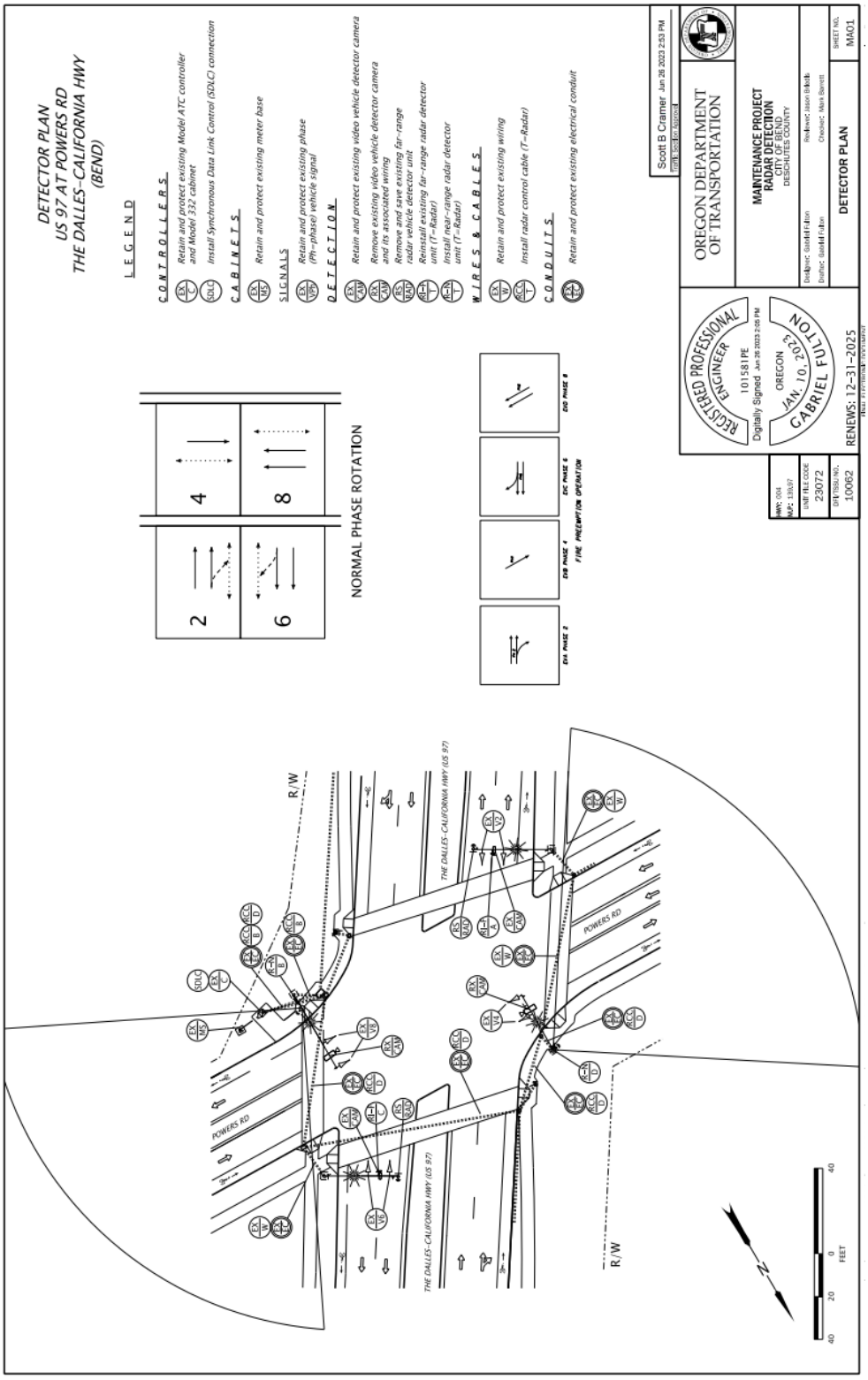


Figure 21-53 | Detector Plan Sheet Example 3 (Adding Non-invasive Detection Only to Existing Signal)



21.10.5 Interconnect Plan

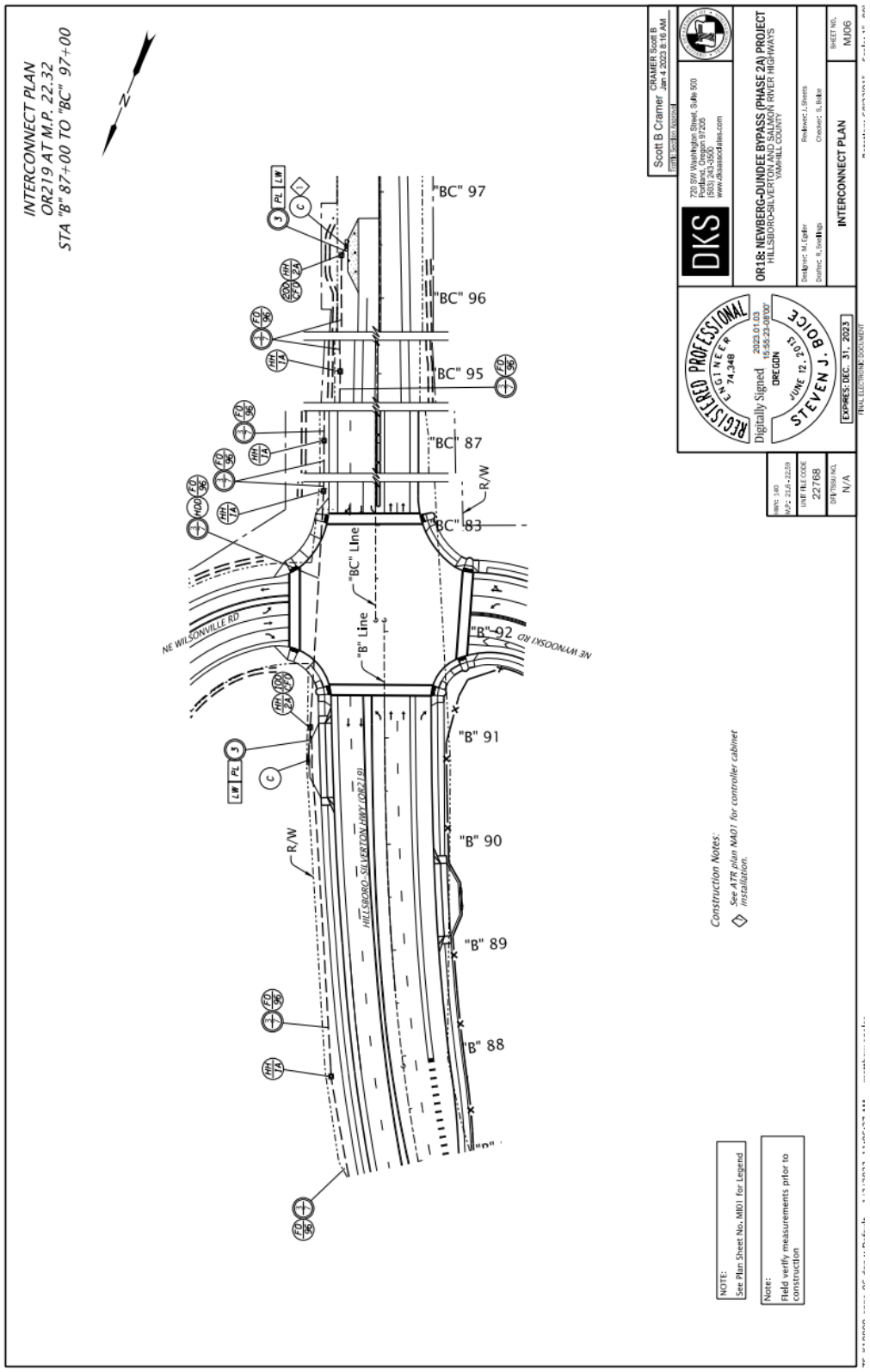
The interconnect plan shall include the following as applicable for the scope of work (see Figure 21-54 for a good example):

- Proposed/new feature symbology:
  - Junction boxes, conduit, wires/cables associated with the interconnect installation.
- Details as necessary as per the ITS unit (e.g., fiber optic splice, radio mount, etc.)
- Use break lines to compress the plan into one sheet when possible (or to reduce the number of sheets needed).
- Proper detailing: bubble note(s) with leader lines to each feature that will be installed as part of the 00990 interconnect bid item (See chapter 19).
- Use appropriate reference bubble notes:
  - "EC" and "DC" bubble notes reference signal and detector plans for conduit respectively
  - "C" bubble note references the signal plan for the controller
  - "JB/SP" and "JB/DP" bubble notes reference the signal and detector plans for junction boxes respectively

Interconnect plan sheet specific MicroStation workflow items to aid in drafting:

- Sheet Tools → Break Line

Figure 21-54 | Interconnect Plan Sheet Example



21.10.6 Railroad Preemption Plan

The railroad preemption plan is included in the rail crossing order, not the contract plans. It shall include the following (See Figure 21-55 through Figure 21-57 for good examples. Also refer to the Railroad Final Drawings Manual for additional information on producing plan sheets specifically for the crossing order):

- Standard preemption operation text template (3 options available) as per chapter 16, filled out as per the instructions. Unique operations may require unique text. Any unique text will be provided by the traffic engineering section.
- Normal phase rotation diagram
- Proposed/new feature symbology:
    - Railroad tracks
    - Poles, mast arms, and pedestals
    - Vehicle signal heads
    - Pedestrian signal heads
    - PTR signs
    - Signs (ground mounted or overhead) that directly relate to the preemption operation:
        - STOP HERE ON RED
        - NO TURN ON RED
- Proper detailing: **Bubble notes are NOT used on the railroad preemption plan**. Instead, the flowing items are labeled with text (with a leader line, or within the item itself):
    - USDOT crossing number, ODOT crossing number, and railroad milepoint adjacent to the railroad tracks
    - PTR sign(s). Use a leader line and state the PTR sign message, typically NO RIGHT TURN.
    - Signs that directly relate to the preemption operation. Use a leader line and state the sign message.
    - Type 7 vehicle signal head. Use a leader line.
    - Vehicle phases in each travel lane.
    - Pedestrian phases in each crosswalk.
- Other features that MAY be included, but are not required:
    - Railroad bungalow
    - Railroad equipment (e.g., gate arms, flashers, cantilevers, etc.)
    - Controller cabinet and service cabinet
    - Stationing
    - Right-of-way

Railroad preemption plan sheet specific MicroStation workflow items to aid in drafting:

- Signal Plans → Rail Matrix (three standard text operation templates with instructions for using them and filling them out)
- Signal Plans → Phase Rotation Dia

Figure 21-55 | Railroad Preemption Plan Sheet Example 1 (Default Standard Template Text)

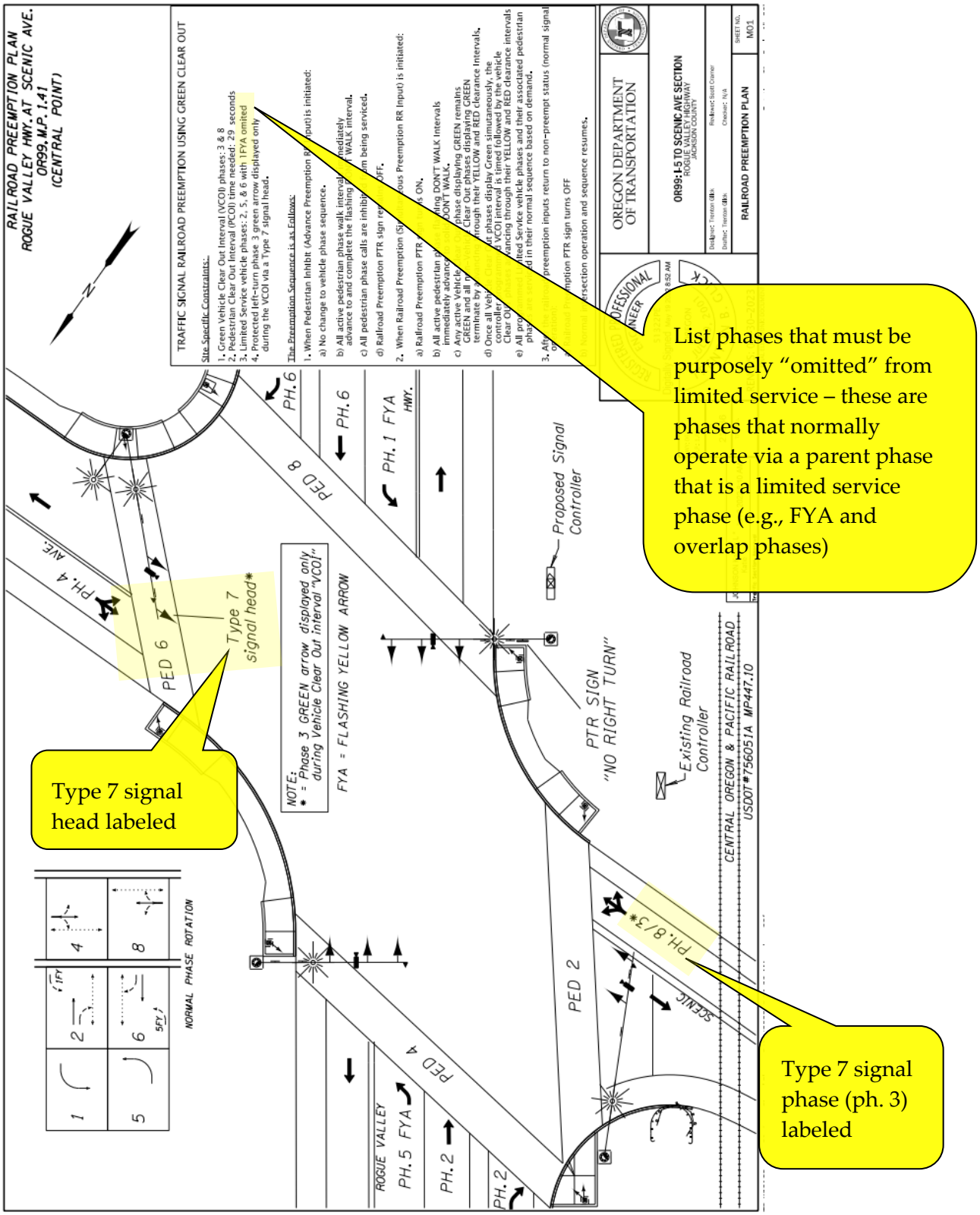


Figure 21-56 | Railroad Preemption Plan Sheet Example 2 (No VCOI Template Text)

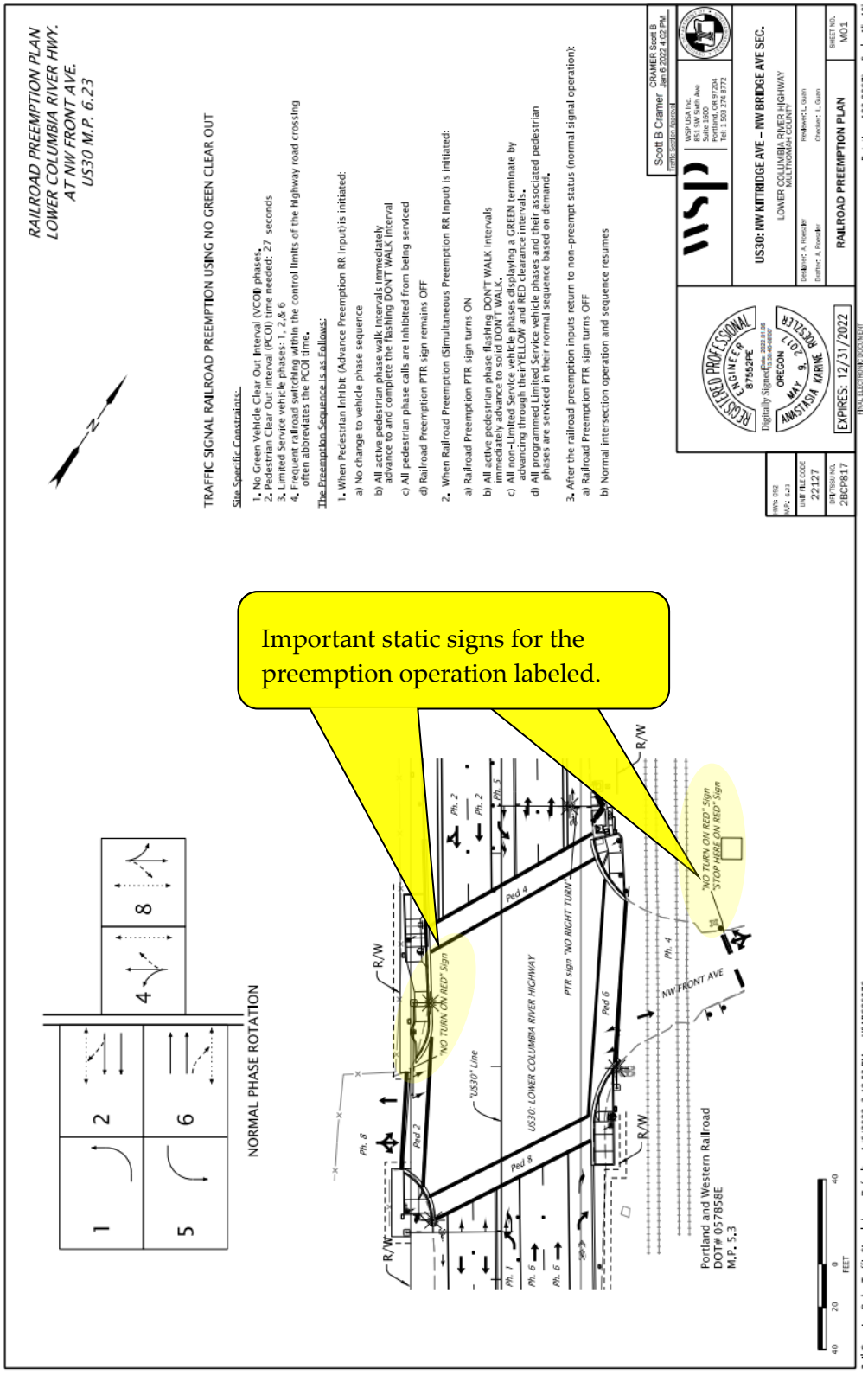
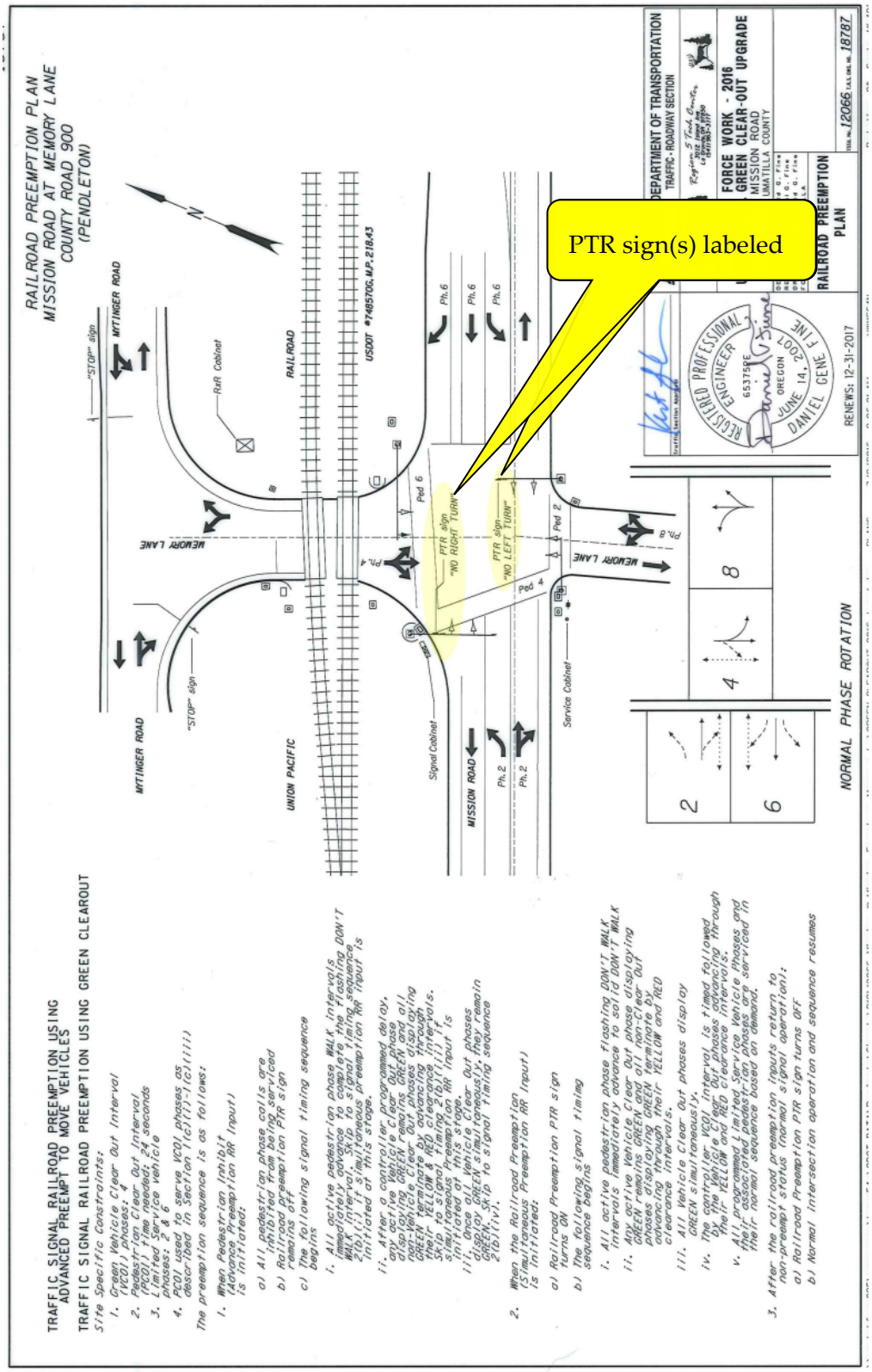


Figure 21-57 | Railroad Preemption Plan Sheet Example 3 (Advanced Template Text)

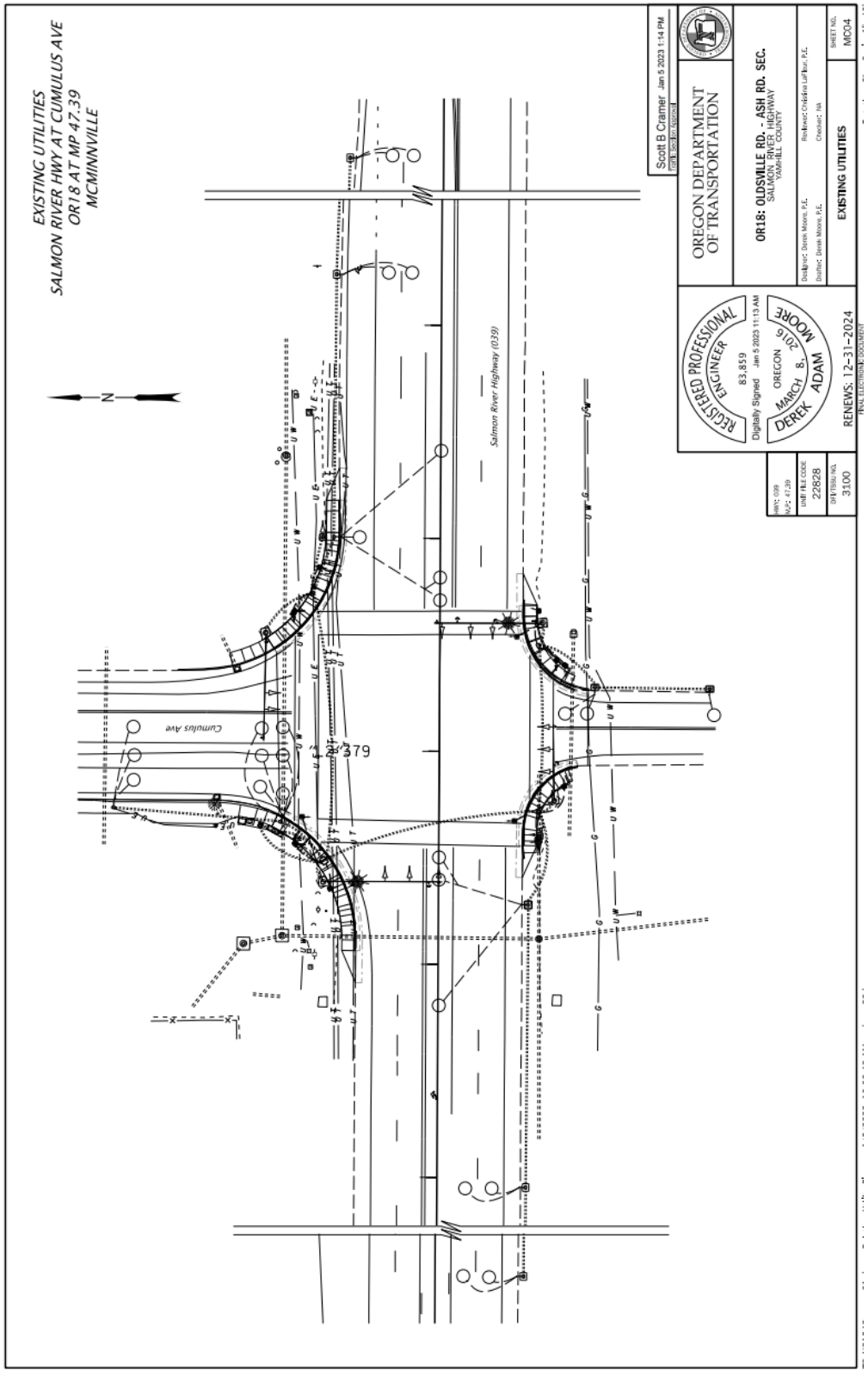


21.10.7 Existing Utilities Plan

The existing utilities plan sheet shall include the following (see Figure 21-58 for a good example):

- Proposed/new feature symbology:
  - All signal features (e.g., poles, pedestals, mast arms, cabinets, conduit, junction boxes, signal heads, etc. that will be installed per the contract plan sheets)
  - All overhead and underground utilities (e.g., telephone, power, natural gas, water, sewer, storm sewer, etc.)
  - Other features that may impact the construction of the signal features.
- All existing signal feature symbology that will be retained and protected per the contract plan sheets.
- **Detailing (bubble notes) is NOT used on the existing utilities plan.** However, if deemed necessary, text notes can label or identify critical features/areas.
- Other features that may be included but are NOT required:
  - Noting any anticipated moves of existing utilities. Often utilities aren't moved before the contract is let, so the exact location of the relocated utility cannot be shown.
  - Noting any utilities that are very close to signal features and providing dimensions/ instructions for installation of these signal features if deemed necessary.

Figure 21-58 | Existing Utilities Plan Sheet Example



21.10.8 Details Plan

The details plan sheet will typically consist of the pole entrance chart, but other site-specific details should be added as necessary for the project. The details plan sheet shall include the following as applicable for the scope of work (see Figure 21-59 and Figure 21-60 for good examples):

- The pole entrance chart correctly filled out with all necessary information including adding additional columns as necessary based on the site-specific project needs. Columns may also be deleted if they aren't applicable to the project (e.g., no mast arm poles, no luminaires, etc.). See chapter 9.
    - Geotech analysis reference
    - The mast arm pole orientation diagram and the pedestal orientation diagram
    - Legend text for brackets and equipment detailed in the pole entrance chart
- Any standard details needed, modified for the project specific work (see chapter 9)
- **Detailing (bubble notes) is NOT typically used in the details plan.**

Details plan sheet specific MicroStation workflow items to aid in drafting:

- Signal Plans → Pole Ent Chart (lots of tools to properly draft and detail)

Figure 21-59 | Details Plan Sheet Example 1 (Pole Entrance Chart)

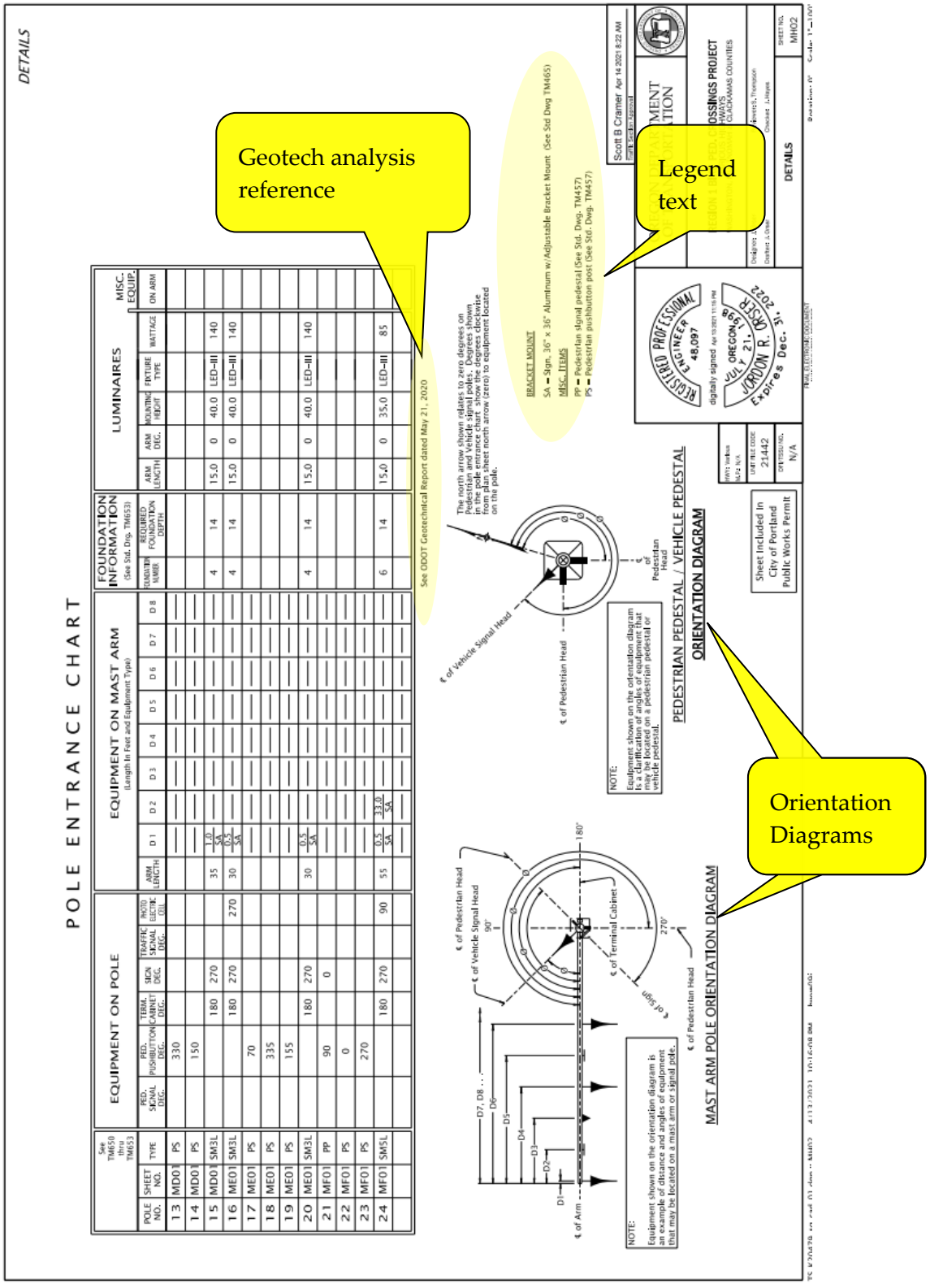
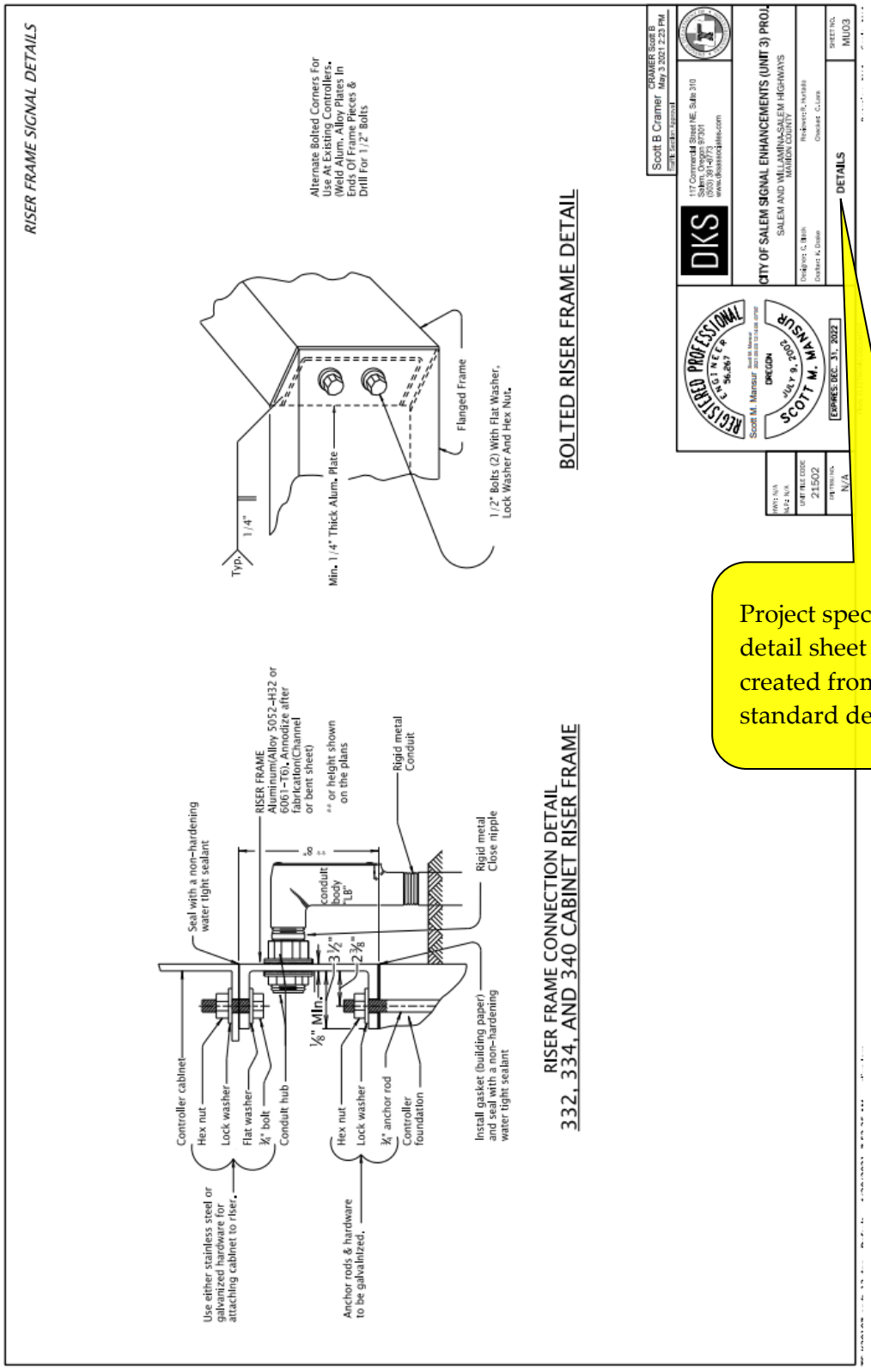


Figure 21-60 | Details Plan Sheet Example 2 (Project Specific Work Details)



21.10.9 Temporary Signal, Detector, Ramp Meter Plan

The temporary signal, detector, or ramp meter plan shall include all the items described in the permanent signal plan (see section 21.10.3), detector plan (see section 21.10.4), or ramp meter plan (see section 21.10.11) with the following items that are unique to temporary signals (see Figure 21-61 through Figure 21-63 for good examples):

- Wood poles and span wires
- Plans sheets as necessary for each stage/phase. The first stage for a temporary signal will detail ALL the equipment just like a regular signal/detector/ramp meter plan sheet. Each following stage will only detail the modification(s) needed for that particular stage. All equipment installed in the previous stage(s) is to be retained and protected unless otherwise detailed.
- The temporary signal, detector, or ramp meter plan shall match the staging shown in the temporary traffic control plans. Show the work zone stage/phase in the upper right corner of the plan sheet.
- Proper detailing: bubble note(s) with leader lines to each feature that will be installed as part of the 00227 temporary traffic signal bid items (See chapter 19).
- Use appropriate reference bubble notes:
    - For each stage following the initial temporary construction, use appropriate "EX", "RX", "RR" bubble notes to show work needed. See section 21.9.7 and chapter 11.
    - Reference workzone plans as needed for clarity.

Figure 21-61 | Temporary Signal Plan Sheet Example 1 (First Stage – Show ALL Equipment Installation)

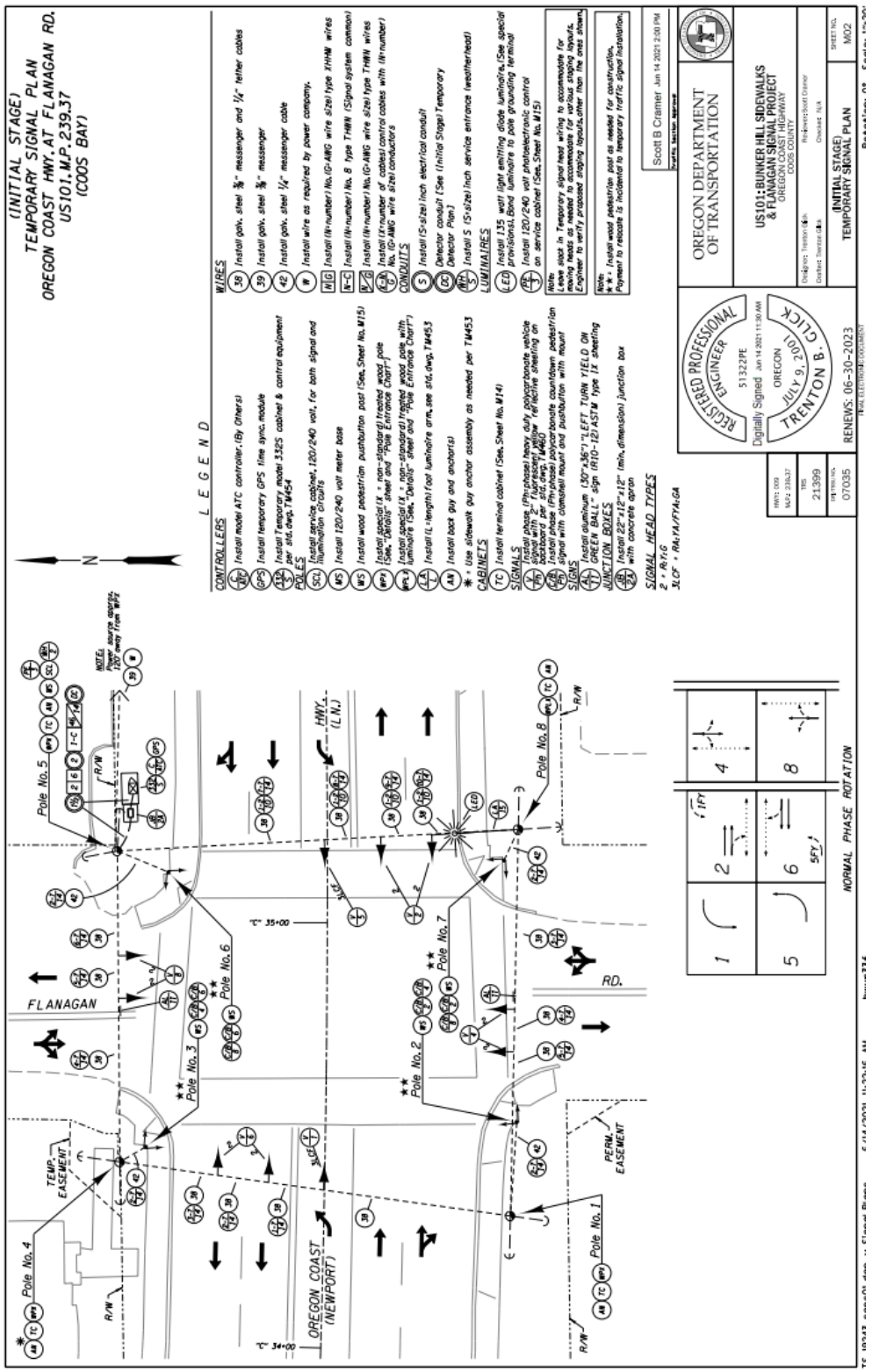


Figure 21-62 | Temporary Signal Plan Sheet Example 2 (Final Stage of Example 1 – Only Show Modifications)

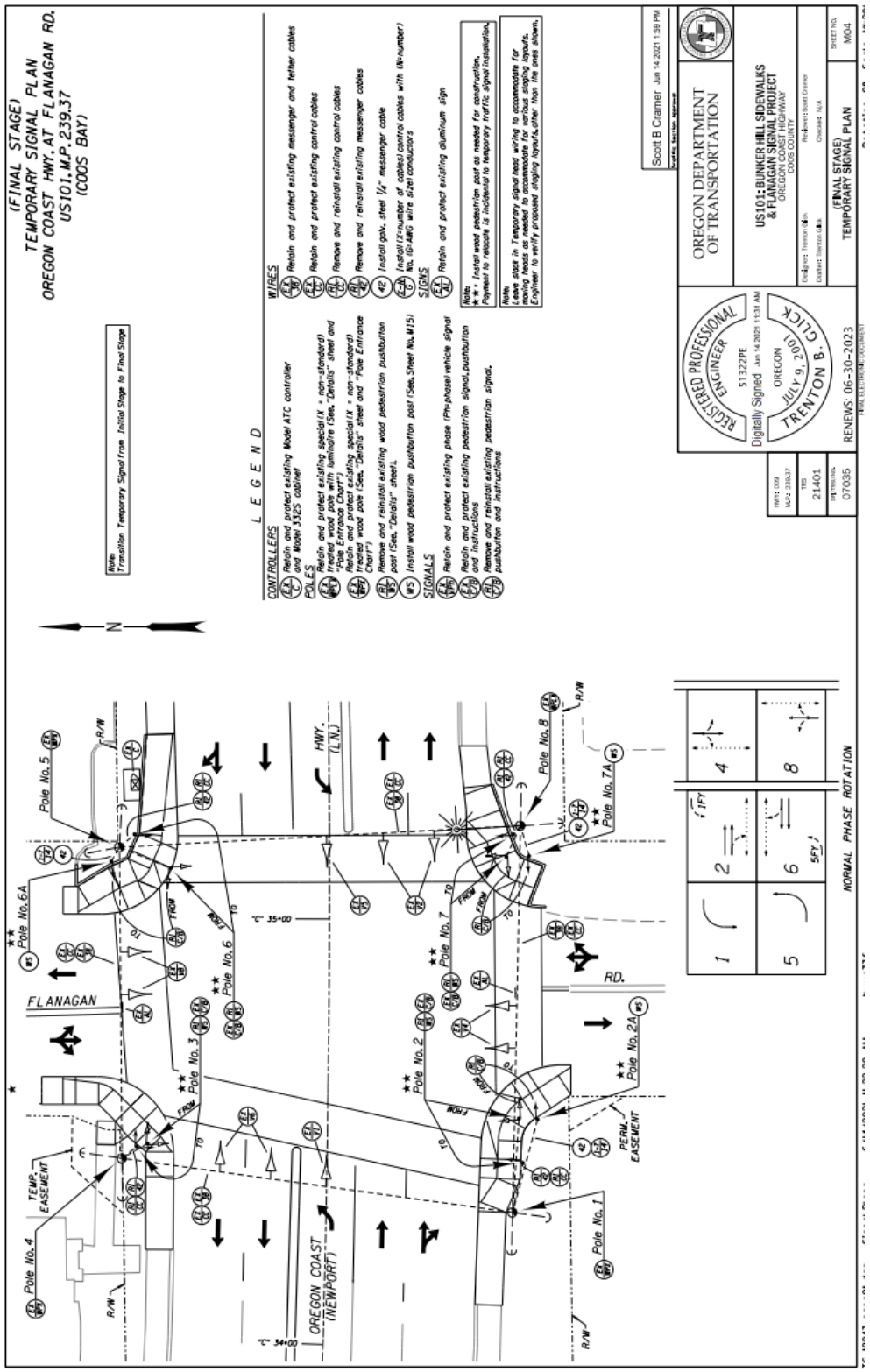
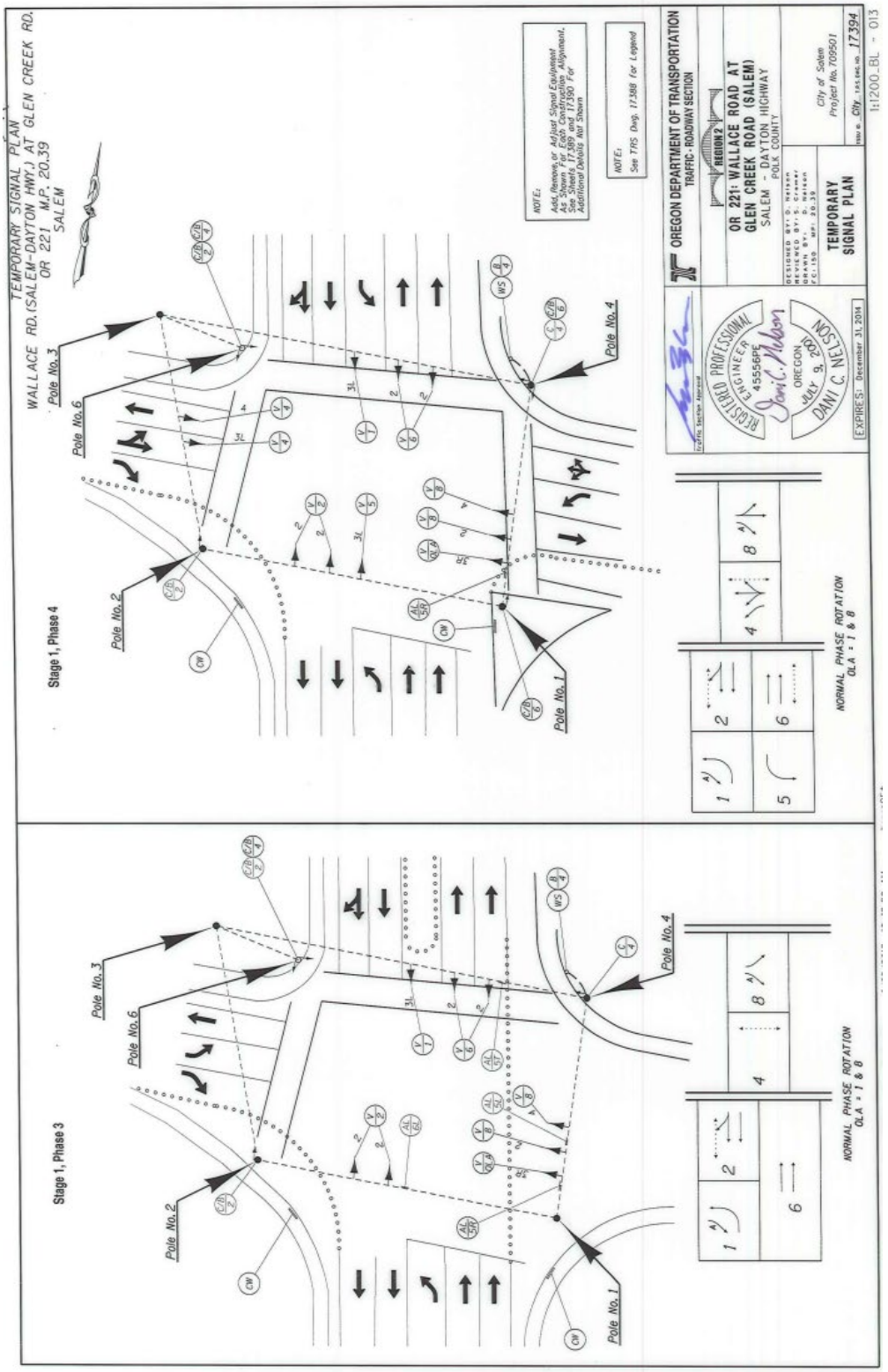


Figure 21-63 | Temporary Signal Plan Sheet Example 3 (Multiple Stages – Only Show Modifications)



21.10.10 Flashing Beacon Plan

The flashing beacon plan sheet shall include the following as applicable for the scope of work (see Figure 21-64 through Figure 21-67 for good examples):

- Proposed/new feature symbology:
  - Power source (existing or new)
  - Controller cabinet
  - Service cabinet
  - Signs
  - Vehicle signal heads/flashing beacons
  - Pushbuttons
  - Junction boxes, conduit, and wires/cables for the signal system
  - Non-invasive detection equipment and wires/cables (as per chapter 6). Detection zones are NOT shown on plan sheets (shown on cabinet print as per chapter 20).
- Proper detailing: bubble note(s) with leader lines to each feature that will be installed as part of the 00990 flashing beacon bid item (See chapter 19).
- Use appropriate reference bubble notes:
  - The hex star bubble note references signing plans for any signs not paid for under the 00990 flashing beacon bid item.

Figure 21-64 | Flashing Beacon Plan Sheet Example 1 (RRFB Hardwire)

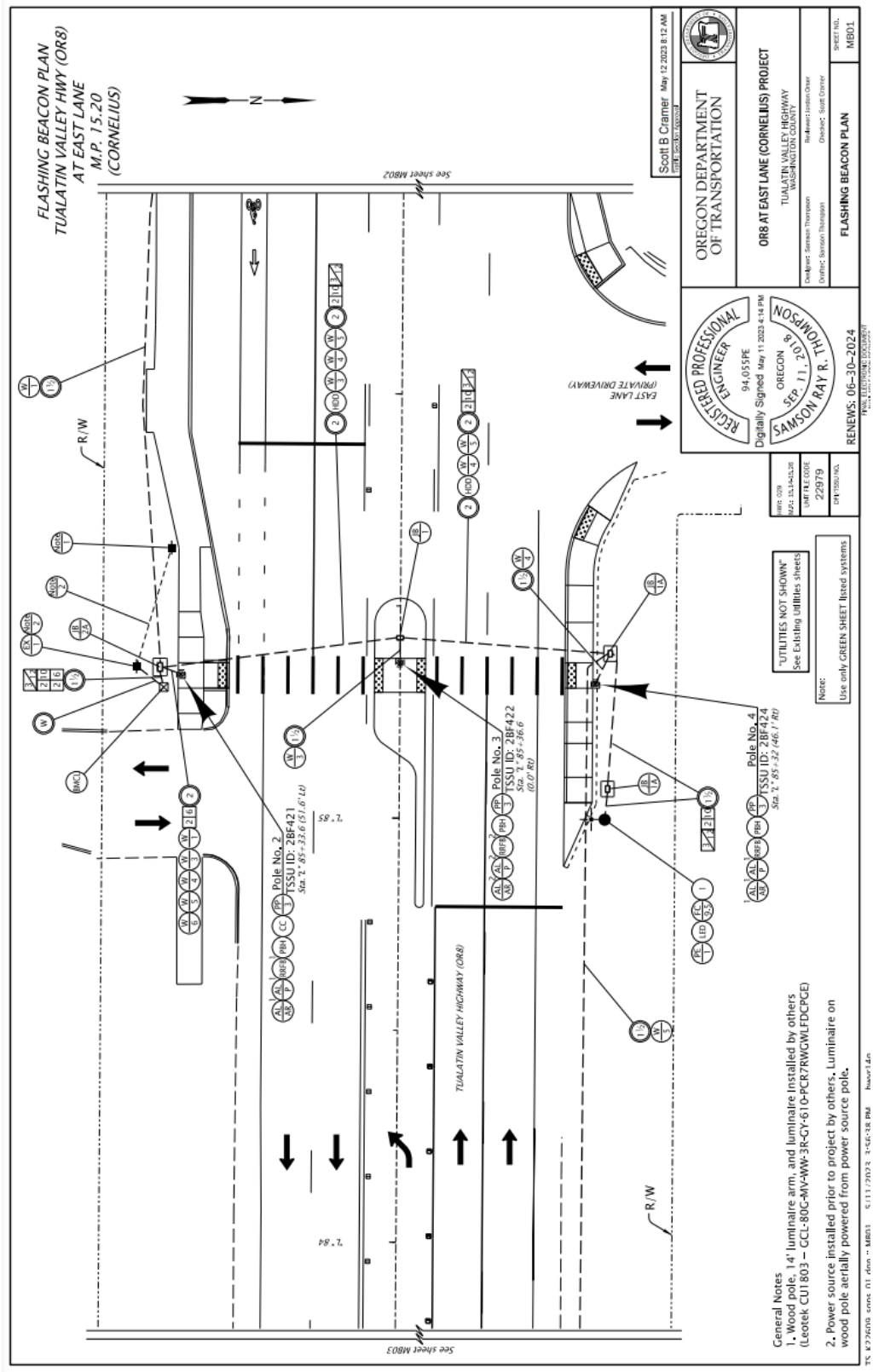


Figure 21-65 | Flashing Beacon Plan Sheet Example 2 (RRFB Solar)

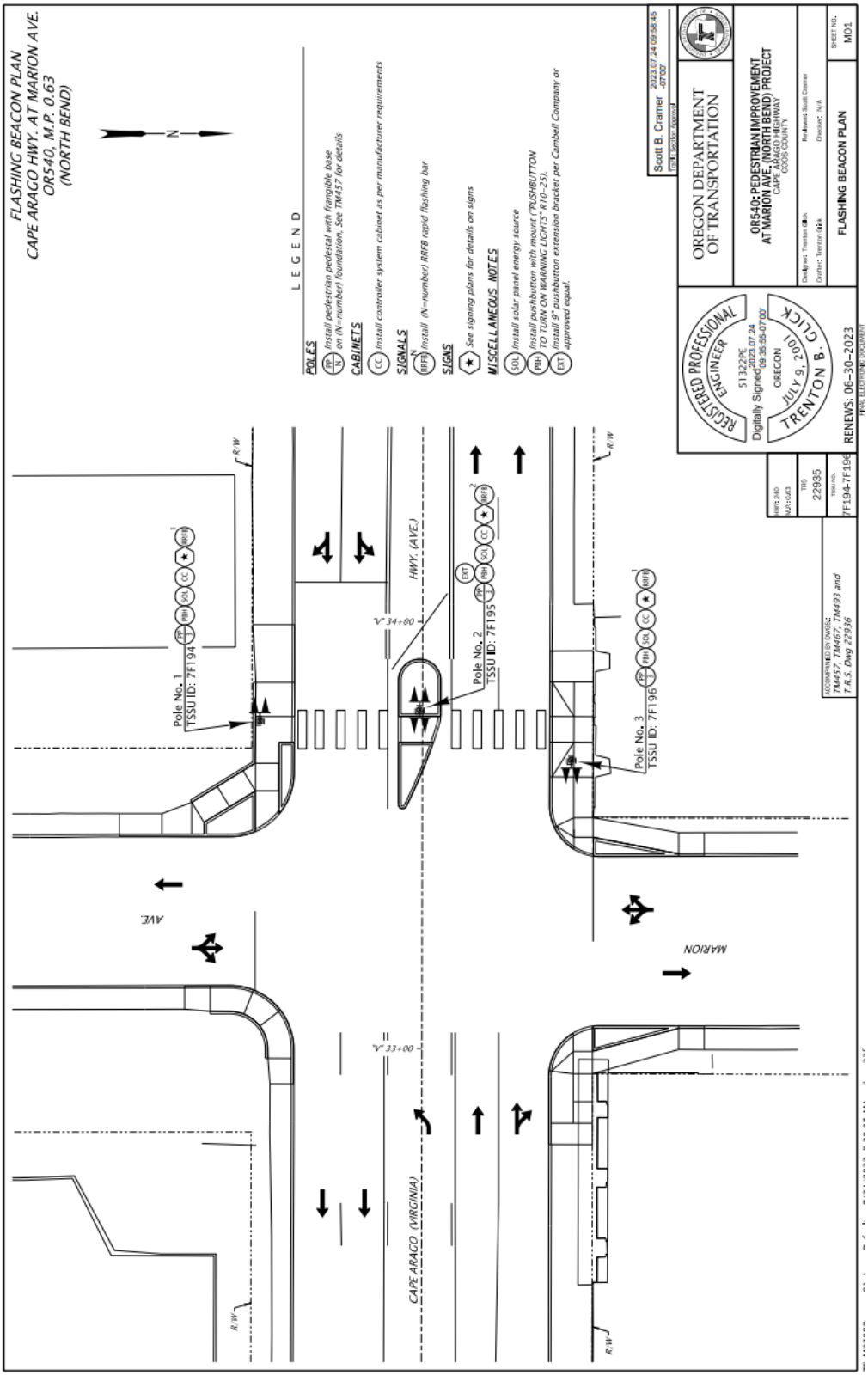


Figure 21-66 | Flashing Beacon Plan Sheet Example 2 (24/7 Solar Flashing Beacons)

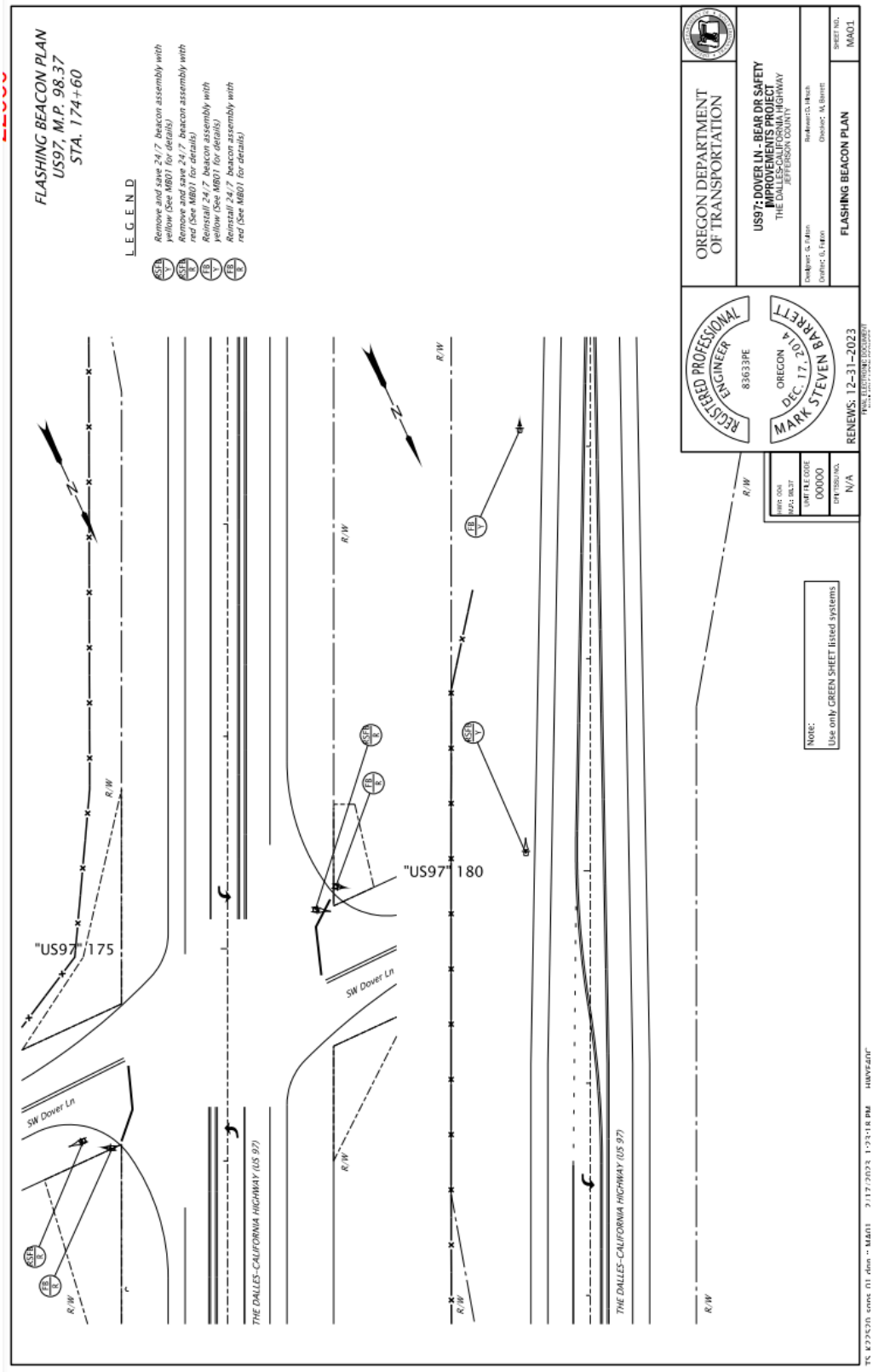
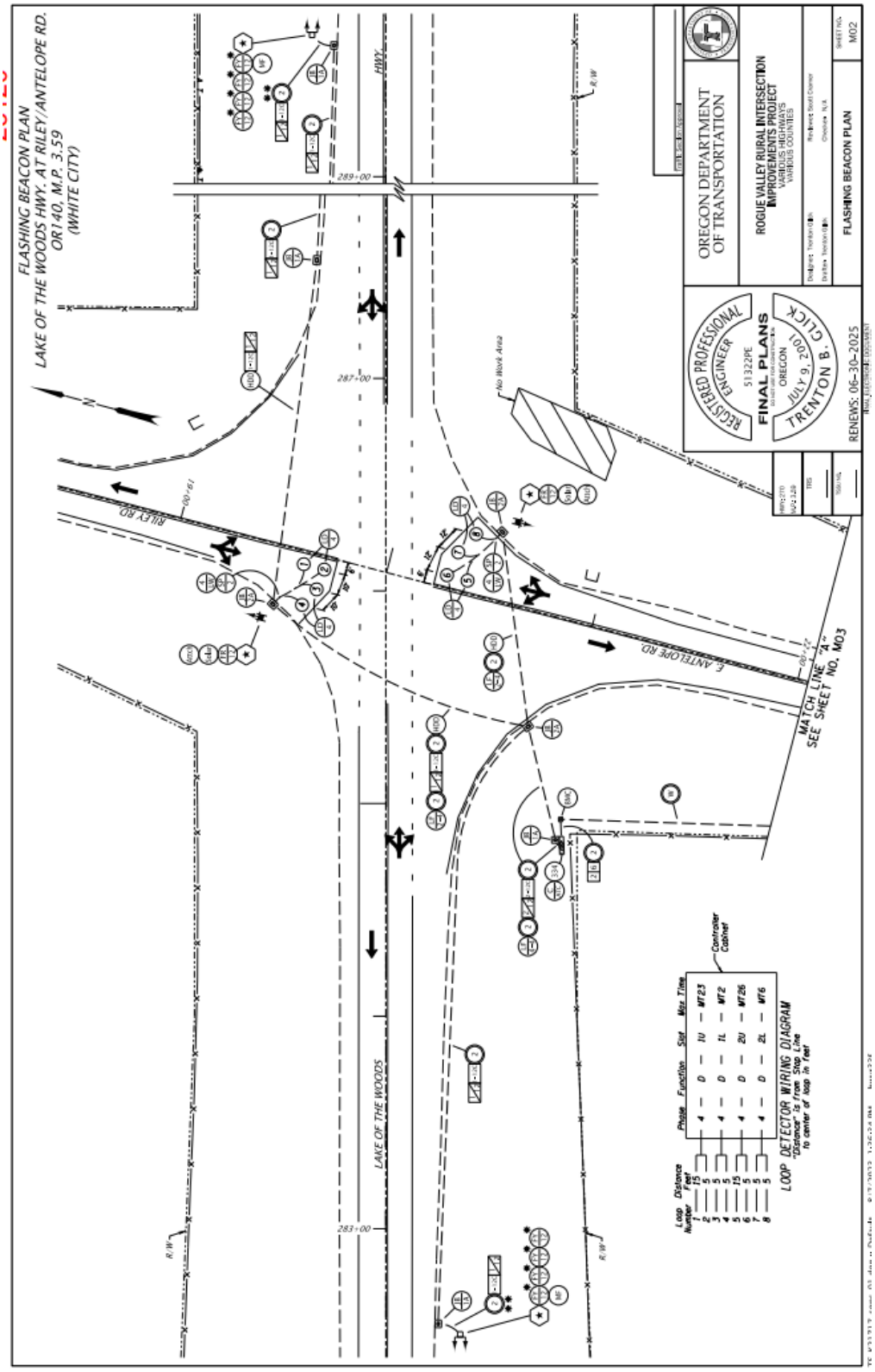


Figure 21-67 | Flashing Beacon Plan Sheet Example 3 (TRAWS)

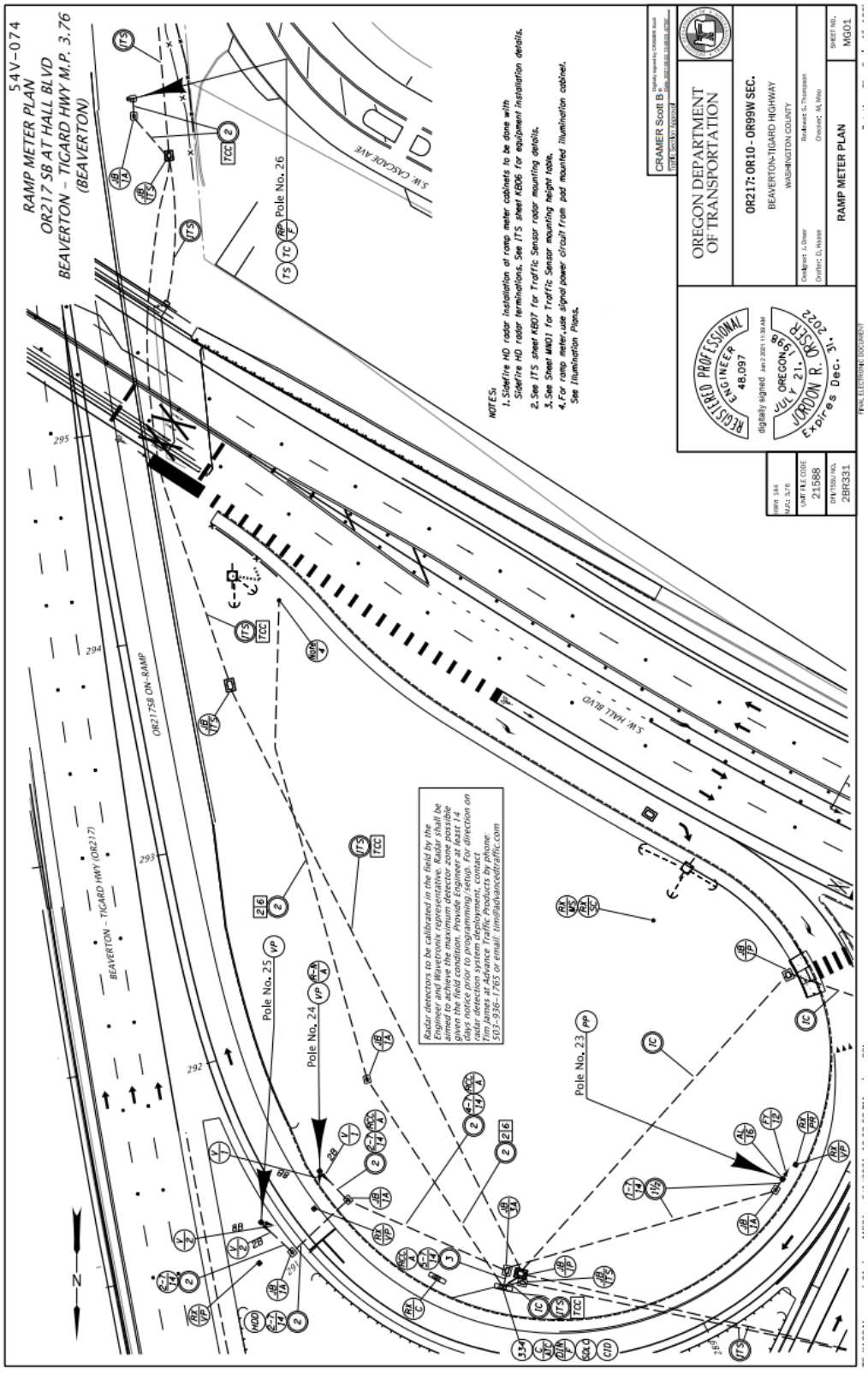


21.10.11 Ramp Meter Plan

The ramp meter plan sheet shall include the following as applicable for scope of work (see Figure 21-68 for a good example):

- Proposed/new feature symbology:
  - Power source (existing or new)
  - Controller cabinet
  - Service cabinet
  - Ramp meter signs with flashing beacons as per chapter 13
  - Ramp meter assemblies or mast arm pole installation
  - Junction boxes, conduit, and wire/cables
  - Non-invasive detection equipment and wires/cables (as per chapter 6). Detection zones are NOT shown on plan sheets (shown on cabinet print as per chapter 20).
- Proper detailing: bubble note(s) with leader lines to each feature that will be installed as part of the 00990 ramp meter signal bid item (See chapter 19).
- Use appropriate reference bubble notes:
  - The hex star bubble note references signing plans for any signs not paid for under the 00990 ramp meter signal bid item. See chapter 13.

Figure 21-68 | Ramp Meter Plan Sheet Example



21.11 MicroStation File Archiving

When using ProjectWise, all MicroStation files will be automatically archived. Follow the guidance contained in the ProjectWise Standards Folder for properly using ProjectWise system.

For projects that aren't required to use ProjectWise (e.g., developer project by permit, local agency project, etc.) archive all MicroStation files using the ODOT EAST engineering archive website instructions.

ODOT employees can search either ProjectWise (for newer projects) or the ODOT EAST engineering archive (for older projects or projects not required to use ProjectWise). Non-ODOT employees can request help in searching either location by contacting the ODOT EAST team via e-mail: odot.east@odot.oregon.gov

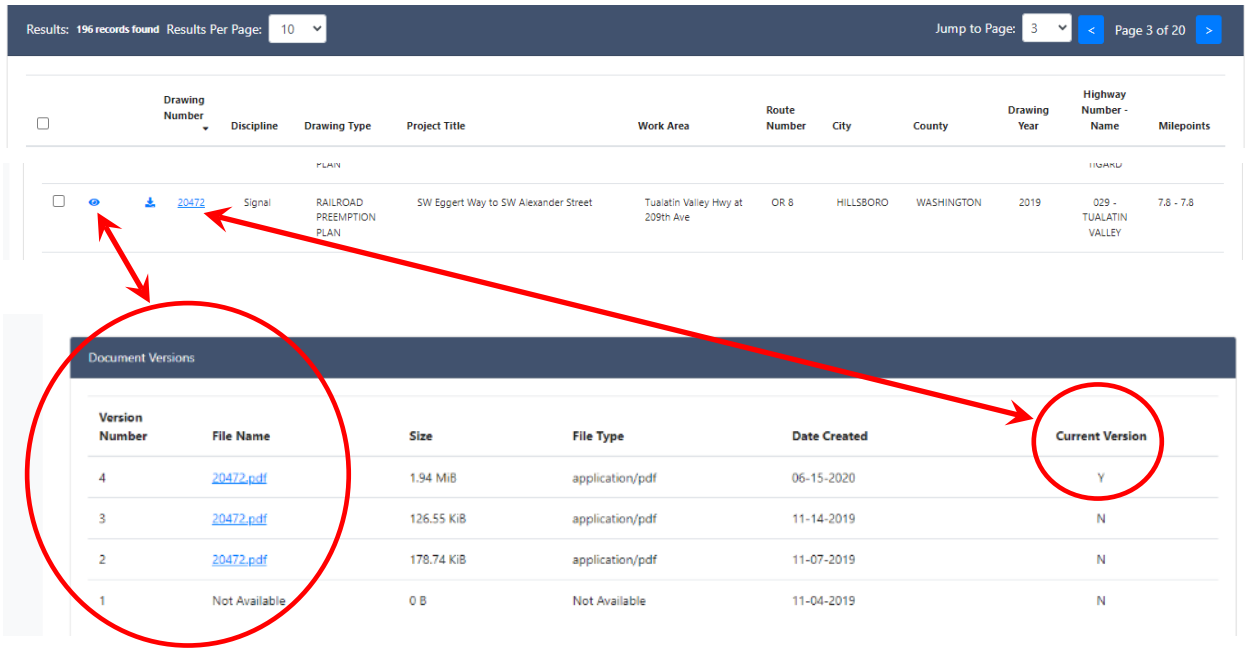
21.12 Plan Sheet (PDF) Archiving

Contract plans (PDFs) that are submitted to the traffic engineering section for drawing numbers or final approval (see chapter 2) are archived by the traffic engineering section in FileNet. Multiple versions of same drawing number may be available, with the most current version noted. See Figure 21-69 for example of how to access the versions.

Revised plans (see section 21.13) require a traffic engineering section review and approval block signature. When that PDF is submitted to traffic engineering section, it will be archived in FileNet.

As-construct plans (see section 21.14) do not require a traffic engineering section review or any digital signatures, but the PDF should be submitted to traffic engineering section to allow for archiving in FileNet.

Figure 21-69 | FileNet Versions Available



21.13 Revised Plans

Plans may need to be revised during the bidding phase. The revision process described in this section is typically only done during this time frame. Plans that are in the preliminary, advanced, or final plans stage do NOT follow the revision process (no need to document or draw attention to revisions that are made in these stages).

The plan revision process may also be used during the construction phase as deemed necessary to document and provide installation information for contract change orders (CCOs). Work with the resident engineer's office to determine if the revision process is necessary or if the CCO form with the changes to the plan sheet(s) documented at the end of the project in the as constructed plans will be adequate.

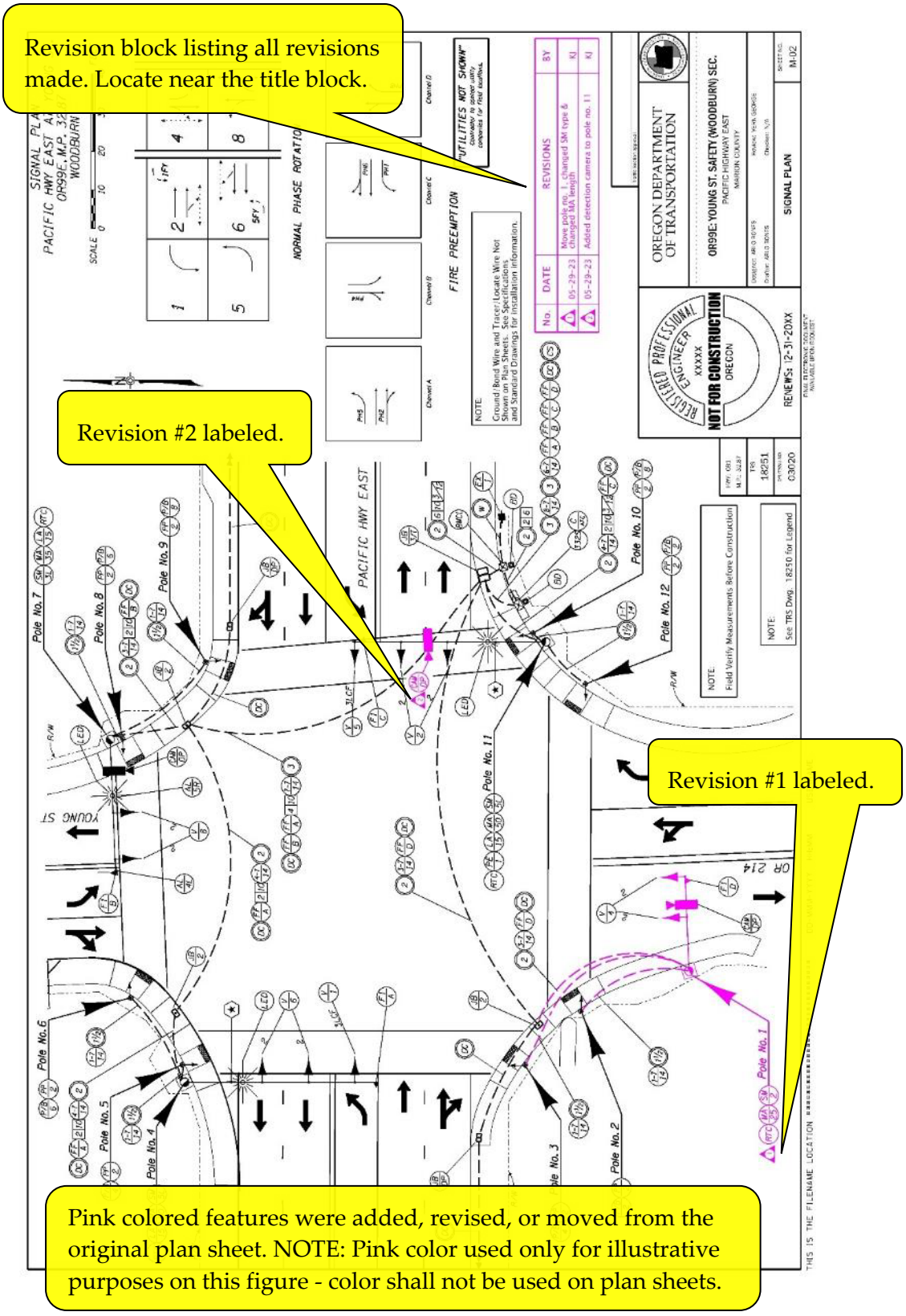
The revision process includes the following (see Figure 21-70 for an example):

- Add numbered revision triangle(s) for all revised content, near the actual revision (typically at the applicable bubble note(s)).
- Place a revision block just above title block and fill out the date, revision summary, and revision maker initials for each revision triangle used. If the revision block cannot fit above the title block, it should be placed as close as possible to the title block.
- Submit the sealed, revised plan to traffic engineering section for review and approval.
- **The use of "cloud" lines around the revised work are no longer used.**

Revised plan sheet specific MicroStation workflow items to aid in drafting:

- Sheet Tools → Revision Block

Figure 21-70 | Revision Process (During Bidding/Construction Only)



21.14 As-Constructed Plans

The purpose of producing as-constructed plans is to accurately reflect the actual project as it was constructed in the field. As-constructed plans are important to agency electricians for maintenance and also to signal designers for use in future design work.

Red-lined plans are made by the contractor and submitted to the resident engineer's office (see specification 00960.71). These plans are reviewed by the resident engineer's office and then follow the process described in technical bulletin RD22-01(B). The signal designer will have an opportunity to review these as constructed plans before they are archived. For projects produced by a consultant, developer, or local agency, an electronic copy of the as-constructed traffic signal plans should be submitted to the state traffic signal engineer within 60 working days after completion of the contract work.

While not required, it is preferred that the signal designer or drafter update the MicroStation file(s) and produce a new, clean electronic version of the hard copy red-line mark-ups to archive instead of the hand drawn red-lines. Typically, the changes are minimal from the original plan sheet, so creating a new as-constructed plan sheet is not excessively time consuming.

As-constructed plans shall include (see Figure 21-71 for an example):

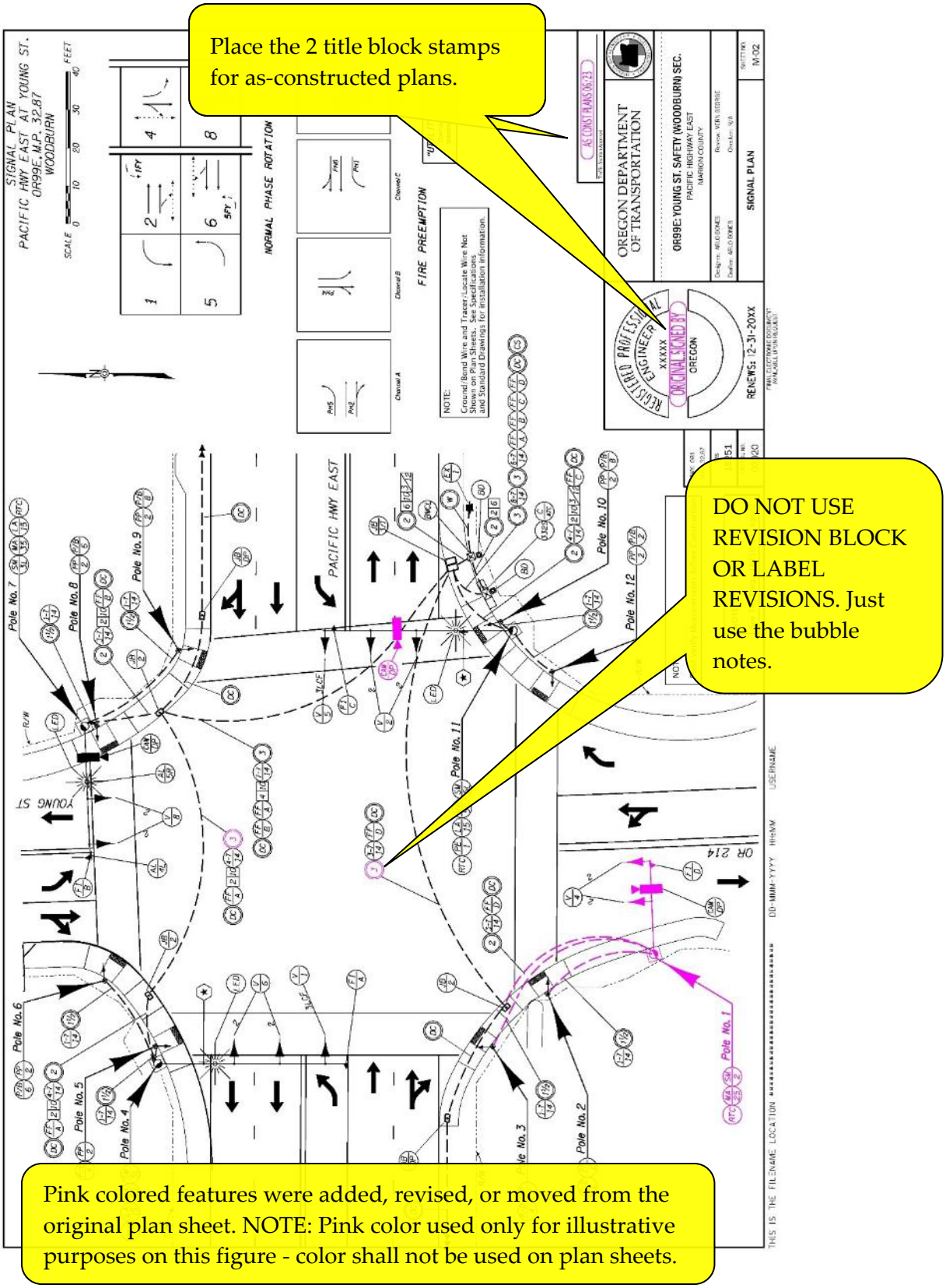
- An "original signed by" stamp on the engineer seal
- An "as const plans mm/yy" stamp with the date filled out placed on the traffic section approval box.
- Incorporating all red-lines into the drawing and deleting any original plan sheet information that conflicts with the red-lines (e.g., no need to highlight the change(s) from the original plans as per section 21.13).

As-constructed plan sheet specific MicroStation workflow items to aid in drafting:

- Sheet Tools → Stamps

The electronic as-constructed plan sheets for all traffic signal work should be sent to the traffic engineering section (in pdf form) where they will be archived in FileNet.

Figure 21-71 | Completed As-Constructed Plans Example



21.15 Final Design/Drafting Checklist

Before submitting plans for design review/approval (see chapter 2), use the following checklist.

		Signal Design/Drafting Checklist	For Information See:
APPROVALS			
	1	RTE/STE Operational approval(s) complete & plans match PSOD (phasing, crosswalk closures, fire preemption, etc.)	Section 3.1 and 5.7
	2	Loop detection is approved by the state traffic signal engineer and correctly detailed	Section 6.1.1
	3	LPIF documentation complete	Section 19.4
COORDINATION WITH OTHERS			
	4	Coordination with ITS unit on interconnect/communication plan is complete	Chapter 7
	5	Coordination with workzone designer is complete (temporary features, stagging a signal turn-on to avoid obstructing the view of existing signal indications, etc.)	Chapter 11
	6	Coordination with sign designer is complete (custom signs, determining bid items)	Section 5.3 & 5.3.2
	7	Coordination with geotech designer is complete (pole foundations)	Section 9.3.4
	8	Coordination with roadway designer and striping designer is complete (ADA ramps, turning templates, accesses, lane shifts, raised medians, stop bars, crosswalks, crosswalk closures, walkways for controller cabinet and BMCL as per TM482, etc.)	Section 5.1, 5.4, & 5.10.1
	9	Coordination with illumination designer is complete	Section 5.6
	10	Coordination with region utility specialist and utility is complete	Section 5.5.4
	11	Coordination with region mobility liaison is complete (overhead vertical clearance)	Section 5.5.2
	12	Coordination with region electrical crew maintaining the installation is complete	Section 2.9
	13	Coordination with region signal timer is complete (detection zone needs)	Chapter 6 & Chapter 20
BASIC DRAFTING – LAYOUT AND INFORMATION			
	14	M series plan sheets in correct order	Section 21.7.2
	15	All sheets are clear and easy to read (no inappropriate overlapping of features/bubble notes, unnecessary layers turned off, clutter minimized, etc.)	Chapter 21.2
	16	All sheets meet basic drafting layout and info requirements (sheet scale, upper right title info, sheet title, north arrow, stationing/scale bar, lane use arrows, street names, striping, right-of-way, etc.)	Multiple subsections in Section 21.7
	17	Current, standard symbology and bubble notes as per MicroStation workflow are used. Customization is limited to only what is necessary	Sections 21.4, 21.8.1, & 21.9
	18	All bubble note variables have been filled out correctly on the plan sheets	Section 21.9.1
	19	Reference bubble notes (EC, DC, IC, JB/SP, JB/DP, JB/IP, C, etc.) and cross reference text (see sheet MXX for legend) are used when necessary	Sections 21.3, 21.7.13 & 21.9.4
	20	All title block information is complete	Section 21.7.3
	21	List of applicable standard drawings is complete ("accompanied by dwgs. box")	Section 21.7.5
	22	All digital signature blocks for EOR and traffic engineering section approval are complete	Section 21.7.4
	23	Specifications, bid items, and cost estimate complete	Chapter 19
PLAN SHEET AND DESIGN ELEMENT SPECIFIC DRAFTING			
	24	Statewide goals, priority and implementation have been incorporated into project	Section 4.1.2
	25	All bubble notes used in the plan sheets are listed in the legend	Section 21.10.1
	26	All Phase rotation diagrams and fire preemption diagrams complete	Sections 3.3 & 3.4
	27	All poles and pedestals numbered	Section 21.8.3
	28	All Illumination equipment location and detailing correct	Section 5.6
	29	All signal head type, phase, location, and detailing correct	Sections 5.2, 21.9.1 & 21.9.2
	30	All pedestrian signal heads and pushbutton location, phase and detailing correct	Section 5.4*
	31	All sign size, message, location, and detailing correct	Section 5.3
	32	All fire preemption equipment location and detailing correct	Section 5.7
	33	All non-invasive detection equipment location, type, mount and detailing is correct	Chapter 6
	34	Pole entrance chart complete	Section 21.10.8 & Chapter 9
	35	All service cabinet locations and detailing correct	Sections 5.8 & 5.11
	36	All controller cabinet location, orientation, and detailing correct	Section 5.10
	37	All Cabinet prints are complete (detection zones shown, etc.)	Chapter 20
	38	All Junction box location, size and detailing correct	Section 5.12*
	39	All Conduit routing, size, future/spare, and detailing is correct	Sections 5.13* & 21.8.2
	40	All wire/cable number, type, gauge and detailing is correct for ALL equipment	Section 5.14*
	41	Existing utility plan sheet complete	Section 21.10.7
	42	Railroad preemption plan sheet complete	Section 21.10.6 & Chapter 16
	43	All standard details necessary for project are incorporated into a DETAIL sheet	Section 9.5

*Also see application specific sections of the manual such as fire preemption, railroad, PTR signs, RRFB, etc.

21.16 Standard Bubble Note List

This section contains all the standard bubble notes in the MicroStation workspace. See It is current at the date this manual is web posted in January, however, changes to the MicroStation workspace can occur at any time during the year as necessary. Therefore, the MicroStation workspace is the official location for the most up-to-date content. See Figure 21-72 through Figure 21-87.

Figure 21-72 | Standard Bubble Notes - Controllers

CATEGORY	CONTROLLERS
INSTALL NOTES	(332S) Install a model 332S cabinet & control equipment with riser frame, orient louvered door as shown (332) Install a model 332 cabinet & control equipment with riser frame, orient louvered door as shown (C / ATC) Install model ATC controller (Agency furnished & installed) (334) Install a model 334 cabinet & control equipment with riser frame, as shown (ramp meter) (C) Install controller cabinet (see signal plan) (FYA / Ph) Install solid and flashing from yellow arrow section of type 3L signal head for phase (Ph = phase) (Agency installed) (SDLC) Install synchronous data link control (SDLC) connection (Agency installed) (GPS) Install GPS time sync. module (OF) Install new output file (Agency furnished & installed) (AUX) Install new auxiliary file (Agency furnished & installed) (DIN / C) Install communications bracket for copper. Use only green sheet listed systems. (DIN / F) Install communications bracket for fiber. Use only green sheet listed systems. (DA / N) Install (N=number) loop detector amplifier(s) in existing controller cabinet (Agency installed) (LS / N) Install (N=number) load switch(s) in existing controller cabinet (Agency installed) (RF) Install bolted riser frame under controller cabinet (TB) Install temporary (332) traffic signal controller cabinet base
RETAIN & PROTECT NOTES (EX)	(EX / C) Retain and protect existing model ___ controller and model ___ cabinet
REMOVE NOTES (RX)	(RX / C) Remove existing controller cabinet & equipment (R) Remove existing signal cabinet (see removal plan) (RX / OF) Remove existing output file (completed by Agency)
REMOVE & RELOCATE NOTES (RR)	(RR / C) Remove and relocate existing controller
REINSTALL NOTES (RI)	(RI / C) Reinstall existing controller
ABANDON NOTES (AX)	NONE – NOT APPLICABLE

Figure 21-73 | Standard Bubble Notes – Fiber Optic

CATEGORY	FIBER OPTIC
INSTALL NOTES	FO N — Install fiber optic cable with (N=number) fiber strands FP — Install fiber optic connection patch panel with SC connectors L CFO — Install coil (L=length) feet of each fiber optic cable
RETAIN & PROTECT NOTES (EX)	NONE
REMOVE NOTES (RX)	
REMOVE & RELOCATE NOTES (RR)	
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

Figure 21-74 | Standard Bubble Notes – Poles

CATEGORY	POLES
INSTALL NOTES	(SM/T) Install (T=type) standard traffic signal mast arm pole (see pole entrance chart) (SM/X) Install special (X = non-standard) traffic signal mast arm pole (see pole entrance chart) (MA/L) Install (L=length) foot traffic signal mast arm (ARM) Install traffic signal mast arm on day of signal turn on (LA/L) Install (L=length) foot luminaire arm (WPX) Install special (X=non-standard) treated wood pole (see pole entrance chart) (LP) Install luminaire pole (see metal light pole table) (MB) Install metal pole barrier (see sheet no. ___) (AN) Install back guy and anchor(s) (WP) Install wood pedestrian post (PP/N) Install pedestal with frangible base on number (N=number) foundation (PP/NS) Install pedestal with frangible base on number (N=number) foundation with sloped concrete slab (see sheet no. ___)
RETAIN & PROTECT NOTES (EX)	(EX/1) Retain and protect existing power pole (power source) (EX/2) Retain and protect existing utility pole (EX/SP) Retain and protect existing strain pole (EX/MP) Retain and protect existing traffic signal mast arm pole (EX/PP) Retain and protect existing pedestrian signal pedestal (EX/VP) Retain and protect existing vehicle signal pedestal (EX/LP) Retain and protect existing luminaire pole (EX/WP) Retain and protect existing wood pole
REMOVE NOTES (RX)	(RX/SP) Remove existing strain pole & terminal cabinet (RX/MP) Remove existing traffic signal mast arm pole & terminal cabinet (RX/PP) Remove existing pedestrian signal pedestal (RX/VP) Remove existing vehicle signal pedestal (RX/LP) Remove existing luminaire pole (RX/WP) Remove existing wood pole (SP/R) Remove existing signal pole (see removal plan)
REMOVE & RELOCATE NOTES (RR)	(RR/PP) Remove and relocate existing pedestrian signal pedestal
REINSTALL NOTES (RI)	(RI/PP) Reinstall existing pedestrian signal pedestal
ABANDON NOTES (AX)	NONE – NOT APPLICABLE

Figure 21-75 | Standard Bubble Notes – RRFB

CATEGORY	R R F B
INSTALL NOTES	(AL N / P) Install (N=number) aluminum (36"x36") pedestrian crossing sign (W11-2) ASTM type IX sheeting (AL N / T) Install (N=number) aluminum (36"x36") trail crossing sign (W11-15) ASTM type IX sheeting (AL N / S) Install (N=number) aluminum (36"x36") school crossing sign (S1-1) ASTM type IX sheeting (AL N / AR) Install (N=number) aluminum (18x30") diagonal downward pointing arrow plaque (W16-7P) ASTM type IX sheeting (AL N / AH) Install (N=number) aluminum (18x30") "AHEAD" plaque (W16-9P) ASTM type IX sheeting (CC) Install actuated beacon system controller cabinet (PBH) Install pushbutton with mount & instruction sign R10-25 (PAH) Install audible pushbutton with mount & instruction sign R10-25 (PAH BD) Install audible pushbutton with bidirectional arrow with mount & instruction sign R10-25 (XT / S) Install (S=size) inch long pushbutton adaptor/extension (X90) Install 90 degree extension bracket adaptor (RRFB N) Install (N=number) RRFB rapid flashing bar (SOL) Install solar panel energy source
RETAIN & PROTECT NOTES (EX)	NONE
REMOVE NOTES (RX)	
REMOVE & RELOCATE NOTES (RR)	
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

Figure 21-76 | Standard Bubble Notes – Beacons

CATEGORY	BEACONS
INSTALL NOTES	FB/OB — Install 24/7 flashing beacon assembly for obstruction (see sheet no. ___) FB/YF — Install 24/7 flashing beacon assembly with yellow & speed feedback (see sheet no. ___) FB/Y — Install 24/7 beacon assembly with yellow (see sheet no. ___) FB/R — Install 24/7 beacon assembly with red (see sheet no. ___) AB/P — Install actuated flashing beacon assembly with ped/bike (see sheet no. ___) AB/EV — Install actuated flashing beacon assembly with EV (see sheet no. ___) AB/BP — Install actuated flashing beacon assembly for "BE PREPARED TO STOP" sign (see sheet no. ___) AB/SZ N — Install actuated flashing beacon assembly w/school & (N=number) backside vehicle signal (see sheet no. ___) AB/SZF N — Install actuated flashing beacon assembly w/school, speed feedback, & (N=number) backside vehicle signal (see sheet no. ___) USF — Install unintegrated speed feedback assembly (see sheet no. ___)
RETAIN & PROTECT NOTES (EX)	NONE
REMOVE NOTES (RX)	
REMOVE & RELOCATE NOTES (RR)	
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

Figure 21-77 | Standard Bubble Notes – Signals

CATEGORY	SIGNALS
INSTALL NOTES	V/Ph — *Install phase (Ph=phase) vehicle signal with 2" fluorescent yellow reflective sheeting on backboard* V/Ph — *Install phase (Ph=phase) polycarbonate vehicle signal with 2" fluorescent yellow reflective sheeting on backboard* GPL — *Install geometrically programmed louvers. Pelco model GL-1010 with ___ degree view cut-off or approved equal* 45/DEG — *Install 12" diameter, 18" deep, 45 degree angle visor* TTL — *Install tattletale (white) LED light wired directly to the red vehicle signal indication. Coordinate aiming of light with Engineer.* FR/12 — *Install 12" diameter flashing red beacon* FY/12 — *Install 12" diameter flashing yellow beacon* A/Ph — *Install phase (Ph=phase) audible pedestrian pushbutton with mount & instruction sign R10-3* B/Ph — *Install phase (Ph=phase) pushbutton with mount & instruction sign R10-3* P/B/Ph — *Install phase (Ph=phase) pedestrian signal with pedestrian signal mount and pushbutton with mount & instruction sign R10-3* P/A/Ph — *Install phase (Ph=phase) pedestrian signal with pedestrian signal mount and audible pushbutton with mount & instruction sign R10-3* P/Ph — *Install phase (Ph=phase) pedestrian signal with pedestrian signal mount* XT/S — *Install (S=size) inch long pushbutton adaptor/extension* X90 — *Install 90 degree extension bracket adaptor* BD A/Ph — *Install phase (Ph=phase) audible pushbutton with mount & instruction sign R10-3 with bidirectional arrow* BD B/Ph — *Install phase (Ph=phase) pushbutton with mount & instruction sign R10-3 with bidirectional arrow* BD P/B/Ph — *Install phase (Ph=phase) pedestrian signal with pedestrian signal mount and pushbutton with mount & instruction sign R10-3 with bidirectional arrow* BD P/A/Ph — *Install phase (Ph=phase) pedestrian signal with pedestrian signal mount and audible pushbutton with mount & instruction sign R10-3 with bidirectional arrow*
RETAIN & PROTECT NOTES (EX)	EX/VPh — *Retain and protect existing phase (Ph=phase) vehicle signal* EX/P/B — *Retain and protect existing pedestrian signal, pushbutton & instruction sign* EX/B — *Retain and protect existing pedestrian pushbutton & instruction sign* EX/P — *Retain and protect existing pedestrian signal*
REMOVE NOTES (RX)	RX/V — *Remove existing vehicle signal* RX/P — *Remove existing pedestrian signal* RX/P/B — *Remove existing pedestrian signal, pushbutton & instruction sign* RX/B — *Remove existing pedestrian pushbutton & instruction sign*
REMOVE & RELOCATE NOTES (RR)	RR/V — *Remove and relocate existing vehicle signal*
REINSTALL NOTES (RI)	RI/VPh — *Reinstall existing phase (Ph=phase) vehicle signal*
ABANDON NOTES (AX)	*NONE – NOT APPLICABLE*

Figure 21-78 | Standard Bubble Notes – Cabinets

CATEGORY	CABINETS
INSTALL NOTES	TC — Install terminal cabinet RTC — Install recessed terminal cabinet BMC — Install base mounted service cabinet, 120/240 volt metered for signal system BMCL — Install base mounted service cabinet, 120/240 volt metered for signal & llumination system BMCF — Install base mounted service cabinet, 120/240 volt metered for signal & flashing beacon system BMC/FL — Install base mounted service cabinet, 120/240 volt metered for signal, flashing beacon, & illumination system SC — Install service cabinet, 120/240 volt for signal system SCL — Install service cabinet, 120/240 volt for signal & illumination system MS — Install 120/240 volt meter base FR — Install meter socket jumper cover required for flat rate billing (factory installed)
RETAIN & PROTECT NOTES (EX)	EX/TC — Retain and protect existing terminal cabinet EX/RTC — Retain and protect existing recessed terminal cabinet EX/SC — Retain and protect existing service cabinet EX/MS — Retain and protect existing meter base
REMOVE NOTES (RX)	RX/SC — Remove existing service cabinet RX/MS — Remove existing meter base
REMOVE & RELOCATE NOTES (RR)	NONE – NOT APPLICABLE
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

Figure 21-79 | Standard Bubble Notes – Signs (Aluminum)

CATEGORY	S I G N S (aluminium)
INSTALL NOTES	AL 1L *Install aluminum (30"x36") "ONE WAY" left arrow sign (R6-2L) ASTM type IX sheeting* AL 1R *Install aluminum (30"x36") "ONE WAY" right arrow sign (R6-2R) ASTM type IX sheeting* AL 3 *Install aluminum (30"x36") "NO TURN ON RED" sign (R10-11a) ASTM type IX sheeting* AL 3U *Install aluminum (30"x36") "U TURN PERMITTED" sign (OR3-12) ASTM type IX sheeting* AL 4 *Install aluminum (30"x36") left and right arrow sign (OR3-5TD) ASTM type IX sheeting* AL 4L *Install aluminum (30"x36") left and through arrow sign (R3-6L) ASTM type IX sheeting* AL 4R *Install aluminum (30"x36") through and right arrow sign (R3-6R) ASTM type IX sheeting* AL 4T *Install aluminum (30"x36") left, through, and right arrow sign (OR3-5TT) ASTM type IX sheeting* AL 5L *Install aluminum (30"x36") left arrow "ONLY" sign (R3-5L) ASTM type IX sheeting* AL 5R *Install aluminum (30"x36") right arrow "ONLY" sign (R3-5R) ASTM type IX sheeting* AL 5T *Install aluminum (30"x36") through arrow "ONLY" sign (R3-5a) ASTM type IX sheeting* AL 6 *Install aluminum (36"x36") "NO TURNS" sign (R3-3) ASTM type IX sheeting* AL 6L *Install aluminum (36"x36") no left turn symbol sign (R3-2) ASTM type IX sheeting* AL 6R *Install aluminum (36"x36") no right turn symbol sign (R3-1) ASTM type IX sheeting* AL 7 *Install aluminum (36"x36") "DO NOT ENTER" sign (R5-1) ASTM type IX sheeting* AL 8 *Install aluminum (24"x30") "ONE VEHICLE PER GREEN" sign (R10-28) ASTM type IX sheeting* AL 8S *Install aluminum (24"x12") "ONE VEHICLE PER GREEN" sign (OR20-1) ASTM type IX sheeting* AL 9 *Install aluminum (24"x36") "STOP HERE ON RED" sign (R10-6) ASTM type IX sheeting* AL 11 *Install aluminum (30"x36") "LEFT TURN YIELD ON GREEN" ball symbol sign (R10-12) ASTM type IX sheeting* AL 12 *Install aluminum (30"x30") "TURNING VEHICLES STOP FOR PEDS" sign (R10-15a) ASTM type IX sheeting* AL 16 *Install aluminum (36"x36") "RAMP METERED WHEN FLASHING" sign (W3-8) ASTM type IX sheeting* AL 17 *Install aluminum (24"x30") "FORM 2 LANES WHEN METERED" sign (OR20-5) ASTM type IX sheeting* AL 18 *Install aluminum (36"x36") "BE PREPARED TO STOP" sign (W3-4) ASTM type IX sheeting* AL 19 *Install aluminum (24"x18") "WHEN FLASHING" sign (W16-13P) ASTM type IX sheeting* AL 20 *Install aluminum (24"x12") "EXCEPT BUSSES" sign (R3-7a) ASTM type IX sheeting*
RETAIN & PROTECT NOTES (EX)	EX AL *Retain and protect existing aluminum sign and mount*
REMOVE NOTES (RX)	RX AL *Remove existing aluminum sign and mount*
REMOVE & RELOCATE NOTES (RR)	RR AL *Remove and relocate existing aluminum sign and mount*
REINSTALL NOTES (RI)	RI AL *Reinstall existing aluminum sign and mount*
ABANDON NOTES (AX)	*NONE – NOT APPLICABLE*

Figure 21-80 | Standard Bubble Notes – Signs (PTR, Interior Illuminated, and Other)

CATEGORY	S I G N S (PTR)
INSTALL NOTES	(PR / 6L) Install (36"x36") no left turn symbol part time restriction sign (R3-2) (PR / 6R) Install (36"x36") no right turn symbol part time restriction sign (R3-1)
RETAIN & PROTECT NOTES (EX)	(EX / PR) Retain and protect existing part time restriction sign
REMOVE NOTES (RX)	(RX / PR) Remove existing part time restriction sign
REMOVE & RELOCATE NOTES (RR)	(RR / PR) Remove and relocate existing part time restriction sign
REINSTALL NOTES (RI)	(RI / PR) Reinstall existing part time restriction sign
ABANDON NOTES (AX)	NONE – NOT APPLICABLE

CATEGORY	S I G N S (Interior Illuminated)
INSTALL NOTES	NONE
RETAIN & PROTECT NOTES (EX)	(EX / OS) Retain and protect existing interior illuminated sign
REMOVE NOTES (RX)	(RX / OS) Remove existing interior illuminated sign
REMOVE & RELOCATE NOTES (RR)	NONE – NOT APPLICABLE
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

CATEGORY	S I G N S (other)
INSTALL NOTES	(*) See signing plans for details on sign and attachment
RETAIN & PROTECT NOTES (EX)	NONE
REMOVE NOTES (RX)	
REMOVE & RELOCATE NOTES (RR)	
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

Figure 21-81 | Standard Bubble Notes – Junction Boxes

CATEGORY	JUNCTION BOXES
INSTALL NOTES	JB 1 — Install 17"x10"x12" (min. dimension) precast concrete or hybrid junction box JB 2 — Install 22"x12"x12" (min. dimension) precast concrete or hybrid junction box JB 3 — Install 30"x17"x12" (min. dimension) precast concrete or hybrid junction box JB 3/T — Install tandem 30"x17"x12" (min. dimension) precast concrete or hybrid junction boxes JB SP — Junction box (see signal plan) JB DP — Junction box (see detector plan) JB IP — Junction box (see interconnect plan) JB X — Install ___" X ___" X ___" (min. dimension) galv. cast iron junction box with gasketed galv. steel cover SP S — Install 6" max. sand pocket block-out with (S=size) inch conduit to junction box HH 1 — Install 24"x30"x24" fiber optic hand hole HH 2 — Install 30"x48"x24" fiber optic hand hole HH 3 — Install 30"x48"x36" fiber optic hand hole
RETAIN & PROTECT NOTES (EX)	EX JB — Retain and protect existing junction box EX HH — Retain and protect existing fiber optic hand hole
REMOVE NOTES (RX)	RX JB — Remove existing junction box JB R — Remove existing junction box (see removal plan) RX HH — Remove existing fiber optic hand hole
REMOVE & RELOCATE NOTES (RR)	NONE – NOT APPLICABLE
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

Figure 21-82 | Standard Bubble Notes – Detection

CATEGORY	DETECTION
INSTALL NOTES	(L / F) Install 6' round or 4' diamond ramp meter detector loop with (F=function) function D = Demand C = Count P = Passage Q = Queue (LD / Ph) Install phase (Ph=phase) 6' round or 4' diamond vehicle detector loop (LD / C) Install 6' round or 4' diamond vehicle count loop (LB / Ph) Install phase (Ph=phase) 2 1/2' diamond bicycle detector loop (PD / Ph) Install phase (Ph=phase) 4' diamond preformed vehicle detector loop (PL / Ph) Install phase (Ph=phase) 6' square preformed vehicle detector loop (LB / Ph) Install phase (Ph=phase) parallelogram bicycle detector loop (LF / X-Ph) Install (X=number of cables) phase (Ph=phase) loop feeder cable(s) (F18 / X-Ph) Install (X=number of cables) phase (Ph=phase) no. 18 AWG loop feeder cable(s) (LF / X-F) Install (X=number of cables) function (F=function) loop feeder cable(s) (N / LW) Install (N=number) pair of loop wires (CAM / T) Install video detector camera (T=camera) (CAM / DP) Video detector camera (see detector plan) (R-S / T) Install side fire, dual beam radar detector unit (T=radar) (R-F / T) Install far-range radar detector unit (T=radar) (R-N / T) Install near-range radar detector unit (T=radar) (HVR / T) Install hybrid video/radar detector (T = hybrid detector)
See next page for EX, RX, RR, RI, and AX information	

Figure 21-83 | Standard Bubble Notes – Detection, Continued

CATEGORY	DETECTION (continued)
RETAIN & PROTECT NOTES (EX)	EX CAM — Retain and protect existing video detector camera EX RAD — Retain and protect existing radar detector unit EX DPh — Retain and protect existing phase (Ph=phase) detector loop EX FPh — Retain and protect existing phase (Ph=phase) loop feeder cable(s) EX D-F — Retain and protect existing ramp meter (F=function) detector loop EX LF-F — Retain and protect existing ramp meter (F=function) loop feeder cable(s)
REMOVE NOTES (RX)	RX FPh — Remove existing phase (Ph=phase) loop feeder cable(s) RX LF-F — Remove existing ramp meter (F=function) loop feeder cable(s) RX CAM — Remove existing video detector camera RX RAD — Remove existing radar detector unit
REMOVE & RELOCATE NOTES (RR)	RR CAM — Remove and relocate existing video detector camera RR RAD — Remove and relocate existing radar detector unit
REINSTALL NOTES (RI)	RI CAM — Reinstall existing video detector camera RI RAD — Reinstall existing radar detector unit
ABANDON NOTES (AX)	AX D — Abandon existing detector loop

Figure 21-84 | Standard Bubble Notes – Wires and Cables

CATEGORY	WIRES & CABLES
INSTALL NOTES	N-C — Install (N=number) no. 8 AWG THWN wire(s) for signal system common N-12C — Install (N=number) no. 12 AWG THWN wire(s) for pedestal common N/G — Install (N=number) no. (G=wire size) AWG THWN wire(s) N|G — Install (N=number) no. (G=wire size) AWG XHHW wire(s) X-N/G — Install (X=number of cables) control cable(s) with (N=number) no. (G=wire size) AWG conductors W/P — Install wiring to serve pole (P = pole number) as required by the manufacturer PL — Install poly pull line VDP/T — Install video detection coaxial and power cable for camera (T=camera) VDP/T — Install combo video/radar detection coaxial and power cable for camera (T=camera) RCC/T — Install radar control cable (T=radar) 38 — Install galv. steel 3/8" messenger and 1/4" tether cables 39 — Install 3/8" galv. steel messenger cable 41 — Install 1/4" galv. steel stabilizer cable and bars 42 — Install 1/4" galvanized steel messenger cable Ph — Includes 3 spare wires for phase (Ph=phase) as per table
RETAIN & PROTECT NOTES (EX)	EX/W — Retain and protect existing wiring EX/CC — Retain and protect existing control cables EX/38 — Retain and protect existing messenger and tether cables EX/39 — Retain and protect existing messenger cable EX/40 — Retain and protect existing tether cable
REMOVE NOTES (RX)	RX/W — Remove existing wiring RX/CC — Remove existing control cables RX/38 — Remove existing messenger and tether cables RX/39 — Remove existing messenger cable RX/40 — Remove existing tether cable
REMOVE & RELOCATE NOTES (RR)	NONE
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

Figure 21-85 | Standard Bubble Notes – Conduits

CATEGORY	CONDUITS
INSTALL NOTES	(S) Install (S=size) inch conduit (CS) Install 2" conduit stub (for future use, cap ends) (DC) Detector conduit (see detector plan) (EC) Electrical conduit (see signal plan) (HDD) Install conduit by horizontal directional drilling, open trench not allowed (IC) Interconnect conduit (see interconnect plan) (BC S) Install (S=size) inch rigid metallic conduit, conduit bodies, expansion fittings, and surface mounted metallic junction boxes as required. Submit proposed method of attachment to the bridge for approval. (CJ) Splice new electrical conduit to existing electrical conduit (W) Install conduit and wire as required by power company
RETAIN & PROTECT NOTES (EX)	(EX EC) Retain and protect existing electrical conduit (EX DC) Retain and protect existing detector conduit (EX IC) Retain and protect existing interconnect conduit (EX CS) Retain and protect existing conduit stub (EX S) Retain and protect existing (S=size) inch conduit (EX C S) Retain and protect existing (S=size) inch conduit
REMOVE NOTES (RX)	(RX EC) Remove existing electrical conduit (RX DC) Remove existing detector conduit (RX IC) Remove existing interconnect conduit (R) Remove existing electrical conduit (see removal plan)
REMOVE & RELOCATE NOTES (RR)	NONE – NOT APPLICABLE
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	(AX C) Abandon existing conduit

Figure 21-86 | Standard Bubble Notes – Luminaires and Fire Preemption

CATEGORY	LUMINAIRES
INSTALL NOTES	(LED) Install ___ watt light emitting diode luminaire (see special provisions). Bond luminaire to pole grounding terminal. (PE / 1) Install photocontrol electronic relay on pole (PE / 2) Install photocontrol electronic relay on luminaire head (IP) Install luminaire (see illumination plans)
RETAIN & PROTECT NOTES (EX)	NONE
REMOVE NOTES (RX)	
REMOVE & RELOCATE NOTES (RR)	
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

CATEGORY	FIRE PREEMPTION
INSTALL NOTES	(FP) Install fire preemption interface in controller cabinet (Agency installed) (FN / Ch) Install channel (Ch=channel), (N=number) barrel fire preemption detector unit (FF / Ch) Install channel (Ch=channel) fire preemption detector feeder cable
RETAIN & PROTECT NOTES (EX)	(EX / FD) Retain and protect existing fire preemption detector unit (EX / FF) Retain and protect existing fire preemption feeder cable
REMOVE NOTES (RX)	(RX / FD) Remove existing fire preemption detector unit (RX / FF) Remove existing fire preemption feeder cable
REMOVE & RELOCATE NOTES (RR)	(RR / FD) Remove and relocate existing fire preemption detector unit
REINSTALL NOTES (RI)	(RI / FD) Reinstall existing fire preemption detector unit
ABANDON NOTES (AX)	NONE – NOT APPLICABLE

Figure 21-87 | Standard Bubble Notes – Miscellaneous and Heads & Brackets

CATEGORY	MISCELLANEOUS
INSTALL NOTES	(CW) Install crosswalk closure support with signs (both sides of support) (Note N) See sheet note number (N=Number)
RETAIN & PROTECT NOTES (EX)	NONE
REMOVE NOTES (RX)	(RX CW) Remove existing crosswalk closure support with sign(s)
REMOVE & RELOCATE NOTES (RR)	NONE
REINSTALL NOTES (RI)	
ABANDON NOTES (AX)	

CATEGORY	HEADS & BRACKETS CAMERA TYPES
NON-INVASIVE DETECTOR UNIT MOUNTS	VL = Video detection camera bracket, cable mount, 1-piece with 23" tube (Pelco part no. AS-0175 or approved equal) Mount camera on luminaire arm. Mount camera on flat part of luminaire arm or as directed by engineer. VM = Video detection camera bracket, cable mount, 1-piece with 74" tube (Pelco part no. AS-0175 or approved equal) Mount camera on mast arm. VRM = Video/ Radar detection camera bracket, cable mount, 1-piece with 74" tube (Pelco part no. AS-0175 or approved equal) Mount Video/Radar unit on mast arm per manufacturers recommendations. VP = Video detection camera bracket, 1-piece with 11" tube (Pelco part no. SH-0527 or approved equal) Mount camera on verticle pole.
NON-INVASIVE DETECTOR UNIT TYPES	20 = Black and white video detector camera 21 = Color video detector camera 22 = Thermal imaging detector camera 23 = Radar detector 24 = Combo Video/ Radar detector
SIGNAL HEAD TYPE ABBREVIATIONS	1Y = FY 1R = FR 2 = R:Y:G 3L = RA:YA:GA 3LCF = RA:YA/FYA:GA 3R = RA:YA:GA 3RCF = RA:YA/FYA:GA 4 = R:Y:G:GA 7 = R:Y:G:GA 8 = R:G 9 = R:Y:GA:GA 12 = RB:YB:GB 12M = RB:YB:GB

22 Construction Support

Once the project has been let, the signal designer will provide assistance to the office administering the contract during the advertisement and construction phases. This typically consists of:

- Handing off electronic design files to the construction office for their use & verification
- Clarifying/interpreting information shown in the plans and specifications
- Adding, modifying or deleting information in the plans and specifications as necessary
- Providing a cost estimate for your expected amount of construction support
- Reviewing submittals
- Attending meetings as requested
- Periodic inspection of work as requested

Construction support should be the highest priority for the signal designer.

22.1 Authority over the Contract Work

Once the project is let (during the advertisement phase and the construction phase) the engineer has full authority over the work contained in the contract documents. The engineer is defined in the specifications as the chief engineer of the agency acting directly or through authorized representative (section 00110.20). The specifications also define the project manager as the engineer's representative who directly supervises the engineering and administration of a contract (section 00110.20) and the states the duties and authorities of the project manager (section 00150.01). One of the duties of the project manager is to address any clarification, interpretation, corrections, etc. of the contract documents. This is to ensure that clear, concise information/direction is given to the bidders or the contractor. Contract clarification or interpretation obtained from persons other than the project manager (e.g., the signal designer) are not binding on the agency and unnecessarily complicate administration of the contract.

The engineer as defined by the contract documents (project manager/resident engineer) has authority of the contract work. Always work directly with the project manager's office when providing construction support. DO NOT WORK DIRECTLY WITH THE BIDDER OR CONTRACTOR!

22.2 Addenda

Changes or corrections to the plans, special provisions or bid items may be required during the advertisement phase. These changes are made by addenda.

If the addendum includes modifying a plan sheet, the plan sheet will need to follow the "revised plans" process described in chapter 21. Revision triangles are required on ALL revised plan sheets as shown in the Contract Plans Development Guide, NO EXCEPTIONS.

In addition, traffic engineering section review and design approval of the revised plan sheet is required as per chapter 2. The TRS dwg. number does not change from the original plan sheet.

22.3 Pre-Construction Conference

After the contract has been awarded and prior to starting work, the contractor must meet with the resident engineer for a pre-construction conference (pre-con). The pre-construction meeting will typically cover the following topics that can impact signal design:

- Utility relocation and potential conflicts
- Identifying known problem areas, identifying procedures to resolve those problems, and establishing a process to resolve future problems in a timely manner
- Calling attention to unique design requirements in the plans and specs
- Project schedule
- Temporary traffic control and staging
- Identification of key personnel and channels of communication

The signal designer should attend the pre-con conference if possible, especially if there are known problem areas, unique design requirements, and/or the contractor or inspector have limited traffic signal construction experience. Obtaining a copy of the agenda can maximize your efficiency as it is not necessary to stay for the entire pre-con, which can be lengthy and cover a wide array of contract topics.

22.4 Material Submittals and Shop Drawing Review

The signal designer may receive different types of submittals to review, but the three main required construction submittals are pole drawings, blue & green sheets, and field verification forms.

22.4.1 Pole and Foundation Submittals

The signal designer should review these features when receiving pole submittals:

- Are the shop drawing(s) prequalified or not? Verify the shop drawing manufacturer and drawing number(s) with the prequalified list that is in the special provisions 00962.05(a). If the shop drawings are prequalified, no additional structural review is necessary. If the shop drawings are NOT prequalified, contact the region bridge unit for review of the structural aspects.
- The information in shop drawing matches the information in the plans/pole entrance chart:
    - Pole type
    - Mast arm length
    - Mast arm orientation
    - Luminaire arm length
    - Luminaire arm height
    - Luminaire arm orientation
    - Hand hole orientation
    - RTC orientation
    - Loading on the mast arm & pole
    - Any other appurtenances that are specified on the plans (e.g., ornamental base shoes).

After reviewing the submittals, mark them as REVIEWED including your signature and the date. Submit the back to the construction office.

22.4.2 Blue Sheets and Green Sheets

The traffic engineering section maintains two lists of materials and equipment that show a list of prequalified equipment for use on signal projects. These lists are commonly referred to as the blue and green sheets. They are updated frequently and posted on the traffic signal standards website (click on "product evaluation and approval").

The blue sheets contain a list of items that are normally qualified by the project manager's office according to the Non-Field Tested Materials Guide.

The green sheets contain a list of items that are normally accepted for environmental and functional testing by the traffic system services unit (TSSU). This is typically the controller cabinet and equipment contained within.

The contractor is responsible for downloading, appropriately filling out, and submitting copies of the blue and green sheets to the project manager prior to starting work. The second page of the blue and green sheets contains detailed instructions for how to use and process each document.

While the signal designer is not directly involved in approving the blue or green sheets, the signal designer should be involved in reviewing them and providing assistance to the resident engineer's office as requested. Review and assistance typically entails making sure the contractor has included all of the necessary components as required by the plans and specifications.

When reviewing the blue or green sheets, always read through and follow the instructions listed on the second page of the submittal.

22.4.1 Field Verification Forms (For Signal Poles and Signal Pole Foundations)

There are two field verification forms, one for signal poles and one for signal pole foundations. These two forms are required for each large pole on the project (not required for pedestals). Both forms contain information that is intended to verify the exact location of the pole foundation, the vertical clearance for all equipment mounted on the mast arm will meet the 18' min. to 19' max., and the anchor rod projection is installed per specification. The forms as well as additional information about their use (flow chart and roles & responsibilities) are on the traffic structures website (click "signal supports, field verification forms").

These forms are filled out by the project manager's office prior to installation of the signal pole foundations based on the information provided in the signal plan sheets and design files. However, the signal designer may be asked to help fill them out or review the content.

22.5 Cabinet Print

Per the 00990.70 specification, the cabinet print is provided to the contractor via the project manager's office during the construction phase. This should occur near the pre-construction conference project milestone, prior to the signal being constructed. See chapter 20 for more information on the process for completing the cabinet print.

22.6 Requests for Information

The project manager's office will contact the engineer of record when there is a need for interpretation of the plans or the specifications. As mentioned in section 22.1, all requests for information should come from the project manager's office. If a request from someone other than the project manager office is received, do NOT answer any project specific questions and direct them to the project manager's office for proper processing of the issue. This may seem overly bureaucratic and unhelpful, but the importance of this process cannot be understated; it is vital that agency communication is directed through a single official source to avoid conflicting, confusing, or inappropriate release of information that may result in time delays, unnecessary expense, or construction claims.

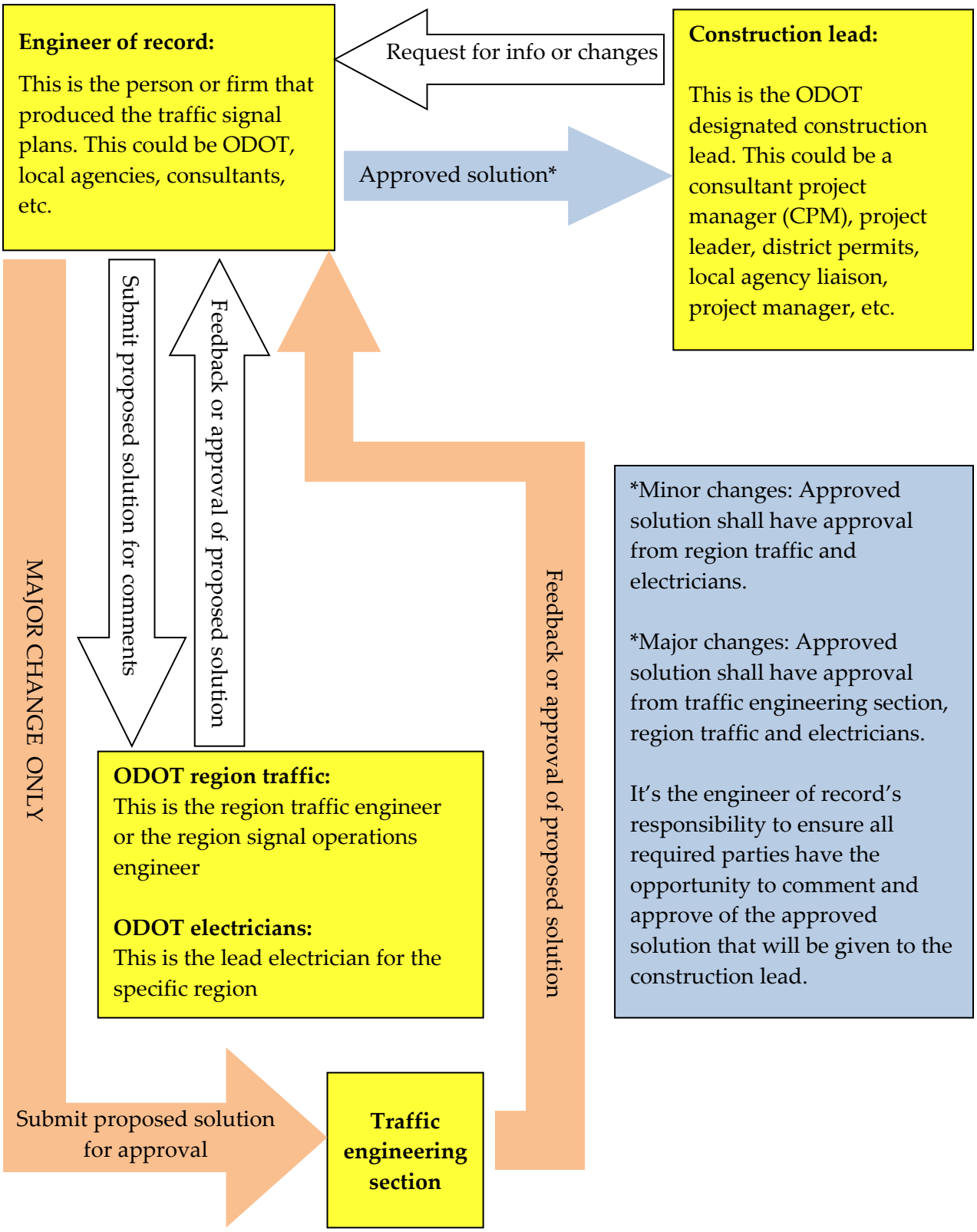
The construction lead will submit any contractor questions, contractor proposals, errors in the plans/specifications, etc. to the engineer of record for review and comment. The engineer of record will determine a proper response back according to the following:

- If clarification of the plans is all that is needed, the engineer of record will provide this information to the project manager with no further action needed from the EOR.
- If a minor change to plans and/or specifications is needed, the engineer of record will submit a proposed solution to region traffic and the region electricians for review and approval. A minor change would be anything that falls under current standard practice. The EOR will give the approved solution to the construction lead (see section 22.7) who will then direct the contractor.
- If a major change to plans and/or specifications is needed, the engineer of record will submit a proposed solution to the traffic engineering section, region traffic and the region electricians for review and approval. A major change would involve any deviation from standards. The EOR will give the approved solution to the construction lead (see section 22.7) who will then direct the contractor.

The engineer of record is responsible for providing a solution to issues that arise during construction. The construction lead is responsible for making sure that solution is carried out.

The following flow chart, Figure 22-1, outlines this basic process for handling requests for information and resolving issues during construction.

Figure 22-1 | Changes During Construction Flow Chart



22.7 Contract Change Orders

Changes or corrections to the plans, special provisions or bid items may be required during the construction phase. These changes are made by contract change orders (CCO).

If a CCO includes modification to a plan sheet, there are two options for resolution:

- Provide written or verbal direction to the project manager of the required change. This change will then be documented in the CCO paperwork and on the plan sheet as-built when the project is completed. If the change is major or includes a deviation from standards, verbal or written approval (such as e-mail) is required by the traffic engineering section.
- Produce a revised sealed plan sheet for inclusion into the CCO (see chapter 21 for the revised plans process). This option is recommended if the revision is complex enough that written or verbal directions to the construction lead would be insufficient to properly understand and implement the change. Revision triangles are required on ALL revised plan sheets as shown in the Contract Plans Development Guide, NO EXCEPTIONS. The revised plan sheet does NOT need to be submitted to the traffic-roadway section for review and design approval if the proposed change is minor and doesn't deviate from standards (e.g., adjustment or deletion of an optional lane use sign). If the change is major (e.g., deviates from the requirements stated in the operational approval) or involves a deviation from standards, the revised plan sheet shall be submitted to the traffic engineering section for review and design approval as per chapter 2. The TRS dwg. number does not change from the original plan sheet.

CCO plan sheet revisions are given the highest priority for traffic engineering section review.

Verbal approval by the traffic engineering section for changes that deviate from standard is acceptable for moving forward during construction.

22.8 Certified Traffic Signal Inspection Certification

The traffic engineering section provides training and certification each year for inspection of ODOT traffic signal installations. While this training is specific to inspection and NOT a requirement for signal designers, it is highly recommended as it will give a better understanding of the materials and construction process related to traffic signals. Class topics include:

- Material qualifications (blue and green sheets)
- Review of the current Inspector's Manual for Signal Construction
- Exposure to basic signal design
- Standard drawings
- Reading of plans and specifications

The training is taught in two different formats; a 2-day full class and a 1-day re-certification class for those that are more familiar with the subject topics and just need a refresher course highlighting the recent changes. A self-paced virtual training is also available for both formats. An exam is given at the end of each class and certification is given to those that pass. Certification is good for three years.

For more information on these classes, access to the current version of the Inspector's Manual for Signal Construction, and to register for up-coming classes, visit the ODOT Inspector Certification Program website.

22.9 Construction Issues

This section takes excerpts from actual construction change orders and project manager narratives, grouped into basic categories. See Figure 22-2 through Figure 22-24. Some of these issues could have been resolved prior to construction during the design phase by a site visit to the field to verify conditions or by coordinating with other disciplines. Some result from ambiguity, incomplete, or conflicting information in the contract documents. Others are the result of unexpected conditions that were uncovered during the construction process and would have been hard to predict ahead of time. While not all contract change orders can be avoided, the goal is to minimize the number of CCOs needed to build the contract by producing complete, concise, and field verified contract plans.



The traffic engineering section reviews contract change order and project manager narratives as they are posted on the ODOT server.

It is always more cost effective for the contractor to bid and build what's shown in the original contract documents than to issue a change order during construction for the same work.

22.9.1 Detection

Figure 22-2 | CCO – Detection, April 2013

THIS CONTRACT IS HEREBY MODIFIED AS FOLLOWS (DESCRIPTION AND LOCATION OF WORK COVERED BY THIS ORDER):

This Contract Change Order will provide a method of payment to install Loops #23 and #24 at Boones Ferry Road and to be connected to existing feeder cables. However, field investigation showed the loop feeder cables did not exist.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$1,347.96
	DECREASE		

Figure 22-3 | CCO – Detection, November 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

Region 1 determined that a proposed future project will reconfigure the ramp meter detector loops at the US26 EB straight on ramp and therefore, the loop replacement work shown on the project plans was deleted in this contract. ODOT Region 1 requested this change. The price for cutting loops in the sub-sub-contract for Bid Item 117, for Ramp Meter Modification: EB ON-Ramp at 185th, was $6,360 for 14 loops, which equals $454.28 per loop. At the 185th ramp to EB US26 six loops were not removed and replaced. Six loops at $454.28 each plus 17% mark-up is $3,189. Splicing the loops to the loop feeder cable would take about 1/2 day at $72/hour plus $15/hour for equipment and materials is an additional $348 for time and materials. The total associated with this work, and appropriate for credit to ODOT, is $3,537.

The attached email dialogue documents agreement from sub-contractor O'Neill Electric Inc. to credit ODOT $3,537.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE		($3,537.00)
	DECREASE	X	

Figure 22-4 | CCO – Detection, Extra Work Order, August 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

There are several locations where there are old steel street loop boxes that will be impacted by the pavement grinding. The old steel street boxes will be replaced by new PVC loop pockets. There are also several locations that will require new conduit that was not shown in the contract plans. This EWO will compensate the contractor for the added electrical work as directed by the engineer.

PAY ITEM	REASON CODE	WORK TYPE	DESIGN (E OR I)	PM (E OR I)	DESCRIPTION	ESTIMATED AMOUNT
803	26	F	I	I	0900 EWJ26-0 FA Compensate Contractor For Added Electrical Work.	$4,860.00

Figure 22-5 | CCO – Detection, PM Narrative May 2012

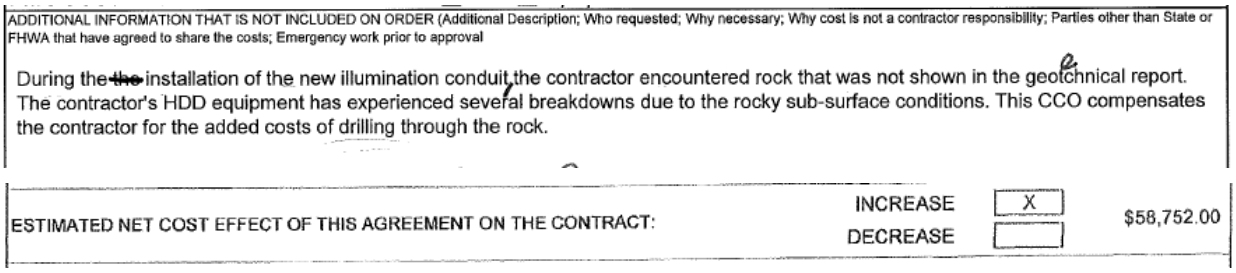
SECTION I – SPECIFIC FEEDBACK FOR PROJECT DESIGNER(S) and/or PROJECT DELIVERY TEAM

Provide constructive feedback to the project Designer(s) and/or Project Delivery Team identifying project components and aspects that worked well, and which could/should be used on other projects. Identify project components or aspects which were problematic along with suggested solutions to avoid repeating on future projects. For Design-Build projects, include feedback to the DB Project Manager or Project Leader regarding contract language which was problematic, along with suggested solutions. Also identify contract language which worked well.

These type of paving projects usually do not get adequate amount of time for quality control. Perhaps for future projects, it would be good to check the existing loops and connections, quality of J-Boxes and Wiring. In most cases, the plans call for adjust boxes, extend wires, etc..., the directions in the plans for the installations are usually not specific enough, leading to conflicts, delays, and extra costs.

22.9.2 Conduits

Figure 22-6 | CCO – Conduits, January 2013

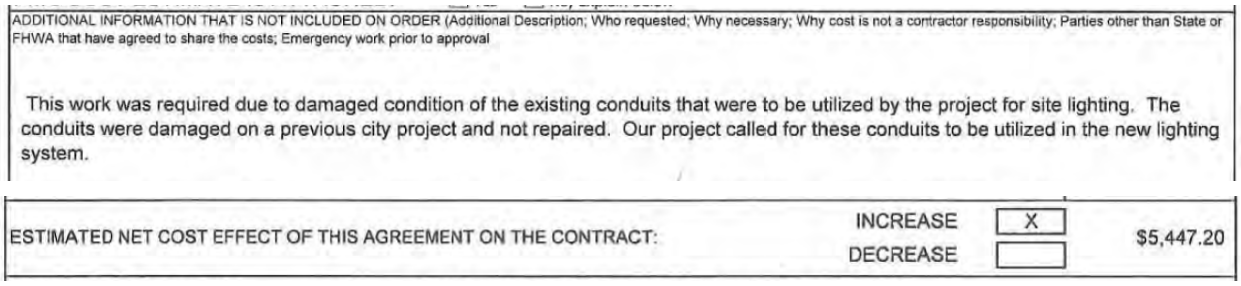


ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

During the ~~the~~ installation of the new illumination conduit, the contractor encountered rock that was not shown in the geotechnical report. The contractor's HDD equipment has experienced several breakdowns due to the rocky sub-surface conditions. This CCO compensates the contractor for the added costs of drilling through the rock.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$58,752.00
	DECREASE		

Figure 22-7 | CCO – Conduits, May 2012

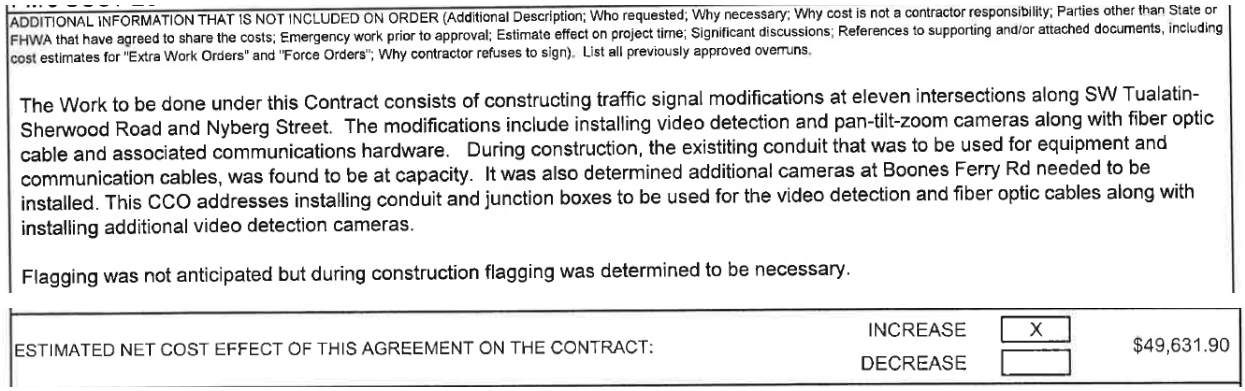


ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

This work was required due to damaged condition of the existing conduits that were to be utilized by the project for site lighting. The conduits were damaged on a previous city project and not repaired. Our project called for these conduits to be utilized in the new lighting system.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$5,447.20
	DECREASE		

Figure 22-8 | CCO – Conduits, October 2011



ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

The Work to be done under this Contract consists of constructing traffic signal modifications at eleven intersections along SW Tualatin-Sherwood Road and Nyberg Street. The modifications include installing video detection and pan-tilt-zoom cameras along with fiber optic cable and associated communications hardware. During construction, the existiting conduit that was to be used for equipment and communication cables, was found to be at capacity. It was also determined additional cameras at Boones Ferry Rd needed to be installed. This CCO addresses installing conduit and junction boxes to be used for the video detection and fiber optic cables along with installing additional video detection cameras.

Flagging was not anticipated but during construction flagging was determined to be necessary.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$49,631.90
	DECREASE		

22.9.3 Utility Conflicts

Figure 22-9 | CCO – Utility Conflicts, February 2013

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

During the Utility pre-construction meeting, the ODOT Electrical Crew Manager voiced concerns about the location of the existing interconnect conduit and junction boxes located in the median ditch. The existing conduit appeared to be in conflict with the plan design to regrade the median and excavate the shoulders. The Engineer verified that a locate was not performed during design and the interconnect will be in conflict and require relocation during construction. The current design only addressed the removal and new installation of the interconnect wire from Ringuette to Redwood Hwy. This change order compensates the contractor for the additional work needed to remove a portion of the existing conduit and install approximately 1000' of new conduit and required junction boxes for installing the new wire.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$10,888.00
	DECREASE		

Figure 22-10 | CCO – Utility Conflicts, PM Narrative, September 2012

8. Part 900 – Permanent Traffic Control & Illumination Systems

Included in the scope of this project was installing a new traffic signal on NE Columbia Blvd. and the 82nd street off ramp. One pole was relocated due to a fiber optic cable bank in the same alignment.

Figure 22-11 | CCO – Utility Conflicts, Extra Work Order, July 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

Several of the illumination pole sites have potential utility/structure conflicts that were not clearly shown in the plans. This EWO will compensate the contractor for potholing as directed by the engineer.

PAY ITEM	REASON CODE	WORK TYPE	DESIGN (E OR I)	PM (E OR I)	DESCRIPTION	ESTIMATED AMOUNT
801	26	F	I	I	0900 EW 26 ~~F A~~ Illumination Potholing As Directed	$3,400.00

Figure 22-12 | CCO – Utility Conflicts, Force Order, April 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other that State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and / or attached documents, including estimates of costs for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

The $3,000 cost is for WOEC to provide electrical power for illumination on this project. This amount will come from the Construction Engineering budget as it was not included in the Anticipated Items.

22.9.4 Poles & Foundations

Figure 22-13 | CCO – Poles & Foundations, PM Narrative, October 2012

Section I: Specific Feedback for Project Designer(s) and/or Project Delivery Team

Provide constructive feedback to the project Designer(s) and/or Project Delivery Team identifying project components and aspects that worked well, and which could/should be used on other projects. Identify project components or aspects which were problematic along with suggested solutions to avoid repeating on future projects. For Design-Build projects, include feedback to the DB Project Manager or Project Leader regarding contract language which was problematic, along with suggested solutions. Also identify contract language which worked well.

There was no Specific Feedback on this project ☐

The traffic signal pole vendor and resulting issues in obtaining final approval of their submittals was the driving force behind project delays. The Prime Contractor and electrical Sub-contractor were advised by the Project Manager that delays to the Project may occur if the signal pole supplier was NOT a pre-approved ODOT supplier. This may have been averted to some degree if the following language had been added in the Special Provisions: "Only 'pre-approved' material suppliers will be considered for Signal and/or Luminaire Pole manufacture, purchases or installations for Oregon Department of Transportation Projects". Exceptions would require special approval of the State Structural Materials Engineer before proceeding.

Figure 22-14 | CCO – Poles & Foundations, August 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

While drilling Signal Pole Foundation (Pole #1) water was first encountered at a depth of 6.5 feet (Required Footing depth = 10.5'). As drilling continued, infiltrating water began to collapse the shaft wall. The contractor was directed to place a temporary steel casing in the shaft thereby protecting the shaft from collapsing further. The pour was postponed until the next day due to the water. Plans were made to rent a Vacujet, pump the shaft free of water immediately prior to concrete pour and to pull the casing slowly enough to seal the water as the concrete was poured to 6.5 feet from the bottom. Although none of the remaining three foundations encountered enough water to require sleeving, the extra costs for Pole Foundation #1 are being compensated because it is considered a 'Changed Condition' as the Geotechnical report stated the water table to be at 12 feet or deeper.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$2,215.00
	DECREASE		

Figure 22-15 | CCO – Poles & Foundations, PM Narrative, November 2012

SECTION I – SPECIFIC FEEDBACK FOR PROJECT DESIGNER(S) and/or PROJECT DELIVERY TEAM

Provide constructive feedback to the project Designer(s) and/or Project Delivery Team identifying project components and aspects that worked well, and which could/should be used on other projects. Identify project components or aspects which were problematic along with suggested solutions to avoid repeating on future projects. For Design-Build projects, include feedback to the DB Project Manager or Project Leader regarding contract language which was problematic, along with suggested solutions. Also identify contract language which worked well.

The two issues that caused the most problems on this project were: #1 the existing signal heads were wired incorrectly. This problem would be hard to catch unless an electrician had opened up the junction boxes and looked for problems. # 2 the signal pole was not tall enough. The 4x4 sign that was called for on this pole arm is not the norm for standard signal poles. Therefore, the use of a non-standard pole should have been considered.

Additionally, the pole was placed in the clear zone. If roadway design had been involved, they may have noticed the clear zone issue.

22.9.5 Unique Situations

Figure 22-16 | CCO – Unique Situations, Historic Bridge Issue, October 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

The signal plans show surface mounted conduit on the face of the span 4 arched curtain walls on both the upstream and downstream sides of the structure to provide power to the northbound and southbound Highway 99 traffic signals. The plans also show retaining the signal controller on the Hwy 99 face of Pier 1 along with the pedestal mounted pedestrian push button. This change will run the power through a larger 3" conduit under the center of the structure, thus eliminating the outside surface mounted conduit giving the signal installation a much cleaner look. It would also move the signal controller to the downstream face of Pier 1 next to the service cabinet and meter base. Other changes include moving the power to the under deck lighting shown on drawing #81882, note 5 to the service cabinet. The pedestrian signal push button would be moved to the Pier 1 wall face. These changes will provide a much cleaner installation on this historic bridge.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$11,642.77
	DECREASE		

22.9.6 Temporary Signals

Figure 22-17 | CCO – Temporary Signals, February 2013

THIS CONTRACT IS HEREBY MODIFIED AS FOLLOWS (DESCRIPTION AND LOCATION OF WORK COVERED BY THIS ORDER):

This contract change order pays for some of the initial costs the Contractor has incurred to install a temporary traffic signal installation on this project. A contract change order to address Contractor's cost reduction proposal for use of the temporary traffic signal system instead of 24 hour flagging will be written when all costs and savings associated with the temporary signal installation can be evaluated. The initial costs paid for in this contract change order will be included in the cost reduction proposal. Removal costs will be tracked by Force Account and paid by CCO at a later date.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$52,542.09
	DECREASE		

22.9.7 Signs

Figure 22-18 | CCO – Signs, December 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

Work to be Done:

4006A: Install "Truck Route' Sign on the Mast Arm at the intersection of Lombard and St. Louis
4006B: Install additional interconnect on N Lombard to N John

Reason for Work:

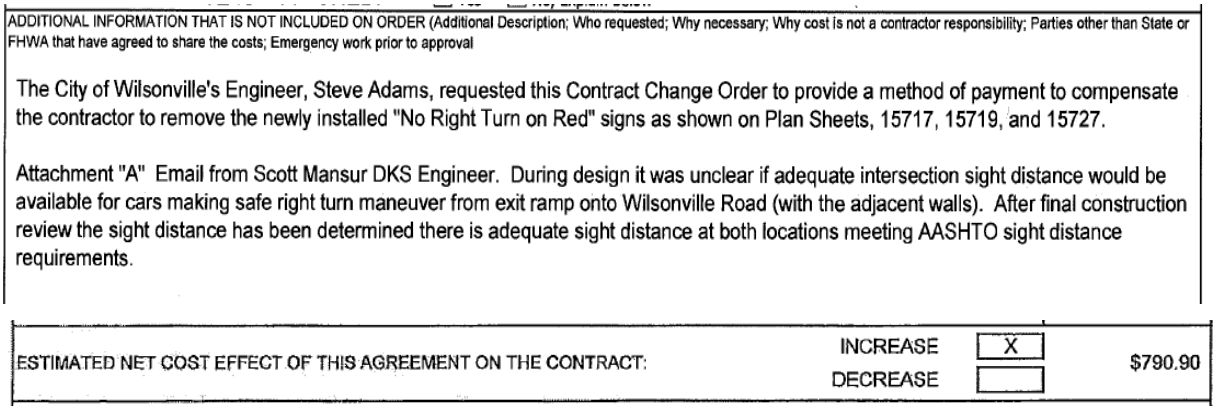
4006A: The sign was mounted in a center island that was removed. The directional sign had to stay in that area and the mast arm of the signal was the best location.
4006B: In order to provide a completed system this interconnct had to be extended.

Cost Justification:

4006A: Directional sign and Safety issue
4006B: To provide a successful project

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$3,575.45
	DECREASE		

Figure 22-19 | CCO – Signs, April 2013



ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

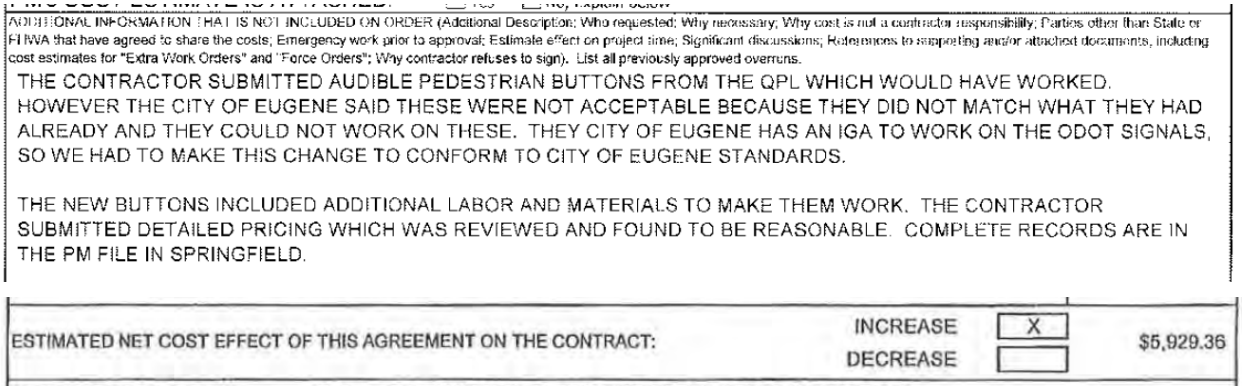
The City of Wilsonville's Engineer, Steve Adams, requested this Contract Change Order to provide a method of payment to compensate the contractor to remove the newly installed "No Right Turn on Red" signs as shown on Plan Sheets, 15717, 15719, and 15727.

Attachment "A" Email from Scott Mansur DKS Engineer. During design it was unclear if adequate intersection sight distance would be available for cars making safe right turn maneuver from exit ramp onto Wilsonville Road (with the adjacent walls). After final construction review the sight distance has been determined there is adequate sight distance at both locations meeting AASHTO sight distance requirements.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$790.90
	DECREASE		

22.9.8 Pushbuttons

Figure 22-20 | CCO – Pushbuttons, October 2012



ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

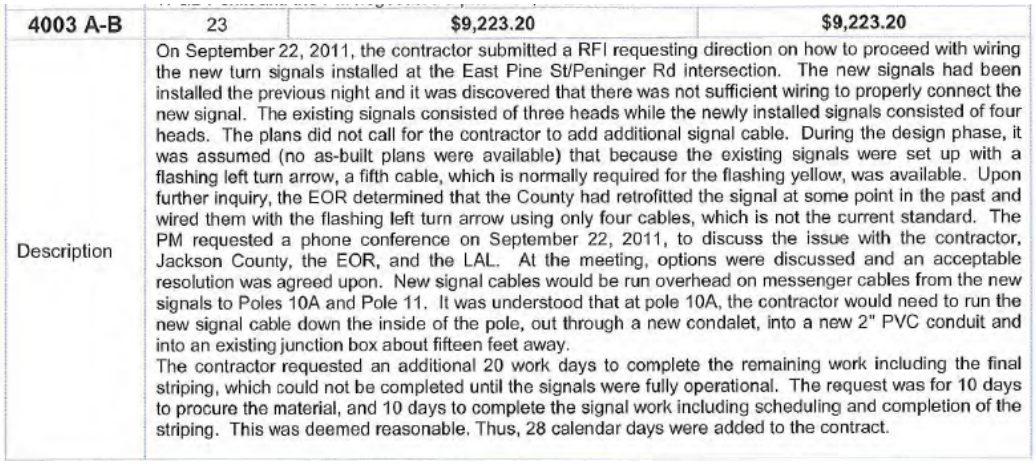
THE CONTRACTOR SUBMITTED AUDIBLE PEDESTRIAN BUTTONS FROM THE QPL WHICH WOULD HAVE WORKED. HOWEVER THE CITY OF EUGENE SAID THESE WERE NOT ACCEPTABLE BECAUSE THEY DID NOT MATCH WHAT THEY HAD ALREADY AND THEY COULD NOT WORK ON THESE. THEY CITY OF EUGENE HAS AN IGA TO WORK ON THE ODOT SIGNALS, SO WE HAD TO MAKE THIS CHANGE TO CONFORM TO CITY OF EUGENE STANDARDS.

THE NEW BUTTONS INCLUDED ADDITIONAL LABOR AND MATERIALS TO MAKE THEM WORK. THE CONTRACTOR SUBMITTED DETAILED PRICING WHICH WAS REVIEWED AND FOUND TO BE REASONABLE. COMPLETE RECORDS ARE IN THE PM FILE IN SPRINGFIELD.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$5,929.36
	DECREASE		

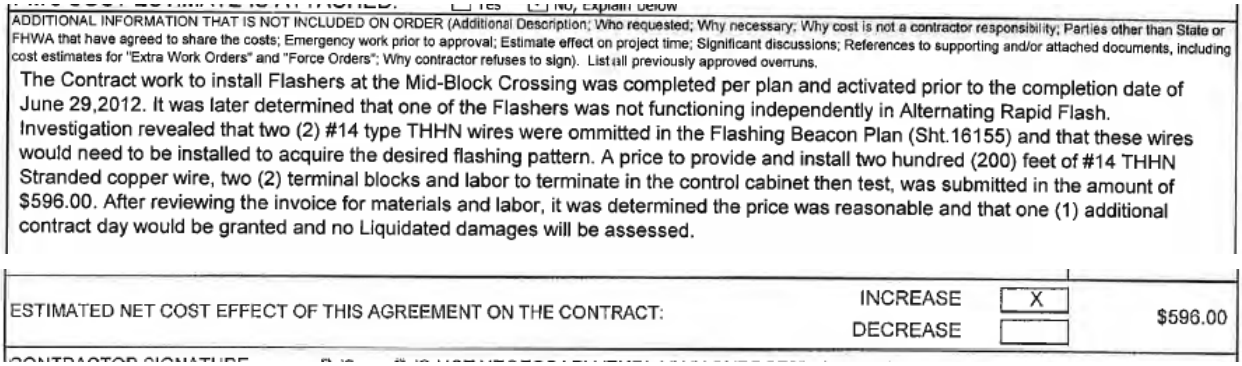
22.9.9 Wiring

Figure 22-21 | CCO – Wiring, PM Narrative, June 2012



4003 A-B	23	**$9,223.20**	**$9,223.20**
Description	On September 22, 2011, the contractor submitted a RFI requesting direction on how to proceed with wiring the new turn signals installed at the East Pine St/Peninger Rd intersection. The new signals had been installed the previous night and it was discovered that there was not sufficient wiring to properly connect the new signal. The existing signals consisted of three heads while the newly installed signals consisted of four heads. The plans did not call for the contractor to add additional signal cable. During the design phase, it was assumed (no as-built plans were available) that because the existing signals were set up with a flashing left turn arrow, a fifth cable, which is normally required for the flashing yellow, was available. Upon further inquiry, the EOR determined that the County had retrofitted the signal at some point in the past and wired them with the flashing left turn arrow using only four cables, which is not the current standard. The PM requested a phone conference on September 22, 2011, to discuss the issue with the contractor, Jackson County, the EOR, and the LAL. At the meeting, options were discussed and an acceptable resolution was agreed upon. New signal cables would be run overhead on messenger cables from the new signals to Poles 10A and Pole 11. It was understood that at pole 10A, the contractor would need to run the new signal cable down the inside of the pole, out through a new condalet, into a new 2" PVC conduit and into an existing junction box about fifteen feet away. The contractor requested an additional 20 work days to complete the remaining work including the final striping, which could not be completed until the signals were fully operational. The request was for 10 days to procure the material, and 10 days to complete the signal work including scheduling and completion of the striping. This was deemed reasonable. Thus, 28 calendar days were added to the contract.		

Figure 22-22 | CCO – Wiring, August 2012



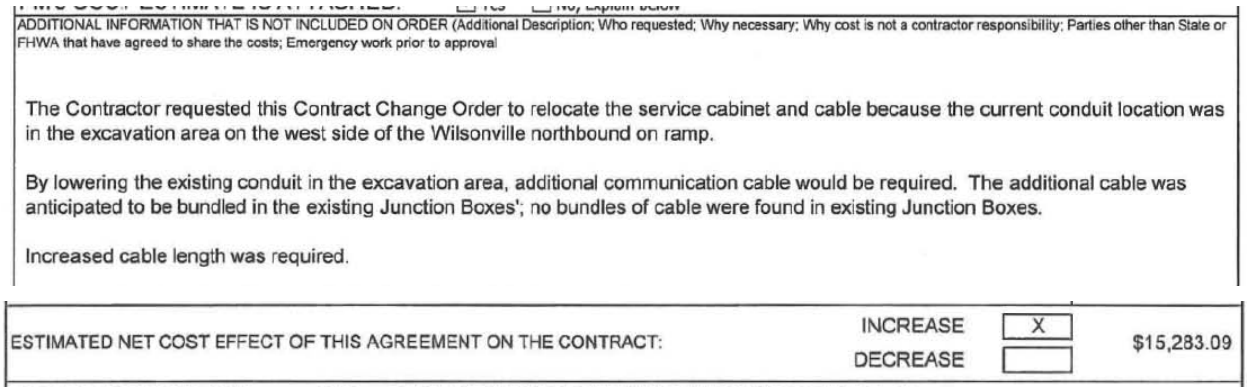
ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

The Contract work to install Flashers at the Mid-Block Crossing was completed per plan and activated prior to the completion date of June 29,2012. It was later determined that one of the Flashers was not functioning independently in Alternating Rapid Flash. Investigation revealed that two (2) #14 type THHN wires were ommitted in the Flashing Beacon Plan (Sht.16155) and that these wires would need to be installed to acquire the desired flashing pattern. A price to provide and install two hundred (200) feet of #14 THHN Stranded copper wire, two (2) terminal blocks and labor to terminate in the control cabinet then test, was submitted in the amount of $596.00. After reviewing the invoice for materials and labor, it was determined the price was reasonable and that one (1) additional contract day would be granted and no Liquidated damages will be assessed.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$596.00
	DECREASE		

22.9.10 Service Cabinet

Figure 22-23 | CCO – Service Cabinet, May 2012



ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

The Contractor requested this Contract Change Order to relocate the service cabinet and cable because the current conduit location was in the excavation area on the west side of the Wilsonville northbound on ramp.

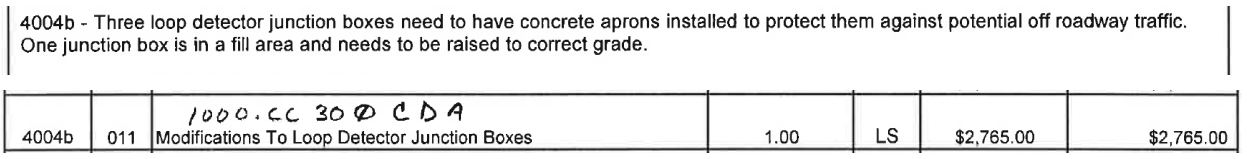
By lowering the existing conduit in the excavation area, additional communication cable would be required. The additional cable was anticipated to be bundled in the existing Junction Boxes'; no bundles of cable were found in existing Junction Boxes.

Increased cable length was required.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$15,283.09
	DECREASE		

22.9.11 Junction Boxes

Figure 22-24 | CCO – Junction Boxes, September 2011



4004b - Three loop detector junction boxes need to have concrete aprons installed to protect them against potential off roadway traffic. One junction box is in a fill area and needs to be raised to correct grade.

4004b	011	1000.CC 30 @ CDA Modifications To Loop Detector Junction Boxes	1.00	LS	$2,765.00	$2,765.00

23 State Force Work

Signal modifications that are performed by state forces, not a contractor, are classified as state force work. Often, these modifications are small in scope, inexpensive, and/or need to be done quickly which is why the work is not contracted out in a traditional project development process. Depending on the type of signal modification, additional ODOT crews may need to be involved (e.g., signing crew, striping crew, etc.).

23.1 Is Operational Approval Needed?

This type of work still requires operational approval (depending on the proposed modification), as per chapter 3. State force work is comprised of **modifications** to existing signal installations. The following list contains common state force work items, but is not all inclusive:

- Adding or deleting regulatory signing attached to signal equipment
- Adding or deleting signal heads
- Modifying signal head type
- Adding, deleting or modifying signal phasing
- Adding or deleting detection
- Adding or deleting crosswalks/pedestrian phases
- Adding or deleting emergency preemption
- Changing intersection lane use

State force work does NOT include standard MAINTENANCE work such as replacing signal equipment in-kind due to end-of-service life or malfunction.

23.2 Are Plan Sheets and Design Approval Required?

Plan sheets are required for all state force work. While creating plan sheets can be time consuming and seem like an unreasonable task for minor work performed by state forces that really don't need a plan sheet to understand or install the proposed changes, a plan sheet provides the mechanism for documentation, archival, and accurate installation information used by future personnel.

Design approval as per chapter 3 is required for all state force work. Due to the nature of state force work (small scope of work and the informal payment/inspection inherent in state forces performing the work), the design approval process can typically be completed much faster than plans developed for contract.

23.3 Plan Sheet

The plan sheets for state force work should follow the guidelines used for standard contract plan development with the following exceptions:

23.3.1 Title Block

The title block should state "STATE FORCE WORK" in the project information area to clearly identify that the modifications are not contract work. See Figure 23-1.

Figure 23-1 | State Force Work Title Block



23.3.2 Detailing Work and Referencing Prior Plan Sheets

The plan sheet should only detail the work to be done and just show the symbology for the other signal equipment that is not impacted by the work. Also, placing a reference to prior plan sheets can be helpful so that accessing the additional information on the signal equipment that is just shown symbolically is easier. This simplifies the plan sheet and makes it much easier to see what work needs to be done. See chapter 21 for more information and examples of using "EX" bubbles notes and reference notes appropriately.

23.4 Are Specifications, Standard Drawings and Cost Estimate Required?

Standard specifications and modifications shown in the special provision boiler plates for the technical aspects of installation (materials, certain construction methods) should be understood and followed by those performing the state force work. Other parts of the specifications pertaining to contract administration and payment simply do not apply to work done in-house. Because there is no need for a formal contract for in-house work, there is no need to formally produce specifications to accompany the plan sheets. It is assumed that that those performing the work are staying current with their agency's standards and procedures.

Similar to the specifications, those performing the work should understand and follow the most current version of the standard drawings. The standard drawings that are applicable to the state force work should be listed in the title block (just like for contract work), but do not necessarily need to be provided with the work as those performing the work most likely have their own copies and are well informed of the current standards.

Depending on where the funding for the state force work is coming from (e.g., electrical budget, region safety or operational budget, claim against other, etc.), a cost estimate may or may not be performed by the signal designer. If a cost estimate is requested for budget planning purposes, it is best to gather the data from those performing the work because the standard cost estimating tools used for contract work will not be as accurate due to factors that are inclusive to the bid item (such as profit margin).

24 Moveable Bridges

24.1 General

Traffic control for moveable bridges is covered in section 4J of the Manual on Uniform Traffic Control Devices. Additional information specific to Oregon is presented in this chapter.

24.2 Design Responsibility

The bridge section has historically been responsible for the design, maintenance and operation of all traffic control devices that are activated by the moveable bridge control system (which includes the signal indications and flashing beacon warning devices). As such, the signal designer has had little involvement in the past with the traffic control devices used for moveable bridges. However, due to several recent moveable bridge projects, it became clear that more information about the traffic control devices used and more coordination between the traffic engineering section and the bridge section was needed. The bridge, signal, and sign designer should work closely together to ensure that the design for each discipline is detailed or referenced appropriately.

24.2.1 Bridge Plan Sheets

The bridge plan sheets should detail the following items:

- Control system that activates the traffic signals and flashing beacons (cabinets, power source, termination of wires, etc.)
- Location of gate arms
- Audible devices for warning traffic
- Non-standard:
    - Poles
    - Foundations
    - Mounting for signal heads, signs, and flashing beacons
- Electrical conduit routed on/through the bridge structure (including expansion fittings)
- Junction boxes located on the bridge structure

24.2.2 Signal Plan Sheets

The signal plan sheets should detail the following items:

- Location of the traffic signals
- Location of the STOP line
- Use of and location of the flashing beacon warning devices
- PTR signs (site specific for the I-5 NB and SB Columbia river bridge only)
- Wiring from the traffic signals and flashing beacons to the control system (wire terminations are detailed on the bridge plans)
- Electrical conduit not routed on/through the bridge structure
- Connection details for conduit going onto (or off of) the bridge structure (junction box, expansion fitting, etc.)
- Standard:
    - Poles
    - Foundations
    - Mounting for signal heads, signs & flashing beacons

24.2.3 Signing Plan Sheets

The signing plan sheets should detail the following items:

- Ground mounted signs that do not have a flashing beacon

24.3 Operational Approval

The decision to install a moveable bridge resides with the bridge section. Moveable bridges are typically not the most economical type of bridge to build or maintain, making it unlikely that a new moveable bridge will be built today. If a new moveable bridge is installed, the MUTCD Section 4J.01 requires both signals and gates (allowing a few exceptions under certain conditions). Therefore, STE operational approval is NOT required. Bridge section is also responsible for the how the activated devices are operated during a bridge opening. **The yellow change interval duration shall follow the requirements stated in the ODOT Traffic Signal Policy and Guidelines.**

24.4 Design Approval

Design approval of the signal plan sheets is required. The drawing title for the plan sheets should be “signal plan”.

24.5 Existing Moveable Bridges on the State Highway System

There are 11 existing moveable bridges on the state highway system that will require repair or replacement in future years. It is likely that complete bridge replacement projects will decrease the number of existing moveable bridges as time goes on.

Table 1 below shows the location of the 11 existing bridges and the type of lift.

Table 1 | List of Moveable Bridges in Oregon

Bridge Name		Region	Route	ODOT Highway No.	Milepoint	Type of Bridge
1	Columbia River (Interstate) NB	1	I-5	1	308.38	Vertical Lift
2	Columbia River (Interstate) SB	1	I-5	1	308.38	Vertical Lift
3	New Youngs Bay	2	US 101	9	4.91	Vertical Lift
4	Old Youngs Bay	2	US 101B	105	6.89	Bascule: Double Leaf
5	Lewis and Clark River	2	US 101B	105	4.78	Bascule: Single Leaf
6	Siuslaw River	2	US 101	9	190.98	Bascule: Double Leaf
7	Umpqua River & McIntosh Slough	3	US 101	9	211.11	Swing
8	Coos River (Chandler)	3	OR 241	241	3.73	Vertical Lift
9	Isthmus Slough (Eastside)	3	OR 241	241	0.42	Bascule: Double Leaf
10	South Slough (Charleston)	3	OR 540	240	8.33	Bascule: Double Leaf
11	Coquille River (Bullards)	3	US 101	9	259.65	Vertical Lift

24.5.1 Non-Compliant Existing Traffic Control Devices (TCD)

There are several moveable bridges with traffic control devices that were commonly used in the past but are no longer compliant with the current standards as described in this chapter. These devices, listed below, should be removed or replaced with compliant devices when possible:

- Signal heads mounted horizontally. See Figure 24-1.
- Use of a single type 2 signal head to stop traffic. See Figure 24-1.
- Use of only bridge warning gates with no traffic signals (e.g., Coos River – Chandler moveable bridge). Note: all 11 existing moveable bridges require both signals and gates as per the MUTCD. See Figure 24-2.
- Mounting a STOP sign to the bridge warning gate. See Figure 24-3.
- Use of an advance single signal head to warn traffic (custom type: a signal head with flashing yellow, green, flashing yellow indications or a type 2 signal head). See Figure 24-4 and Figure 24-5.
- Use of signs no longer in the MUTCD or the Oregon Sign Policy and Guidelines (e.g., DRAW BRIDGE AHEAD sign, DRAWBRIDGE ½ MILE sign). See Figure 24-6 and Figure 24-7.

Figure 24-1 | Non-Compliant Existing TCD: Single Signal Head to Stop Traffic Mounted Horizontally



Figure 24-2 | Non-Compliant Existing TCD: Use of Only Bridge Warning Gates with No Traffic Signals



Figure 24-3 | Non-Compliant Existing TCD: Mounting a STOP Sign to the Warning Gate



Figure 24-4 | Non-Compliant Existing TCD: Single Advance Signal Head, Example 1



Figure 24-5 | Non-Compliant Existing TCD: Single Advance Signal Head, Example 2



Figure 24-6 | Non-Compliant Existing TCD: Outdated Signs, Example 1



Figure 24-7 | Non-Compliant Existing TCD: Outdated Signs, Example 2



24.6 Bridge Warning Gate and STOP Line Placement

The bridge warning gate location is the control point that influences the location of all other associated traffic control devices, starting with the STOP line location. The signal heads and advance signing are then located based on the STOP line location. The bridge designer is responsible for determining the location of the warning gate. See the MUTCD Section 4J.02 for guidance on warning gate placement.

If feasible, the location of the STOP line should be at least 8 feet from the gate arm. The bridge structure and alignment should also be considered when determining the best placement of the STOP line to maximize sight distance to the signal heads.

Historically, the bridge warning gate has been installed near the signal indications or even downstream from the signal indications (rather than near the STOP line). See Figure 24-8. Modifying the placement of the existing warning gate, STOP line and/or the signal heads may not always be practical due to the structural and electrical systems already in place and the scope of the project. These existing systems have been in operation for many years and unless there is an operational or safety concern with the location of the bridge warning gate, signal heads and/or stop line (e.g., non-compliance of the gate, vehicles stopping at the wrong location, broken gate arms, poor sight distance, crash history, near-misses, etc.), the location of these devices does not require modification.

Figure 24-8 | Example of Existing Warning Gate Arm Located Downstream from Signal Indications

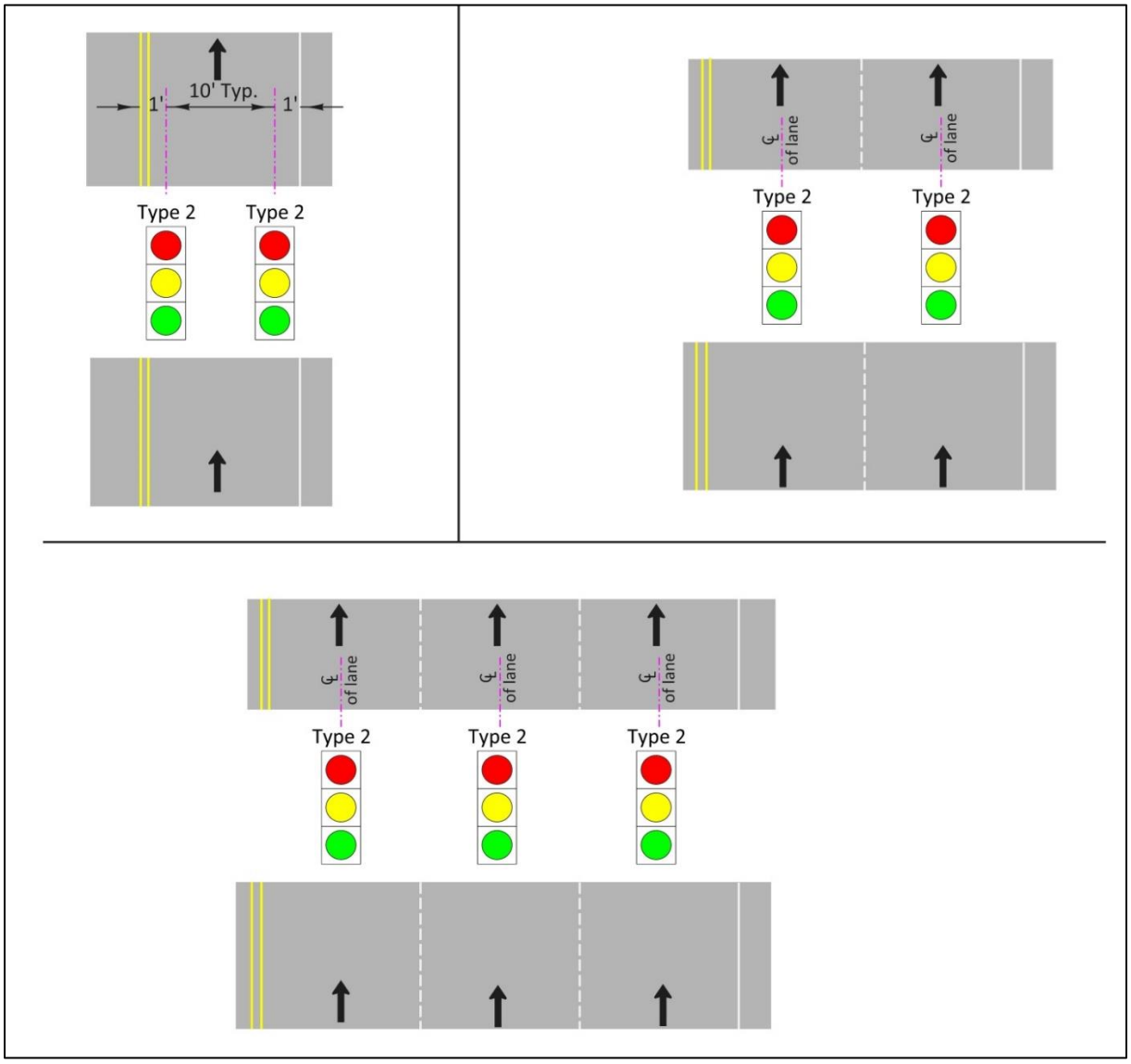


24.7 Signal Head Type and Placement

Basic requirements for signal head type and placement:

- A minimum of two type 2 signal heads mounted vertically overhead shall be used to stop traffic
- Heads shall be at least 8 feet apart, desirable 10 feet apart
- Heads shall not be less than 45 feet from the STOP line, desirable 80 to 100 feet
- Supplemental heads may be used if necessary to improve sight distance to the signal indications
- A signal head per lane shall be used when there are 2 or more approach lanes

Figure 24-9 | Signal Head Type and Placement



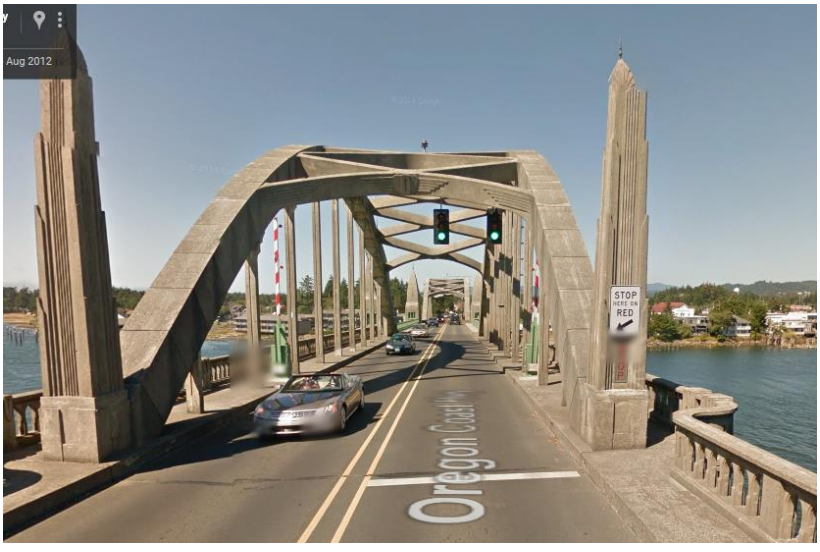
24.8 Mounting Signal Heads and Signs

The bridge structure and alignment will determine how the signal heads and signs will be mounted. Signal heads shall be mounted vertically. Some locations will be able to accommodate standard traffic signal mast arm poles (with a custom foundation incorporated into the bridge structure) and standard sign and pedestal supports. See Figure 24-10. Other locations will require the signal heads and/or signs to be custom mounted on the bridge structure or on a custom support. See Figure 24-11. The bridge designer is responsible for any custom mounting or support details.

Figure 24-10 | Standard Traffic Signal Mast Arm Pole Incorporated into the Bridge Deck



Figure 24-11 | Signal Heads and Sign Custom Mounted on Bridge Structure



24.9 Traffic Control Device Sequence

The following sections 24.9.1 through 24.9.3 show the standard sequence of signs and flashing beacons in advance of the moveable bridge based on the required sight distance to the signal heads. **Section 24.9.4 is specific to the I-5 NB Columbia river crossing and section 24.9.5 is specific to the SB Columbia river crossing.**

Sign location dimensions shown in sections 24.9.1 through 24.9.3 are based on AASHTO and MUTCD guidance; they may be adjusted as necessary according to site-specific constraints, such as:

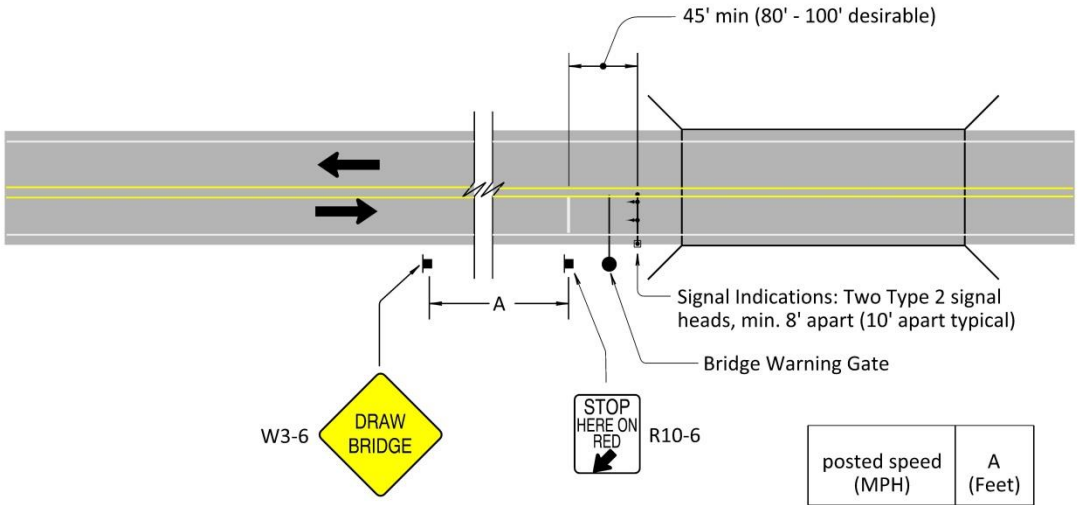
- Maximizing sight distance
- Allowable locations on the bridge structure to mount traffic control devices and electrical features
- Obtaining appropriate spacing between other required signs, especially those with flashing beacons (e.g., NARROW BRIDGE sign, bridge height/weight restriction signs, curve warning signs, bikes/peds on bridge when flashing sign).
- Expected queue lengths during bridge openings
- Location of nearby approaches/accesses

24.9.1 No Sight Distance Restrictions to Signal Heads

Figure 24-12 shows the standard traffic control device sequence when the sight distance to the signal indications meets or exceeds the distances stated in MUTCD Table 4D-2. All signs are typically ground mounted. A supplemental signal head may be used to achieve the sight distance requirement.

The sign designer is responsible for the two ground mounted signs.

Figure 24-12 | Sign Placement – No Sight Distance Restrictions to Signal Heads



posted speed (MPH)	A (Feet)
30 & under	100
35	100
40	125
45	175
50	250
55	325
60	400
65	475

W3-6 placement values (from stop line) based on MUTCD Table 2C-4 condition B, deceleration to 0 MPH.

24.9.2 Sight Distance Restrictions to Signal Heads

Figure 24-13 shows the standard traffic control device sequence when the sight distance to the signal heads does not meet the distance specified in the MUTCD Table 4D-2 (and a supplemental signal head still does not meet the distances specified). This standard sequence may also be warranted regardless of sight distance if the bridge has high traffic volumes, frequent bridge openings, is in a rural location, high speeds, high percentage of heavy vehicles, or high percentage of unfamiliar drivers. Signs are typically ground mounted, but overhead mounting should be considered as per section 2A.17 of the MUTCD. If overhead mounting is used, the OR15-14 sign with two type 1Y flashing beacons shall be used instead of the W3-4 sign with W16-13p rider. The two flashing beacons shall flash in a wig-wag pattern.

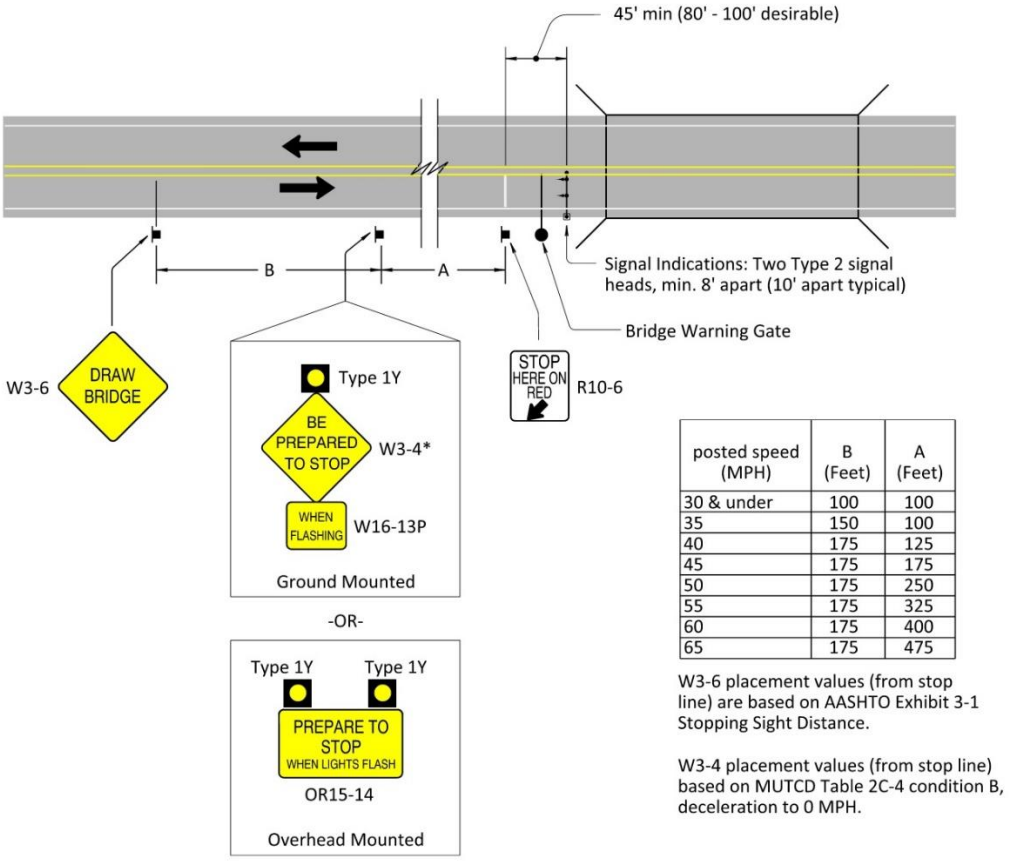
The sign designer is responsible for:

- The DRAW BRIDGE sign (W3-6)
- The STOP HERE ON RED sign (R10-6)

The signal designer is responsible for:

- The sign assemblies with type 1Y flashing beacons

Figure 24-13 | Sign Placement – Sight Distance Restrictions to Signal Heads



posted speed (MPH)	B (Feet)	A (Feet)
30 & under	100	100
35	150	100
40	175	125
45	175	175
50	175	250
55	175	325
60	175	400
65	175	475

W3-6 placement values (from stop line) are based on AASHTO Exhibit 3-1 Stopping Sight Distance.

W3-4 placement values (from stop line) based on MUTCD Table 2C-4 condition B, deceleration to 0 MPH.

24.9.3 Sight Distance Restrictions to Signal Heads (Special Application Only)

Figure 24-14 shows the traffic control device sequence for special applications when the sight distance to the signal heads does not meet the distance specified in the MUTCD Table 4D-2 (and a supplemental signal head still does not meet the distances specified). Signs are typically ground mounted. The following sequence may only be used in the following circumstances:

- When the AADT is low (3000 or less) with a high percentage of familiar drivers
- Moveable bridge operation is infrequent
- Urban locations where sign placement location is limited

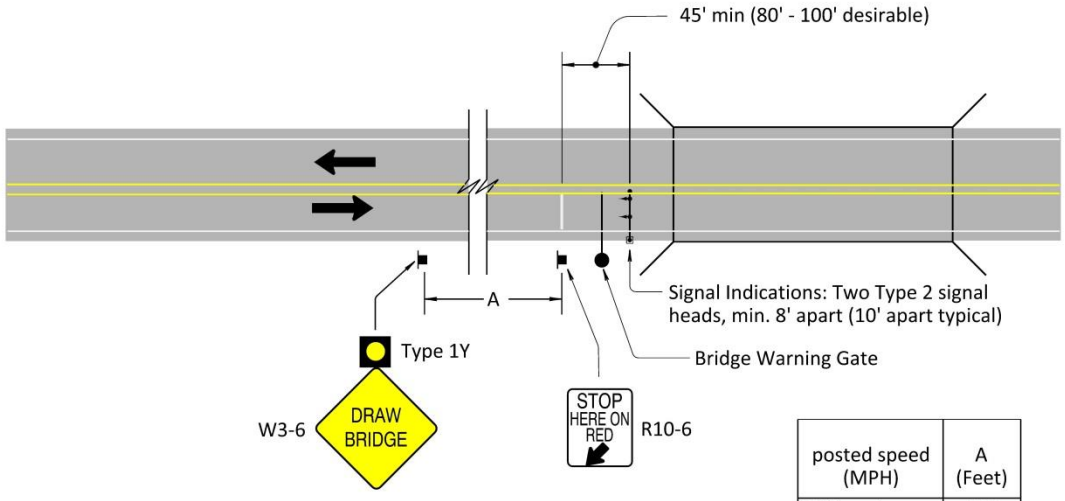
The sign designer is responsible for:

- STOP HERE ON RED sign (R10-6)

The signal designer is responsible for:

- The DRAW BRIDGE sign (W3-6) with the type 1Y flashing beacon

Figure 24-14 | Sign Placement – Sight Distance Restrictions to Signal Heads (Special Application Only)



posted speed (MPH)	A (Feet)
30 & under	100
35	100
40	125
45	175
50	250
55	325
60	400
65	475

W3-6 placement values (from stop line) based on MUTCD Table 2C-4 condition B, deceleration to 0 MPH.

24.9.4 Unique Traffic Control Devices: Columbia River (Interstate) NB

Being a major interstate bridge, the traffic control devices used and the placement are unique from the other 10 existing bridges. All traffic control devices are custom mounted to the structure, except one device mounted on a sign bridge. This moveable bridge has been slated for replacement; however, it is uncertain when that project will move forward. If the existing traffic control devices need to be replaced, they should be replaced in-kind:

- 1st warning device: approx. 600 feet south of MLK overcrossing, two type 1Y flashing beacons mounted next to the custom DRAWBRIDGE PREPARE TO STOP WHEN LIGHTS FLASH sign. See Figure 24-15.
- 2nd warning device: two type 1Y flashing beacons mounted next to the custom DRAWBRIDGE PREPARE TO STOP WHEN LIGHTS FLASH sign. See Figure 24-16.
- 3rd warning device: two type 1Y flashing beacons mounted next to the STOP AHEAD PTR sign. See Figure 24-17.
- Signals: three type 2 signals heads (one per each approach lane) and two "STOP" PTR signs. See Figure 24-18.

Figure 24-15 | Columbia River NB: 1st Warning Device



Figure 24-16 | Columbia River NB: 2st Warning Device

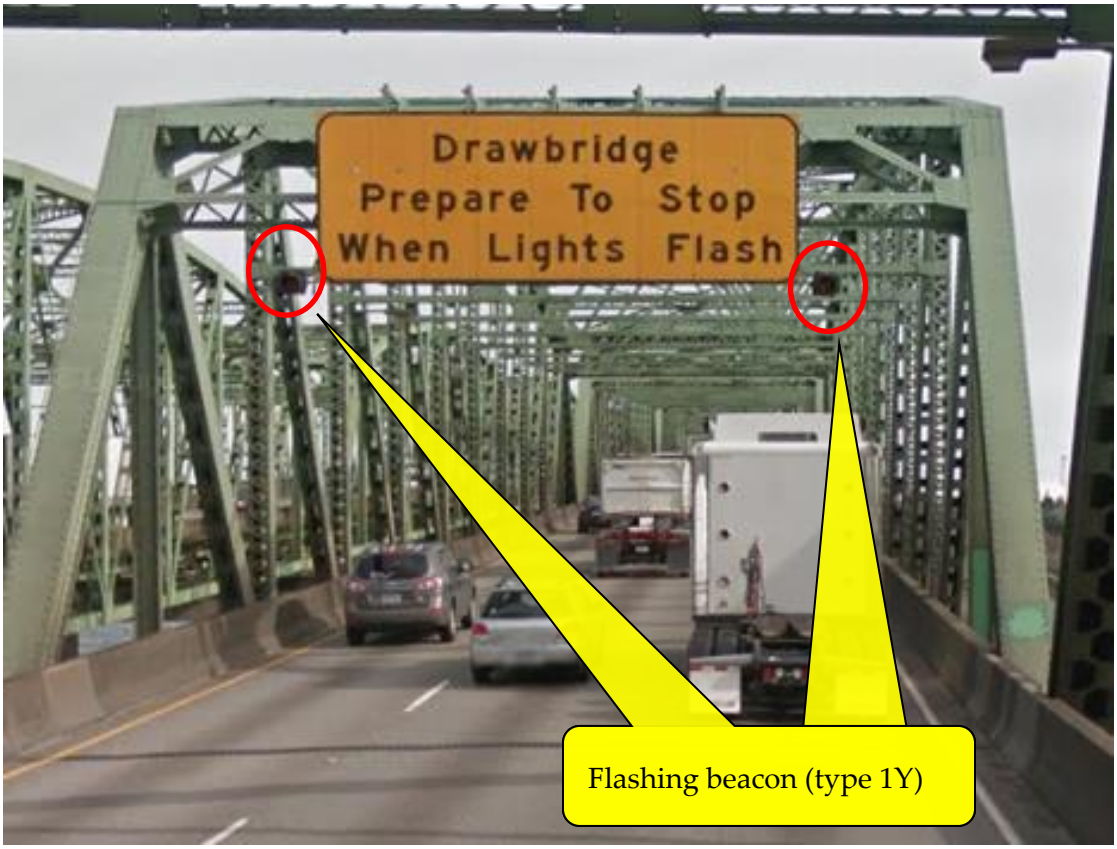


Figure 24-17 | Columbia River NB: 3st Warning Device

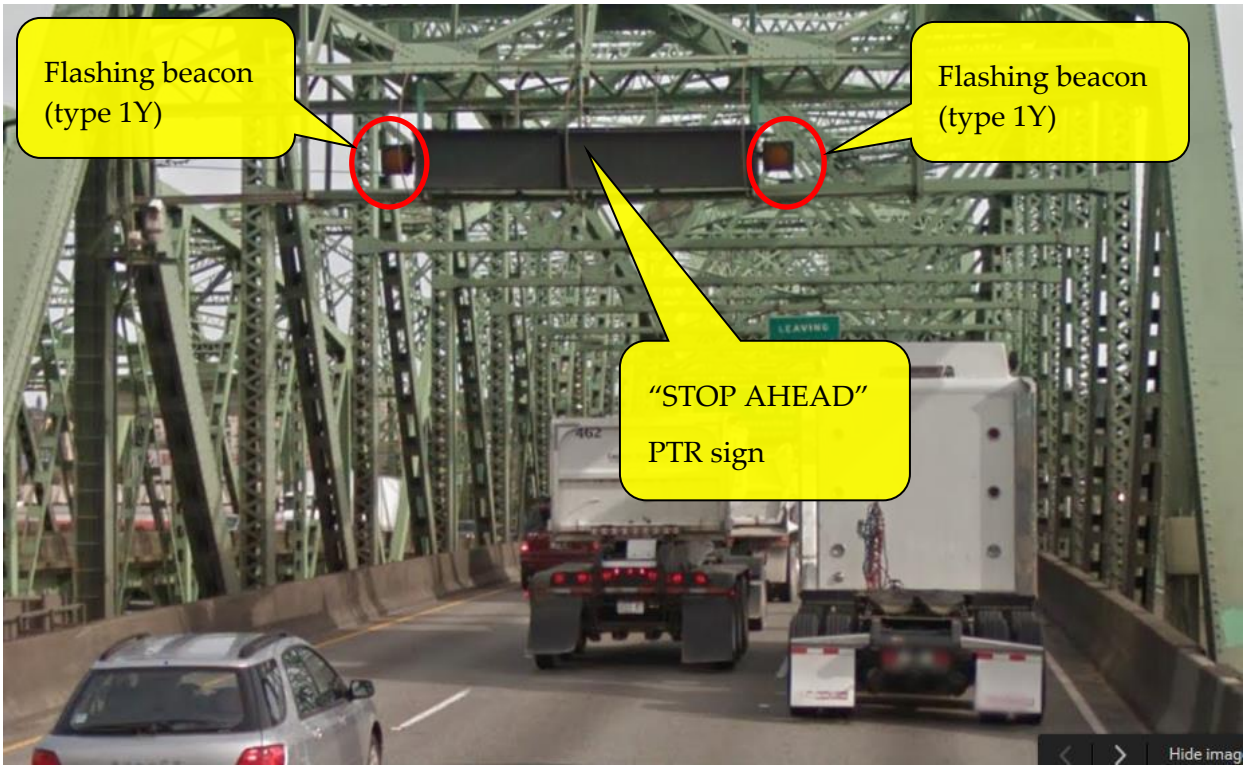
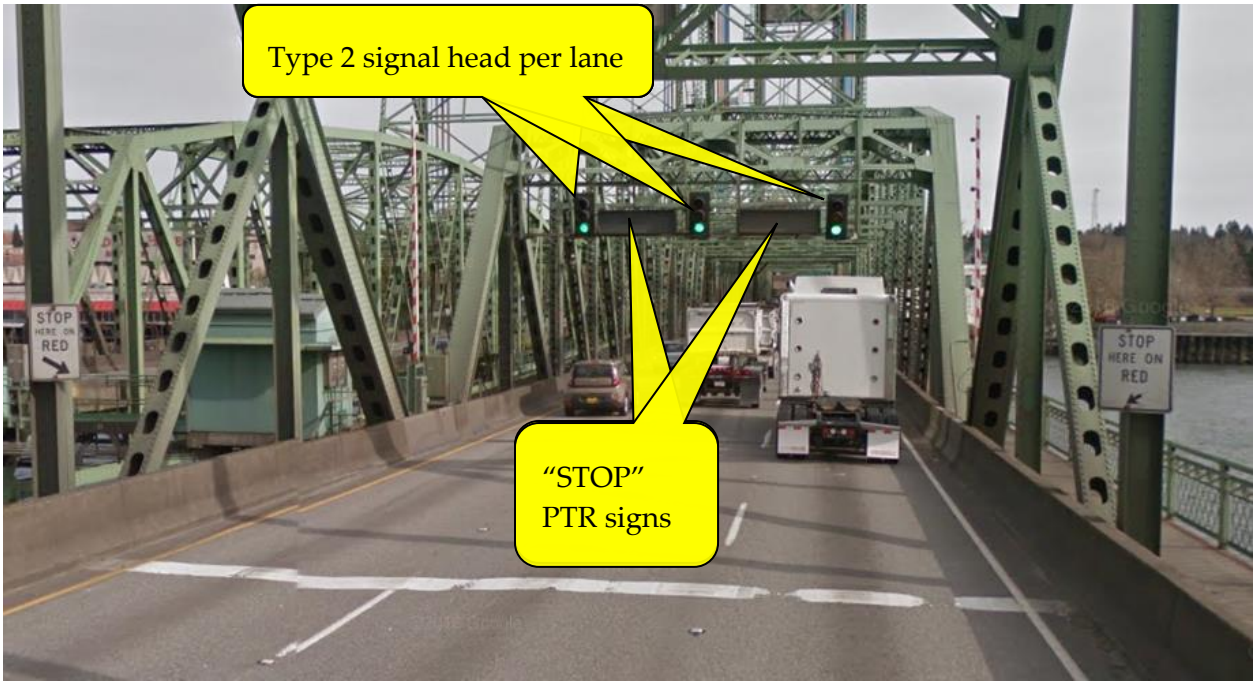


Figure 24-18 | Columbia River NB: Signals



24.9.5 Unique Traffic Control Devices: Columbia River (Interstate) SB

Being a major interstate bridge, the traffic control devices used and the placement are unique from the other 10 existing bridges. All traffic control devices are custom mounted and located on WashDOT facilities which will require coordination during design. This moveable bridge has been slated for replacement; however, it is uncertain when that project will move forward. If the existing traffic control devices need to be replaced, they should be replaced in-kind:

- Warning device: one type 1Y flashing beacon mounted next to the custom PTR sign. See Figure 24-19.
- Signals: three type 2 signals heads (one per each approach lane) and two "STOP" PTR signs. See Figure 24-20.

Figure 24-19 | Columbia River SB: Warning Device

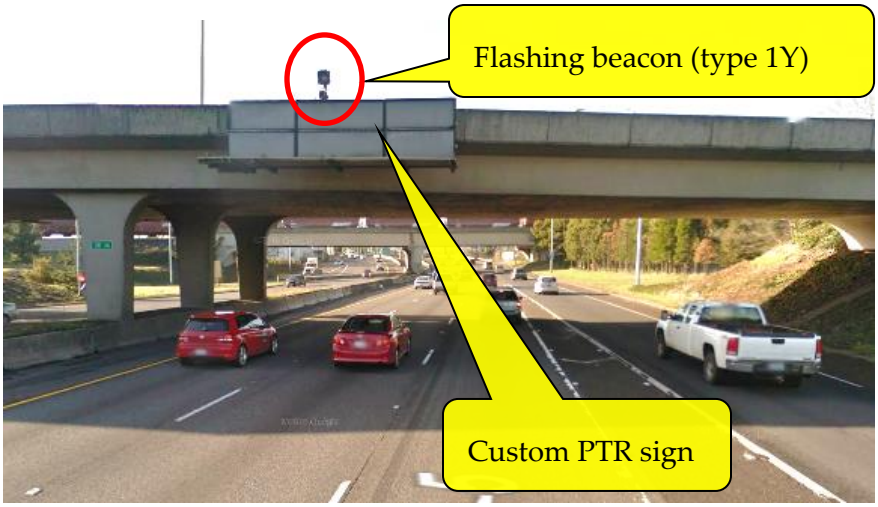
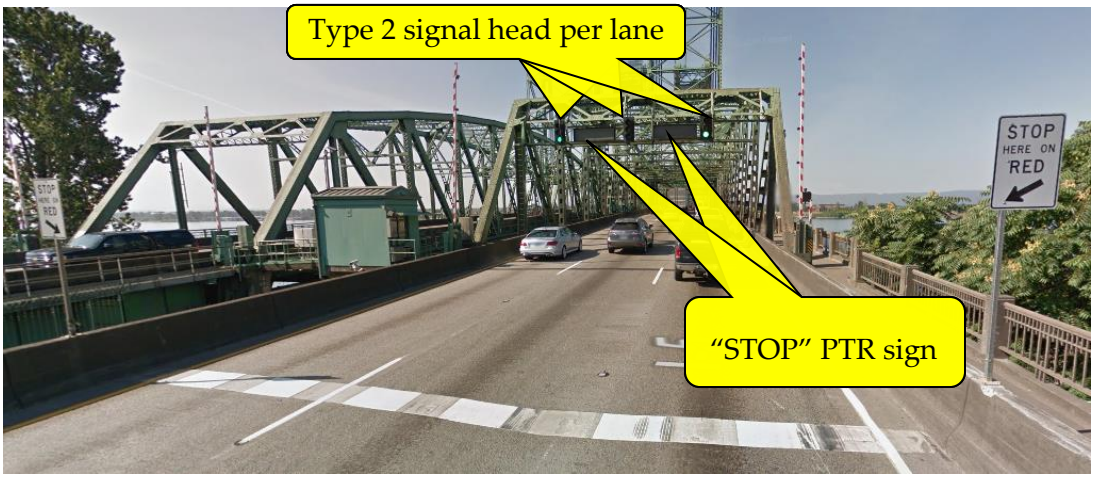


Figure 24-20 | Columbia River SB: Signals



25 Automatic Traffic Recorder (ATR) plan

25.1 General

Automatic traffic recorder (ATR) stations are operated and maintained by the transportation systems monitoring unit (TSM unit). This chapter provides the design standards for stand-alone ATR installations.

There are a handful of existing ATR sites that are part of a traffic signal. These ATR sites are no longer allowed for new construction as they are difficult to maintain and disruptions to data collection are more likely to occur. These existing sites should be designed to the current standards contained in the chapter. However, if it is not feasible to separate the traffic signal and the ATR, work with the state traffic signal engineer and the TSM unit to determine the site-specific design needs.

25.2 Design Responsibility for ATR Plans

The signal designer is responsible for producing ATR plans for new ATR sites, replacing detection due to other project work, and upgrading existing ATR sites at the end of their service life at the direction of the TSM unit.

Existing ATR stations are often overlooked during scoping and design because the TSM unit is typically not involved in STIP project development. As such, the signal designer shall verify if the project limits include any ATR sites and if they will be impacted by the project work. Verification tools include the ATR locations map and the ODOT TransGIS (see section 25.18 for information on using the TransGIS tool). If an ATR site will be impacted, contact the TSM unit at 503-986-4147 or e-mail trafficcounts@odot.state.or.us to coordinate the design details and plan reviews.

25.3 Detection - General

ATR sites, depending on the type of data to be collected, use different forms of detection:

- Inductive loops only - for basic counting needs
- Inductive loops AND piezoelectric sensors (piezos) - for accurately collecting the full FHWA 13 vehicle classifications

Note that non-invasive detection (e.g., radar or video) and newer technologies are currently being tested and evaluated by the TSM unit. See section 25.6.

The TSM unit will provide direction on which form of detection is required at each site. If only loops are required, the design should accommodate the potential for a future installation of piezos as per section 25.7.

25.4 Inductive Loops

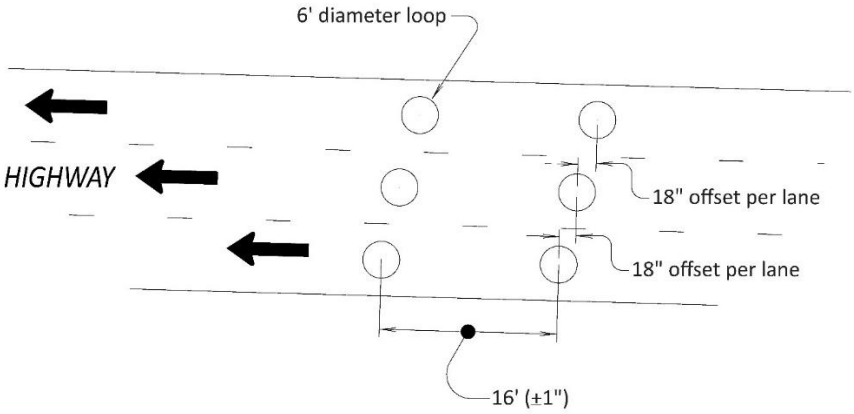
Loop detection works by measuring a change in inductance. When the loop wire is coiled and a current is applied to the coil, a magnetic field is produced. A vehicle entering the magnetic field causes the inductance of the loop to decrease which is then detected by the controller and ultimately used to determine vehicle length and speed.

25.4.1 Loop Layout

The standard ATR loop layout is described below and shown in Figure 25-1.

- 6-foot diameter round loop
- Two loops per lane, spaced 16 feet apart (±1")
- The loops in each lane are staggered 18 inches from the loops in the adjacent lane.

Figure 25-1 | Loop Detection Spacing

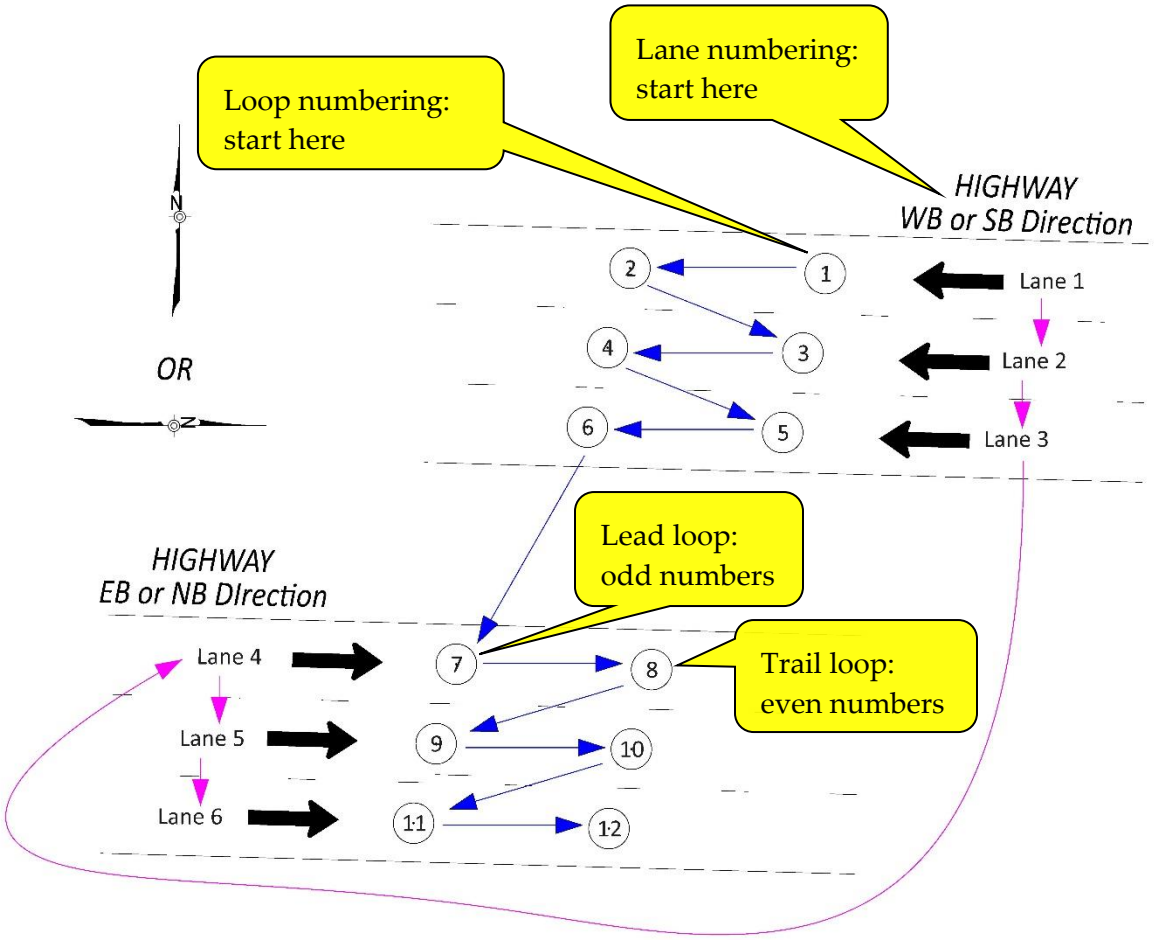


25.4.2 Lane & Loop Numbering

The lane and loop numbering are described below and shown in Figure 25-2:

- Lane no. 1 always starts with the WB or SB direction.
- Lane numbering starts at the outside lane for the WB or SB direction and then over to the outside lane in the other direction.
- Lead loops are always odd numbered and trail loops are always even numbered.

Figure 25-2 | Lane Line and Loop Numbering Example



25.4.3 Loop/Piezo Wiring Diagram

The loop/piezo wiring diagram details the controller cabinet terminal block location for each loop and piezo. Starting with the left most column, the loop or piezo number is listed, followed by the lane number in the next column. The horizontal line for each loop/piezo after the lane number column represents the loop feeder cable/piezo cable for each loop/piezo which then

crosses the rectangle that represents the controller cabinet (e.g., loop feeder cable/piezo cable entering the controller cabinet). Each loop/piezo requires a separate loop feeder cable/piezo cable back to the controller cabinet. ATR loops/piezos are never wired in series. Within the controller cabinet, the location where the loop feeder cables/piezo cables are terminated and the connection to the controller is shown. See Figure 25-3 for the standard wiring for a 332 cabinet and Figure 25-4 for a 332X cabinet. Note that the information shown in these two figures is specific to the loop/piezo number and does not change. The only modification needed to the wiring diagram is to delete the row(s) of loop/piezo numbers that are not on the project. For example in Figure 25-3, if the project has no piezos and a total of 8 loops, just delete the rows for loops 9 thru 16 and all piezo rows. These standard wiring diagrams are available on DET4480.

Figure 25-3 | Standard 332 Loop/Piezo Wiring Diagram

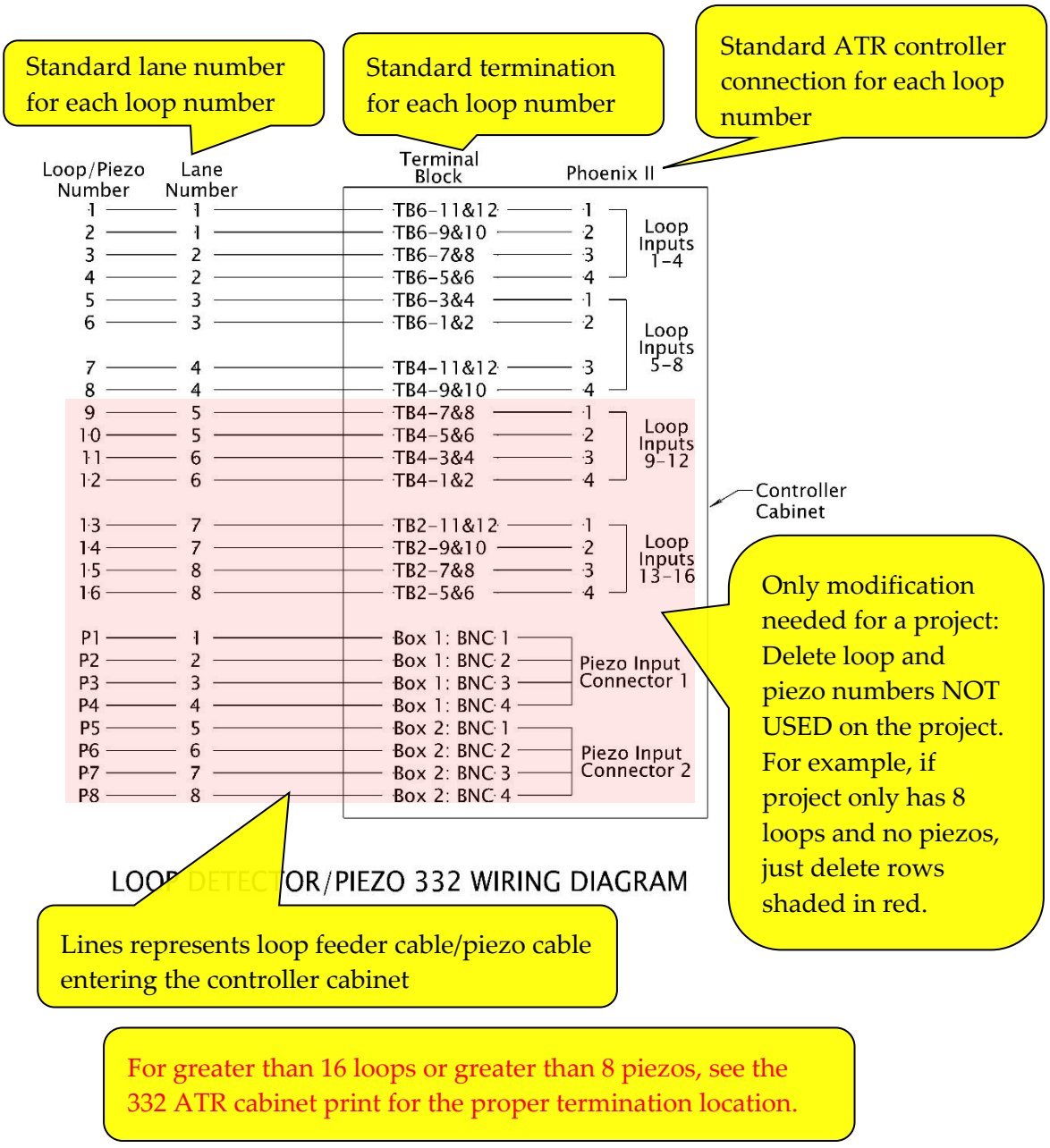
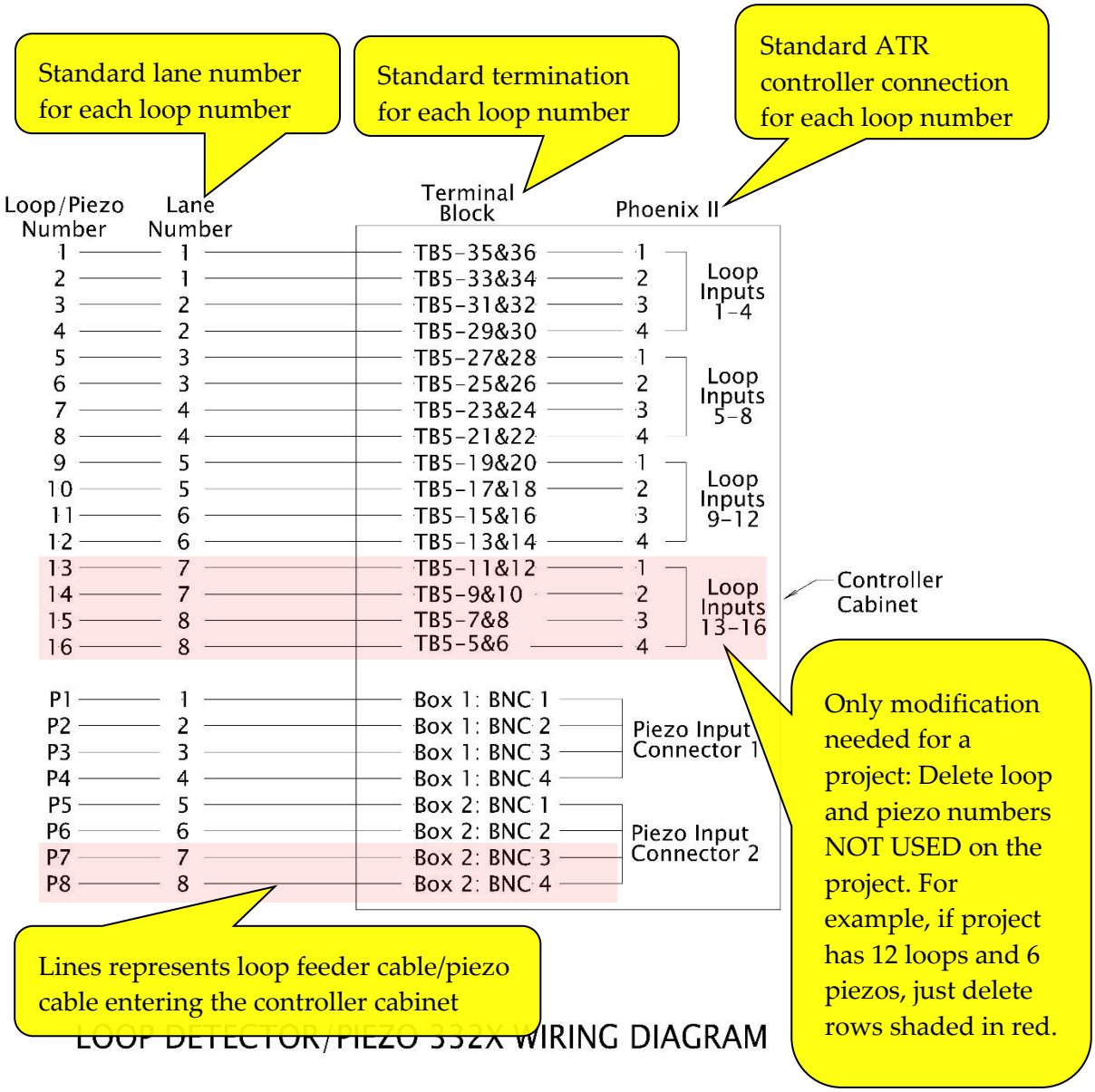


Figure 25-4 | Standard 332X Loop/Piezo Wiring Diagram

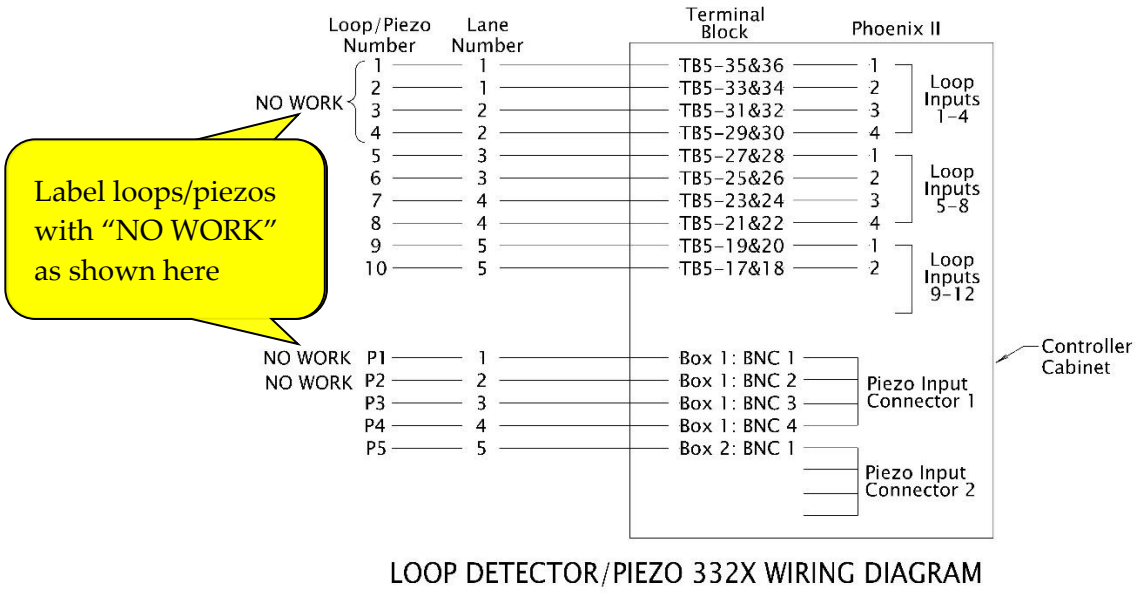


For greater than 16 loops or greater than 8 piezos, see the 332X cabinet print for the proper termination location.

The standard loop terminations for the 332X match the 332 ATR terminations as they relate to the input file slot location (e.g., the input file slot location associated with each loop termination is consistent: I file, slots 2 thru 9). This allows for an easy transition/conversion to the possible future use of an ATC controller that uses the input file.

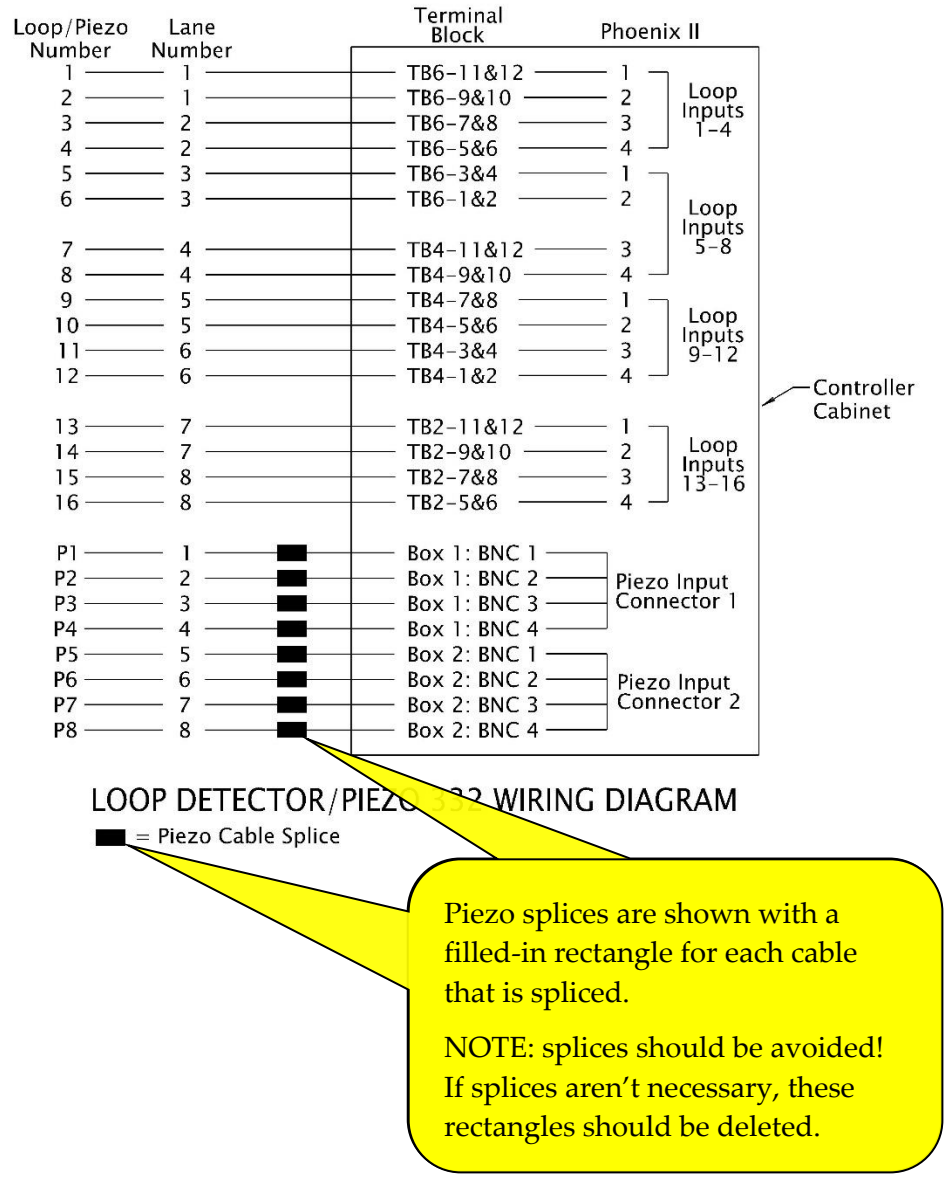
The loop/piezo wiring diagram is shown on the ATR plan sheet in its entirety, even if the project work doesn't include all of the loops/piezos. Loops/piezos that are to be retained and protected are labeled as "NO WORK" on the left side of the wiring diagram, either bracketed or directly next to the loop/piezo number. See Figure 25-5 for how to show no work areas on the wiring diagram.

Figure 25-5 | Showing No Work Areas in Loop/Piezo Wiring Diagram



Splices are normally not used for the piezo cable (see section 25.9.3 for more information), but in the rare case where a splice is used, it will be shown on the plan sheets via the loop detector/piezo wiring diagram. See Figure 25-6.

Figure 25-6 | Piezo Splices Shown in the Loop/Piezo Wiring Diagram



25.5 Piezoelectric Sensors

Piezoelectric sensors (piezos) are used to sense each axle in a vehicle that passes over it. They work by producing a signal (voltage current) when an axle/tire comes in contact with them in the roadway. This signal pattern, which is unique to each vehicle configuration, is detected by the electronics in the controller. Using piezos in combination with loops results in the ability to gather additional data such as number of axles, axle length between individual axles, and overall axle length. It is currently the most accurate way to classify vehicles.

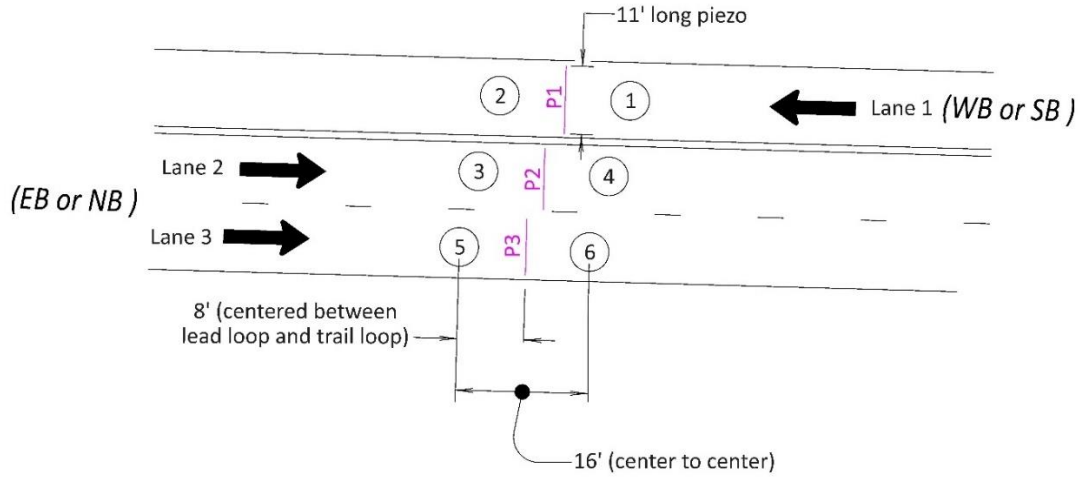
The decision to include piezos at a site is determined by the TSM unit.

25.5.1 Piezoelectric Layout

The piezo numbering and layout are described below and shown in Figure 25-7.

- Piezos are class II and 11 feet in length. They are a state furnished item.
- Piezos are centered between the lead loop and the trail loop (8’ from the center of the loops). When the loops have been staggered according to section 25.4, the piezos in each lane also will be correctly staggered by 18 inches. This stagger is important for the piezo installation (downstream pavement cuts as per section 25.7) and to minimize crosstalk.
- Piezos are numbered according to the lane they are in (e.g., piezo 1 is in lane 1 and abbreviated as “P1”).

Figure 25-7 | Standard Piezo Layout



25.5.2 Piezoelectric Wiring Diagram

See section 25.4.3 for information on how the piezo wiring is shown.

25.6 Non-Invasive Detection

Cameras and radar detection devices are currently being evaluated by the TSM unit at a few trial sites. These are not the same devices used for traffic signal detection. They are typically complete systems from the manufacturer that includes a pole mounted controller cabinet with all the necessary circuitry and wiring. Follow the manufacturer's recommended installation. This is a state furnished item. Items that are not state furnished for this type of installation include:

- The pole (and pole foundation) that the camera and controller cabinet are mounted to. Typically, the mounting height required by the manufacturer will result in a luminaire pole (without the luminaire arm). However, a pedestal may be used to mount the radar as per TM457 if the required mounting height can be accommodated. A 3'x3' concrete pad next to the pole foundation where a person would stand when opening the controller cabinet should be provided. The luminaire pole and foundation should follow the requirements of TM629 thru TM635 and specification 00962.
- The service cabinet. See section 25.10.
- Conduit and wiring from the service cabinet to the controller cabinet. See section 25.9.
- Conduit (typically contractor installed) and wiring (typically utility provided and installed) from the power source to the service cabinet. See chapter 5 for more information.

The detection zones and any other necessary software programming information are configured by the TSM unit and will be shown on the cabinet print, not the ATR plan sheet.

25.7 Junction Boxes, Wire Entrance, and Pavement Cuts

Junction boxes should be installed as per TM472. See chapter 5 for general information on junction box placement and design considerations.

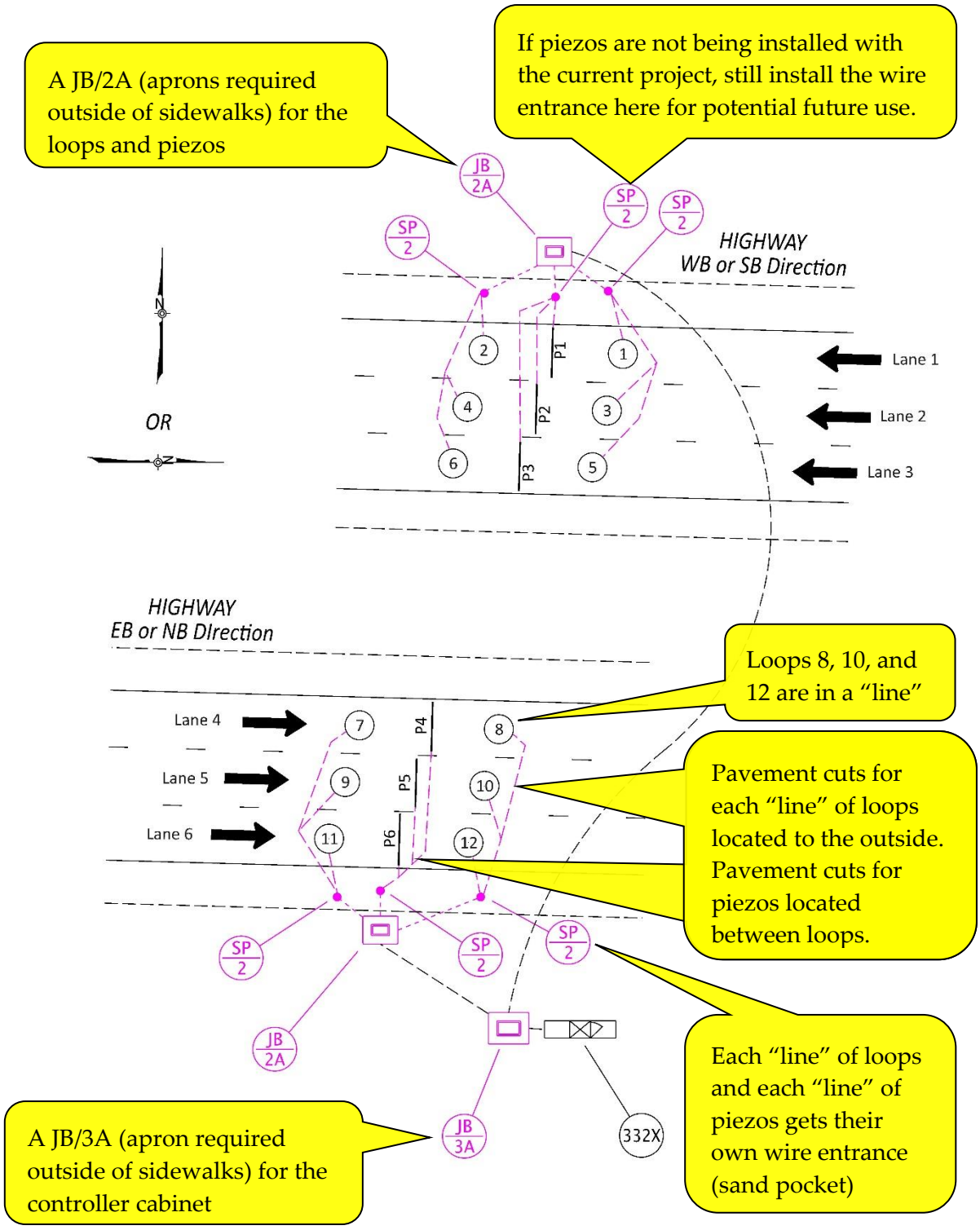
A JB/3 size junction box should be used near the controller. A JB/2 size junction box should be used for the detection, next to the wire entrances (sand pocket as per DET4428).

A separate wire entrance (sand pocket) is used for each "line" of loops and each "line" of piezos. The conduit size for the wire entrance will be either 2" (accommodates 1 to 4 loops OR up to 30 piezo cables) or 2.5" (accommodates 5 to 8 loops). The pavement cuts for each "line" of loops are typically installed to the outside of the loop, leaving the space in between the loops for the "line" of piezos.

If the project only includes loops, install a wire entrance for the piezos that can be used in the future.

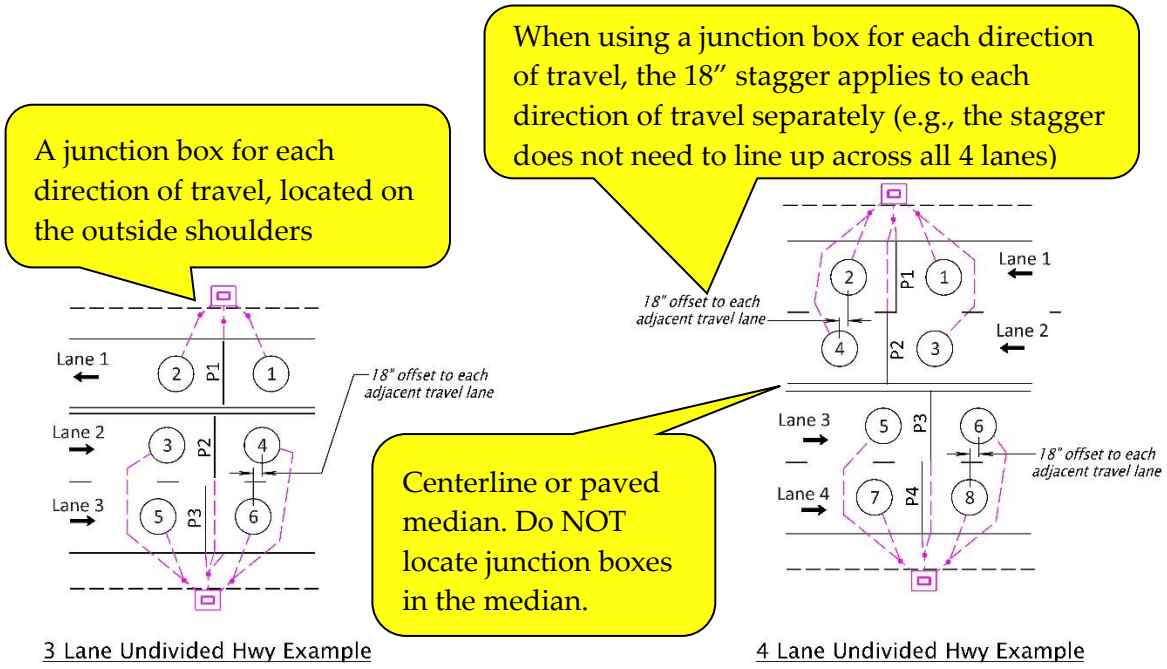
See Figure 25-8 for an illustration of the typical junction box, wire entrance and pavement cuts.

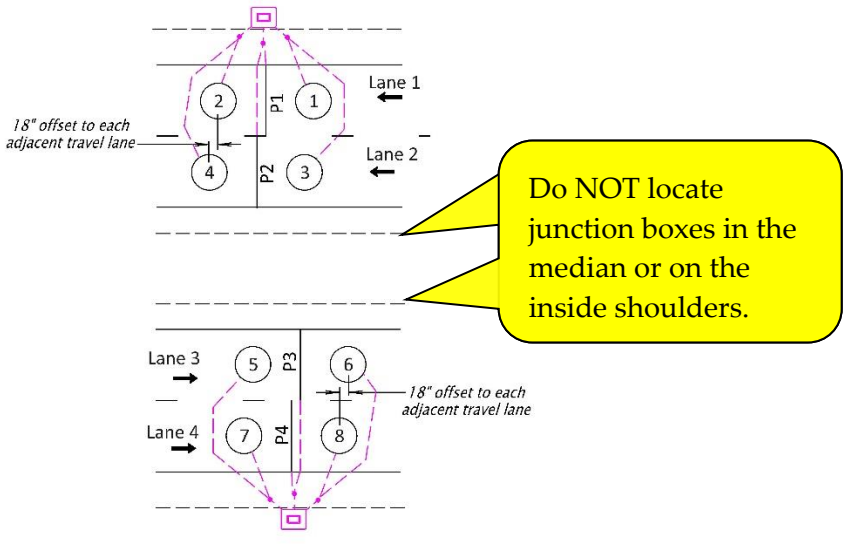
Figure 25-8 | Typical Junction Box, Wire Entrance, and Pavement Cuts



The default standard requires one junction box for each direction of travel. The junction boxes are located on the outside shoulders. Do not locate junction boxes in the median. When using a junction box for each direction of travel, the 18" stagger of detection to adjacent lanes applies to each direction separately (there is no need for line up the stagger for both directions of travel). See Figure 25-9.

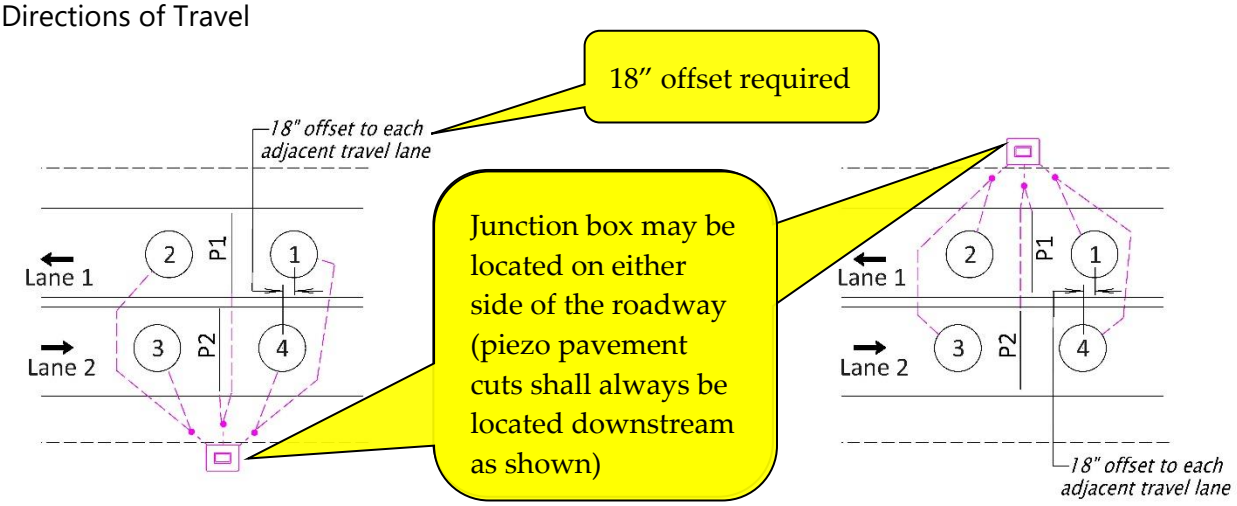
Figure 25-9 | Default Junction Box Standard – One Junction Box for Each Direction of Travel





One exception to the default standard of providing one junction box for each direction of travel is for undivided highways where both directions of travel have just one travel lane. In this case, one junction box should be used for **both** directions of travel and it can be placed on either side of the roadway. The 18" stagger of detection to the adjacent lane is required. See Figure 25-10.

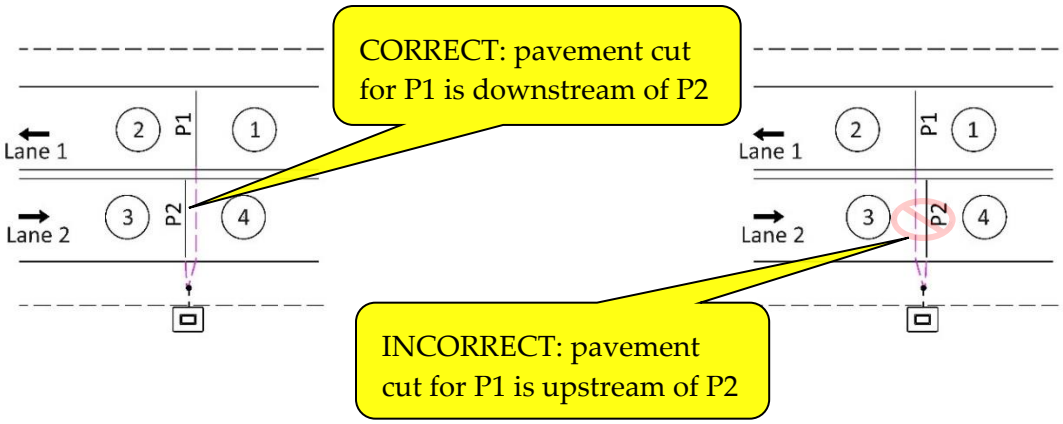
Figure 25-10 | Exception to Junction Box Default Standard – One Junction Box for Both Directions of Travel



2 Lane Undivided Hwy Example

The location of the pavement cuts for piezos is very important. In addition to sensing an axle hitting the piezo itself, the piezo can also pick up the vibration of an axle hitting a nearby crack or pavement cut from a nearby piezo. The piezo is more sensitive to this kind of vibration when the crack is ahead of the piezo. For this reason, the pavement cuts from piezos are always placed downstream of the of the piezos nearer the sand pocket. Verify the stagger of the detection and placement piezo cuts (or future piezo cuts) will be correct. See Figure 25-11.

Figure 25-11 | Piezo Pavement Cuts Always Downstream

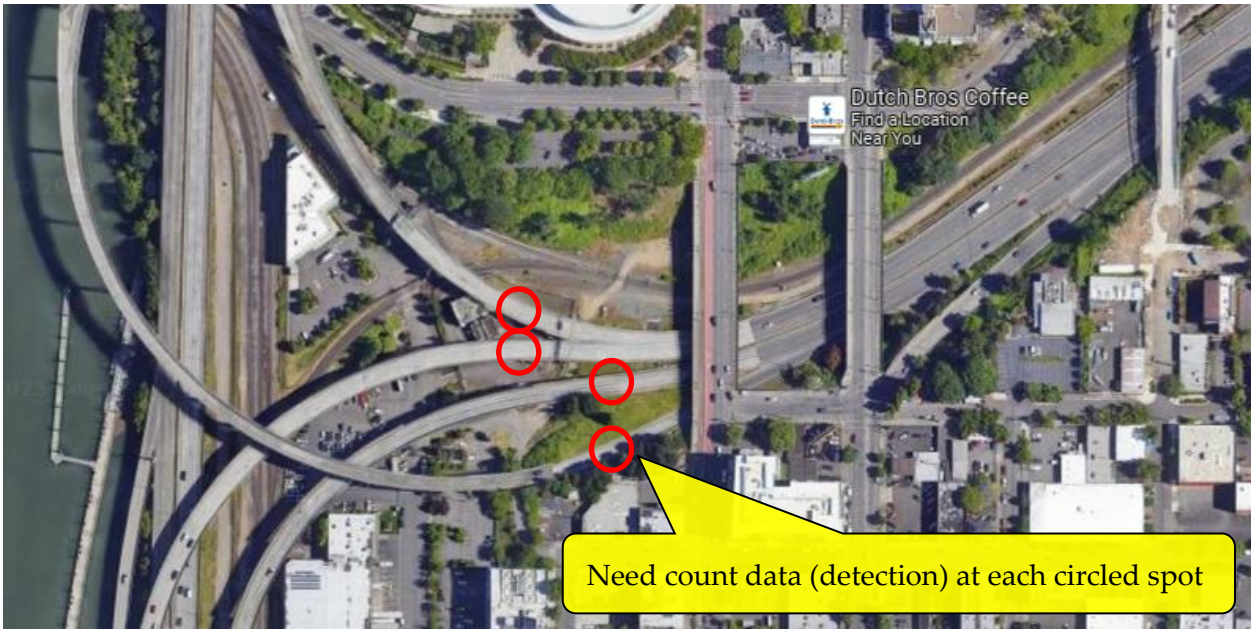


25.8 Unique Geometry Considerations

The previous sections of the manual show a very typical, standard ATR site lane geometry (e.g., two directions of travel, with the two directions of travel located on the same road surface or on two road surfaces separated by a standard median). However, there are various unique geometries (e.g., interchange configurations) that will require an ATR site where the standard ATR design guidance is either not applicable or requires some adjustment to meet the site-specific needs. See Figure 25-12. These unique geometries will require consideration of the project scope, data collection needs, initial installation costs, ability to maintain, and maintenance costs to determine the appropriate:

- Location for controller and service cabinets
- Location to install the detection (and the resulting type of detection). Note: on bridge decks, preformed loops during bridge construction or non-invasive detection are the only options. If possible, moving the detection location off of a bridge deck is preferred.
- Location of junction boxes and conduit

Figure 25-12 | Unique Geometry – Interchange ATR Example



25.9 Conduit and Wiring

Conduit and wiring should be installed as per TM470 and TM471. See chapter 5 for general information on verifying the proper size of conduit and wiring.

25.9.1 Service Cabinet to Controller Cabinet Wiring

The default standard wire used from the service cabinet to the controller cabinet is No. 6 AWG XHHW wire. However, voltage drop must be verified for long runs of wire.

25.9.2 Loop Wire and Loop Feeder Cable

Loop wire is used in the pavement, with a standard of 5 turns of wire as per DET4428. Five turns of wire is adequate to provide the necessary change in inductance for any loops placed closer than 645 feet from the controller cabinet (measured from the circular loop edge to the wire entrance, via the conduit to the controller cabinet, including slack wire), which should accommodate all ATR sites.

Loop feeder cable is used to connect the loop wire (in the pavement) to the controller cabinet. It consists of a polyethylene jacketed shielded twisted pair of No. 14 AWG wire. A smaller gauge loop feeder cable (no. 18 AWG) is also an option for use in retro-fits when the existing conduit cannot accommodate the standard no. 14 AWG cable.

All loop wire is spliced to a loop feeder cable in the junction box (not in the sand pocket). Loop feeder cables are continuous from the junction box all the way to the controller cabinet.

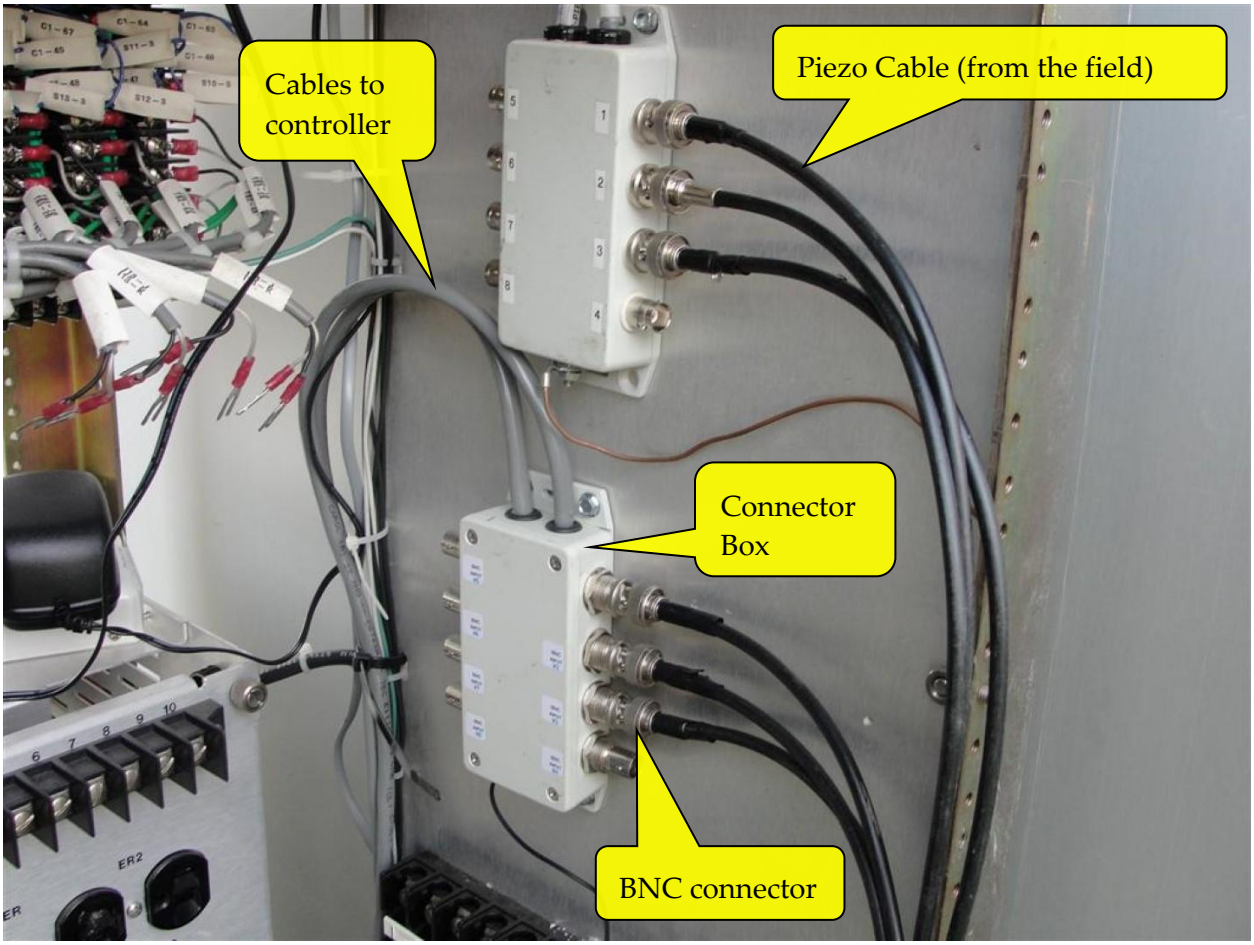
25.9.3 Piezo Cable

Piezo sensors come from the manufacturer with the cable (passive signal cable) already connected as splices are not recommended and should be avoided when possible. The standard piezo cable lengths available are 100, 150, 200, 250 or 300 feet. If the required length will exceed 300 feet (including the required slack as per TM470), contact the manufacture to determine the best solution. The contractor will field verify correct length to install.

The piezo cable is an RG-58 coaxial cable with an underground/direct burial rated outer jacket. The OD of the cable is 0.187 inches.

The piezo cable is terminated in the controller cabinet via a connector box with BNC connections. See Figure 25-13.

Figure 25-13 | Piezo Cable Connection in Controller Cabinet– Connector Box with BNC



If a splice cannot be avoided, it will be done in the junction box (not the sand pocket) and it should be done according to the manufacturer's recommendations:

- The cable that is spliced to the cable attached to the piezo sensor should be the same cable as that supplied with the piezo sensor.
- Sealing should be done with an electrical sealing resin, such as 3M Scotchcast 2130. It is recommended that a splice kit such as a 3M 82-F1 Inline Splice Kit be used to provide the form for the sealing resin.

Piezo cable splices should be shown in the plans via the loop/piezo wiring diagram. See section 25.4.3 for example.

25.9.4 Conduit

The conduit requirements stated in chapter 5 apply to ATR installations. The TSM unit may request larger than the minimum conduit size depending on site-specifics and future needs. Figure 25-14 shows the ODOT minimum conduit sizes for the typical number of loop feeder cables and piezo cables installed. If the project happens to require cables/wires not shown in Figure 25-14, see chapter 5 for information on how to calculate the minimum conduit size.

Figure 25-14 | Loop Feeder Cable and Piezo Cable Allowed in Conduit

Typical Number of Loop Feeder Cable ("LF") + Piezo Cable ("P") in Conduit	ODOT Min. Conduit Size (See Chapter 5)
2 LF + 1 P	1 ½"
4 LF + 2 P	1 ½"
6 LF + 3 P	2"
8 LF + 4 P	2"
10 LF + 5 P	2 ½"
12 LF + 6 P	2 ½"
14 LF + 7 P	3"
16 LF + 8 P	3"
18 LF + 9 P	3"

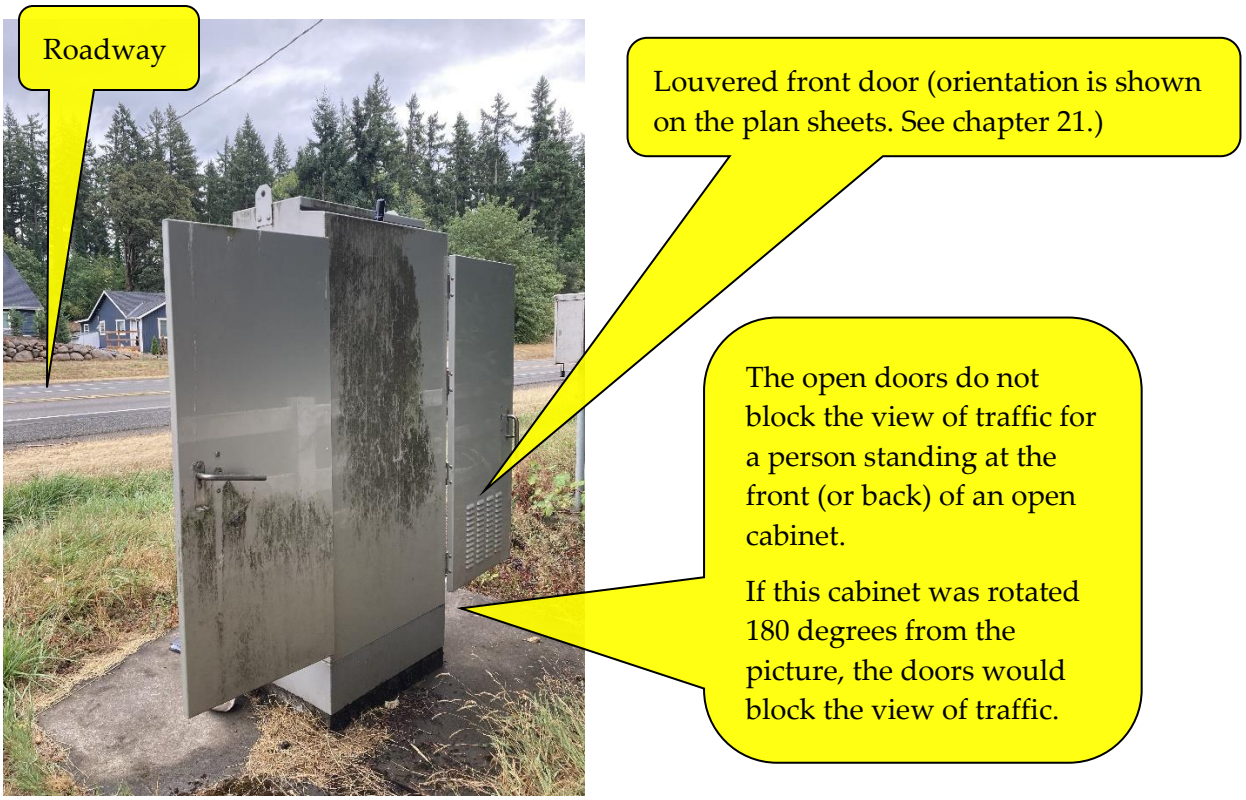
A spare 2" conduit (with capped ends and a poly pull line) shall be installed from the controller cabinet to the first junction box (JB/3). This spare conduit will allow for easy access into the controller cabinet for future devices.

Avoid unnecessary conduit crossings of the roadway by placing junction boxes, the controller cabinet and/or the service cabinet on the same side of the roadway when possible.

25.10 Controller Cabinet and Service Cabinet

A 332X controller cabinet is standard (332S cabinet shell with ATR specific hardware configuration), unless using a complete system from the manufacturer (e.g., non-invasive detection as described in section 25.6). The controller cabinet should be located outside the clear zone in rural locations if possible or at the back of sidewalk in urban locations. It should also be located near the detection, with the louvered front door opening so that it will not block the view of roadway when a person is facing the front of the cabinet. See Figure 25-15 for example of proper controller cabinet orientation.

Figure 25-15 | Correct Orientation of Controller Cabinet



Other types of controller cabinets and service cabinets have been used in the past and may continue to be used if they are not at the end of their service life. If an existing controller or service cabinet is damaged or needs to be relocated, it shall be replaced with the current standard.

A base mounted service cabinet (BMC) is the standard service for ATR sites. If possible, it is ideal to place the base mounted service cabinet near the controller cabinet as shown in TM482 for ease of maintenance. However, this may not be possible in all locations. It is typical for the utility to have a maximum distance the service cabinet can be from the power source (e.g., approx. 50 feet). In rural locations, the nearest available power source may be several hundred to several thousand feet from the location of the ATR site. In these cases, the service cabinet will need to be placed according to the utility's requirements. Contact the region utility specialist to determine the requirements/constraints for placement of the service cabinet.

Note that TM482 requires a walkway from the edge of pavement to the both the controller cabinet and the service cabinet foundations. For rural locations, this needs to be shown on the plan sheets, as each walkway will be site-specific. See Figure 25-16 for example. Also, the standard 36"x24" landing pads for the cabinet foundation on TM482 may be enlarged at the direction of the TSM unit to further discourage the surrounding vegetation from encroaching on the equipment in remote areas. This will require a custom detail in the plan sheets. See Figure 25-17 for examples.

Figure 25-16 | Rural Location Walkway to Controller Cabinet Example

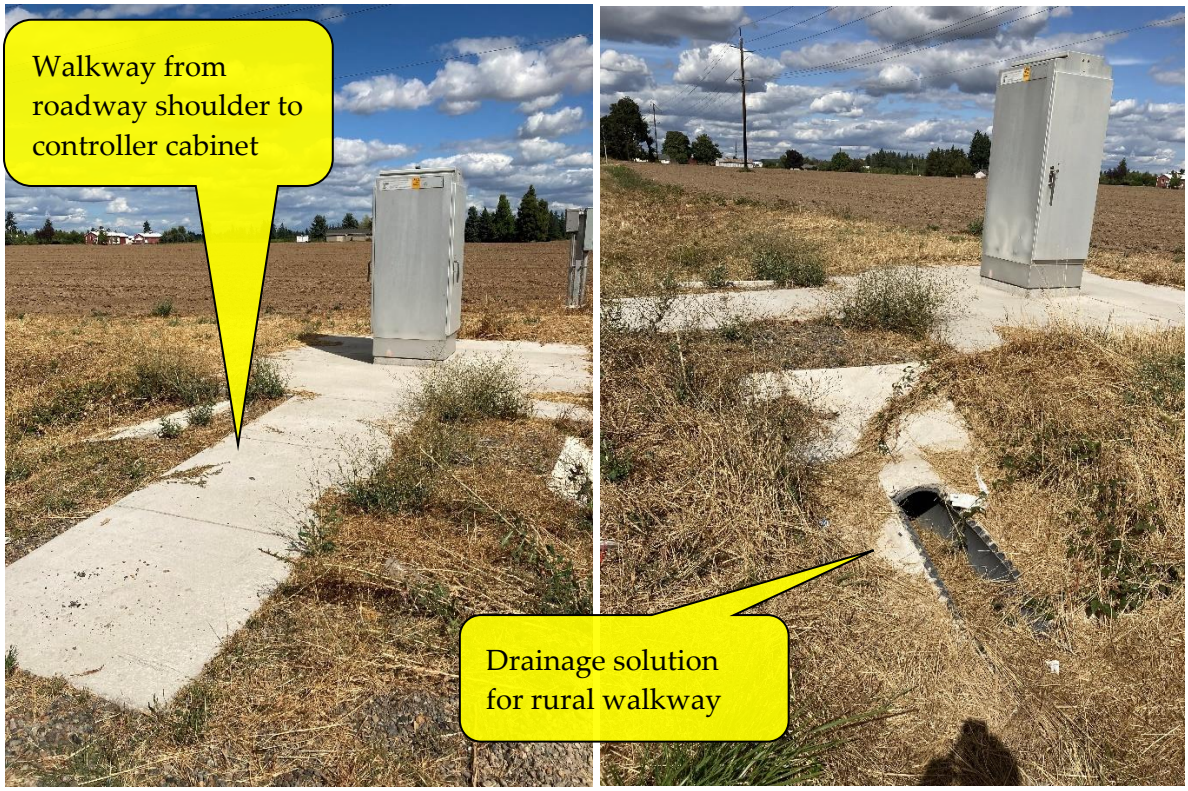


Figure 25-17 | Custom Controller Cabinet Landing Area Examples



25.11 Controller

The phoenix II controller is the standard controller for ATR sites. It can accommodate up to 16 loop detectors and 8 piezos. See Figure 25-18. If more loop detectors or piezos are needed, an additional Phoenix II controller will need to be installed in the controller cabinet. See Figure 25-19. The controller is a state furnished item.

If non-invasive detection is used, a manufacturer specific controller will be required. See section 25.6 for more information.

Figure 25-18 | Phoenix II Controller – Accommodates 16 Loop Detectors and 8 Piezos



Figure 25-19 | Two Phoenix II Controllers – Accommodates 32 Loop Detectors and 16 Piezos



25.12 Communication

Communication for ATR sites is not allowed on the state network. A modem is used with a site-specific private connection that will either be cellular (preferred if cell coverage is available in the area) or dial-up. The TSM unit will provide information on the proper communication plan and equipment needed for each site. The communication equipment is a state furnished item.

25.13 Maintenance Pad

The TSM unit will determine if a maintenance pad should be installed. See Figure 25-20. See chapter 5 for more information on maintenance pad use and design.

Figure 25-20 | ATR Site Maintenance Pad Example



25.14 Anti-Vandalism Treatments

Certain locations may require consideration of anti-vandalism treatments to better protect the controller cabinet and service cabinet. Fences, anti-graffiti coating, custom locking mechanisms, and/or custom fortresses may be necessary. See Figure 25-21 though Figure 25-23. The TSM unit will determine if any of these additional treatments are necessary.

Figure 25-21 | Anti-Vandalism Treatment – Fortress Example

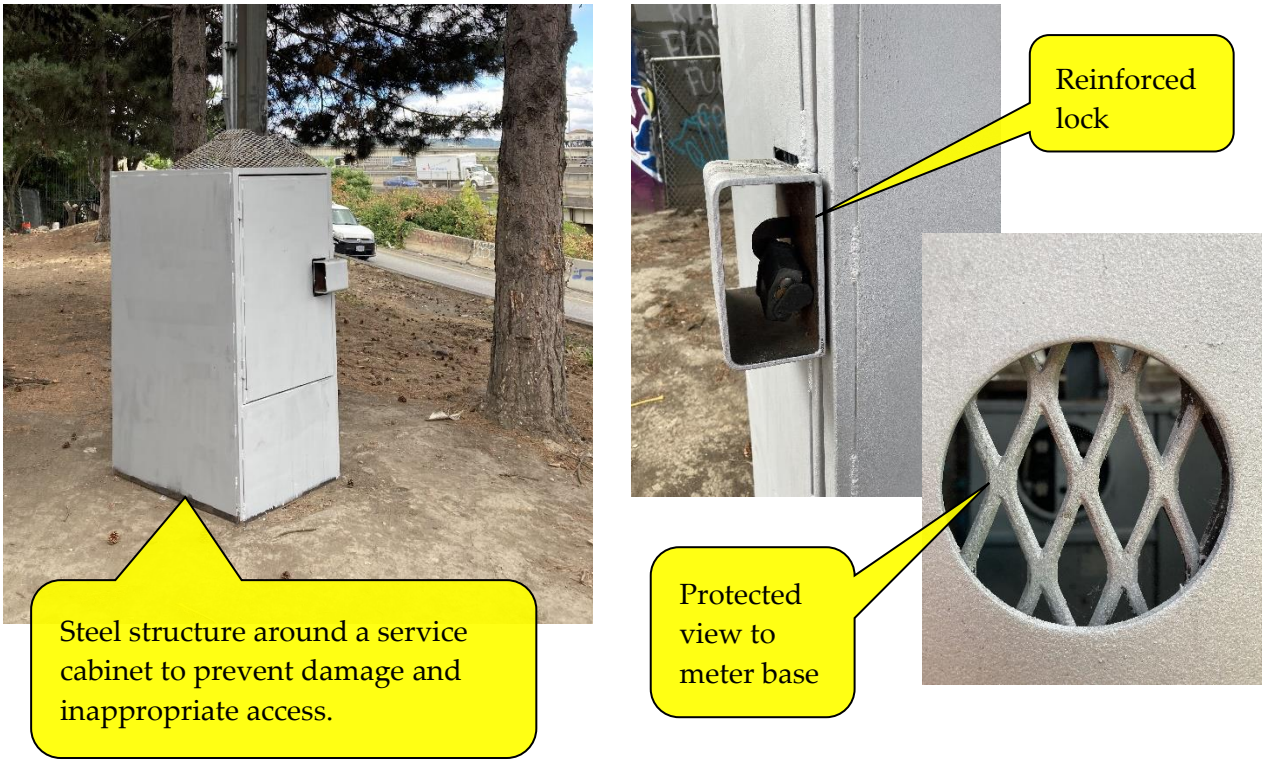
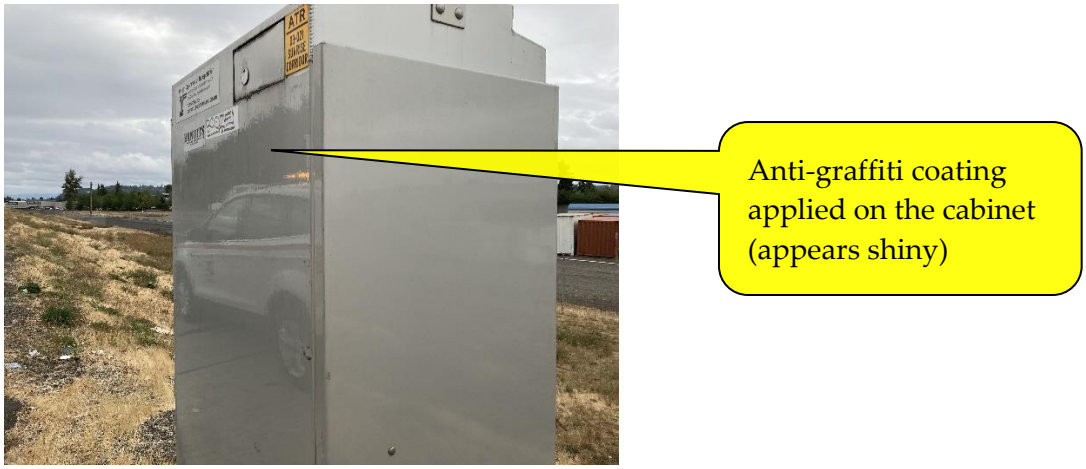


Figure 25-22 | Anti-Vandalism Treatment – Custom Locking Mechanism



Figure 25-23 | Anti-Vandalism Treatment – Anti-Graffiti Coating



25.15 Standard Drawing and Standard Details

The following standard drawings should be referenced for ATR work:

- TM470 for general wiring and cable installation notes
- TM471 for trenching and conduit installation
- TM472 for junction box installation
- TM482 for controller cabinet and base mounted service cabinet foundation
- TM485 for service cabinet wiring details

The following standard details should be used to create site-specific plan sheets for ATR work:

- DET4428 for general loop detection installation
- DET4480 for ATR drafting & wiring diagrams
- DET4481 for ATR typical layout details
- DET4485 for ATR Piezo details

25.16 Specifications, Cost Estimates, Bid Items, and Construction Support

The traffic signal cost estimate spreadsheet may be used for the majority of the items (e.g., conduit, junction boxes, wiring, etc.). The TSM unit will provide cost estimates for any state furnished items (e.g., piezos). State furnished items require a letter of public interest finding (LPIF) and are an anticipated item. See chapter 19 for information on the LPIF process and anticipated items.

Specifications 00960 and 00990, with special provision boiler plates should be used.

The bid item is in 00990, "Automatic Traffic Recorder Installation", as a lump sum.

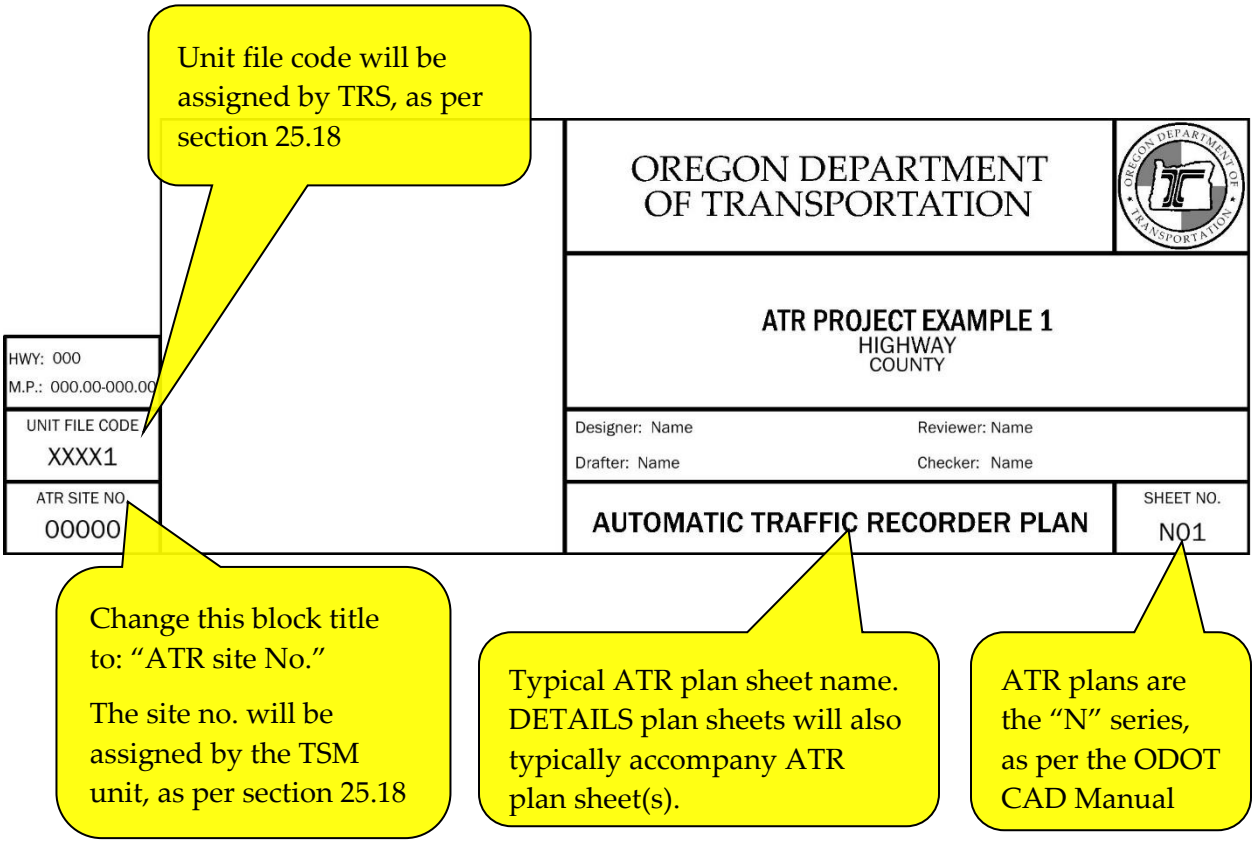
For additional information on specifications, cost estimates and bid items, see chapter 19.

The TSM unit will supply the state furnished items to contractor.

25.17 Drafting Standards

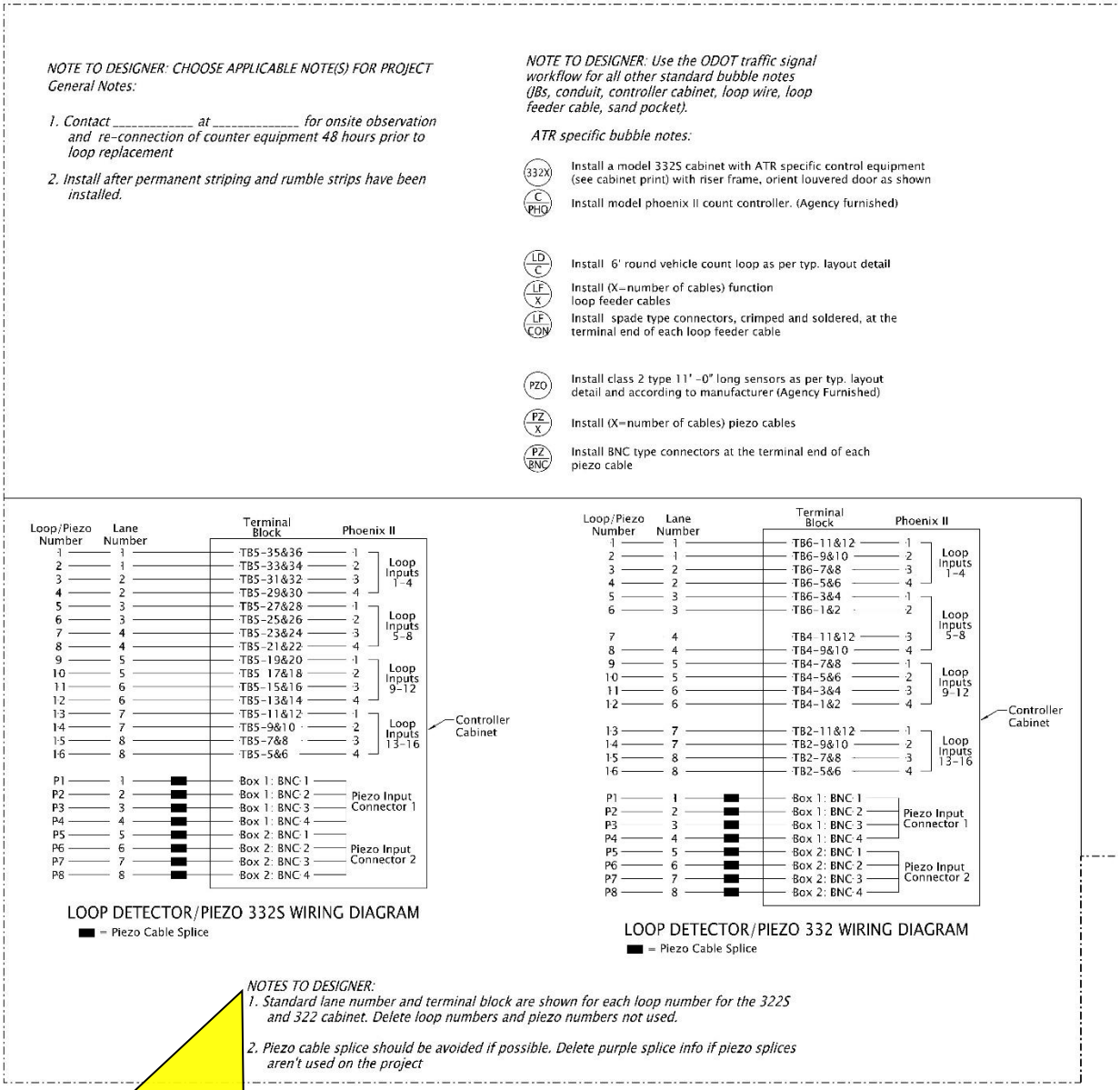
Use the ODOT CAD Manual for all general drafting standards, such as the MicroStation file and plan sheet set-up, title block, project sheet numbering, etc. The scale of the ATR plan sheets should be 1"=20'. See Figure 25-24 for ATR specific title block information.

Figure 25-24 | ATR Specific Title Block Information



ATR plans will be drafted in the same style used for drafting traffic signals. See chapter 21 for more information on traffic signal style drafting. Use the ODOT traffic signal workflow in MicroStation for the symbology, scalable items, bubble notes for standard items (e.g., junction boxes, controller cabinets, conduit, loop wire, loop feeder cable, etc.). ATR specific drafting standards are not in the workspace yet, but are available via DET4480, DET4481, and DET4485. See Figure 25-25 for example of ATR specific drafting standards.

Figure 25-25 | DET4480 Drafting Content Example



Standard details typically have instructions to the designer – follow them and delete them from final plan sheets.

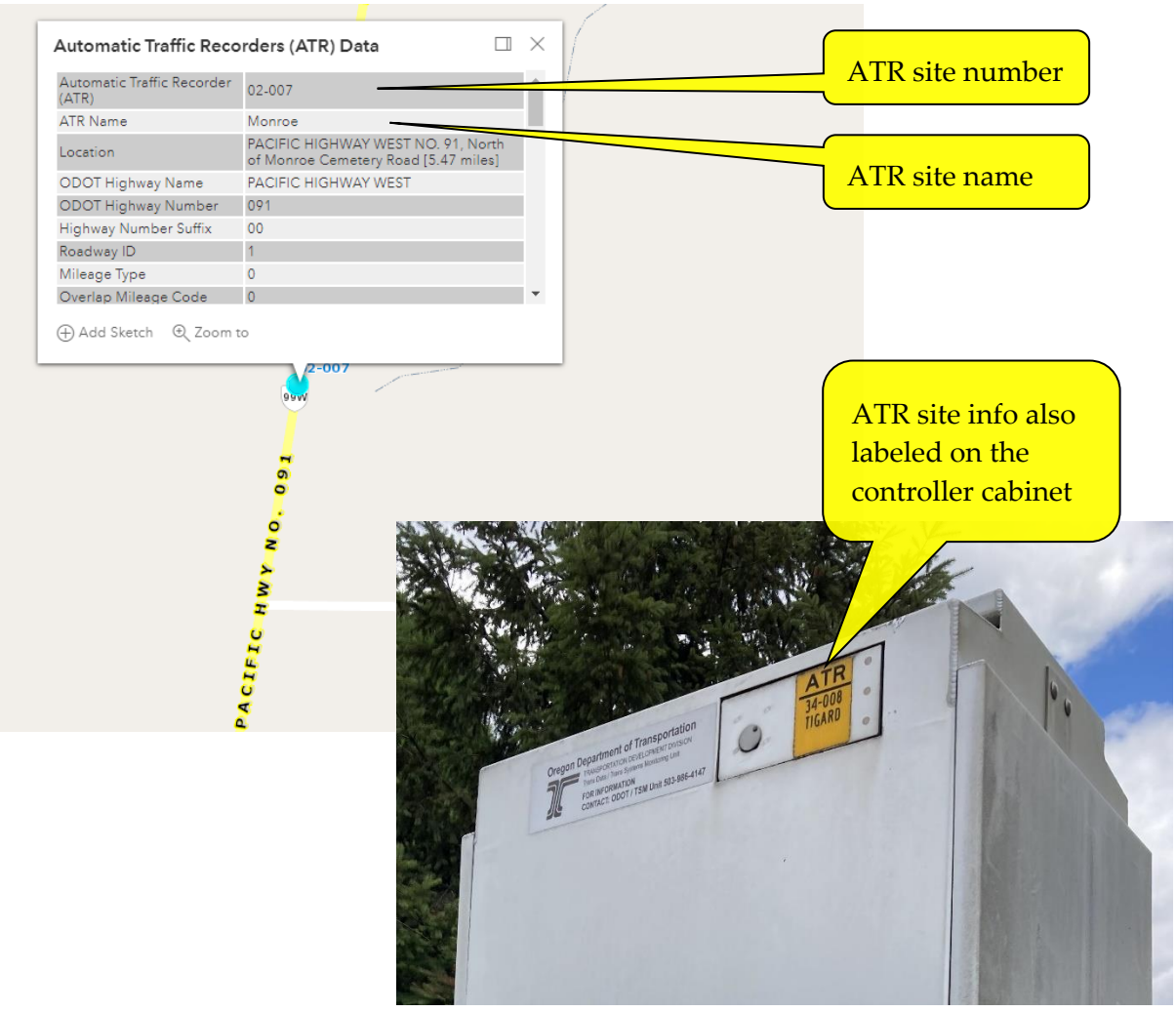
25.18 Design Approval, Drawing Numbers, and ATR Site Number

ATR plan sheets do not require a design approval signature on the plan sheets, but the TSM unit shall review and concur with the design.

Each ATR related plan sheet is issued a unique drawing number (referred to as either "TRS drawing number" or "unit file code") that is assigned by the traffic engineering section. See chapter 2 for the process to get the drawing number(s).

The ATR site numbers are assigned by the TSM unit for all ATR installations. This info is used in producing the various data reports for the Transportation Volume Tables, maintenance, and asset management purposes. The format of the site numbers is 00-000 and is accompanied by a name (e.g., location description), for example "Monroe, 02-007". For existing ATR sites, TransGIS can be used to determine the ATR site number and name using the "Traffic Data" layer which contains "Automatic Traffic Recorders". See Figure 25-26.

Figure 25-26 | TransGIS ATR Layer



25.19 ATR Cabinet Prints

The cabinet print is a schematic representation of the components that are inside the controller cabinet. This schematic is used mainly by the TSM unit and electricians on-contract to perform maintenance. A hard copy of the cabinet print is required to be in the controller cabinet at all times. Cabinet prints must be accurate for proper maintenance of the ATR site and data collection.

The signal designer is responsible for creating the cabinet print(s) for the project. The cabinet print should be completed prior to PS&E, with review by the TSM unit. When completed, the MicroStation file and the PDF file of the cabinet print is sent to the TSM unit, where it is archived. The TSM unit is responsible for any updates to the cabinet print after the project (documenting changes made during maintenance work, correcting typos, etc.).

There are ATR specific Microstation base files for 332X (standard) or the 332 modified (to document existing ATR sites with a 332 cabinet) on the traffic signal standards website. In the MicroStation base files, the areas that can be modified are typically shown in red. There are different levels that can be turned on or off depending on the equipment that is installed. Basic instructions for how to use and properly fill out the cabinet print will also be contained within the file.

Each ATR site should have its own cabinet print file. The file name should begin with the ATR site number followed by name, for example, "02_007_Monroe.dgn"

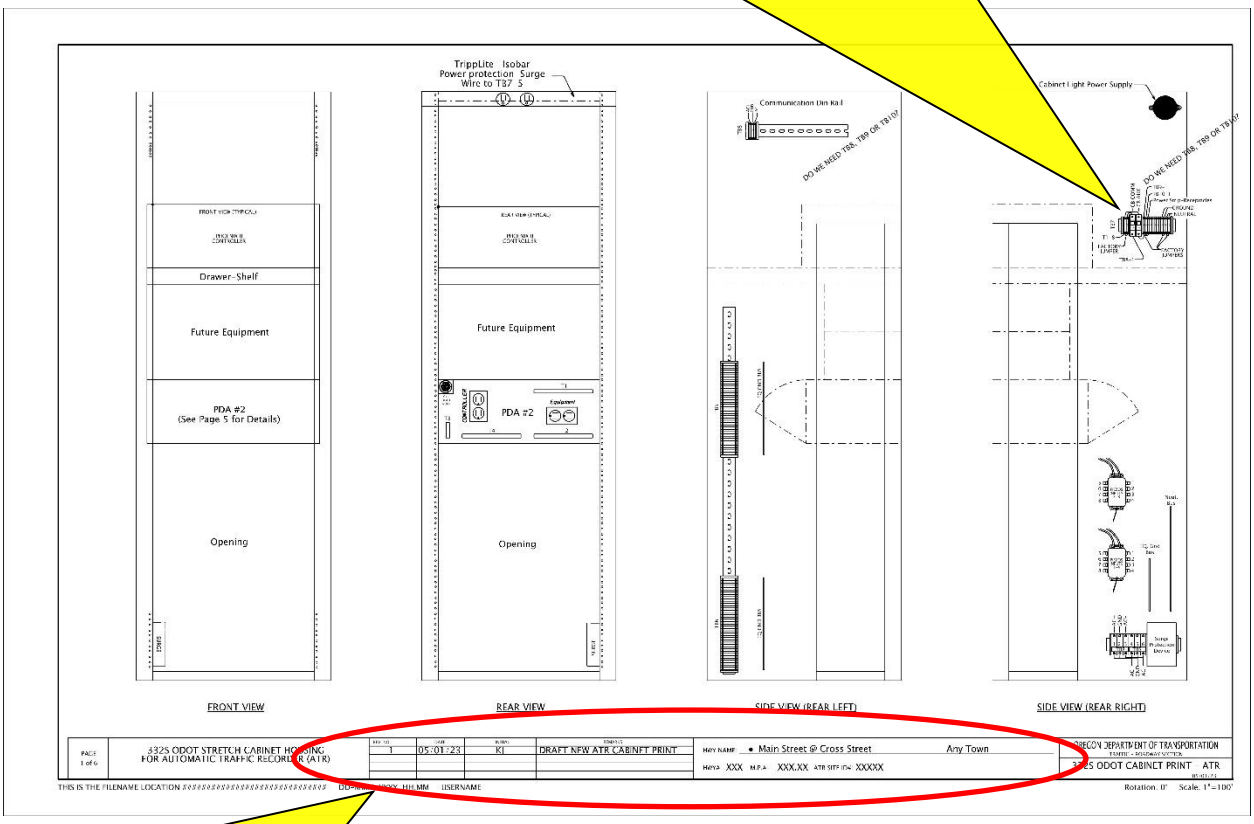
Cabinet prints are formatted for printing on 11x17 paper.

NOTE! All figures in this manual show a 332X cabinet. The cabinet print layout for the 332 will be slightly different, but all contain similar elements. The basic information in this manual can be used in conjunction with the appropriate base file.

25.19.1 Page 1 – Cabinet Layout

Page 1 of the 332X cabinet print shows the front, rear, and both side views of the cabinet. There is not a lot to modify on this sheet, but certain levels and/or references will need to be turned-on or off to show the correct site-specific equipment, (e.g., communication equipment, two controllers, etc.). See Figure 25-27.

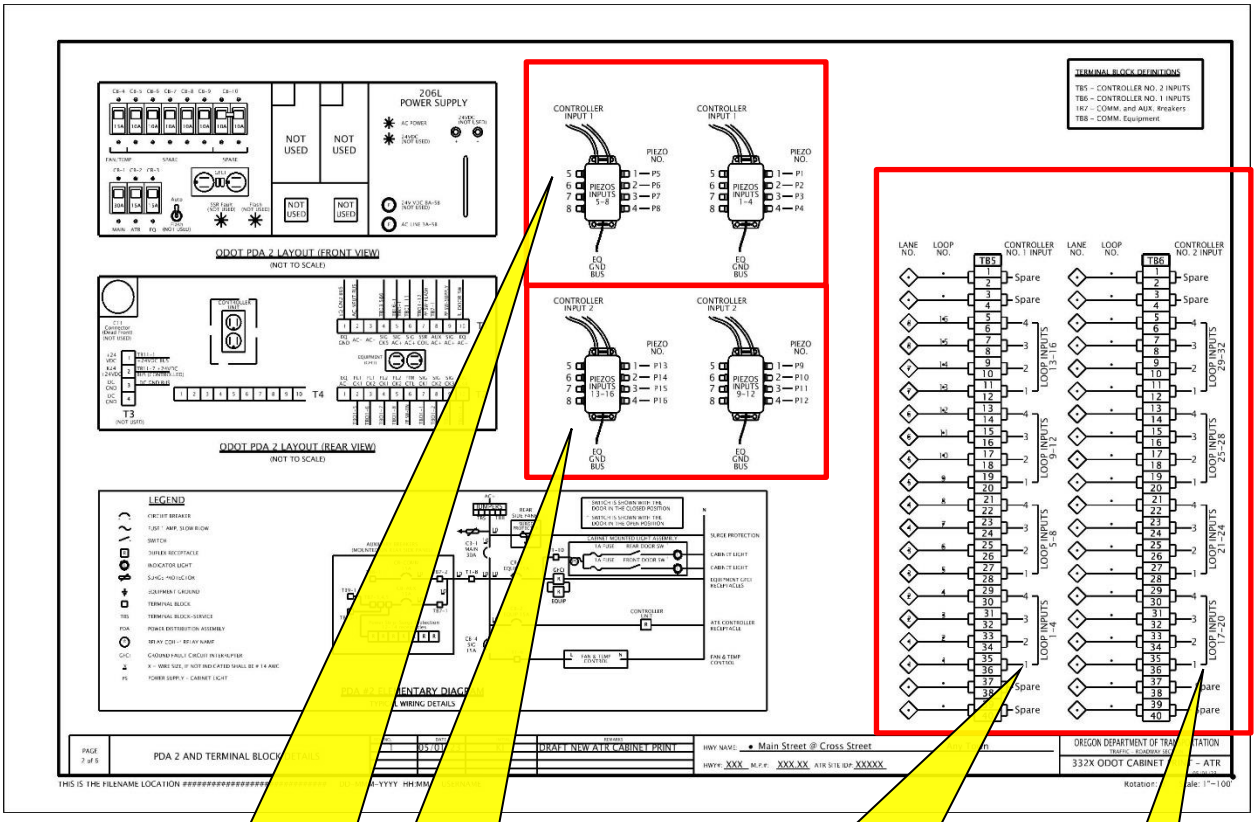
Figure 25-27 | 332X Cabinet Print (Page 1)



25.19.2 Page 2 – Terminations

Page 2 of the cabinet print shows the terminations of the loop feeder cable and piezo cables. The only modifications necessary to this sheet are shown in Figure 25-28.

Figure 25-28 | 332X Cabinet Print (Page 2)



Piezo connector boxes for the standard placement of piezo sensors 1 thru 8.

Piezo connector boxes for the standard placement of piezo sensors 9 thru 16. REQUIRES A SECOND CONTROLLER.

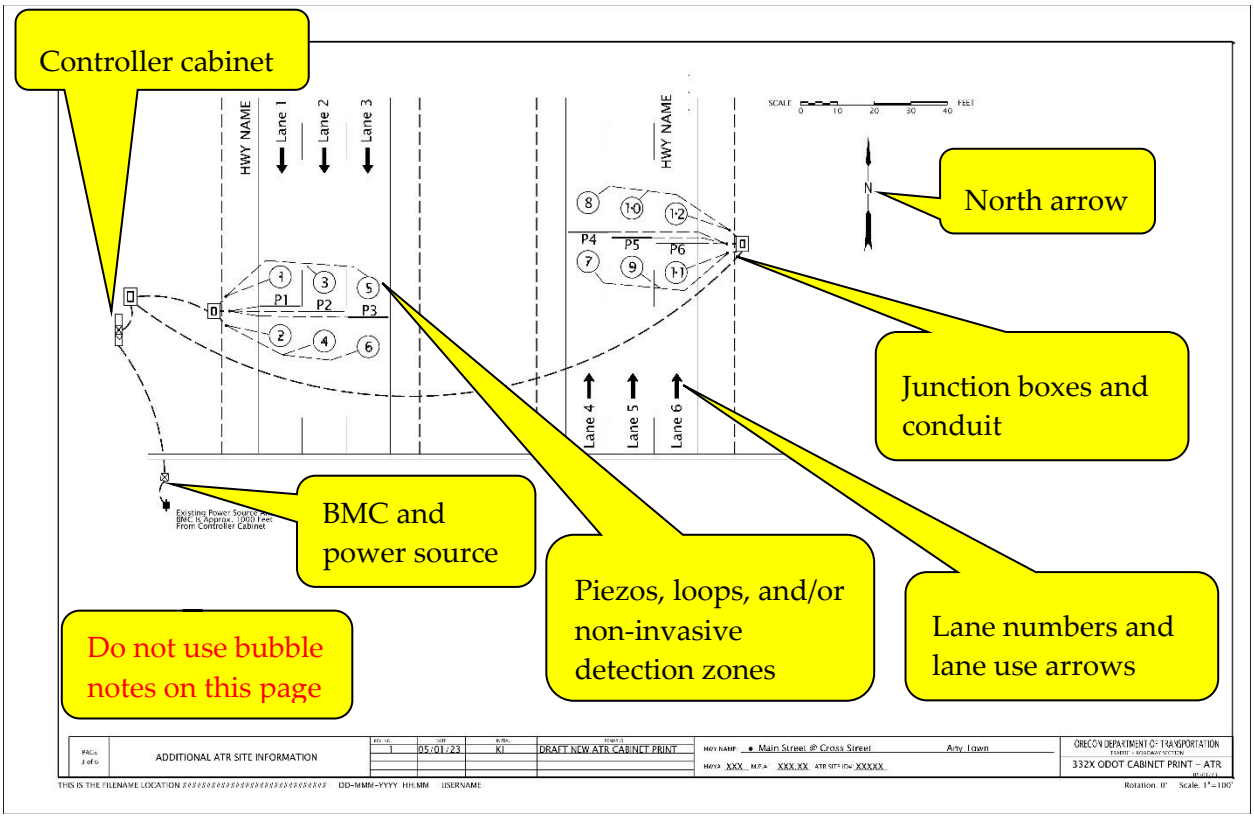
Terminal block TB5 is the standard placement for loops 1 thru 16. Delete loop numbers/loop lane numbers not used.

Terminal block TB6 is the standard placement for loops 17 thru 32. REQUIRES A SECOND CONTROLLER.

25.19.3 Page 3 – ATR Site Drawing

Page 3 of the cabinet print shows the ATR site drawing. The intent of the site drawing is to provide a simplified illustration of critical equipment to allow for the field tech to quickly determine the orientation and location of equipment during routine maintenance and troubleshooting. See Figure 25-29 for what to include on this page.

Figure 25-29 | 332X Cabinet Print (Page 3)



25.20 Example Plan Sheets

Example project 1 includes both loops and piezos, which will typically have three plan sheets as shown in Figure 25-30 thru Figure 25-32.

Example project 2 includes non-invasive detection as shown in Figure 25-33 and Figure 25-34.

These figures are typical examples and highlight information that should be included on the project plan sheets.

Figure 25-30 | ATR Project Example 1, Sheet N01

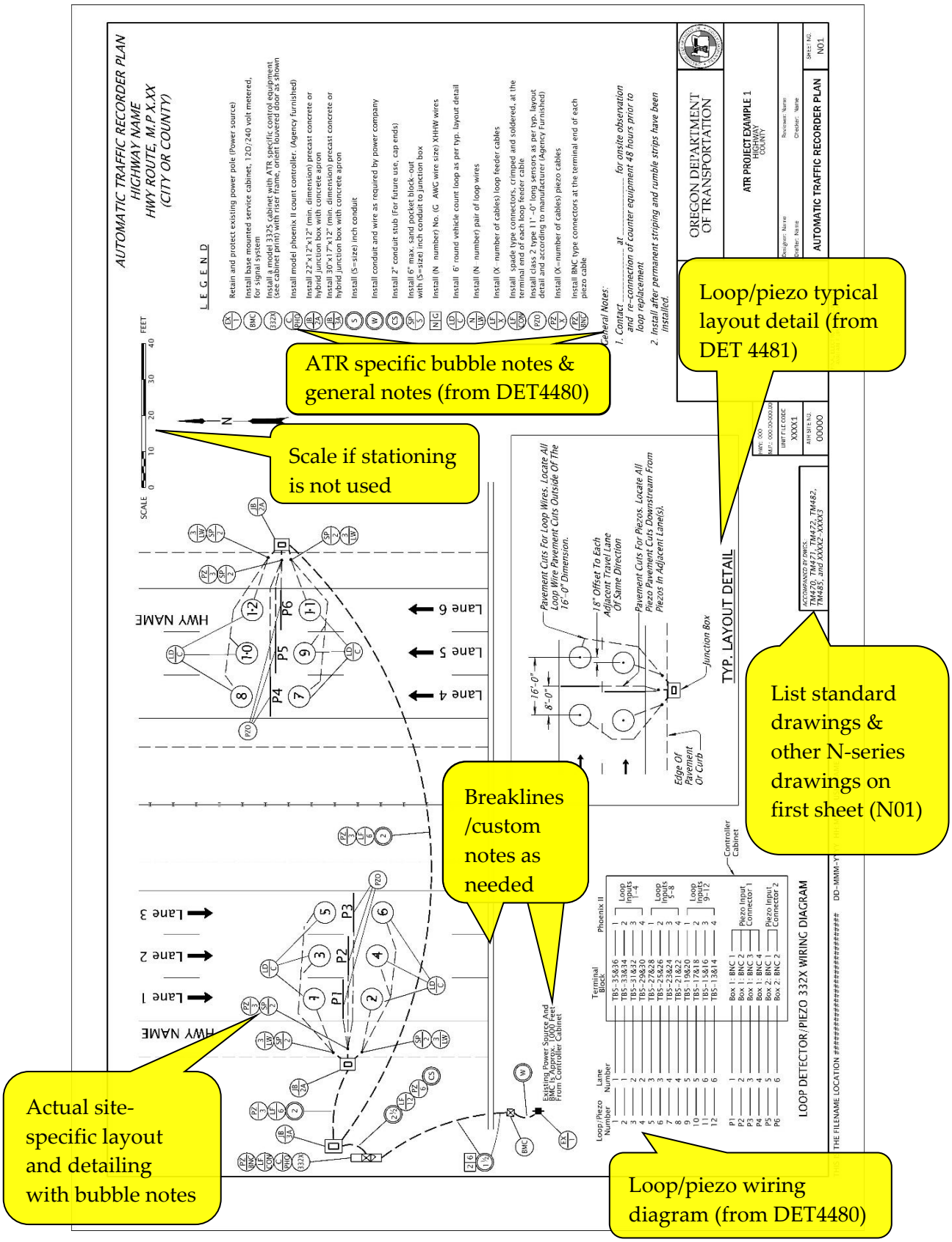


Figure 25-31 | ATR Project Example 1, Sheet N02

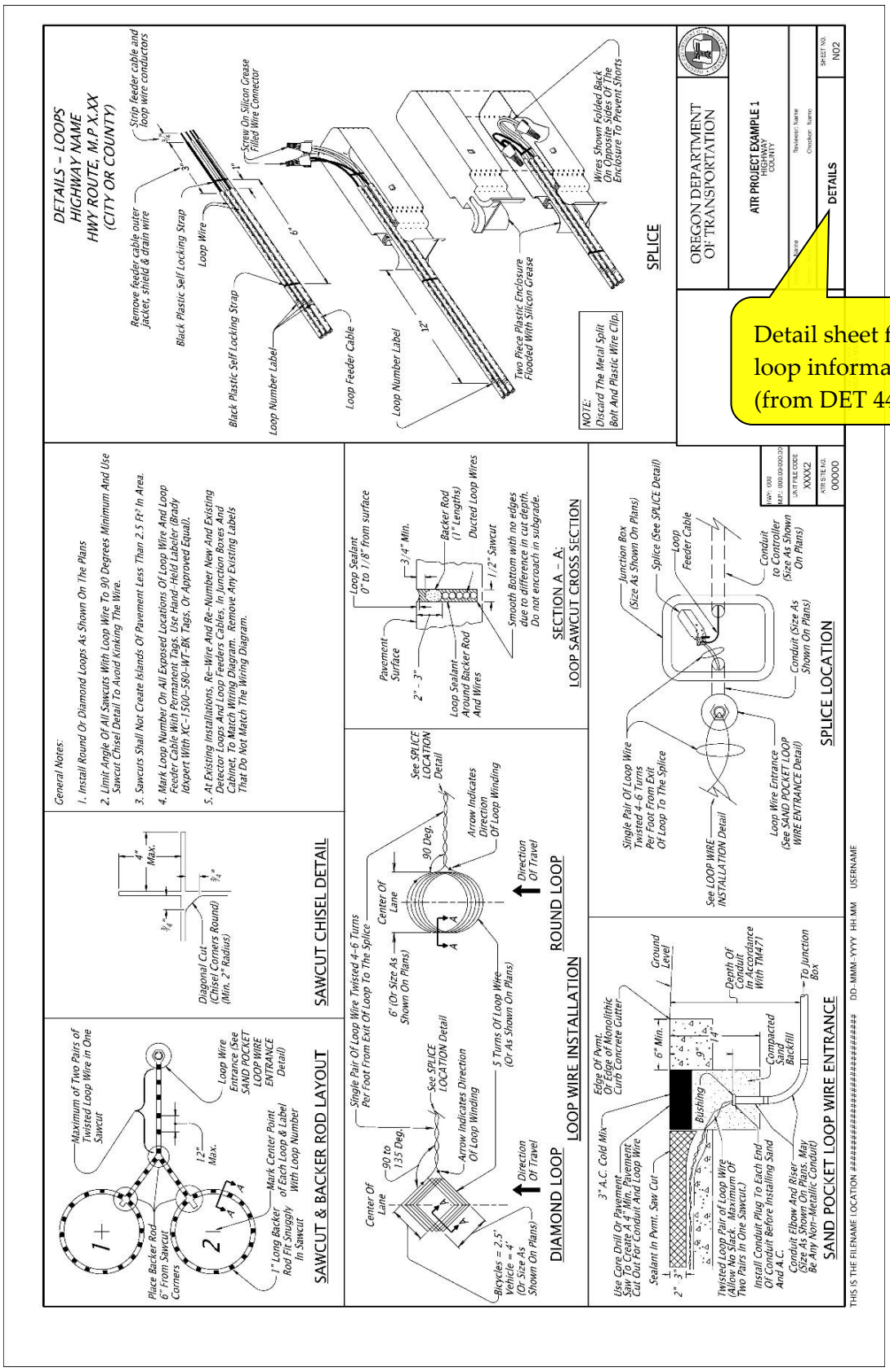


Figure 25-32 | ATR Project Example 1, Sheet N03

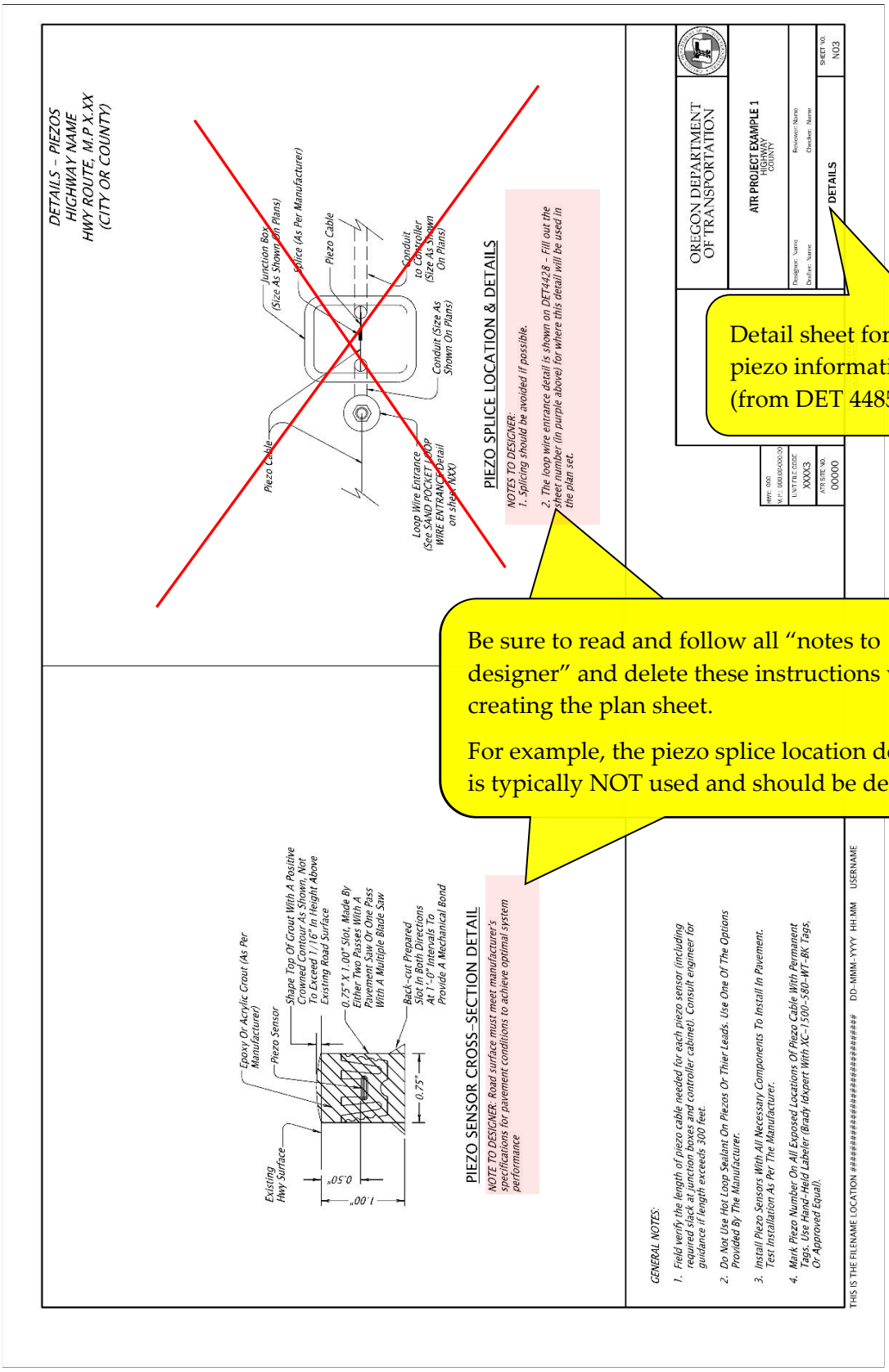


Figure 25-33 | ATR Project Example 2, Sheet NA01

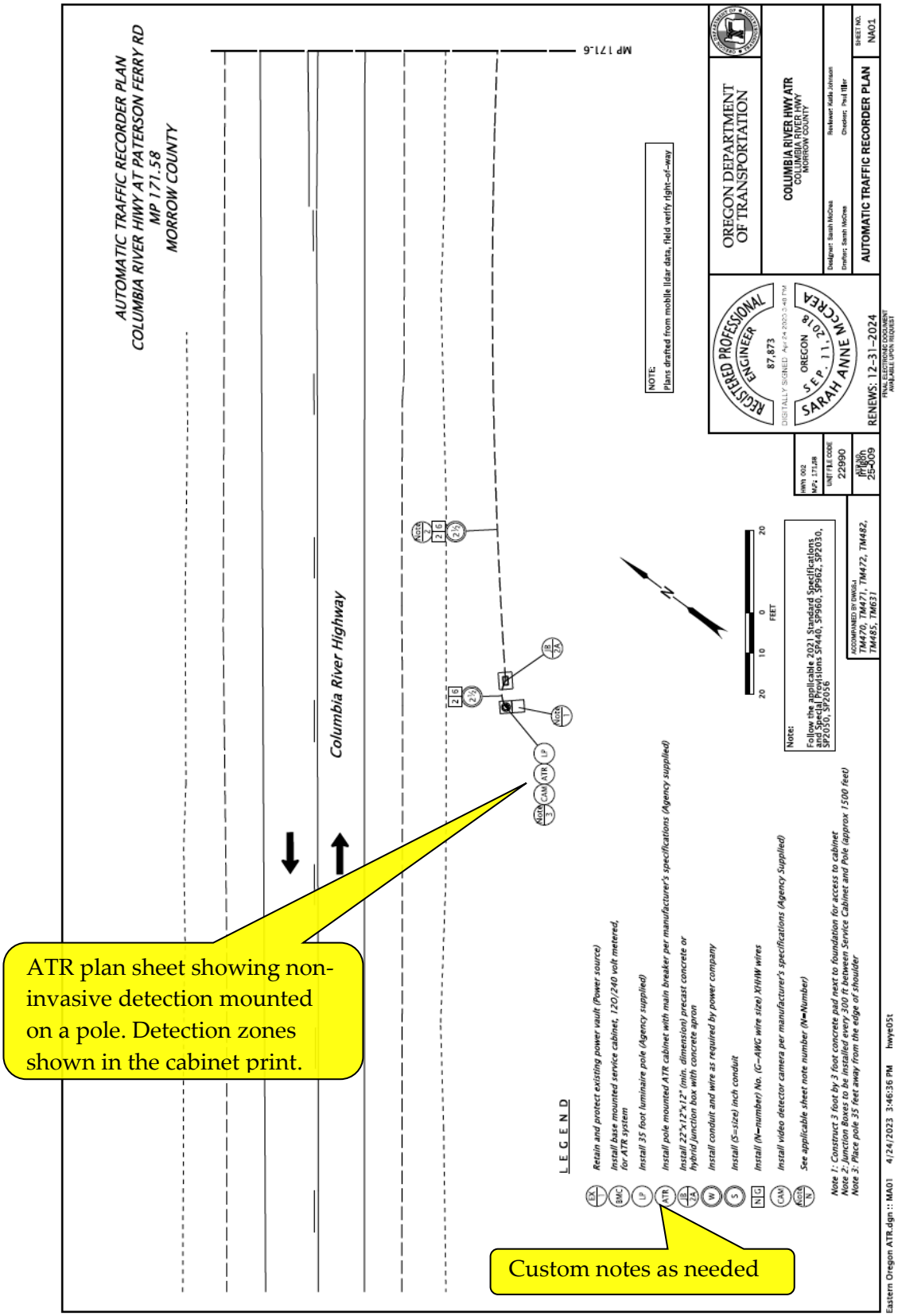
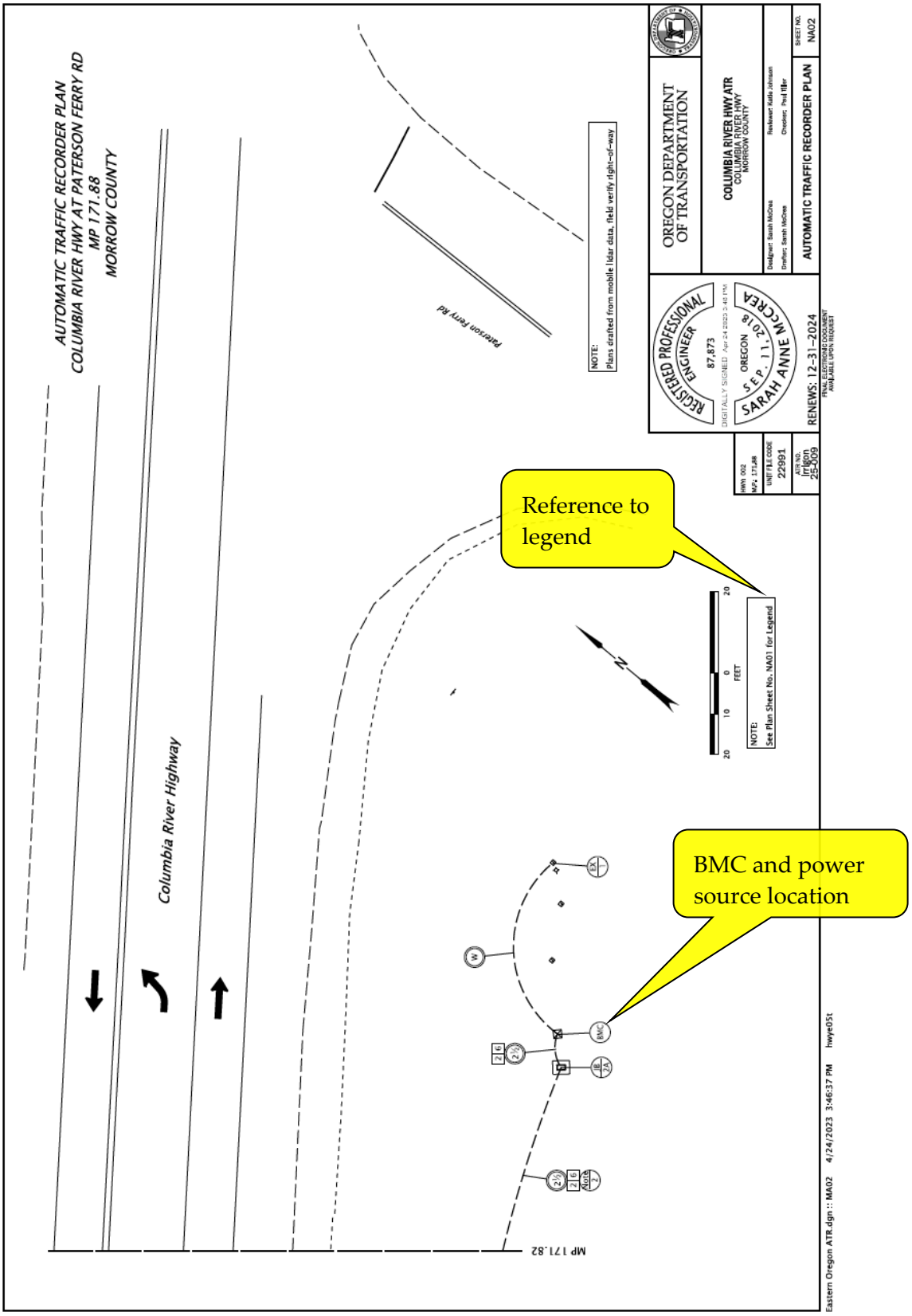


Figure 25-34 | ATR Project Example 2, Sheet NA02



26 Quick Reference

26.1 General

The quick references are comprised of information, tables, and charts that are contained within the manual. They are placed in this chapter without the accompanied explanation text for experienced signal designers to have quick reference to common design standards.

26.2 Basic Wiring Guidelines

An AC positive ("hot" = "+") wire and an AC negative ("Neutral" = "-") wire is required to complete the circuit for each piece of equipment (from the equipment to the power source).

Basic Wiring Guidelines for Individual Conductors **Note: current standard is to use control cables** 120V Wiring shall be sized for a maximum 3% voltage drop			
120 Volt AC	Signal System Neutral: Poles Over 4" in Diameter	One #8 THWN (-)	Used to complete the circuit for indications in vehicle or pedestrian signals mounted on large signal poles.
	Signal System Neutral: Pedestals 4" in Diameter	One #12 THWN (-)	Used to complete the circuit for indications in vehicle or pedestrian signals mounted on pedestals.
	Vehicle Signals	Three #14 THWN (+)	Typically one wire for each indication color: Red, Yellow, & Green. Certain signal head types require a different number wires. (Note: see signal system neutral)
	Pedestrian Signals	Two #14 THWN (+)	One wire for each indication: walk & flashing don't walk. (Note: See signal system neutral)
	Luminaires	Two #10 XHHW* (120V = + & -) (240V = + & +)	From service cabinet to each luminaire (no daisy chaining). Never routed through the controller cabinet.
	Photoelectric Cells	Three #12 THWN* (+ & -)	From the service cabinet, for the luminaire circuit. Never routed through the controller cabinet.
	Part-Time Restriction Signs	Two #12 THWN* (+ & -)	For each sign.
	Power Supply	Two #6 XHHW* (+ & -)	From service cabinet to controller cabinet.
Low Voltage DC	Pedestrian Pushbuttons	One #14 THWN (+)	For each pedestrian phase.
	Pushbutton Common	One #14 THWN (-)	Used to complete the circuit for pedestrian pushbutton.
	Interconnect	One 6 twisted pair cable (n/a)	Unspliced from controller cabinet to controller cabinet. NOTE: no longer used for new installations or maintained for existing installations.

*Common wire is inclusive to wire count.

26.3 Loop Detector Information

Loop Detector Placement		
Location	Posted Speed (MPH)	Detector Spacing (ft.) from stop bar to center of detection
Mainline Note: If mainline has a shared thru-left turn lane, install stop bar detection in the lane at 5' & 15' in addition to the detection shown for mainline based on posted speed.	25	140
	30	180
	35	110/220
	40	160/320
	45	160/320
	50	190/380
	55	225/450
Right Turn Lane (mainline) Note: not applicable to unsignalized slip lanes		140 (115 if lane is short)
Side Street & Left Turns		5/15/75
Interchange Ramps	Low volume &/or low exit speed	5/15/75/150
	High volume &/or high exit speed	5/15/110/220
Bike Lane (mainline)	15	50
Bike Lane (side street)	10	5/50
Mainline Temporary Bridge (one lane/two-way)		5/15/100 & 65 for bypass loop in opposing lane

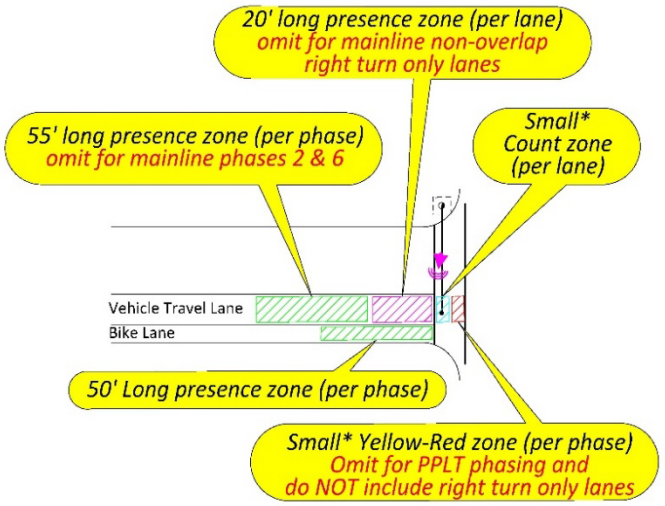
*Note: Regions may have a minimum value that is larger than the statewide minimum standard. Verify with Region Traffic and Region Electrical.

Loop Feeder Cables Allowed in Conduit	
# of Loop Feeders	**Conduit Size***
1-5	1 ½"
6-9	2"
10-13	2 ½"
14-21	3"

Loop Wire Entrance
Sand Pocket

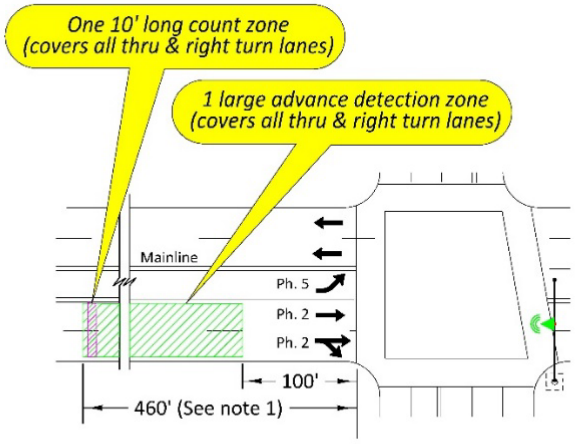
Loop Wires Allowed in Loop Wire Entrance Conduit	
Number of Loops (one loop has 2 loop wires entering the loop wire entrance conduit)	**Loop Wire Entrance Conduit Size**
1-2 Preformed Loops	2"
3-4 Preformed Loops	2 ½"
1-4 Standard Loops	2"
5-8 Standard Loops	2 ½"
Note: If more than 4 preformed loops or more than 8 standard loops need to enter at one location, install multiple loop wire entrances.	

26.4 Non-Invasive Detection Information



*Small zones are typically less than 1 foot long

STANDARD PRESENCE DETECTION (Near-Range Unit)



STANDARD ADVANCE DETECTION (Far-Range Unit)

Notes:

1. Detection that starts 100' from the stop bar and extends a minimum of 460' from the stop bar is acceptable for all posted speeds. However, the standard far-range unit is likely to start detection prior to 100' and is capable of reaching 600'. The alternative far-range unit is capable of reaching 900' if necessary (verify with Region Traffic).

2. If MaxAdapt is used (Verify with Region Traffic), add a Near-Range Unit to provide advance Count Detection Zones as shown below

26.5 Input File Info

26.5.1 Input File for 332S

I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14
Ø 1 C1-56 MT1 MT13 C1-60 Ø 1	Ø 1 C11-16 MT29 MT30 C11-20 Ø 1	Ø 2 C1-39 MT2 MT3 C1-43 Ø 2	Ø 2 C1-63 MT4 MT5 C1-76 Ø 2	Ø 2 C1-47 MT6 MT31 C11-10 Ø 2	Ø 3 C1-58 MT7 MT14 C1-62 Ø 3	Ø 3 C11-18 MT32 MT33 C11-22 Ø 3	Ø 4 C1-41 MT8 MT9 C1-45 Ø 4	Ø 4 C1-65 MT10 MT11 C1-78 Ø 4	Ø 4 C1-49 MT12 MT34 C11-12 Ø 4	SPARE C11-23 C11-25 SPARE	SPARE C11-24 C11-26 SPARE	2 PED C1-67 C1-69 4 PED	6 PED C1-68 C1-70 8 PED
J1	**J2**	**J3**	**J4**	**J5**	**J6**	**J7**	**J8**	**J9**	**J10**	**J11**	**J12**	**J13**	**J14**
Ø 5 C1-55 MT15 MT 27 C1-59 Ø 5	Ø 5 C11-15 MT35 MT36 C11-19 Ø 5	Ø 6 C1-40 MT16 MT17 C1-44 Ø 6	Ø 6 C1-64 MT18 MT19 C1-77 Ø 6	Ø 6 C1-48 MT20 MT37 C11-11 Ø 6	Ø 7 C1-57 MT21 MT28 C1-61 Ø 7	Ø 7 C11-17 MT38 MT39 C11-21 Ø 7	Ø 8 C1-42 MT22 MT23 C1-46 Ø 8	Ø 8 C1-66 MT24 MT25 C1-79 Ø 8	Ø 8 C1-50 MT26 MT40 C11-13 Ø 8	SPARE C1-54 C1-75 GPS	PCOI C1-51 C1-52 VCOI	EVA C1-71 C1-73 EVC	EVB C1-72 C1-74 EVD

INPUT FILE I & J (FRONT VIEW)

(NOT TO SCALE)

DEFAULT STANDARD FOR VIDEO DETECTION EQUIPMENT LAYOUT

		1	2	3	4	5	6	7	8	9	10	11	12
"I" File	Upper	4 I/O: T		VIP: T		2 I/O: T	4 I/O: T		VIP: T		2 I/O: T	V.R.C.M.	
	Lower												
"J" File	Upper	4 I/O: T		VIP: T		2 I/O: T	4 I/O: T		VIP: T		2 I/O: T		
	Lower												

#	*Slot Number*
Equip.	*Video Equipment*

Definitions:
- VIP = Video Image Processor
- 2 I/0 = 2 channel Input/Output Module
- 4 I/0 = 4 channel Input/Output Module
- T = camera

V.R.C.M. = Video Remote Communications Module

26.5.2 Input File for 332

1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1 E,C MT1 C1-56 1 E,C	2 E,C C1-39 MT2 MT3 C1-43 2 E,C	2 E,C C1-63 MT4 MT5 C1-76 2 E	2 C MT6 C1-47 2 C	3 E,C MT7 C1-58 3 E,C	4 E,C C1-41 MT8 MT9 C1-45 4 E,C	4 E,C C1-65 MT10 MT11 C1-78 4 E	4 C MT12 C1-49 4 C	1 E,C C1-60 MT13 MT14 C1-62 3 E,C	—	—	2 Ped C1-67 C1-69 4 Ped	6 Ped C1-68 C1-70 8 Ped	—	Channel 1 Input File "I" Channel 2
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
5 E,C MT15 C1-55 5 E,C	6 E,C C1-40 MT16 MT17 C1-44 6 E,C	6 E,C C1-64 MT18 MT19 C1-77 6 E	6 C MT20 C1-48 6 C	7 E,C MT21 C1-57 7 E,C	8 E,C C1-42 MT22 MT23 C1-46 8 E,C	8 E,C C1-66 MT24 MT25 C1-79 8 E	8 C MT26 C1-50 8 C	5 E,C C1-59 MT27 MT28 C1-61 7 E,C	—	C1-54 C1-75	EVA C1-71 C1-73 EVC	EVB C1-72 C1-74 EVD	—	Channel 1 Input File "J" Channel 2

DEFAULT STANDARD FOR VIDEO DETECTION EQUIPMENT LAYOUT

		1	2	3	4	5	6	7	8	9	10	11
"I" File	Upper	2 I/0: T Ph. 2	VIP: T Ph. 2	Ph. 2	4 I/0: T Ph.5	Ph.5	VIP: T Ph. 4	Ph. 4	4 I/0: T Ph.4	Ph. 7	V.R.C.M.	
	Lower		Ph. 2	Ph. 2			Ph. 4	Ph. 4		Ph. 7		
"J" File	Upper	2 I/0: T Ph. 6	VIP: T Ph. 6	Ph. 6	4 I/0: T Ph.1	Ph.1	VIP: T Ph. 8	Ph. 8	4 I/0: T Ph.8	Ph. 3		
	Lower		Ph. 6	Ph. 6			Ph. 8	Ph. 8		Ph. 3		

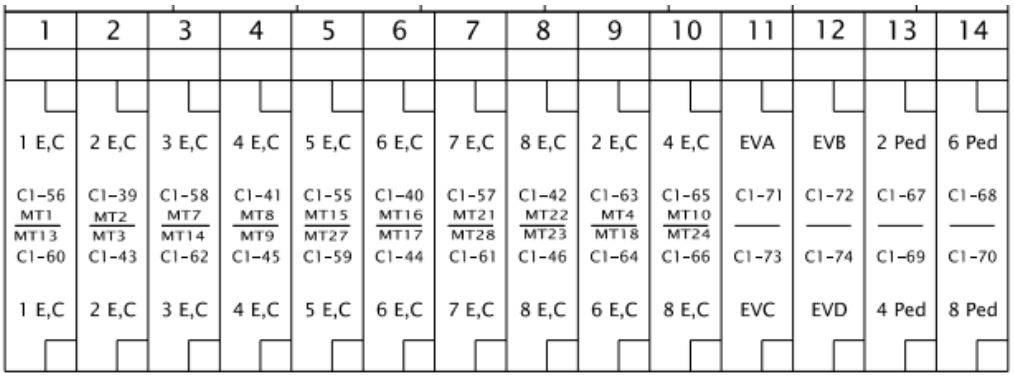
#	*Slot Number*
Equip.	*Video Equipment*
Fn	*Slot Function*

Note: video layout phase assignment is different than the default standard phase assignment shown above.

Definitions:

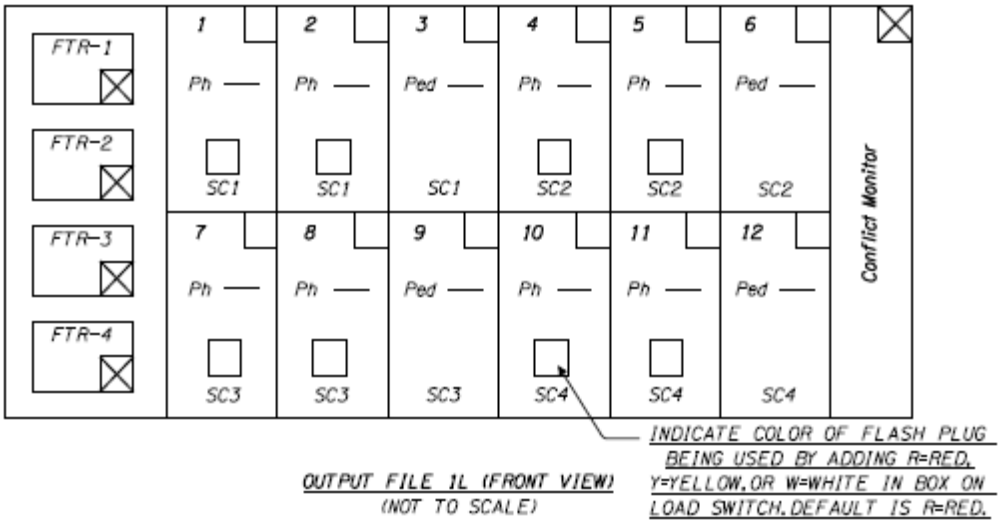
VIP = Video Image Processor
2 I/0 = 2 channel Input/Output Module
4 I/0 = 4 channel Input/Output Module
T = camera
V.R.C.M. = Video Remote Communications Module

26.5.3 Input File for 336

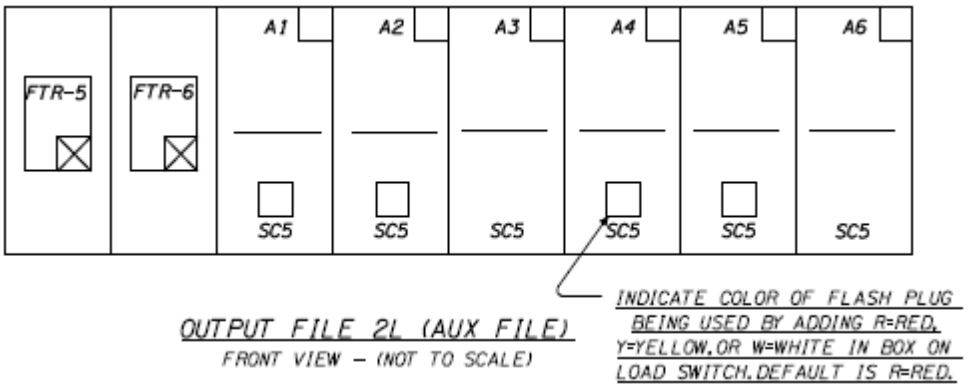


26.6 332S and 332 Cabinet Limitations – Output File

1. 18 switch packs
2. 16 are conflict monitored
    a. Switch packs A3 and A6 are not monitored
    b. 2018 monitor can be used in extreme cases for all 18 switch packs
3. 12 have the ability to cabinet flash via flash plugs
    a. Switch packs 3, 6, 9, 12, A3, and A6 go dark in cabinet flash



OUTPUT FILE 1L (FRONT VIEW)
(NOT TO SCALE)



OUTPUT FILE 2L (AUX FILE)
FRONT VIEW – (NOT TO SCALE)

26.7 332S and 332 Cabinet Limitations – Input File

1. 28 vehicle inputs for a 332 using 9 slots and 2 input files
    a. Slots 10, I11, and 14 have no inputs
        - Slots 1, 4, 5, and 8 have one input per slot (not two)
        - 4 ped
        - 4 EV
        - 2 rail – indirect via 4 C1 pins using a 252 Isolator
        - 0 spares
2. 40 vehicle inputs for a 332S using 10 slots and 2 input files
    a. All 14 slots are populated with C1 and C11 pins
        - 4 ped
        - 4 EV
        - 2 rail – direct via 2 C1 pins using inverting a 255 Isolator
        - 1 GPS
        - 5 spares

332 cabinet

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 E,C C1-56 VD1 1 E,C	2 E,C C1-39 VD9 / VD10 C1-43 2 E,C	2 E,C C1-63 VD11 / VD12 C1-76 2 E	2 C C1-47 VD13 2 C	3 E,C C1-58 VD3 3 E,C	4 E,C C1-41 VD14 / VD15 C1-45 4 E,C	4 E,C C1-65 VD16 / VD17 C1-78 4 E	4 C C1-49 VD18 4 C	1 E,C C1-60 VD2 / VD4 C1-62 3 E,C	—	—	2 Ped C1-67 C1-69 4 Ped	6 Ped C1-68 C1-70 8 Ped	—
1	2	3	4	5	6	7	8	9	10	11	12	13	14
5 E,C C1-55 VD5 5 E,C	6 E,C C1-40 VD19 / VD20 C1-44 6 E,C	6 E,C C1-64 VD21 / VD22 C1-77 6 E	6 C C1-48 VD23 6 C	7 E,C C1-57 VD7 7 E,C	8 E,C C1-42 VD24 / VD25 C1-46 8 E,C	8 E,C C1-66 VD26 / VD27 C1-79 8 E	8 C C1-50 VD28 8 C	5 E,C C1-59 VD6 / VD8 C1-61 7 E,C	—	C1-54 C1-75	EVA C1-71 C1-73 EVC	EVB C1-72 C1-74 EVD	—

332S cabinet

I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14
ϕ1 C1-56 VD1 / VD2 C1-60 ϕ1	ϕ1 C11-16 VD29 / VD30 C11-20 ϕ1	ϕ2 C1-39 VD9 / VD10 C1-43 ϕ2	ϕ2 C1-63 VD11 / VD12 C1-76 ϕ2	ϕ2 C1-47 VD13 / VD31 C11-10 ϕ2	ϕ3 C1-58 VD3 / VD4 C1-62 ϕ3	ϕ3 C11-18 VD32 / VD33 C11-22 ϕ3	ϕ4 C1-41 VD14 / VD15 C1-45 ϕ4	ϕ4 C1-65 VD16 / VD17 C1-78 ϕ4	ϕ4 C1-49 VD18 / VD34 C11-12 ϕ4	SPARE C11-23 C11-25 SPARE	SPARE C11-24 C11-26 SPARE	2 PED C1-67 C1-69 4 PED	6 PED C1-68 C1-70 8 PED
J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14
ϕ5 C1-55 VD5 / VD6 C1-59 ϕ5	ϕ5 C11-15 VD35 / VD36 C11-19 ϕ5	ϕ6 C1-40 VD19 / VD20 C1-44 ϕ6	ϕ6 C1-64 VD21 / VD22 C1-77 ϕ6	ϕ6 C1-48 VD23 / VD37 C11-11 ϕ6	ϕ7 C1-57 VD7 / VD8 C1-61 ϕ7	ϕ7 C11-17 VD38 / VD39 C11-21 ϕ7	ϕ8 C1-42 VD24 / VD25 C1-46 ϕ8	ϕ8 C1-66 VD26 / VD27 C1-79 ϕ8	ϕ8 C1-50 VD28 / VD40 C11-13 ϕ8	SPARE C1-54 C1-75 GPS	PCOI C1-51 C1-52 VCOI	EVA C1-71 C1-73 EVC	EVB C1-72 C1-74 EVD

INPUT FILE I & J (FRONT VIEW)

26.8 332S and 332 Cabinet Limitations – Conflict Monitor

1. 16 channels with 32 outputs of conflict monitoring (green & yellow)
    a. Monitor all green, flashing yellow arrow, and walk indications
    b. Do not monitor solid yellows (exception: solid yellow cannot be separated from the flashing yellow arrow when using a center flash signal head and therefore will be monitored)
2. Flashing yellow arrow
    a. Use the overlap green outputs
    Example
        - 3 section FYA signal head on Phase 1 (center flash)
            - Use R & G outputs on switch pack 1 (phase 1)
                - Monitor G on channel 1
            - Use G output on switch pack A1 (OLA) for FYA and solid YA
                - Monitor FYA/YA on channel 9

CONFLICT MONITOR – TYPICAL CONNECTOR PIN ASSIGNMENTS

Term	Function	Pin
130	SP2–G	1
115	SP3–W	2
135	SP8–Y	3
103	SP5–G	4
106	SP6–W	5
108	SP–11Y	6
133	SP7–G	7
114	SP3–Y	8
126	SP1–Y	9
124	SP10–G	10
105	SP6–Y	11
117	SP4–Y	12
A123	ASP1–G	13
–	NC	14
–	T&B	15
–	T&B	16
–	NC	17
–	T&B	18
–	NC	19
TB01–9	EQ Gnd	20
TB01–10	AC–	21
C4–37	Watch Dog	22
TB02–1	+24VDC	23
LRCoIL	Interlock	24
TB02–2	Interlock	25
–	NC	26
–	NC	27
TB01–11	Norm. Closed	28

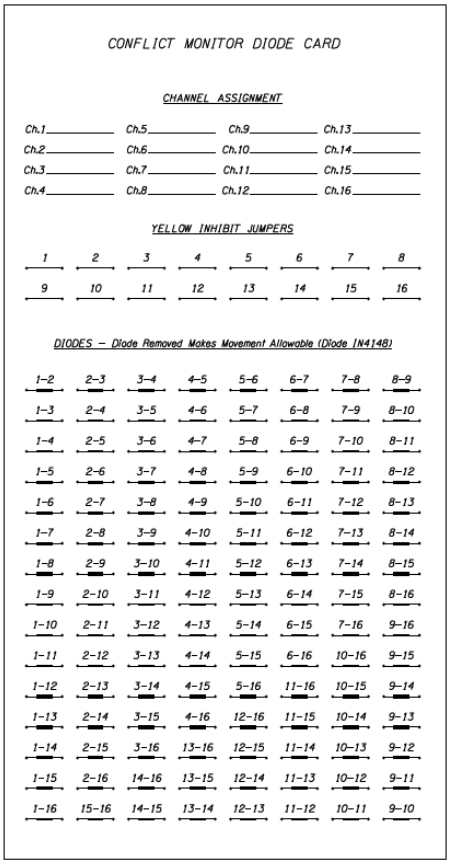
CHANNEL ASSIGNMENTS (TYPICAL)

Ch	PH
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	OLA, Ø1FYA/YA
10	OLB, Ø3FYA/YA
11	OLC, Ø5FYA/YA
12	OLD, Ø7FYA/YA
13	2PED
14	4PED
15	6PED
16	8PED

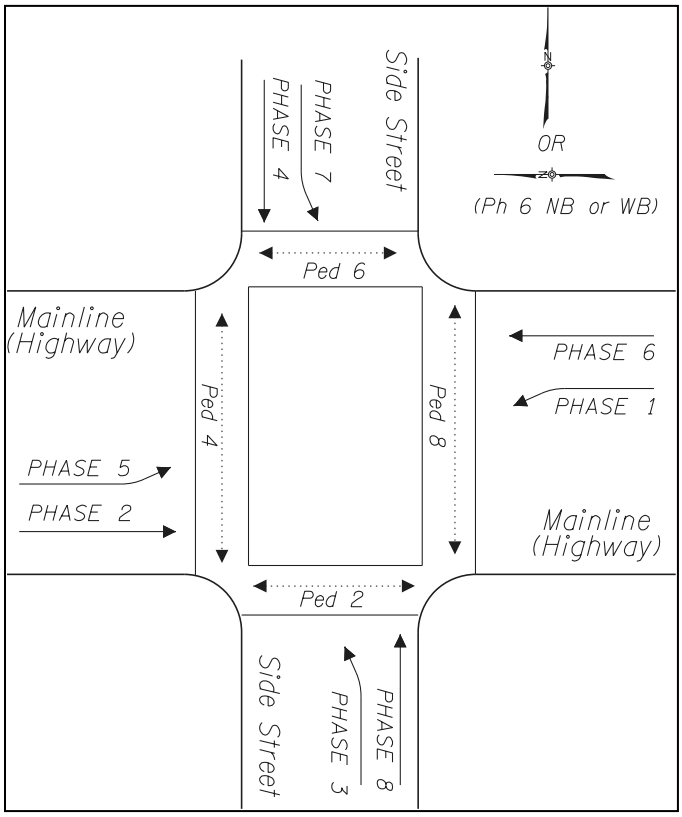
T&B= Tied & Bundled

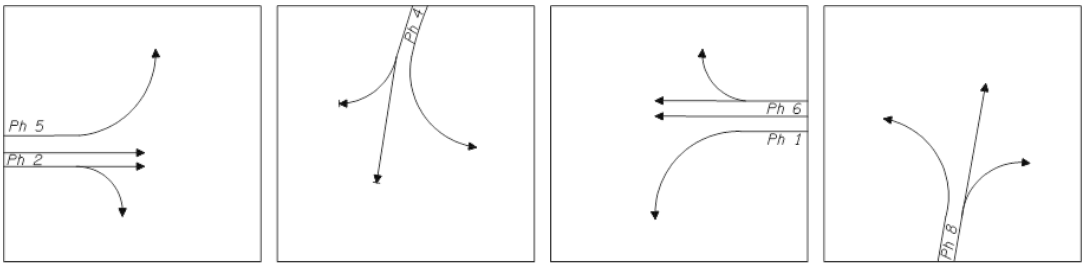
Pin	Function	Term
A	SP2–Y	129
B	SP8–G	136
C	SP9–W	121
D	SP5–Y	102
E	SP11–G	109
F	SP12–W	112
H	SP7–Y	132
J	SP1–G	127
K	SP9–Y	120
L	SP10–Y	123
M	SP4–G	118
N	SP12–Y	111
P	NC	–
R	ASP2–G	A126
S	ASP4–G	A116
T	NC	–
U	T&B	–
V	ASP5–G	A103
W	NC	–
X	NC	–
Y	DC Gnd	TB02–2
Z	Ext. Reset	TB02–5
AA	T&B	–
BB	Stop Time	TB02–3
CC	NC	–
DD	NC	–
EE	Clapper	TB01–12
FF	AC+	TB01–11

CONFLICT MONITOR



26.9 Phasing Standards





FIRE PREEMPTION OPERATION

26.10 Signal Pole & Signal Head Information

Signal Head Placement/Spacing Dimensions	
From the stop line to signal face	45′ minimum
From the stop line to signal face	180′ or greater requires a near-side head
Spacing of heads for the same phase	8′ minimum, 10′ desirable
Spacing of heads to adjacent phase	6′-12′ desirable
Spacing of heads (except Type 4L head) to adjacent sign	3′ minimum
Spacing of Type 4L head to adjacent sign	4′ minimum

Signal Pole Placement
18″ minimum from face of curb to any equipment mounted on pole.
5′ recommended minimum from face of curb
6′ recommended minimum from EP
5′ recommended minimum clearance on all sides of a raised island

Mast Arms		
Mast Arm Length	**Std. Dwg. TM650**	
	Pole Type	**Pole Type W/Illum.**
15′	SM1	SM1L
20′	SM2	SM2L
25′	SM2	SM2L
30′	SM3	SM3L
35′	SM3	SM3L
40′	SM4	SM4L
45′	SM4	SM4L
50′	SM5	SM5L
55′	SM5	SM5L
	Std. Dwg. TM655	
60′	N/A	SM6L
65′	N/A	SM6L
70′	N/A	SM7L
75′	N/A	SM7L

26.11 Sign Information

SIGN NUMBERS & SIZE (signs beginning with an "O" are Oregon specific)	SIGN TYPES: Aluminum	SIGN TYPES: Part Time Restriction	RECOMMENDED OR REQUIRED
R6-2L 30"x36"	AL 1L		Required for one-way streets. One way signs can be installed on the mast arm (R6-2L) OR ground mounted (R6-1L). See MUTCD 2B.40(P10)
R6-2R 30"x36"	AL 1R		Required for one-way streets. One way signs can be installed on the mast arm (R6-2R) OR ground mounted (R6-1R). See MUTCD 2B.40(P10)
R10-11A 30"x36"	AL 3		Region Traffic Engineer Operational Approval Required
OR3-12 30"x36"	AL 3U		StateTraffic-Roadway Engineer Operational Approval Required
R5-2 30"x30"	AL 3T		StateTraffic-Roadway Engineer Operational Approval Required (typically used in conjuction with U-turn permitted sign)
OR3-5TD 30"x36"	AL 4		
R3-6L 30"x36"	AL 4L		
R3-6R 30"x36"	AL 4R		
OR3-5TT 30"x36"	AL 4T		
R3-5L 30"x36"	AL 5L		Required for a trap lane (where a through lane becomes a mandatory turn lane at the intersection) if the trap lane does not have a signal head with arrow indications
R3-5R 30"x36"	AL 5R		Required for a trap lane (where a through lane becomes a mandatory turn lane at the intersection) if the trap lane does not have a signal head with arrow indications
R3-5A 30"x36"	AL 5T		
R3-3 36"x36"	AL 6		Use of appropriate lane use signs is preferred over R3-3
R3-2 36"x36"	AL 6L	PR 6L	Use of appropriate lane use signs is preferred over R3-2. PTR version used for RxR applications
R3-1 36"x36"	AL 6R	PR 6R	Use of appropriate lane use signs is preferred over R3-1. PTR version used for RxR applications
R5-1 36"x36"	AL 7		
R10-28 24"x30"	AL 8		For overhead mounting
OR20-1 24"x12"	AL 8s		
R10-6 24"x36"	AL 9		
R10-12 30"x36"	AL 11		Required with aType 4L signal head. Recommended when a permissive left turn phase has an exclusive left turn lane or a Type 7 signal is used. Optional otherwise.
R10-15a 30"x30"	AL 12		Required with aType 5 signal head
W3-8 36"x36"	AL 16		
OR20-5 24"x30"	AL 17		
W3-4 36"x36"	AL 18		
W16-13p 24"x18"	AL 19		
R3-7a 24"x12"	AL 20		

SIGNS NO LONGER USED

OR10-10L 30"x36"	"LEFT TURN SIGNAL" sign
OR10-10R 30"x36"	"RIGHT TURN SIGNAL" sign
OR17-1 30"x36"	"LEFT TURN YIELD TO ONCOMING TRAFFIC" sign replaced by R10-12
OR22-14 30"x36"	"RIGHT TURN YIELD TO PEDS ON GREEN ball symbol" sign replaced by OR10-15

26.12 Junction Box & Conduit Information

Minimum Junction Box Type/Size	
Type/Size	**Location/use**
JB-3T: Two (Tandem) 30″x17″x12″ boxes	The same quadrant as the signal controller: first access point for all signal, detector, and interconnect circuits.
JB-2: Single 22″x12″x12″ box	All quadrants without the signal controller: secondary access point for signal, detector, and/or interconnect circuits
JB-1: Single 17″x10″x12″ box	All approach legs: detector and/or interconnect circuits

Type	Size	Total Conduit Diameters Allowed (Inches)	Remarks	Material
JB-1	17″x10″x12″	12	Non-traffic areas only	Concrete
JB-2	22″x12″x12″	18	Non-traffic areas only	Concrete
JB-3	30″x17″x12″	34	Non-traffic areas only	Concrete

Junction Box Spacing
300′ maximum spacing. Check with the region electrical crew for the preferred spacing.

Conduit Requirements*	
Conduit crossing mainline or side street	2″ minimum
Spare conduit from large signal pole to nearest junction box (if alternative detection is NOT used on project)	2″
Spare conduit from controller cabinet to nearest junction box	2″
Minimum conduit size allowed	1 ½″
Maximum conduit size allowed	3″
Max wire fill for new conduits	70% of NEC maximum
Max wire fill for existing conduits	100% of NEC maximum

*Note: Regions may have a minimum value that is larger than the statewide minimum standard. Verify with region traffic and region electrical crew.

26.13 Electrical Crew Preferences

The electrical crew that will be maintaining the signal (ODOT or local agency) shall have a chance to review and comment on signal plans during the design phase. Send plan sheets directly to the electrical crew lead/manager or ensure that they are included on the plan distribution list for project milestone reviews. Use the following checklist as a guide for verifying the electrical crew preferences.

	Electrical Crew Design Preferences to Verify	Section in Manual for More Information
1	Any existing equipment that should be removed and/or replaced	4.2
2	Equipment to salvage and location to stockpile	4.2, 10.2, & 19.4
3	Equipment that may be removed and relocated	4.2 & 10.5
4	Need for a maintenance pad	5.1.7
5	Vehicle and pedestrian signal material (aluminum or polycarbonate)	5.2.2 & 5.4.13
6	Utility clearances below ODOT default standard, but still meeting NESC requirements	5.5.4
7	Illumination mounting height, LED fixture, and fixture wattage	5.6 & 5.6.1
8	Need for battery back-up	5.9
9	Controller cabinet location	5.10.1
10	Junction box location and preferred spacing of junction boxes	5.12.2
11	Feasibility of reusing any existing wiring, splicing new conduit to existing conduit, or adjustments of existing junction boxes	5.12.4 & 5.13.5
12	Feasibility of adding new wire to existing conduit (conduit condition and wire fill)	5.13.1
13	Need for conduit sizes above the ODOT default standard	5.13.1
14	Need for any unique site specific bonding/grounding	5.14.4
15	Radar cable splice preference when there is no RTC on pole	6.8
16	Terminal cabinet orientation (when it cannot be placed at the default standard 180 degrees)	9.3.2
17	Flashing beacon power source of commercial or solar	12.4
18	Maintenance access to ramp meter detector units	13.6.1

26.14 Salvage Cost Estimate Equations (LPIF)

Salvage Cost Estimate Equations For each savaged item, calculate and use the highest value of the 2 equations		
Depreciated Value Based on Service Life	Salvage Cost Estimate 1	$= \frac{\text{Service Life}^{(a)} - \text{Item Age}^{(b)}}{\text{Service Life}^{(a)}} \times \text{Cost of New Item}^{(c)} \times \text{Depreciation Factor}^{(d)}$
Scrap Value Based on Material Recycling	Salvage Cost Estimate 2[(e)]	$= \text{Quantity of item}^{(f)} \times \text{Scrap Cost Per Quantity}^{(g)}$

a: Use the following values (Contact the state traffic engineer for service life information of other items):
- * 50 yrs for a large pole or steel structure
- * 10 yrs for a controller cabinet
- * 5 yrs for radar
- * 3 yrs for video detection

If the item age is greater than or equal to the service life, equation 1= $0

b: Use as-built plans or maintenance history to determine the item age

c: Use recent project cost data or signal cost estimating tools to determine the cost of a new item

d: Use the following depreciation factors:
- * 0.03 for 1st generation standard (e.g. truss arm, custom cabinet, radar/video model no longer sold, etc.)
- * 0.05 for 2nd generation standard (e.g., curved mast arm, 336 cabinet, etc.)
- * 0.10 for 3rd generation standard (e.g., 4-bolt base pole, 332 cabinet, etc.)
- * 0.30 for current standard (e.g. 8-bolt base pole, 332S cabinet, etc.)

e: Equation 2 is typically applicable for large poles (steel scrap value). All other traffic signal items that are commonly salvaged are of a material type or quantity that is not economical to seek scrap value.

f: Use industry standard for recycling material (e.g. pounds of steel)

g: Use recent industry data

26.15 Final Design/Drafting Checklist

Before submitting plans for design review/approval (see chapter 2), use the following checklist.

		Signal Design/Drafting Checklist	For Information See:
APPROVALS			
	1	RTE/STE Operational approval(s) complete & plans match PSOD (phasing, crosswalk closures, fire preemption, etc.)	Section 3.1 and 5.7
	2	Loop detection is approved by the state traffic signal engineer and correctly detailed	Section 6.1.1
	3	LPIF documentation complete	Section 19.4
COORDINATION WITH OTHERS			
	4	Coordination with ITS unit on interconnect/communication plan is complete	Chapter 7
	5	Coordination with workzone designer is complete (temporary features, stagging a signal turn-on to avoid obstructing the view of existing signal indications, etc.)	Chapter 11
	6	Coordination with sign designer is complete (custom signs, determining bid items)	Section 5.3 & 5.3.2
	7	Coordination with geotech designer is complete (pole foundations)	Section 9.3.4
	8	Coordination with roadway designer and striping designer is complete (ADA ramps, turning templates, accesses, lane shifts, raised medians, stop bars, crosswalks, crosswalk closures, walkways for controller cabinet and BMCL as per TM482, etc.)	Section 5.1, 5.4, & 5.10.1
	9	Coordination with illumination designer is complete	Section 5.6
	10	Coordination with region utility specialist and utility is complete	Section 5.5.4
	11	Coordination with region mobility liaison is complete (overhead vertical clearance)	Section 5.5.2
	12	Coordination with region electrical crew maintaining the installation is complete	Section 2.9
	13	Coordination with region signal timer is complete (detection zone needs)	Chapter 6 & Chapter 20
BASIC DRAFTING – LAYOUT AND INFORMATION			
	14	M series plan sheets in correct order	Section 21.7.2
	15	All sheets are clear and easy to read (no inappropriate overlapping of features/bubble notes, unnecessary layers turned off, clutter minimized, etc.)	Chapter 21.2
	16	All sheets meet basic drafting layout and info requirements (sheet scale, upper right title info, sheet title, north arrow, stationing/scale bar, lane use arrows, street names, striping, right-of-way, etc.)	Multiple subsections in Section 21.7
	17	Current, standard symbology and bubble notes as per MicroStation workflow are used. Customization is limited to only what is necessary	Sections 21.4, 21.8.1, & 21.9
	18	All bubble note variables have been filled out correctly on the plan sheets	Section 21.9.1
	19	Reference bubble notes (EC, DC, IC, JB/SP, JB/DP, JB/IP, C, etc.) and cross reference text (see sheet MXX for legend) are used when necessary	Sections 21.3, 21.7.13 & 21.9.4
	20	All title block information is complete	Section 21.7.3
	21	List of applicable standard drawings is complete ("accompanied by dwgs. box")	Section 21.7.5
	22	All digital signature blocks for EOR and traffic engineering section approval are complete	Section 21.7.4
	23	Specifications, bid items, and cost estimate complete	Chapter 19
PLAN SHEET AND DESIGN ELEMENT SPECIFIC DRAFTING			
	24	Statewide goals, priority and implementation have been incorporated into project	Section 4.1.2
	25	All bubble notes used in the plan sheets are listed in the legend	Section 21.10.1
	26	All Phase rotation diagrams and fire preemption diagrams complete	Sections 3.3 & 3.4
	27	All poles and pedestals numbered	Section 21.8.3
	28	All illumination equipment location and detailing correct	Section 5.6
	29	All signal head type, phase, location, and detailing correct	Sections 5.2, 21.9.1 & 21.9.2
	30	All pedestrian signal heads and pushbutton location, phase and detailing correct	Section 5.4*
	31	All sign size, message, location, and detailing correct	Section 5.3
	32	All fire preemption equipment location and detailing correct	Section 5.7
	33	All non-invasive detection equipment location, type, mount and detailing is correct	Chapter 6
	34	Pole entrance chart complete	Section 21.10.8 & Chapter 9
	35	All service cabinet locations and detailing correct	Sections 5.8 & 5.11
	36	All controller cabinet location, orientation, and detailing correct	Section 5.10
	37	All Cabinet prints are complete (detection zones shown, etc.)	Chapter 20
	38	All Junction box location, size and detailing correct	Section 5.12*
	39	All Conduit routing, size, future/spare, and detailing is correct	Sections 5.13* & 21.8.2
	40	All wire/cable number, type, gauge and detailing is correct for ALL equipment	Section 5.14*
	41	Existing utility plan sheet complete	Section 21.10.7
	42	Railroad preemption plan sheet complete	Section 21.10.6 & Chapter 16
	43	All standard details necessary for project are incorporated into a DETAIL sheet	Section 9.5

*Also see application specific sections of the manual such as fire preemption, railroad, PTR signs, RRFB, etc.