City of Portland Bureau of Transportation –
Signals, Street Lighting & ITS Division

Traffic Signal Design Guide

Supplemented by the ODOT Traffic Signal Design Manual

Version 1

January 2017

PBOT
PORTLAND BUREAU OF TRANSPORTATION

Traffic Signal Design Guide

Supplemented by the ODOT Traffic Signal Design Manual

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1 INTRODUCTION

The Traffic Signal and Street Lighting Design Guide contains materials to be supplemented by the ODOT *Traffic Signal Design Manual* and is generally organized with the same chapter numbers and headings for easy cross-referencing.

The material contained herein is for informational purposes and may be used to aid new designers and those unfamiliar with the City of Portland Bureau of Transportation (PBOT) practices regarding City of Portland traffic signals and street lighting at signalized intersections. It also provides guidance on plan presentation and content in order to maintain consistency in design. The intended user of this document is the City or consultant design engineer (referred to as the "designer" in this document), or the PBOT Signals and Street Lighting Division Engineer responsible for reviewing design plans (referred to as the "reviewer" or SSL Division Engineer in this document).

This Guide is intended to be used as a guidance document and is not a standard. As such, much of the information contained and referenced herein is PBOT's typical practice based on guidance and standards contained in the following:

- *Manual on Uniform Traffic Control Devices* (MUTCD) and the Oregon Supplements to the MUTCD,
- National Association of City Transportation Officials (NACTO):
    - *Urban Street Design Guide*
    - *Urban Bikeway Design Guide*
- *Americans with Disabilities Act* (ADA), United States Access Board – ADA Draft Recommendations
- *National Electrical Code* (NEC)
- *National Electric Safety Code* (NESC)
- City of Portland *Standard Construction Specifications*
- City of Portland Standard Drawings and Details

1.1 PBOT TRAFFIC SIGNALS, STREET LIGHTING & ITS DIVISION

PBOT Traffic Signals, Street Lighting & ITS Division (SSL) is responsible for developing and maintaining standards, specifications, and best practices relating to the City's traffic signal, street lighting, and intelligent transportation systems. Additionally, the Division is responsible for maintaining the City's existing infrastructure, overseeing the construction of new infrastructure, and serving as a review body for development-driven construction activities (permit projects). A map of areas covered by District Engineers and their contact information can be found here and key contacts are provided below:

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1.2 AVAILABILITY

This manual can be accessed and printed in its entirety from the PBOT web site.

1.3 UPDATES

Traffic signal, street lighting, and ITS standards change as technology changes and the City strives to improve its practices over time. This manual provides PBOT's current practices for design at the time of publishing; therefore, some information contained herein may not be current if a project is initiated after the date of publication. It is important to contact the assigned PBOT SSL Division Engineer as early as possible in the design process to ensure that the design considers any updates not yet incorporated into this guide.

1.4 SPECIFICATIONS AND DETAILS

The current versions of the City of Portland *Standard Construction Specifications*, Special Provisions, Standard Drawings, and *Electrical Equipment and Materials List* shall supersede information contained in this document. The information can be found online at the following web links:

1.4.1 *Standard Construction Specifications*

http://www.portlandoregon.gov/transportation/article/312962

1.4.2 *Special Provisions*

http://www.portlandoregon.gov/transportation/53295

1.4.3 *Unique Special Provisions*

http://www.portlandoregon.gov/transportation/article/175875

1.4.4 *Standard Drawings & Details*

http://www.portlandoregon.gov/transportation/50383

1.4.5 *Electrical Equipment and Materials List*

http://www.portlandoregon.gov/transportation/article/574320

1.4.6 *Controller Equipment List*

http://www.portlandoregon.gov/transportation/article/493812

1.5 PLAN REQUIREMENTS AND DRAFTING STANDARDS

While this guide focuses on design elements of traffic signals and street lighting at traffic signals, the requirements for sheets and items to include in plan sets are included in Appendix A. PBOT maintains CADD Cell libraries for plan design, which include standard signal and street lighting symbols, details, CADD annotation bubbles, and standard signal and street lighting legend text. Contact the SSL Division Engineer for information on obtaining the CADD Cell libraries.

Appendix B includes commonly used signal equipment symbols, as well as the signal legend code for annotating plan sheets.

2 DESIGN APPROVAL PROCESS

See Chapter 2 of the ODOT *Traffic Signal Design Manual* for general guidance on the design approval process for traffic signals at ODOT-owned intersections within the City of Portland. The design approval process for signals at City-owned intersections is detailed in the following sections.

2.1.1 *Permit Projects*

For permit projects (i.e. project initiated by a party other than PBOT), design approval will go through the Bureau of Development Services (BDS) and then routed to the appropriate SSL Division Engineer at the City for coordination and review. The designer should work closely with the SSL Division Engineer to define the scope of improvements, requirements of the project, and plan requirements. Check lists for early assistance/inquiry on signal and street lighting projects are provided in Appendix C.

For all permit projects, the SSL Division Engineer will provide the 30% (Concept)/60% (Design)/90% (Final)/100% (Vellum) design checklists for traffic signals and/or street lighting, filled out with specific requirements of the project, after the appropriate permits are filed by the developer/landowner. These check lists are provided in Appendix D. The designer should submit these completed checklists (with signature) with each BDS design submittal.

The permit number should be included on all plans in the title block.

2.1.2 *City-led Projects*

For City-led or administered projects, the designer should work closely with the appropriate SSL Division Engineer to understand the scope of improvements, requirements of the project, and plan requirements.

The typical design process for City-led projects follows the same 30% (Concept)/60% (Design)/90% (Final)/100% (Vellum) design and review phases required for permit projects. The design check-lists in Appendix D should be followed on City-led projects as well to ensure a complete and consistent design.

2.1.3 *Design Review Phases*

The following provides a general overview of the various design stages and the intent and outcomes of each stage. These apply to both permit projects and City-led projects described above.

30% (Concept Development):

The objective of the 30% design phase is to confirm the general design concept and scope, set major equipment locations (poles, controllers, panels), and identify any significant conflicts. For signal plans, the general signal operations and phasing should be identified, pole types and locations set, and controller cabinet location identified. For street lighting plans, light pole locations should be set. Any required photometric analysis should be performed during this stage to inform pole locations.

60% (Design Development):

Most of the detailed design work is performed during the 60% design phase, since the general design concept has already been confirmed. Along with detailing the plans with all equipment, wiring, controllers, etc., the pole foundation types should be confirmed, and coordination with the electric utility companies should take place to determine the power source.

For traffic signals, plans are detailed and labeled with equipment, wiring, and pole and mast arm details. Detection is detailed, and the signal wiring diagram is provided at 60%.

For street lighting, conflicts between trees and street lights should be identified and resolved, and all poles, equipment and wiring should be detailed on the plans. Additionally, voltage drop calculations should be performed by the designer and provided to PBOT for review. Service panel schematics and circuit diagrams should be provided in the plans at 60%.

90% (Final Plans):

The objective of the 90% design and review phase is to address all comments received at 30% and 60%, develop any special details, and develop draft Special Provisions for review. The Standard Drawings used in the design should also be identified and provided with the plan sets.

100% (Vellums):

All remaining comments from the previous stages are addressed during the 100% plans phase, and signed Vellum plans are submitted for Final Plan Approval (see Section 2.1.4 below). Special Provisions are finalized and signed by the Engineer of Record. Electronic copies of the design plans are also provided to PBOT for records and documentation of the project.

2.1.4 *Final Plan Approval*

The plans must be reviewed, approved, and signed by the Division Manager and the City Engineer. The designer should coordinate with both the SSL Division Engineer and the Division Manager as early as practical for feedback on the overall scope of improvements, to avoid late changes in the design or scope of improvements.

2.1.5 *As-Built Drawings*

The engineer of record is responsible for providing electronic CADD (.DGN files) as-built drawings to the PBOT SSL Division upon completion of construction. Drawings must show a complete representation of all equipment in the field for the signalized intersection/location. This includes the equipment installed as part of the project and the existing equipment that is part of the traffic signal. For example, if work was only done on one corner of an intersection, the as-built must show and call out the existing equipment, conduit, wiring, etc. for the rest of the intersection. Existing equipment information will be provided by PBOT SSL staff.

3 SIGNAL OPERATIONS AND OPERATIONAL APPROVAL

See Chapter 3 of the ODOT *Traffic Signal Design Manual* for general guidance on signal operations and operational approval. Not all information will be applicable to all PBOT projects. For example, projects on ODOT facilities within the City of Portland need to follow ODOT approval procedures. The designer should contact the SSL Division Engineer early in the design process to determine which procedures will be required.

Preliminary design information shall be approved by the SSL Division Engineer. Failure to obtain approval or have plans that do not correspond to this approval may result in significant project delay and/or needless redesign work. Preliminary design information should address the following concerns:

- Number of Lanes and Lane Use
- Phase Diagram and Rotation
- Pedestrian and Bicycle Movements
- Emergency Pre-emption
- Railroad Pre-emption
- Transit Priority
- Cross-Walk Closures
- Other Unique Requirements
- Future Expansion/Changes

4 STARTING THE DESIGN

See Chapter 4 of the ODOT *Traffic Signal Design Manual* for guidance on establishing design parameters, the information needed for design, and general design work-flow. Not all information will be applicable to all PBOT projects. For example, projects on ODOT facilities may need to follow ODOT standards. The designer should contact the SSL Division Engineer early in the design process to determine which standards will be required.

This section in ODOT's manual contains a lot of useful information and many excellent tips on how to start the design of a traffic signal or street lighting system, what information to gather at the start of design, and how to set up a design project file; therefore, the designer is well advised to review this section of ODOT's manual. Field visits are particularly useful. The designer should make at least one field visit and take many photos to reference throughout the design process. Additionally, the designer should consider overhead and underground utilities and clearance requirements. Clearance requirements to overhead utilities lines can be especially problematic when designing for traffic signal poles and street light poles.

5 SIGNAL DESIGN

This chapter discusses the design elements that are shown on a signal plan sheet. See Chapter 5 of the ODOT *Traffic Signal Design Manual* for detailed information on signal design. This chapter covers information specific to the City of Portland that differs from ODOT design practice.

5.1 ROADWAY DESIGN

The City of Portland *Pedestrian Design Guide* provides guidance on sidewalk corridors and the allocation of space for various functions (street furnishings, pedestrian through zone, etc). The *Pedestrian Design Guide* should be consulted when developing sidewalk and ramp/crosswalk facilities. In general, all signal and street lighting equipment should be placed in the furnishing zone, and outside the through pedestrian zone in each direction at intersection corners. Exceptions to the guideline apply in relation to the location of signal poles and pedestrian pushbuttons near ADA ramps. (See page A-7 in U.S. Access Board Draft Recommendations.)

The signal designer should work closely with the roadway designer in placing signal equipment. The proposed roadway design should be shown on the signal plans. Some elements that need to be coordinated between disciplines are the following:

- Pedestrian ramps and pushbutton locations to meet ADA.
- Pedestrian ramp placement to minimize crossing distances.
- Placement of signal equipment/cabinets to ensure adequate sight distance for turning vehicles to pedestrian crossings.
- Placement of signal equipment out of potential vehicle turning paths.

The roadway designer should show the proposed signal equipment (poles, pull boxes, and cabinets) on the roadway plans for reference. The roadway designer should show the pole locations and elevations on the roadway elevation detail plans.

5.1.3 Selecting & Locating Pedestrian Ramps for Proper Crosswalk Alignment

At intersections where pedestrian ramps need to be rebuilt, the type and location must be approved by City of Portland Civil Design Services (CDS) and or Traffic Design Services (TDS). The City of Portland generally requires two ramps per corner to meet ADA standards.

5.1.5 Driveway Approaches at Signalized Intersections

The ODOT Signal Design Manual specifies that all driveway approaches at a signalized intersection must be signalized. PBOT sometimes allows unsignalized minor driveway approaches at signalized intersections, based on guidance provided in the MUTCD. Section 4D.34 discusses the use of STOP signs on a minor street or driveway approach to a signalized intersection if an extremely low potential for

conflict exists. The designer should confirm with the SSL District Engineer during the scoping phase of the project whether any minor driveway approaches should be signalized or not.

In instances where the signalization of a private driveway approach is required due to traffic conflict generated specifically by the development being served, PBOT typically requires that the signal installation costs be covered by the development. In addition, agreements are typically required to be put in place with the developer for on-going maintenance and operating expenses for the signal equipment. Detection on private driveway approaches should be carefully considered, to ensure enough space is provided for loops, or another means of detection can be provided (i.e. radar). If loops are provided on the private driveway approach, maintenance easements will need to be provided by the development for access to the loops and pull boxes.

5.2 VEHICLE SIGNAL HEAD LAYOUT

Follow the MUTCD and the ODOT *Traffic Signal Design Manual* for guidance on vehicle signal head types and layout, supplemented as follows.

Information on plan sheet numbering conventions for vehicle signal heads, pedestrian signal heads, and signal and light poles is provided in Appendix A. Figure 5-1 also illustrates the typical intersection movement numbers and signal head numbering convention for PBOT signals.

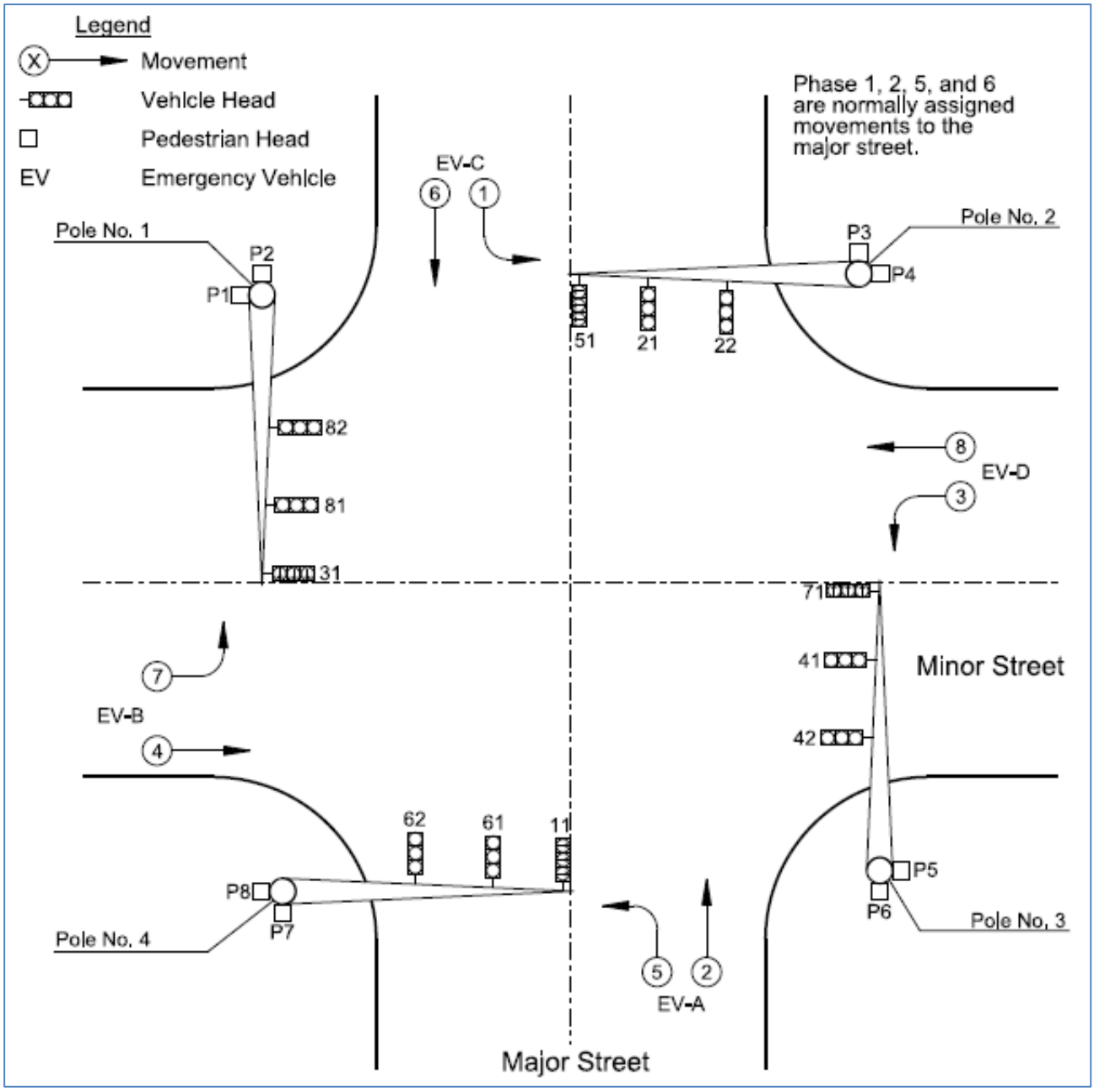


Figure 5-1 Typical Intersection Movements and Signal Head Numbering

5.2.1 Head Types

PBOT nomenclature differs from ODOT for signal head types and plan callouts. In general, PBOT standard matches the MUTCD in using vehicle signal heads with all 12" LED indications for new signal installations and most retrofit situations. Section 4D.07 of the MUTCD, and the Oregon supplements to the MUTCD, discuss situations where the use of 8" signal heads may be appropriate. In such situations allowed for by the MUTCD (such as streets with speeds of 30 mph or less), 8" vehicle signal heads may be used in retrofit situations where structural loading or ground clearance is an issue.

Figure 5-2 illustrates the common vehicle signal head types, with appropriate plan symbology and plan callouts. The ODOT equivalent head type is provided for reference to the figures in Chapter 5 of the ODOT *Traffic Signal Design Manual*. A more comprehensive list of vehicle signal heads used in the City of Portland is provided in the signal legend in Appendix B.

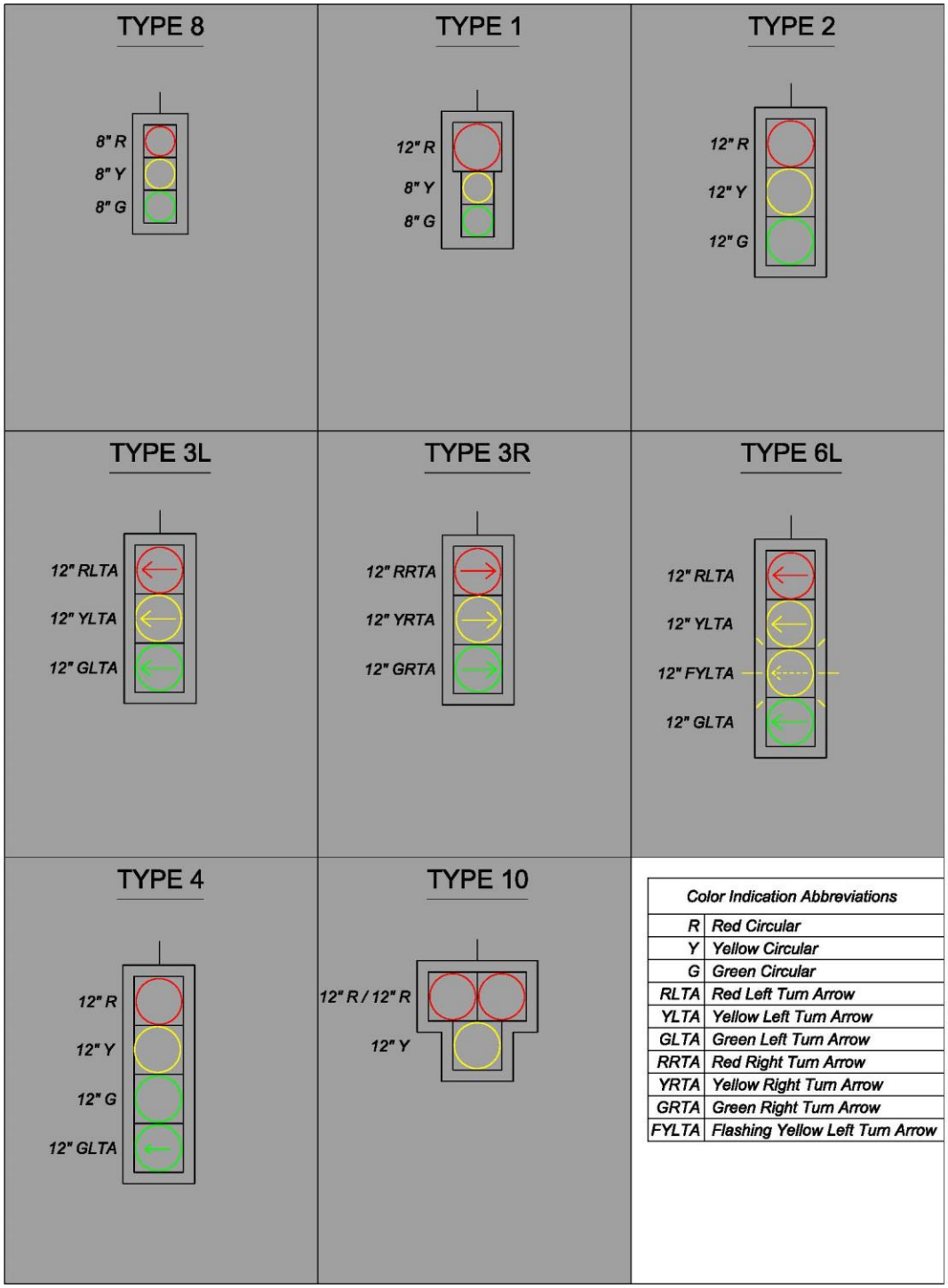


Figure 5-2 PBOT Signal Head Types

5.2.2 Head Placement

Part 4D.11 of the MUTCD requires a minimum of two traffic signal heads for each approach to a signalized intersection. Placement of traffic signal heads should generally follow the guidelines provided in the MUTCD and by ODOT, with the exceptions described below.

For roadway approaches with three or more receiving lanes, PBOT allows one signal head placed over each lane line. See Table 5-1 below as a replacement for the guidance provided in the ODOT manual.

Table 5-1 Standard Signal Heads for Through Movement Phases

Number of Receiving Lanes	Number and Placement of Signal Heads
Single receiving lane	Two Type V11 signal heads (12"R-12"Y-12"G), placed one foot inside the projected receiving lane lines
Two receiving lanes	Two Type V11 signal heads (12"R-12"Y-12"G), one placed in the center of each receiving lane
More than two receiving lanes	Type V11 signal head (12"R-12"Y-12"G) placed above each of the lane lines dividing receiving lanes (minimum of two signal heads)

For example, for a three lane approach, one signal head would be placed above the lane line separating each lane, resulting in two signal heads for the approach. See the photo example in Figure 5-3 below.

Source: Google Street View

Figure 5-3 Typical Signal Head Placement for Three-Lane Approach

PBOT standards require all signal heads to be uniformly mounted at the same height above the roadway (minimum 18 feet, maximum 19 feet). The tops of adjacent signs should be level with the tops of the signal heads. Mast arm clearance calculations are required for each mast arm and are to be included on the plans. Contact PBOT SSL staff to access the current version of the calculation tool (Microsoft Excel spreadsheet).

5.2.3 Head Mounting

PBOT uses pipe tenons and plumbizers for attaching signal heads to mast arms (ODOT no longer uses this method). In some cases, adjustable brackets are used in place of pipe tenons to provide proper ground clearance. See PBOT standard drawings for mounting details.

5.2.4 Signal Head Louvers

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 visors should be used. Signal plans should call out where louvers or visors are needed. Optically programmed signal heads are not allowed.

5.2.5 Bicycle Signal heads

PBOT uses bicycle signal heads to control unique bike movements at locations where conflicts between bicycles and other modes would otherwise not be controlled adequately. Bicycle signals should only be used in specific circumstances and the signal designer should work with the PBOT SSL District Engineer to determine if they are needed.

If used, the PBOT standard is to use 12" LED bicycle signal heads for far-side signal control, and 4" or 8" LED bicycle signal heads for near-side signal control. Far side signals should be mounted on poles per standard drawings, and near side bicycle signals should be mounted at a height of 5-feet from the bottom of the signal head to the sidewalk or finished surface.

PBOT standard practice is to mount a "bike symbol & BIKE SIGNAL" sign (PBOT sign code S3630) directly underneath the far side bike signal head. See Figure 5-4 and the signal legend for details.

See the signal legend in Appendix B for appropriate callouts and plan symbology for bicycle signals.

5.3 SIGN REQUIREMENTS AND LAYOUT

Follow the MUTCD and the ODOT *Traffic Signal Design Manual* for guidance on sign placement at signalized intersections. Note that the City of Portland sign manual includes unique sign codes for signs mounted overhead. Refer to the sign code for the current City sign standards.

Figure 5-4 below includes commonly used signs for traffic control at signalized intersections, with the appropriate plan callout and City of Portland sign code. The figure is meant as a City-specific supplement to Figure 5-31 in the ODOT *Traffic Signal Design Manual.* Additionally, the signal plan legend in Appendix B provides a more comprehensive list of commonly used signs and associated plan legend text.

In some instances, where sign visibility is particularly important, lighted LED signs are used in place of retroreflective aluminum signs. These signs are indicated in the plan with "LED" in the top portion of the bubble callout. In other instances, it may only be necessary or desired to display a sign at particular

times where conflicts exist. In these cases, LED "part-time restriction" (PTR) or LED "part-time warning" (PTW) signs are used. Appendix B includes commonly used LED (static), PTR and PTW signs.

Note that PBOT uses pipe tenons and plumbizers for attaching signs to mast arms (ODOT no longer uses this method). See PBOT standard drawings P-627 and P-629.

5.3.1 Street Name Signs

Overhead street name signs are to be included on signal mast arms at signalized intersections. At intersections of one-way streets, post-mounted street name signs should also be installed on pedestrian poles or street lighting poles to provide for pedestrian way-finding. Street name signs should be designed per Standard Drawing P-420 and mounted on mast arm poles per P-629. The overhead street name sign should be positioned such that it is to the right of the first signal head.

The Signal Plan Notes or Legend sheet should include the proposed street name signs.

In some instances, new overhead street name signs may be required to be mounted on existing mast arm poles. Because adequate structural information is typically not available for mast arm poles installed before 2007, the following guidance dictates mounting criteria for new overhead street name signs on existing poles:

- Poles installed after 2007 – "Single height" overhead street name sign (Standard Drawing P-420) may be installed on the mast arm without any structural calculations.
- Poles installed prior to 2007 – overhead street name signs may be attached to the pole riser, but not on the mast arm.

5.3.2 Signs for Pole Construction Loading

PBOT Standard Drawings P-601 and P-602 include loading criteria for the number and size of signs and signal heads on a mast arm pole. The "pole design loading" table on these standard drawings specifies the horizontal distances from the riser to the appurtenance. Exceeding the specified distances or appurtenance size may require additional engineering calculations or special pole designs to ensure proper structural support.

COP - R5040V MUTCD - R6-2L 24" X 30"	ONE WAY ←	RS 1L
COP - R5060V MUTCD - R6-2R 24" X 30"	ONE WAY →	RS 1R
COP - R4200V 24" X 30"	LEFT TURN SIGNAL	RS 2L
COP - R4220V 24" X 30"	RIGHT TURN SIGNAL	RS 2R
COP - R4400V MUTCD - R10-11A 24" X 30"	NO TURN ON RED	RS 3
COP - R3410V MUTCD R3-6 24" X 30"		RS DT
COP - R3320V MUTCD - R3-6L 30" X 36"		RS 4L
COP - R3340V MUTCD - R3-6R 30" X 36"		RS 4R
COP - R3225V MUTCD - R3-5L 30" X 36"	ONLY	RS 5L
COP - R3245V MUTCD - R3-5R 30" X 36"	ONLY	RS 5R
COP - R3300V MUTCD - R3-5A 30" X 36"	ONLY	RS 5T
COP - R3020V MUTCD - R3-2 24" X 24"		RS 6LS
COP - R3040V MUTCD - R3-1 24" X 24"		RS 6RS
COP - R3000V MUTCD - R3-3 24" X 24"	NO TURNS	RS 7
COP - R5100V MUTCD - R5-1 30" X 30"	DO NOT ENTER	RS 8S
COP - R4000V MUTCD - R10-6 24" X 36"	STOP HERE ON RED	RS 9
COP - R4500V MUTCD - R10-12 24" X 30"	LEFT TURN YIELD ON GREEN ●	RS LTG
COP - R4460V 24" X 30"	LEFT TURN YIELD TO ONCOMING TRAFFIC	RS LTY
COP - R3180V 24" X 36"	U TURN PERMITTED ON LEFT ARROW ONLY	RS UT
COP - R4480VL 30" X 36"	LEFT TURN YIELD TO PEDS	RS 12L
COP - R4480VR 30" X 36"	RIGHT TURN YIELD TO PEDS	RS 12R
COP - W3210V MUTCD - W11-2 30" X 30"		RS PX
COP - S1100G MUTCD - S1-1 30" X 30"		RS SC
COP - S3630 24" X 30"	BIKE SIGNAL	RS BS

Figure 5-4 Common Signs Used for Traffic Control

5.4 PEDESTRIAN SIGNAL EQUIPMENT LAYOUT

Signal poles should be placed to allow for proper alignment and view of pedestrian signal heads through the crosswalks. If at all possible, the head should be located within the extension of the crosswalk that the head is serving, but not occluded by a stopped vehicle. Each intersection corner must provide a pedestrian signal head for each crossing terminating on that corner. In most cases there will be two pedestrian signal heads on each corner: one for the east-west crossing and one for the north-south crossing. Options for placement of the pedestrian signal heads include:

- Place one or both pedestrian signal heads on the traffic signal pole.
- Place one or both pedestrian signal heads on a stand-alone pedestal.
- Place one or both pedestrian signal heads on a street light pole.
    - *Note: Street lights on traffic signal poles should be powered through the traffic signal service.*

Whenever possible, traffic signal equipment should be consolidated at one location while providing adequate visibility of the pedestrian signal heads to reduce the impact of multiple sidewalk obstructions. Pedestrian signal heads should not be located on a pole where a turning vehicle might mount the curb and shear off the head.

Figure 5-1 in Section 5.2 shows the standard head numbering for pedestrian signals on plans.

5.4.1 Pushbuttons

Accessible pushbuttons are recommended by the Access Board at all pedestrian crossings at new signals. The MUTCD provides flexibility in the application of pushbuttons. Accessible pushbuttons are typically not installed at fixed-time signals in the Central City area. Outside the Central City and at detection-actuated signals, PBOT will upgrade or install APS pushbuttons at existing signals only upon a valid request or where the need is otherwise documented. PBOT practice is to activate the audible tone at APS pushbuttons only when initiated by a pedestrian by pressing the button (i.e. the audible tone is not automatically activated for each pedestrian phase).

The MUTCD and Access Board guidelines provide specific guidance on the location of pushbuttons at signalized crossings. See Section 5.5.4 below for more information.

5.5 POLE SELECTION AND PLACEMENT

See Section 5.5 of the ODOT *Traffic Signal Design Manual* for general guidance on signal pole selection and placement, supplemented as follows.

PBOT's standard is the use of mast arm poles in all new signal and retrofit installations. Span wire installations are allowed if mast arms will not allow for proper signal head placement or where overhead streetcar or light rail wires interfere with the installation of mast arms.

The signalization plan shall include a table for pole entrance locations for all attachments such as mast arms, service cabinet, pedestrian signal, terminal cabinet, hand hole, etc. The pole entrance chart is discussed further in Chapter 9 of this document.

5.5.4 Roadside Placement Requirements

The City of Portland *Pedestrian Design Guide* provides guidance on sidewalk corridors and the allocation of space for various functions (street furnishings, pedestrian through zone, etc.). These criteria call for the center of the signal pole to be located 2'-6" from the face of curb, or centered in the furnishing zone (if the furnishing zone is greater than 5 feet). Where space permits, traffic signal pole centers should be located 3 feet from the face of curb, within the furnishing zone, and outside of the curb radius. At locations where there would be a high potential for signal poles to be struck by trucks (due to geometric constraints and/or a large number of trucks), consideration should be given to placing the traffic signal pole at the back of sidewalk.

The traffic signal poles must be located such that they do not interfere with the curb ramps or the pedestrian travel path. A pedestrian landing area must be provided at the top of every curb ramp to provide consistency with current ADA guidelines for new sidewalk access construction. Pedestrian signal heads and pedestrian pushbuttons that could be mounted on the traffic signal poles must also be placed such that they are visible along the crosswalk (pedestrian signal heads) and convenient for use (pedestrian pushbuttons).

The traffic signal poles should be located as closely as possible to the curb ramp without intruding into the ramp area while maintaining the minimum 2'-6" (3' desirable) spacing from the face of curb. The downstream traffic side of each corner is the preferred location for the traffic signal pole to allow for pedestrian visibility and vehicle turning space.

For locations where pedestrian pushbuttons are required, the above pole placement guidance from the *Pedestrian Design Guide* does not always allow for locating pushbuttons at an accessible location. Poles may need to be located outside the recommended area, or additional poles or pushbutton posts may be needed.

Section 4E.08 of the MUTCD provides specific guidance on the placement of pushbuttons. Pushbuttons must be placed adjacent (within 10-inch reach range) to a 4-foot by 4-foot (minimum dimension) flat landing area (2% maximum cross-slope in any direction), and should be between 1.5 and 6 feet from the edge of curb, shoulder, or pavement. Where constraints make it impractical to place the pushbutton between 1.5 and 6 feet from the edge of curb, it should be no farther than 10 feet. Additionally, where two pushbuttons are placed on the same corner, the pushbuttons should be separated by a distance of at least 10 feet.

5.5.5 Mast Arms Poles

See current PBOT Standard Drawings P-601 through P-607 for standard single arm, dual arm, and combination mast arm pole and foundation details. Mast arm lengths may be specified down to the 1-foot increments, within the ranges specified in the "pole data" tables in the Standard Drawings. Five-foot increments is preferred. The designer should consider potential future need for left turn signals.

5.5.6 Use of Other Agency Approved Poles

For PBOT-led signal projects on an ODOT facility, coordinate with the PBOT SSL Division Engineer to determine the standards to be followed and the type of equipment to be used (ODOT or PBOT standard).

5.6 ILLUMINATION

Illumination is required at all signalized intersections. Where the existing street lighting system does not adequately light the intersection or a decision is made to replace existing lighting on utility poles, luminaires may be included on the signal mast arm pole or other pole as needed. Lighting on a mast arm pole is typically installed with a riser extension and luminaire arm (see combination mast arm pole in Standard Drawing P-602). 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 if necessary.

PBOT standard practice is to use LED cobrahead-style fixtures from the approved electrical equipment list, at the wattage necessary to meet the City lighting standard. The current standards allow for street lights to be mounted at a maximum height of 35-feet above the pole base on single mast-arm poles, and a maximum height of 40-feet on dual mast-arm poles. The maximum luminaire arm length is 20-feet.

A lighting photometric analysis should be performed to determine the lighting requirements, the need for lighting on signal poles, and the specific fixtures to use. Appendix D provides checklists for typical street lighting design requirements. Also see City of Portland street lighting standards [future link here] for more information on required lighting levels and evaluation criteria.

5.6.1 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 luminaires and photo electric cell. Illumination wiring should not be routed through the signal controller cabinet.

- Three No. 10 AWG XHHW wires (hot, neutral, ground) are needed from the service cabinet to the luminaire. Typically, a long-lasting photo electric relay is installed on each luminaire. Daisy chaining illumination wiring from luminaire to luminaire is allowed.

- If a master photo electric relay is used, then three No. 10 AWG THWN or XHHW wires are needed from the service cabinet to the photo electric relay cell.

5.6.2 Signal Equipment on Illumination Poles

Separate stand-alone light poles are often located at intersection corners. In most cases, these light poles should be powered by a separate lighting service. When a light pole is included on an intersection corner specifically to serve the intersection and no other street lighting is included on the adjacent segments, the street light should be powered from a separate breaker in the signal service cabinet. Additionally, if a street light pole is used for pedestrian signals, pushbuttons, or other signal equipment, the street light and signal equipment should be powered from the same service (in this case, the signal service) to avoid mixing two power sources in the same pole.

5.6.3 Utility Pole Coordination

Street lights may exist on utility-owned poles at locations where traffic signals with street lighting are to be installed. In these cases, existing luminaires and luminaire arms should be removed from the utility poles as part of the signal installation. Similarly, new street lighting systems may trigger the need to remove existing luminaires from street light poles.

No signal equipment is allowed on utility poles. When rebuilding signals, any existing signal equipment (including service cabinet) mounted on a utility pole needs to be relocated to a signal pole or pedestal.

The signal plans should call out the removal of existing cobrahead street lights from utility poles with the appropriate plan callouts and legend. The plans should note (in a construction note or general note) that the work is to be performed by a journeyman lineman per PGE Schedule 95.

5.7 FIRE PREEMPTION

Follow Section 5.7 of the ODOT *Traffic Signal Design Manual* for guidance on emergency preemption.

Emergency vehicle preemption detectors (Opticom) should be provided for all approaches to each signalized intersection. However, typically emergency vehicle preemption is not included in the core of the downtown one-way grid. Preemption channels are generally assigned according to those shown on Figure 5-1 for intersections with left-turn phases. For approaches with permissive left-turn phasing, the designer should work with the SSL District Engineer to determine the appropriate channel assignments to meet operational goals and limit possible yellow-trap issues.

The signal plan should show and specify the type and location of the preemption detector. PBOT standard is generally to place preemption detectors on the mast arm on the far side of the intersection for approaching traffic, unless line-of-sight or other constraints exist. Additionally, the plan should show the installation of a preemption phase selector module in the controller cabinet. See the current version of the PBOT *Approved Controller Equipment* list for approved preemption equipment.

5.8 POWER SOURCE

Follow Section 5.8 of the ODOT *Traffic Signal Design Manual* for general guidance on power source for new signals. Commercial power is used to power all electrical installations. When installing a new traffic signal, the engineer should work with the local utility (PGE or Pacific Power) early in the design to determine the nearest location to draw power from. Power is typically fed directly from a transformer. Traffic signal and illumination electrical services are not metered, with the exception of new traffic signal construction in Pacific Power Territory. The traffic signal and illumination service requires commercial power of 120V AC.

For most new signals, the wiring from the power source should enter into the service cabinet via a conduit (sometimes aerial connections are provided to the pole containing the service cabinet, on a case-by-case basis). The design and installation of the conduit and wiring from the power source to the service cabinet is per the requirements of the power company. The plan sheets 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.

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) when using a main breaker up to 60 amps in size.

5.9 BATTERY BACK-UP

Battery back-up may be required on a case-by-case basis in special circumstances. For example, signals interconnected with railroad or light rail gated crossings require battery back-up.

5.10 CONTROLLER CABINETS

Coordinate with the PBOT SSL Division Engineer to determine the current standard signal cabinet and controller to be used and specified in the design. Generally, all new signal installations should use base-mounted signal controller cabinets. Pole-mounted cabinets are no longer allowed for new installations.

Follow Section 5.10 of the ODOT *Traffic Signal Design Manual* for guidance on placement of the controller cabinet at the intersection. In general, locate the controller on the right-hand side of a minor street approach and try to obtain a power source in that quadrant, if possible. Locate the controller cabinet so that it does not obstruct the view for a minor street vehicle turning right-on-red. Locate the controller cabinet so that when it is being serviced, the technician can stand facing the louvered door (the front of the cabinet), and see a minimum of two traffic signal phases. The cabinet should ideally be placed within the furnishing zone and required clearances are maintained.

5.11 SERVICE CABINETS

Service cabinets for PBOT signals are signal pole-mounted per Standard Drawings P-625 or P-670 and should be located on the same corner as the controller cabinet. Signal service cabinets are not metered. Pole-mounted service cabinets should be mounted over the furnishing zone so that they do not project into the pedestrian through zone and in a manner that someone opening it can do so without standing on the curbside of the pole.

The signal plan should be specific as to the type of service cabinet and the number and type of breakers required.

Type "US":

- For a signalized intersection with no street lighting, a Type "US" service cabinet per P-626 can be specified.

Type "A":

- For a signalized intersection with luminaires on the signal poles and/or corner light poles for intersection lighting, a Type "A" service cabinet per P-671 should be specified.
- At a minimum, include one 40-amp traffic signal breaker, one 15-amp breaker for illumination, and a spare slot for a future breaker.
- The spare breaker in the Type "A" cabinet can typically be used for powering additional stand-alone street light poles at the intersection corners, if needed for intersection lighting.

Type "C":

- For signalized intersections where significant additional street lighting must be powered through the signal service, or additional breakers are needed, a Type "C" street lighting service cabinet per P-671 may be considered.
- Switching to a Type "C" cabinet is a costly upgrade and will result in construction change orders if the design and plans do not accurately reflect the type.

Metered Service:

- A metered service may be required for new construction of traffic signals in Pacific Power Territory. Verify with PBOT SSL District Engineer.
- If a metered service is required, install a Base Mounted Service & Control Cabinet with Meter (ODOT Standard Drawing TM485).

Always confirm the service cabinet type to be used with the PBOT SSL District Engineer during the design process.

5.12 PULL BOXES

Section 5.12 of the ODOT *Traffic Signal Design Manual* contains general guidance on placement of pull boxes (described by ODOT as "Junction Boxes") in relation to signal poles, ramps, loop detectors, and the controller cabinet. PBOT standards for pull box sizes, conduit entrances, and types used differ slightly from ODOT standards. PBOT Standard Drawing P-632 provides details on installation of the two most common pull boxes used for traffic signal installations.

Table 5-2 provides a summary of pull box sizes and uses. PBOT preference is to place one or two (or more, if needed) Type "B" pull boxes near the signal controller cabinet to serve as a first access point for signal, detector, and interconnect circuits. Type "B" pull boxes should also be installed on all other quadrants of the intersection where signal poles or equipment are to be located. Poles/devices sharing the same corner as the signal controller cabinet may be directly routed into the signal controller cabinet base. Type "A" pull boxes should be used on approach legs for providing access to loop detectors or intermediate access to interconnect circuits (copper only).

Table 5-2 Default Minimum Pull Box Type/Size

Type /Size	Location/Use
(2) SB-B: Two 24½"x13¼" x12" boxes	The same quadrant as the signal controller: first access point for all signal, detector and interconnect circuits. Use two only if required due to number of conduits and wiring entering pull box.
SB-B: Single 24½"x13¼" x12" box	All quadrants without the signal controller: secondary access point for signal, detector, and/or interconnect circuits.
SB-A: Single 17"x10½"x12" box	All approach legs: detector and/or interconnect circuits.

Table 5-3 provides details for determining the type/size of pull box if the default minimum is not adequate. For example, if more than a total of 18 inches of conduit diameter is entering a Type "B" box near the controller cabinet, use two boxes side-by-side. ODOT Standard Drawing TM472 provides details for installing two pull boxes side-by-side.

Table 5-3 Sizing for Pull Box Type/Size

Type*	Size	Total Conduit Diameters Allowed (Inches)	Remarks	Material
SB-A	17"x10½"x12"	12	Non-traffic areas only	Concrete w/ Galvanized Steel or Polymer Cover
SB-B	24½"x13¼"x12"	18		

*Install with 12" wide concrete apron when located in unpaved area. See PBOT Std. Dwg. P-632.

5.13 UTILITY JUNCTION BOXES

Portland General Electric (PGE) and PacifiCorp are electrical service providers within the City of Portland. Each electrical utility company has their own requirements regarding ownership, size, type and location of utility junction boxes. For example, utility junction boxes in PGE territory are owned by the company. Utility junction boxes in PacifiCorp territory are owned by the customer. The PGE utility junction box (UJB) is typically 17"Wx30"Lx18"D dimensions. Both electrical utility companies should be consulted early in the design process to determine size, type and location of utility junction boxes, conduits, wiring, and other electrical service requirements. In cases where conduit routing between the

utility junction box and service panel requires additional junction boxes to meet NEC code, the additional junction boxes should be specified to have "COP Electrical" written on the lid.

5.14 CONDUIT

Conduit should be sized so that the fill does not exceed 25 percent on new installations. The conduit fill calculations should also include future wiring, for example if a future left turn phase is being considered. Signal, interconnect, lighting and detector wiring may share the same conduit. Unfused service wires require a separate isolated raceway.

5.14.1 Conduit Size

Conduit should be sized to accommodate the actual wires/cables to be installed. Conduit fill should be checked by the designer for all conduit runs to ensure compliance with NEC regulations and to provide adequate capacity for pulling additional wire in the future. Table 5-4 provides the cross sectional area of typical wires and cables used in PBOT installations. Table 5-5 provides the NEC and PBOT maximum fill requirements for conduits based on the number of wires. Note that PBOT uses a maximum fill value of 25% for new conduits to provide ample spare capacity. The NEC value of 40% fill can be used for existing conduits where wire is to be added.

The following are general design guidelines for PBOT conduit sizing:

- Conduit(s) crossing the major street or minor street shall be 3-inch diameter minimum.
- One spare 2-inch conduit with pull line from the controller cabinet to the nearest pull box for future use. The conduit should be capped on both ends.
- 1-inch minimum conduit.
- 3-inch maximum conduit.
- Optional – provide spare 2-inch conduit with pull line when crossing the major street.

Table 5-4 Wire Area

Wire (AWG)	AREA (in²)	Cable (AWG)	AREA (in²)
#14 XHHW	0.0139	2/C #14 THWN	0.1000
#12 XHHW	0.0181	3/C #14 THWN	0.1100
#10 XHHW	0.0243	4/C #14 THWN	0.1257
#8 XHHW	0.0437	5/C #14 THWN	0.1452
#6 XHHW	0.0590	7/C #14 THWN	0.1735
#4 XHHW	0.0814	10/C #14 THWN	0.2922
#3 XHHW	0.0962	15/C #14 THWN	0.3800
#2 XHHW	0.1146	20/C #14 THWN	0.4400
#1 XHHW	0.1534	Opticom Model 138 Cable	0.0784
1/0 XHHW	0.1825	Loop Feeder Standard (14 ga.)	0.0908
2/0 XHHW	0.2190	Loop Feeder Reduced (18 ga.)	0.0616
3/0 XHHW	0.2642	12-Count Fiber Optic Cable	0.1320
4/0 XHHW	0.3197	48-Count Fiber Optic Cable	0.1320
		72-Count Fiber Optic Cable	0.1320
		96-Count Fiber Optic Cable	0.1810
		12-Pair #22	0.4902
		Radar (Wavetronix) Cable	0.1320
		Cat5e Ethernet Cable	0.0452

(For reference only – designer to verify wire sizes)

Table 5-5 Conduit Fill Table (NEC and ODOT Max Fill)

Conduit size (Inch)	Internal Dia. (Inch)	NEC % Max Fill (in²)			PBOT % Max Fill (in²)
		1 Wire	2 Wire	3+ Wire	All
		53%	31%	40%	25%
1	1.063	0.470	0.275	0.355	0.222
1 1/4	1.394	0.809	0.473	0.610	0.382
1 1/2	1.624	1.098	0.642	0.829	0.518
2	2.083	1.806	1.056	1.363	0.852
2 1/2	2.489	2.579	1.508	1.946	1.216
3	3.090	3.975	2.325	3.000	1.875

5.14.2 Conduit Materials

Conduit for PBOT signals and street lighting shall be PVC Schedule 80 for typical installations. HDPE conduit is an option when conduit is installed by horizontal directional drilling. Conduit bends, elbows in conduit in foundations should be rigid steel conduit.

5.14.4 Conduit Routing

Typically, conduit crossings would only be necessary on three of the four legs of a signalized intersection. PBOT standard is to route conduit directly from a pull box to each pole or pedestal on each quadrant.

Conduit installed parallel to the curb may be installed under the sidewalk or in the street. If the conduit is installed under the sidewalk, it must be installed in the frontage zone (e.g., the area between the back of sidewalk and the ROW line) or in the pedestrian through zone. Conduit running parallel to the curb should not be installed under the sidewalk within three feet from the face of curb. This area is reserved for poles, utility vaults, etc. Exceptions may be allowed by variance.

To install conduit parallel to the curb under the street within 3 feet from the face of curb by trenching, a letter is required that the curb will be replaced if the installation causes damage within two years. There is no need to sign a variance if the conduit is installed by direct drilling.

Conduits crossing streets should be installed perpendicular to the street centerline. The design engineer should consider whether specifying horizontal directional drilling (HDD) of conduit is required crossing the major street or minor street, in place or standard trenching. Considerations should include paving moratoriums and/or the potential disruption to traffic open trenching may cause. HDD may not always be a viable option in areas where many utilities exist. The cost of pavement restoration should also be weighed and familiarization with PBOT restoration standards is recommended.

5.15 WIRING

PBOT typically uses 120V AC power both for traffic signals and illumination that is part of the traffic signal (differs from ODOT practice of 240V AC for illumination). 240V may be needed, depending on voltage drop calculations. Note that when wiring a traffic signal, no splicing of wires is allowed between the controller cabinet and the terminal cabinet or device on the pole. The only exception to this rule is splicing loop wire to loop feeder cable in the pull box.

5.15.1 Wire Types

The following wire types are typically used for PBOT signals:

- Vehicle and pedestrian signal heads – No. 14 AWG IMSA 20-1 multi-conductor control cable
- Pushbuttons – No. 14 AWG IMSA 20-1 multi-conductor control cable
- Wiring for cabinet power – 3 No. 6 AWG IMSA 50-2
- Loop feeder wire – No. 14 AWG IMSA 50-2
- Illumination wire – No. 10 AWG XHHW
- Opticom fire preemption cable – Model 138 detector cable
- Interconnect cable – No. 22 AWG (6 or 12 twisted pairs)
    - PE-22 (for overhead installations)
    - PE-39 (for underground installations)
- Loop wire - No. 14 AWG IMSA 51-7

- Locate wire – No. 12 THWN Yellow
- Ground wire – No. 12 THWN Green or Bare

5.15.5 Common/Neutral (Shared) Wire

PBOT uses a common/neutral conductor and does not use ODOT's method for shared common.

PBOT does not use 240V illumination circuits at traffic signals. Because LED luminaires are the standard, 120V AC is sufficient to meet voltage drop requirements.

5.15.6 Wiring Signal Heads

Control cables are provided to signal equipment on traffic signal poles as follows:

- 5-conductor cable from controller cabinet to pole terminal cabinet for each phase served. The cable is terminated on the terminal block. Separate 5-conductor cables are installed to each signal head and jumpered in the pole terminal cabinet.
- 5-conductor cable from controller cabinet to pole terminal cabinet to serve up to two pedestrian phases. Separate 5-conductor cables are installed from the terminal cabinet to each pedestrian head.
- 2-conductor cable from controller cabinet to pole terminal cabinet for each pedestrian pushbutton phase. Separate 2-conductor cables are installed from the terminal cabinet to each pushbutton.
- 7-conductor cable from controller cabinet to pole terminal cabinet. Separate 7-conductor cables are installed from the terminal cabinet to each 4-section signal head.
- For poles without terminal cabinets (e.g., frangible-base poles or pedestrian pipe posts), the cables and conductors are directly connected to the signal devices or wired together in the base of the pole with silicon-filled wire nuts.

If two pedestrian heads are placed on separate poles/pedestals in a given intersection quadrant, the heads may be "daisy chained" between the two poles to consolidate two 5-conductor cables down to one (1) prior to the "home run" back to the signal controller cabinet. This should only be used in retrofit situations where conduit space is limited.

PBOT Standard Drawing P-612 provides the wiring color code for signal phases based on the various control cables. The wiring code is also provided in Figure 5-5.

CIRC.	5/C VEH.	5/C PED.	5/C P.B.	10/C PED./PB.	7/C VEH.	2/C P.B.	3003 CABLE
2G	GREEN				GREEN		
2Y	ORANGE				ORANGE		
2R	RED				RED		
4G	GREEN						
4Y	ORANGE						
4R	RED						
6G	GREEN						
6Y	ORANGE						
6R	RED						
8G	GREEN						
8Y	ORANGE						
8R	RED						
1G	GREEN				BLUE		
1Y	ORANGE				WHITE/BLACK		
1R	RED						
5G	GREEN						
5Y	ORANGE						
5R	RED						
2WK		GREEN		GREEN			
2DW		RED		RED			
4WK		BLACK		BLACK			
4DW		ORANGE		ORANGE			
6WK		GREEN		GREEN/BLACK			
6DW		RED		RED/BLACK			
8WK		BLACK		BLUE			
8DW		ORANGE		ORANGE/BLACK			
PB2			GREEN	GREEN/BLACK		BLACK	
PB4			RED	RED/BLACK		BLACK	
PB6			BLACK	BLUE		BLACK	
PB8			ORANGE	ORANGE/BLACK		BLACK	
PB-			WHITE	WHITE/BLACK		WHITE	
NEUT. (I)	WHITE	WHITE		WHITE	WHITE		
SP	BLACK				BLACK		
+24							BLACK
DC GROUND							WHITE
NORMALLY OPEN CONTACT							RED
NORMALLY OPEN CONTACT							GREEN

Figure 5-5 Signal Wiring Color Code

A signal Wiring Plan sheet should be included in the signal plan set, showing the number and type of wires/cables in each conduit run and to each signal pole and device. The wiring diagram is a simplified representation of the information shown on the signal plan. For any poles with terminal cabinets or pedestals where wires are “daisy chained”, the signal wiring sheet should include terminal cabinet/splice diagrams showing the wires/cables in and out of the terminal cabinet or pole base. See Chapter 9 for more details and requirements of the signal Wiring Plan sheet.

6 DETECTION DESIGN

See Chapter 6 of the ODOT *Traffic Signal Design Manual* for additional guidance on detection systems and design.

6.1 DETECTION TYPE

PBOT provides standards for detection layouts based on roadway type and design speed. Standard 6-foot round inductive loops are generally used for vehicle detection.

Other detection types and devices (radar) are provided on the City approved electrical materials list, but their use must be approved by PBOT SSL staff on a project-by-project basis.

See Sections 6.7 and 6.8 below for details on the detection types used by PBOT.

6.2 DETECTION BASICS

See the ODOT *Traffic Signal Design Manual* for general guidance on signal detection, with the following considerations for PBOT signals.

It should be kept in mind throughout the design process that there are several goals concerning loop detection design, including dilemma zone protection, volume-density extension to provide efficient gap out, initial cost, maintainability, failure mode, and data collection.

6.2.1 Dilemma Zone Protection

The purpose of dilemma zone (a.k.a. indecision zone) protection is to improve safety for the major street through phases by providing amber control, thus reducing the number of vehicles in type 1 and type 2 dilemma zones (where a vehicle is too close to properly stop at the intersection and too far away to properly get thru the intersection before the yellow terminates). It should be noted that this goal is only applicable during light to medium levels of traffic as once volumes meet a certain threshold, any type of dilemma zone protection will extend every phase to the maximum allowable time. This may not be applicable with closely spaced coordinated intersections.

- The loop farthest from the stop bar (advance loop) should be located at the safe stopping distance from the stop bar.
- Trap loops or truck priority loops should be installed further back, e.g., another 100’ or of a sufficient distance as to justify installation.
- Posted speed should be used when determining loop spacing.
- The safe stopping distance may be selected from Table 6-1 for approaches with 0% grade or may be calculated.

6.2.2 Volume-Density Extension

The purpose of volume-density extension is to efficiently terminate the major street through movements once the flow of traffic has reduced to below an optimum level.

- Multiple loops should be employed on approaches to minimize the effective gap
- Table 6-1 provides guidance as to spacing to minimize gap time thus allowing balancing of the competing goals of amber control and efficiency.
- Alternatively, trap loops may be used when speeds are above 35 MPH. The potential benefits of trap loops are:
    - Better amber control for over-speed vehicles
    - More efficient for under-speed vehicles
    - Able to classify vehicles and provide truck priority

6.2.3 Initial Cost

Initial cost should be a consideration in the type of detection used at an intersection. Factors affecting costs are:

- Distance from intersection (conduit/trenching costs)
- Number of loops
- Comparison to radar and other forms of detection

6.2.4 Maintainability

- Pavement type and condition:
    - In some circumstances, pavement condition may not be conducive to installing induction loops. Where significant pavement wear and cracking exists, loops will not maintain longevity. Where condition is an issue, check paving schedules to determine if the street approaches to the signal are scheduled for repaving or maintenance in the near future.
    - On bridge decks or other reinforced concrete surfaces, detection must be in the form of preformed loops or other non-invasive detection (radar).

6.2.5 Failure Mode

The following is general guidance on providing as robust of detection system as possible in the event of loop failure.

- Separation of loop lead-ins: When four stop-bar loops are used, at least two loop lead-ins should be used. This allows redundancy in the loop wiring so not all loops are affected when one loop fails.

6.2.6 Data Collection

The PBOT standard loop layout allows for some data collection. Alternate layouts may be required if additional data collection is desired, such as vehicle classification and speed.

- Vehicle classification: multiple advance loops would be required
- Vehicle counts: In order to effectively allow for vehicle counts in each approach lane, the advance loops should have separate loop lead-ins back to the cabinet.
- System detection loops used for system wide vehicle counts.

6.3 BEYOND BASIC DETECTION

6.3.2 Bicycle Detection

As noted in Table 6-2 below, PBOT uses advance bike detection at 60-feet back from the stop bar on all approaches with dedicated bike lanes. Additionally, PBOT uses stop bar bike presence detection on actuated minor street approaches to provide for bike actuation. Bike stop bar detectors are placed at 3-feet behind the stop bar to the center of the detector.

Section 6.7 below includes guidance on the typical types and applications of advance and stop bar bike detection.

Pushbuttons for bikes may be required at specific locations where a bike loop is either not possible, or where a bicyclist is more likely to expect a pushbutton to indicate their presence at the intersection. Bike pushbutton signs should be clearly visible to the bicyclist and the arrow should indicate the path of bicycle.

Examples of locations where bike pushbuttons may be appropriate are as follows:

- Bicycles cross the intersection approaching from a sidewalk and a bike signal is provided. A bicycle pushbutton may be placed at the ramp interface with the street crossing.
- Multi-use path crossings where bike signals are provided.

Bicycle Detection Indicator Light (Blue Light)

Where bike stop bar presence detection is provided, PBOT may require the installation of a blue LED indicator light mounted overhead on the mast arm opposite the approach.

The blue light is tied to the detection input of the bike stop bar loop and activates when the loop detects a bike presence. The blue light is wired back to the cabinet with a 2-conductor signal cable. Placement of blue light at top right corner of signal indication is desirable. PBOT Special Provision 02925 provides specifications for the blue LED bicycle detection indicator light.

6.4 STANDARD DETECTION LAYOUT

Figure 6-1 shows the PBOT standard detection layout for a typical intersection. This assumes the major street through movements will be recalled, and the minor street and left-turn movements will be actuated by detection. Table 6-1 shows the PBOT standard detection spacing and other parameters for major street through movements given the posted speed.

Table 6-1 Major Street Detection Placement Criteria

Posted Speed (mph)	Detection Zone/Loop Placement				Min gap (sec)	C.O. (sec)	Feet/sec
	1st (co)	2nd	3rd	4th			
30	140 c	68	n/a	n/a	.5	1.4	44.0
35	183 c	115 c	60	n/a	.5	1.0	51.3
40	230 c	130 c	60	n/a	.5	1.6	58.7
45	285 c	190 c	115 c	60	.5	1.0	66.0
50	357 c	245 c	155 c	88	.8	0.8	73.3
55	417 c	275 c	165 c	88	.8	1.1	80.7

Note: The distances shown are from the stop bar to the center of the loop/zone. Where a "c" is shown after the distance, the loop should have carryover (C.O.).

For all minor street approach lanes and major street left-turn movements, locate four loops at the stop bar. The center of the first loop should be 3-feet behind the stop bar with the next four loops located 12 feet apart. Locate a fifth loop 100 feet back from the stop bar.

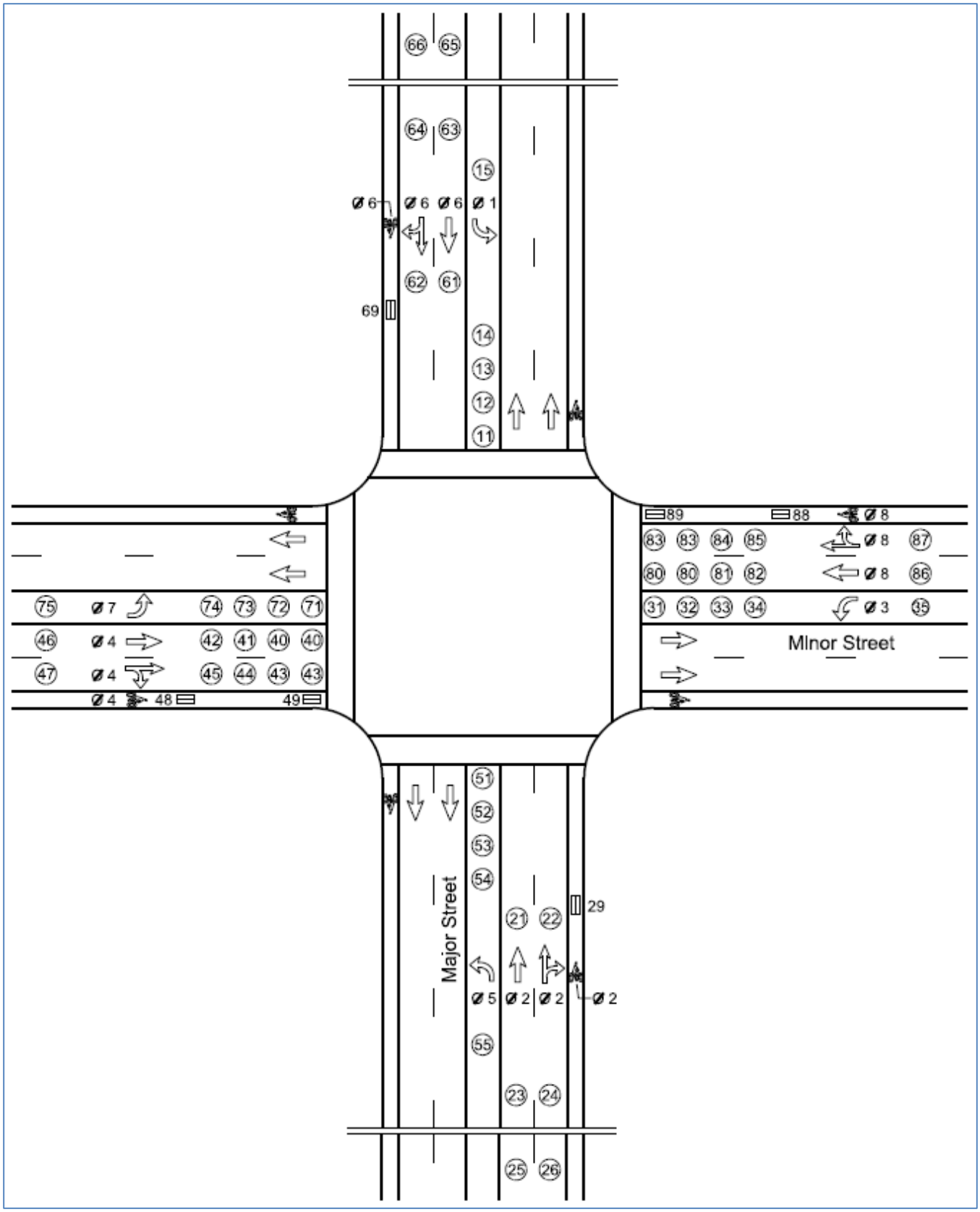


Figure 6-1 PBOT Standard Detection Layout and Numbering

Table 6-2 provides a summary of detection zone/loop placement for all modes and intersection phases.

Table 6-2 Detection Placement Summary

Detection Zone/Loop Placement		
Location	**Posted Speed (mph)**	**Detection Spacing (ft) from stop bar to center of detection**
Major Street Note: if major street has shared through/left turn lane, install four stop bar detectors in the lane in addition to the detection shown based on posted speed.	25	
	30	68 / 140
	35	60 / 115 / 183
	40	60 / 130 / 230
	45	60 / 115 / 190 / 285
	50	88 / 155 / 245 / 357
	55	88 / 165 / 275 / 417
Minor Street & Left-Turn lane	n/a	2 / 14 / 26 / 38 / 100
Bike Lane (major street)	n/a	60
Bike Lane (minor street)	n/a	3 / 60
Shared bike & vehicle lane (major street) – parallelogram loop	n/a	60
Shared bike & vehicle lane (minor street) – stop bar loop (6-foot round) –advance loop (parallelogram)	n/a	 3 60

The signal detection plan should show the location and numbering for all loops/detection zones, conduit and pull boxes serving each detector, and details of wiring back to the controller cabinet.

6.5 MODIFICATIONS TO STANDARD DETECTION PLACEMENT

See the ODOT *Traffic Signal Design Manual* for guidance on when modified loop layouts may be needed. Work with the PBOT engineer to determine the appropriate solution.

6.6 DETECTION INPUT FILE

See Section 6.6 of the ODOT *Traffic Signal Design Manual* for information on the detection input file. Note that ODOT has updated their standard input file layout and numbering for their new Type 332S cabinet. Figure 6-2 below provides the current ODOT and PBOT standard input file for Type 332S cabinet with 2070 controller and C11 connector.

"I" File		1	2	3	4	5	6	7	8	9	10
	Upper	14	1	21	9	16	3	23	11	18	X
		Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 3	Ph 3	Ph 4	Ph 4	Ph 4
		C1-56	C11-16	C1-39	C1-63	C1-47	C1-58	C11-18	C1-41	C1-65	C1-49
		VD 1	VD 29	VD 9	VD 11	VD 13	VD 3	VD 32	VD 14	VD 16	VD 18
	Lower	X	5	30	X	X	7	32	X	20	X
		Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 3	Ph 3	Ph 4	Ph 4	Ph 4
		C1-60	C11-20	C1-43	C1-76	C11-10	C1-62	C11-22	C1-45	C1-78	C11-12
		VD 2	VD 30	VD 10	VD 12	VD 31	VD 4	VD 33*	VD 15	VD 17	VD 34*
				PB6	*PB6*	*PB6*	*PB6*	*PB6*	*PB6*	*PB6*	*PB6*

"J" File		1	2	3	4	5	6	7	8	9	10
	Upper	13	2	22	10	15	4	24	12	17	X
		Ph 5	Ph 5	Ph 6	Ph 6	Ph 6	Ph 7	Ph 7	Ph 8	Ph 8	Ph 8
		C1-55	C11-15	C1-40	C1-64	C1-48	C1-57	C11-17	C1-42	C1-66	C1-50
		VD 5	VD 35*	VD 19	VD 21	VD 23	VD 7	VD 38*	VD 24	VD 26	VD 28
	Lower	X	6	31	X	X	8	SP7	X	19	X
		Ph 5	Ph 5	Ph 6	Ph 6	Ph 6	Ph 7	Ph 7	Ph 8	Ph 8	Ph 8
		C1-59	C11-19	C1-44	C1-77	C11-11	C1-61	C11-21	C1-46	C1-79	C11-13
		VD 6	VD 36*	VD 20	VD 22	VD 37*	VD 8	VD 39*	VD 25	VD 27	VD 40*
		PB6		*PB7*	*PB6*	*PB6*		*SP7*	*PB6*		*PB6*

#	*Slot Number*
#	*SCATS Det #*
Fn	*Slot Function*
C1-##	*C1 Pin #*
VD #	*Voyage Detector #*
XXX	*SCATS Function*

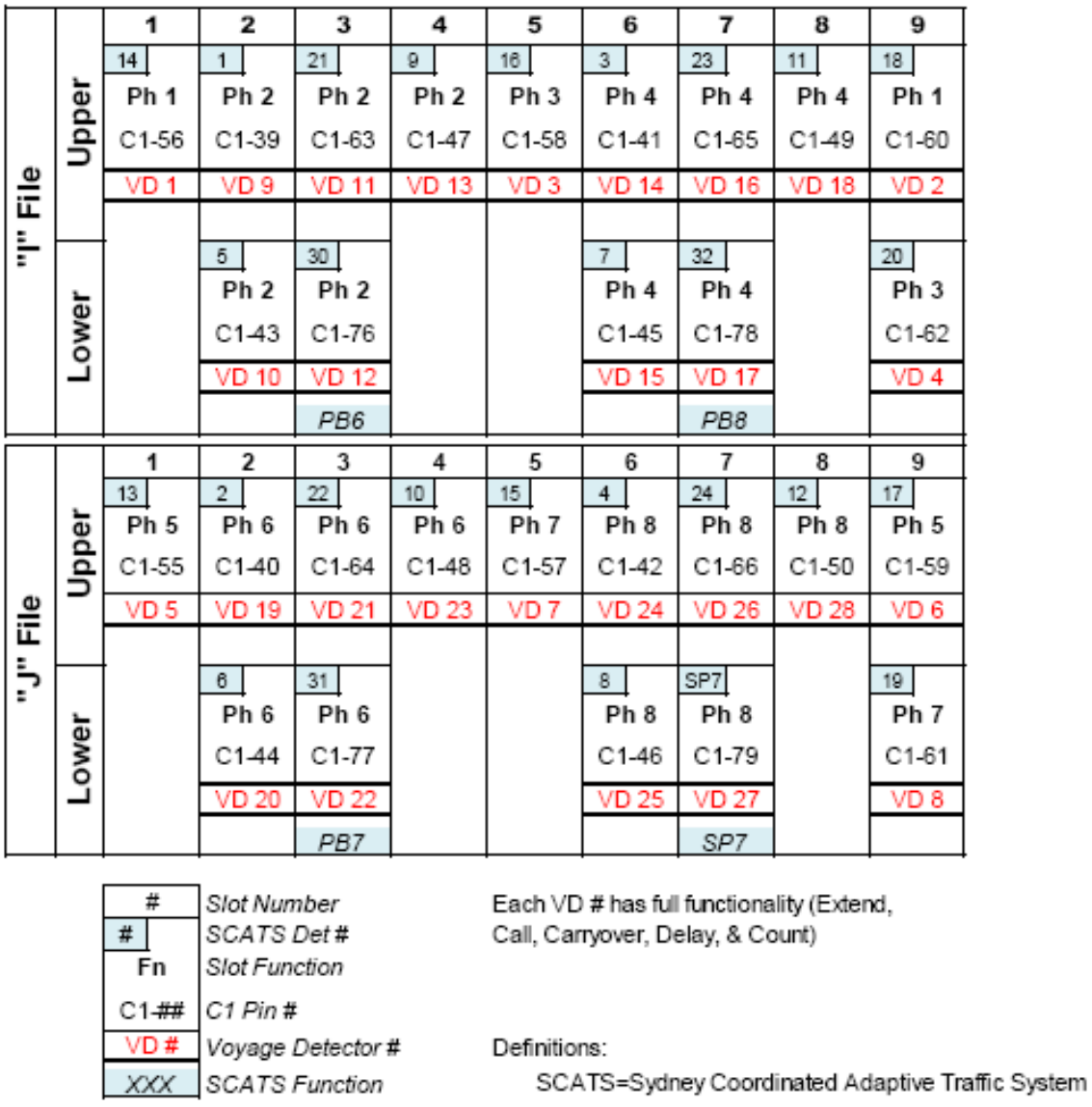
* VD # has limited functionalities (Call and Extend only)
Each VD # without an astericks has full functionality (Extend, Call, Carryover, Delay, & Count)

Definitions:
SCATS=Sydney Coordinated Adaptive Traffic System

Source: ODOT Traffic Signal Design Manual

Figure 6-2 332S Detection Input File Details for 2070 Controller with a C11 Connector

Figure 6-3 below shows the standard input file for the previous standard 332 cabinet with 2070 controller and C1 connector, for designers to reference for previous signal installations (2015 and earlier) that are being modified.



Source: ODOT Traffic Signal Design Manual

Figure 6-3 332 Detection Input File Details for 2070 Controller with a C1 Connector (Existing Installations Only)

6.7 INDUCTION LOOP TECHNOLOGY

See the ODOT *Traffic Signal Design Manual* for information on induction loop technology, supplemented as follows.

Vehicle loops should be 6-feet diameter round, centered in the lane. Loops shall have a minimum 4 turns of No. 14 AWG loop wire, or as needed to meet loop resistance testing requirements. See Standard Drawing P-634 and Standard Specification 00990.43(B) for more details.

Bike loops within dedicated bike lanes shall be 3-feet by 6-feet quadrapole type loops, installed as shown in Standard Drawing P-634.

Where bike lanes are not provided and bicycles share the vehicle lane approaching an intersection, a parallelogram-shaped loop with 4-turns of loop wire should be provided to adequately detect bike traffic. Additionally, on intersection approaches with right-turn lanes where it is expected that a large number of the right-turning vehicles may track over the bicycle loops, smaller 3.5-foot by 4-foot parallelogram loops should be provided in the bike lane for the advance loop. Figure 6-4 provides the layout details for a parallelogram loop. ODOT Standard Detail DET4433 provides details for inductive parallelogram loops.

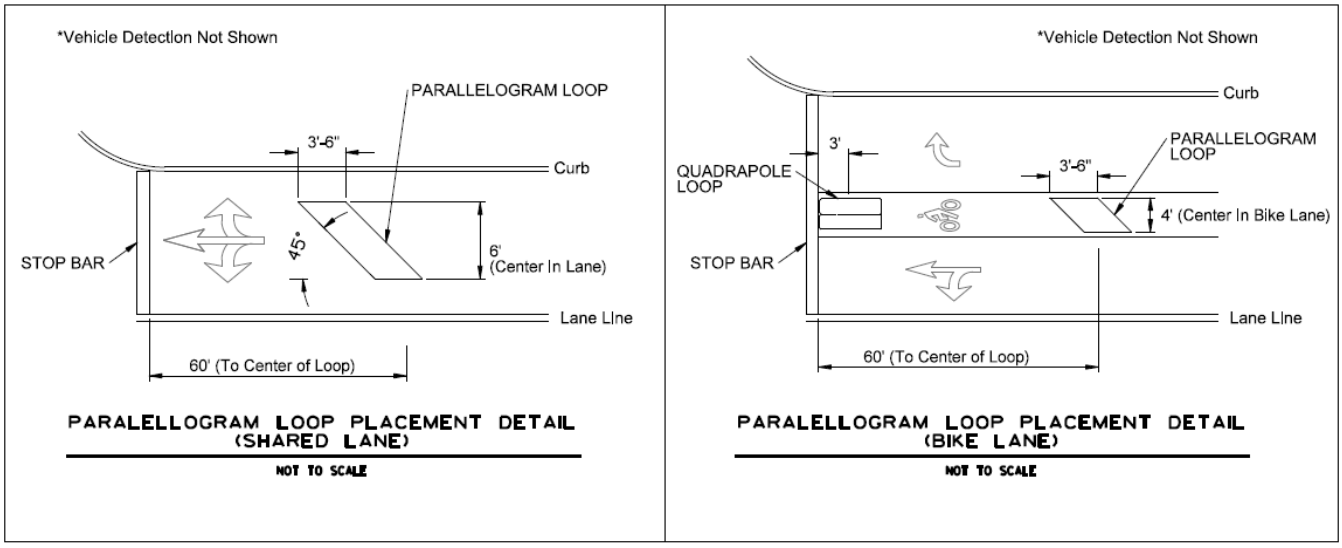


Figure 6-4 Parallelogram Loop Detail

Detector amplifiers should be provided in the controller cabinet when induction loops are used. The plan should specify the number and type of detector amplifiers based on the number of detection inputs being used. Where parallelogram loops are used, a bicycle-specific Reno A&E Bike Amplifier (Model C-1101-B or C-1201-B) should be specified on the plans to ensure bicycles are differentiated from vehicles.

Standard layout and placement of loops should be based on Figure 6-1 and Table 6-1 and Table 6-2.

6.7.1 When and Where to Wire Loops in Series

The ODOT *Traffic Signal Design Manual* provides guidance on when loops can be wired in series. PBOT similarly allows for wiring loops in series to produce a single input to the controller. Except as discussed below, all loops should provide an individual input if possible. The following loops should be wired in series:

- For minor streets - the two loops located at 3-feet and 14-feet from the stop bar
- For minor streets - the two loops located at 26-feet and 38-feet from the stop bar
- For left-turn lanes – the two loops at 3-feet and 14-feet and the two loops at 26-feet and 38-feet from the stop bar.

- The two (or more) advance loops for the major street through phase that are nearest the stop line when multiple through lanes are present.
    - The advance loops furthest from the stop line should always be wired separately to serve a count function.

If needed due to lack of inputs, the following loops may be wired in series:

- The four stop bar loops for each of the minor street approach lanes may need to be wired in series if two minor street approach lanes exist. Wire each pair in series in the pull box, and wire the two sets of pairs together in the cabinet (see loop wiring diagram).

6.7.6 Loop Wiring Diagram

A loop wiring diagram should be included on the detection plan sheet to provide details on loop locations, loops wired in series, loop phases and input file slot. Figure 6-5 shows the typical loop wiring diagram for the loop layout configuration shown in Figure 6-1, given the guidance above for wiring loops in series. Intersections with single lane approaches will require less wiring of loops in series than shown in Figure 6-5.

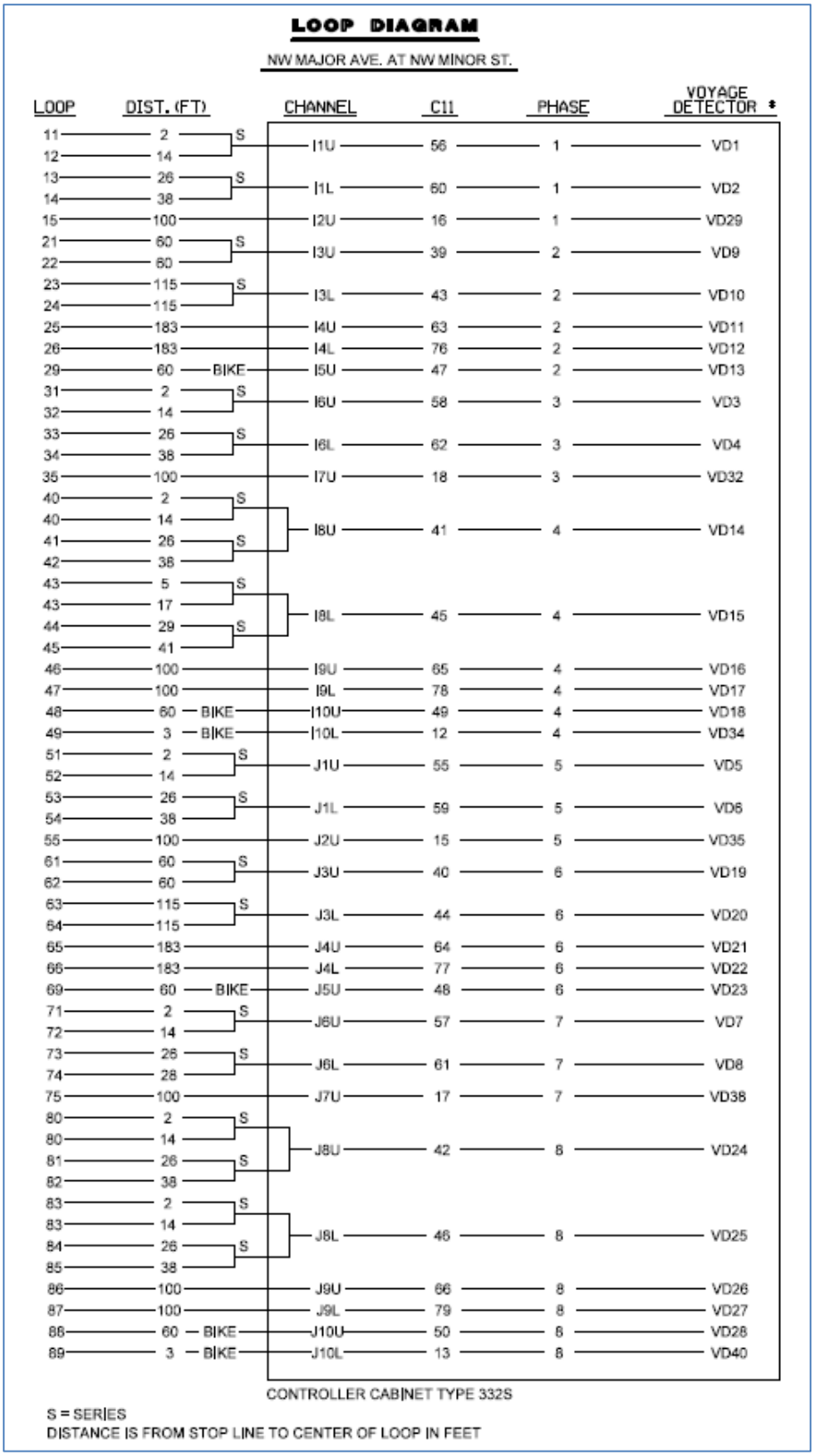


Figure 6-5 Loop Wiring Diagram Example (332S cabinet with 2070 controller and C11 connector)

6.8 ALTERNATIVE DETECTION METHODS

Section 6.10 of the ODOT *Traffic Signal Design Manual* provides basic discussion of Microwave and Radar detection methods. PBOT's preferred alternative to inductive loop detection is radar detection. Radar is applied similar to video detection in the information supplied in the plans and layout of detection zones. Section 6.8 of the ODOT *Traffic Signal Design Manual* details video detection design.

Radar detection units should be mounted per the manufacturer's recommendation. These sensors have many possible applications, such as vehicle detection, incident detection, vehicle counting, classification, and activation of warning signs.

The detector plan sheets should detail the equipment to be used, the mounting, the wiring, and any necessary detailing inside the controller cabinet (detector input file, contact closure cards, etc.). Refer to the PBOT *Controller Equipment List* for current approved radar detection products. Plan sheet layout and bubble note structure for radar or microwave is very similar to the video detection layout.

The distance from where the detection zone is located in relation to the stop bar is shown graphically on the plan view and listed in the radar detection wiring diagram (similar to inductive loop wiring diagram). The distance mimics the placement of inductive loop detection (Figure 6-1 and Table 6-1), and indicates where the radar detection zone is generally located. In the instances where inductive loops are typically wired in series (e.g. left turn stop bar loops), only one radar detection zone is used.

Radar sensor units should be numbered and labeled similar to video camera numbering shown in Section 6.8 of the ODOT *Traffic Signal Design Manual*.

7 INTERCONNECT & ITS COMMUNICATION DESIGN

Chapter 7 of the ODOT *Traffic Signal Design Manual* provides general information and guidance on signal interconnect.

The need for interconnect to a signalized intersection should be determined and coordinated early in the design process. Considerations should include type of interconnect, overhead or underground installation, coordination with affected utilities, future network considerations, and applicable codes. The primary types of signal interconnect used by PBOT at this time are twisted pair copper and fiber optic.

If interconnect is included in the scope of the traffic signal design, the plan set should include an interconnect plan sheet showing the details of the installation, the required equipment, and any notes or details regarding coordination with the utility companies involved. Rob Jennings (503-823-6279) and the PBOT ITS Team should be consulted early in the scoping and design process, and should be involved in reviewing the interconnect plans as the design process proceeds.

7.1 WHEN IS INTERCONNECT NEEDED?

Multiple signal installations along a route may be coordinated to help provide an uninterrupted flow of traffic along that route. Coordination is achieved through an interconnect system from controller cabinet to controller cabinet. Any signal that is located in an urban area may benefit if they interconnected.

Interconnect capable of central communications (see Section 7.3) can also be used to allow remote access and manipulation of the signal timing, which may be desirable even for isolated intersections.

Always contact the ITS Team and District Engineering staff to discuss the need for interconnection to the new signal.

7.2 BACKGROUND AND DESIGN RESPONSIBILITY

Traffic signal communications have been rapidly changing in the last several years. Migration from the 170E/HC11 controller to the 2070 controller 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 2070 controller is capable of being connected to a network and uses TransCore central software to remotely monitor and manage traffic signal timing performance.

The ITS Team will design certain portions of the work, with District Engineering Staff (or consultants) responsible for other portions of the work. The ITS Team assists with ordering the network and radio

equipment, coordinating the installation and turn-on of the network circuits with the District Engineering staff.

7.3 TYPES OF TRAFFIC SIGNAL COMMUNICATIONS

There are two main types of communications used for traffic signals; central and local or peer to peer. Central communication connects one or more traffic signals to a network server. This type of communication allows the user to access and modify signal timing information from a remote location. Peer to Peer or Local communication connects two or more on-street traffic signals. This type of communication allows multiple signals in a corridor to work in coordination. There is no remote access to signal timing information. The ITS Team, in conjunction with District Engineering Staff, will determine the proper form of communication based on the City's needs.

Central Options:

- Fiber Optic
- Frame Relay
- Telephone
- Cellular Broadband
- DSL/Cable Broadband
- 4.9 GHz or 5.8 GHz Radio

Local Options:

- Fiber Optic
- **Twisted Pair Copper (VDSL)***
- 4.9 GHz or 5.8 GHz Radio

*** Default Standard. This is the only method that the signal designer is completely responsible for designing and does NOT require ITS Team involvement.**

7.4 SCOPING THE TRAFFIC SIGNAL COMMUNICATION SYSTEM

Scoping the traffic signal communication system can be rather simple or very complex depending on the methods and equipment used. It is critical to contact the District Engineering Staff and the ITS Team at the scoping phase of the project. The ITS Team will work with District Engineering staff to determine the best option for the type of communications needed.

As an example, fiber optic local communications is scoped for the project. The traffic signal designer is responsible for the site plan & standard specifications (pull box locations, conduit, and type of wire in the conduit) shown on the interconnect plan sheet. The ITS Team is responsible for the details (splice diagrams, logical diagrams, fiber specifications, etc.) shown on the ITS communication plan sheet or Interconnect Plans. If a third party (consultant) is designing the signal and interconnect system, they

should coordinate with the ITS Team and District Engineering Staff as noted above for requirements and guidance on the various elements of the communication system.

The ITS Team, in conjunction with the District Engineering, 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 Locations maintained and Operated by PBOT (Projects by ODOT or Permit)

The ITS Team should be contacted early during scoping for involvement with the project requirements and the development of the IGA (if applicable). 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 PBOT approved communications equipment. If possible this will be PBOT supplied and the cost reimbursed.

7.7 DESIGN CONSIDERATIONS

7.7.1 Controller

The PBOT standard 2070 "ATC" with Linux operating system controller can accommodate all types of communications for interconnect installations.

7.7.1.1 Communications Equipment

An Ethernet switch is typically installed in the cabinet to accommodate communications. For copper interconnect installations, specify RuggedCom RS930L Ethernet Switch. For fiber optic installations, specify RuggedCom RS900G. The Ethernet switch or other specified communications equipment should be delivered by the contractor to the City for installation.

7.7.2 Pull Boxes

Where provided underground, the interconnect system typically enters the traffic signal controller cabinet through the same conduit and pull boxes as the signal wiring and detection system at the intersection. Beyond the intersection, pull boxes should be placed within the furnishing zone no further than approximately 300-feet apart.

For twisted pair copper installations, Type “A” pull boxes can be used. For fiber optic installations, Type “C” communications pull boxes should be used per PBOT Standard Drawing P-633 to allow for fiber to

enter the pull box from the size rather than the bottom, and to accommodate coiling and splice enclosures.

7.7.3 Conduit

A separate, exclusive 2-inch conduit is typically used for the interconnect system. See section 5.13 for more information on conduit requirements.

The designer should take into account controller locations, detector conduit construction, 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 requires permitting for using the poles that belong to others. It may be more economical in the long run to install the interconnect system underground. This option may be considered if the initial cost of going underground is prohibitive and approval from the utility is received.

Where interconnect cable will be attached to utility poles, the appropriate utility company must be coordinated with to determine limitations, confirm design parameters, and coordinate installation. The proposed overhead interconnect routing must be field-verified to ensure the required clearances are available from electrical lines or other franchise utilities. All applicable codes (NESC, OJUA, OPUC) should be followed for proposed overhead interconnect attachment to utility poles.

7.7.4 Wiring

PBOT standard is to use a “hard wire” system including a shielded cable containing twelve (12) twisted pairs of No. 22 AWG solid wire. Type PE-22 (air core) cable should be used for overhead installations, and type PE-39 (gel core) should be used for underground installations.

All interconnect cable shall be installed in continuous runs from cabinet to cabinet without any splices.

Typical installation of twisted pair copper interconnect cable should include specifying a certain length of spare cable (12-feet typical) to be coiled in the controller cabinet. Confirm with Rob Jennings for the specific signal.

Figure 7-1 below illustrates a typical twisted pair interconnect installation along a corridor using underground conduit.

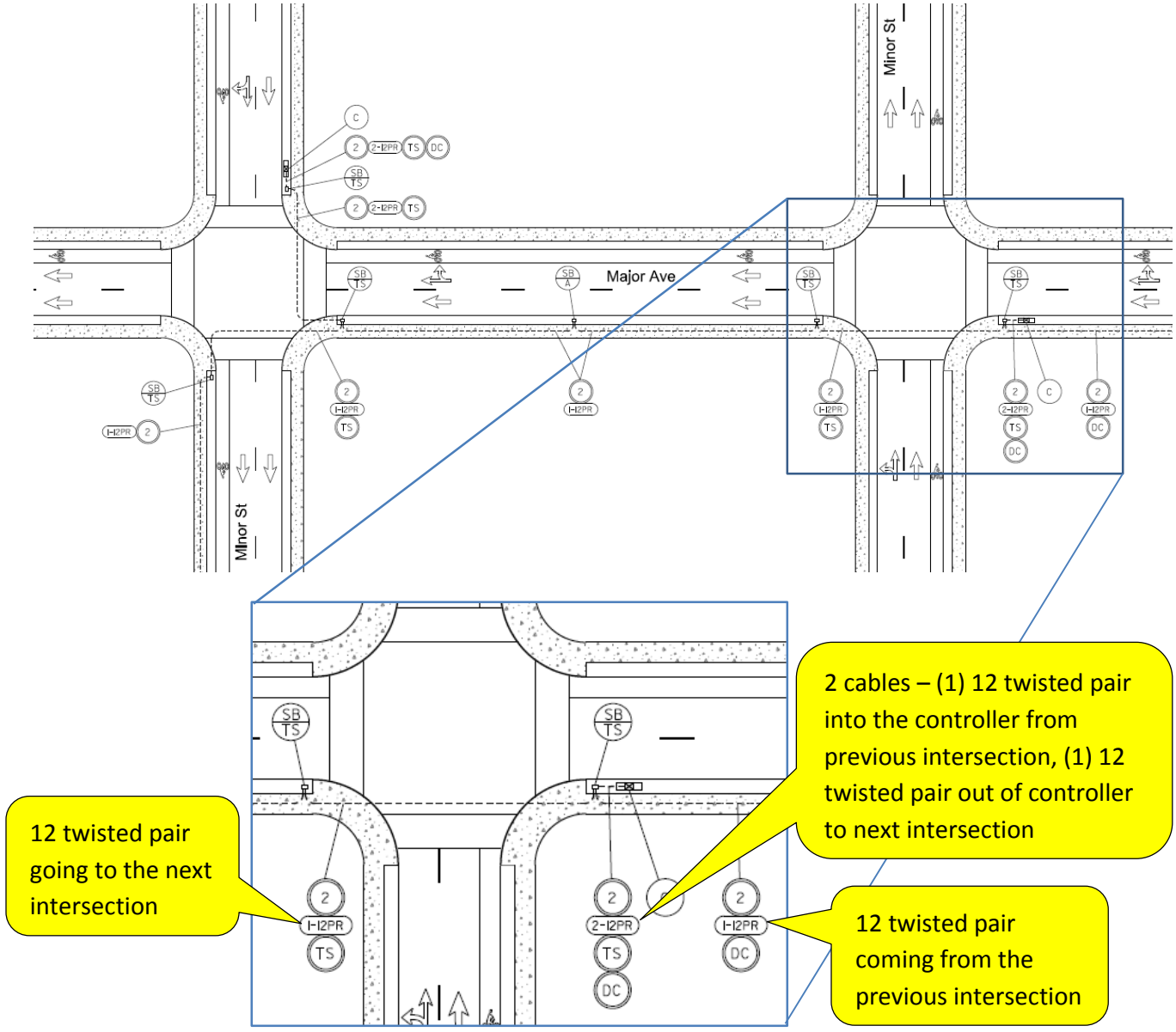


Figure 7-1 Twisted Pair Copper Installation – 12 Pair

For fiber optic interconnect systems, the number of fiber optic strands needed for interconnection is determined by the ITS Team. Fiber optics are spliced as necessary in the pull boxes, again, determined by the ITS Team. Fiber optic interconnect plans should include splice diagram details as well as general fiber layout "logical diagram" details in addition to the Interconnect Plan sheet.

Figure 7-2 below illustrates a typical fiber optic interconnect installation using underground conduit. Note that Type "C" pull boxes are used, separate from the traffic signal pull boxes to accommodate splice enclosures and coiling of fiber optic cable.

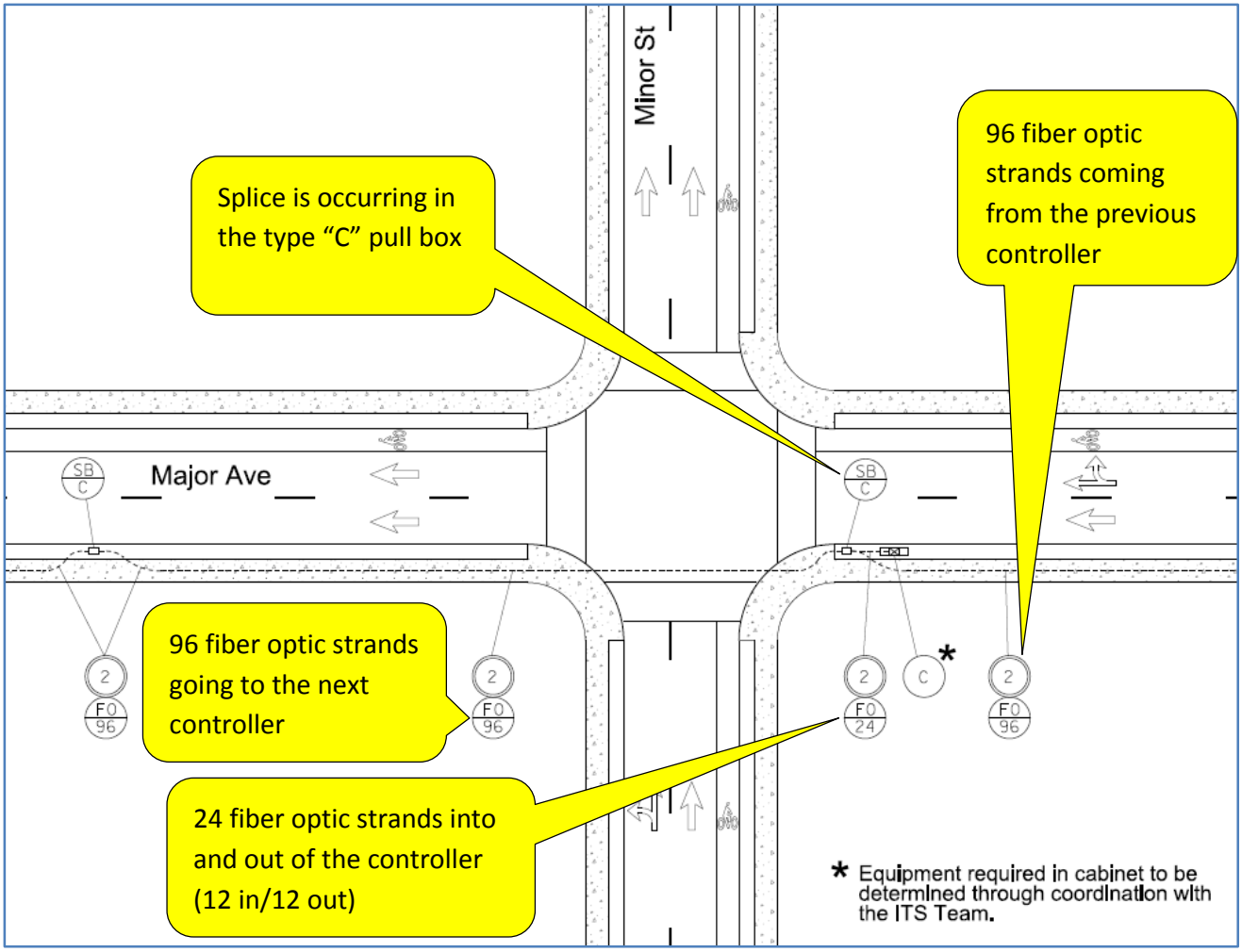


Figure 7-2 Fiber Optic Installation

7.7.5 Telephone Connection

If a cell connection is required, check with the ITS Team to determine if there is adequate cell coverage in the area.

8 UTILITIES

A separate utility plan is not typically provided for PBOT projects. Existing and proposed underground and overhead utilities should be shown on the traffic signal plan sheet.

9 PLAN DETAILS

9.1 POLE ENTRANCE CHART

The Signal Plan should include a pole entrance chart if a new signal pole, pedestrian/vehicle pedestal, or pushbutton post is to be installed. If room does not exist on the Signal Plan, provide the pole orientation chart on a separate details sheet or on the Signal Legend sheet. The pole entrance chart details the type and location of poles, the equipment to be mounted on them along with the orientation.

Figure 9-1 shows an example pole entrance chart based on the signal pole layout in Figure 5-1.

POLE ENTRANCE CHART

N.W. MAJOR AVE. AT N.W. MINOR ST.

POLE NO.	STATION	OFFSET	POLE TYPE	MAST ARM	LUM. ARM	HAND HOLE	PEDESTRIAN SIGNAL	PUSH BUTTON	SERVICE CABINET	TERMINAL CABINET	WEATHER-HEAD
1	XX+XX	XX' LT	MAP	180	-	0	0/270	0/180	-	0	-
2	XX+XX	XX' RT	MAP	270	-	90	0/90	180/270	90	90	-
3	XX+XX	XX' RT	MAP	0	-	180	90/180	0/270	-	180	-
4	XX+XX	XX' LT	MAP	90	-	270	180/270	0/90	-	270	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-

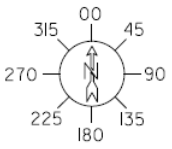


Figure 9-1 Example Pole Entrance Chart

The pole entrance chart should only include the columns where equipment is needed. Additional columns should be added for other equipment not shown in the example, such as vehicle signals or signs attached to the signal pole. Where two pedestrian signal heads or pushbuttons are attached to the same pole, specify the orientation of both devices in the pole orientation chart.

Station and offset may not always be necessary or available depending on the project. Alternatively, pole locations may be called out by "X" and "Y" coordinates, or dimensioned from the curblines on the plan sheet.

The orientation angle used in the pole orientation chart is typically based on true north. If the plan view is rotated on the Signal Plan, care should be taken that the angle specified is still based on north, and not "up" on the plan sheet.

See the PBOT standard drawings for typical attachment orientations for the various equipment mounted on signal poles and pedestals. Note that hand holes should be oriented away from active traffic and accessible from a finished surface (sidewalk). Terminal cabinets are typically oriented at 180-degrees from the mast arm.

9.2 MAST ARM CLEARANCE CALCULATIONS

Mast arm clearance calculations should be provided on the Signal Plan sheet if a new mast arm pole is proposed. If room does not exist on the Signal Plan sheet, the mast arm clearance calculations may be provided on the Signal Legend sheet or a separate Signal Details sheet.

The mast arm clearance calculations show key pole dimensions based on the standard drawings, and helps to ensure proper vertical clearance is provided for the proposed equipment to be attached to the mast arm. PBOT has developed an Excel spreadsheet to perform the mast arm clearance calculations, which can be requested from the SSL Engineer. The Engineer-of-Record should check the calculations to be sure they are correct for the specific project. Figure 9-2 shows an example of the mast arm clearance calculations.

MAST ARM CLEARANCE CALCULATIONS

N.E. MAJOR AVE. & N.E. MINOR ST.
POLE NO. 1

SPAN (FT.)			40.00
RISER (FT.)			19.50
RADIUS (FT.)			135.00
ANGLE (DEGREES)			10.00
STRAIGHT SECTION (FT.)			8.90
CURVED SECTION (FT.)			16.49
ANGLED STRAIGHT SECTION (FT.)			14.95
ELEVATION DIFFERENCE BETWEEN BASE AND STREET (FT.)			0.50
ELEVATION DIFFERENCE BETWEEN BASE AND END OF ARM (FT.)			24.51
DEVICE NUMBER 1			3-12" SIGNAL (AB)
DEVICE NUMBER 2			3-12" SIGNAL
DEVICE NUMBER 3			3-12" SIGNAL
DISTANCE TO DEVICE (FT.) FROM END OF ARM	0.30	10.00	20.00
CLEARANCE UNDER DEVICE (FT.)	19.00 (AB)	19.00	19.00

Figure 9-2 Example Mast Arm Clearance Calculations

If an adjustable bracket (“AB”) for a device is determined to be needed to maintain proper clearances without using excessively long pipe tenons, it should be noted in the clearance calculations for that device. Figure 9-2 shows “Device Number 1” as an example of noting an adjustable bracket mounting.

9.3 WIRING PLAN SHEET

A separate Wiring Plan sheet should be provided for all new or modified signals, showing a simplified representation of poles, equipment, conduit, and controller. The Wiring Plan serves as a “clean” version of the Signal Plan, and provides the necessary details to a contractor for wiring the signal.

The wiring sheet should detail the number and types of wires/cables in each conduit run, along with the size of each conduit. Signal heads and equipment should be shown graphically to detail the type of indication and associated phase, and should show the type of control cable or wire going to each device. Vehicle and pedestrian signals should be numbered to match the numbering provided on the Signal Plan sheet (see Figure 5-1).

In addition to a plan view representation of the intersection wiring, the Wiring Plan sheet should include details for each of the pole terminal cabinets or signal pedestals where "daisy chaining" of signal wiring takes place.

Figure 9-3 shows an example of the wiring plan layout for the typical intersection represented in Figure 5-1 above.

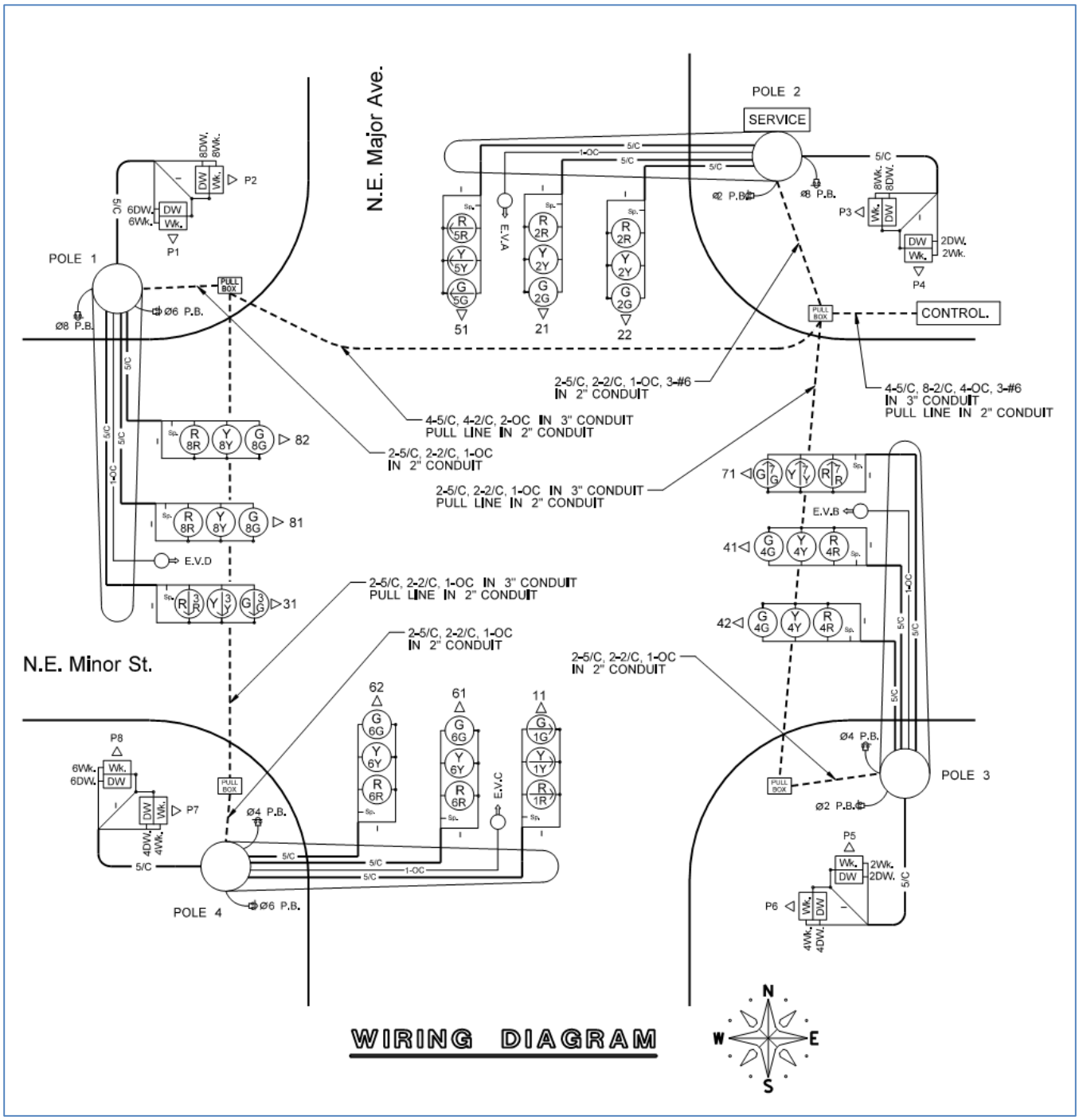


Figure 9-3 Example Wiring Diagram Layout

Figure 9-4 shows an example of the pole terminal cabinet detail to be provided on the Wiring Plan sheet. The example represents the terminal cabinet on Pole 1 shown in Figure 9-3.

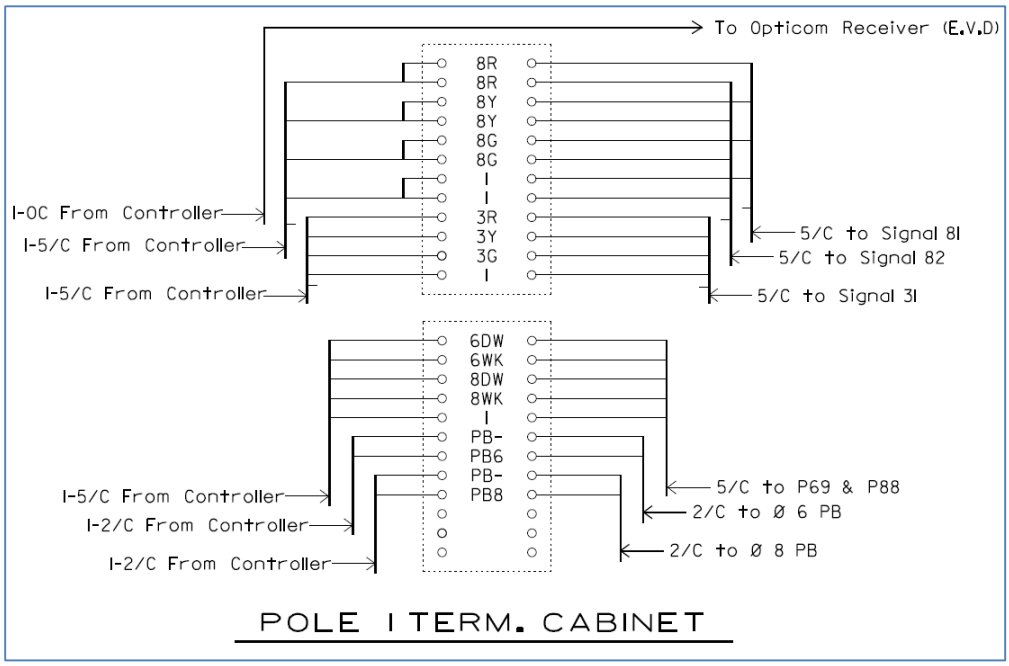


Figure 9-4 Pole Terminal Cabinet Detail

The PBOT Microstation cell library contains the standard symbology to be used for the Wiring Plan sheet.

9.4 POLE ELEVATION DRAWINGS

Where significant overhead utilities exist that may conflict with the placement of poles or mast arms, or conflict with signal head visibility, additional pole elevation details may be required. These details should be based on the specific pole geometry based on standard drawings, and should rely on surveyed overhead utility locations. See Figure 9-5 for an example of a pole elevation detail.

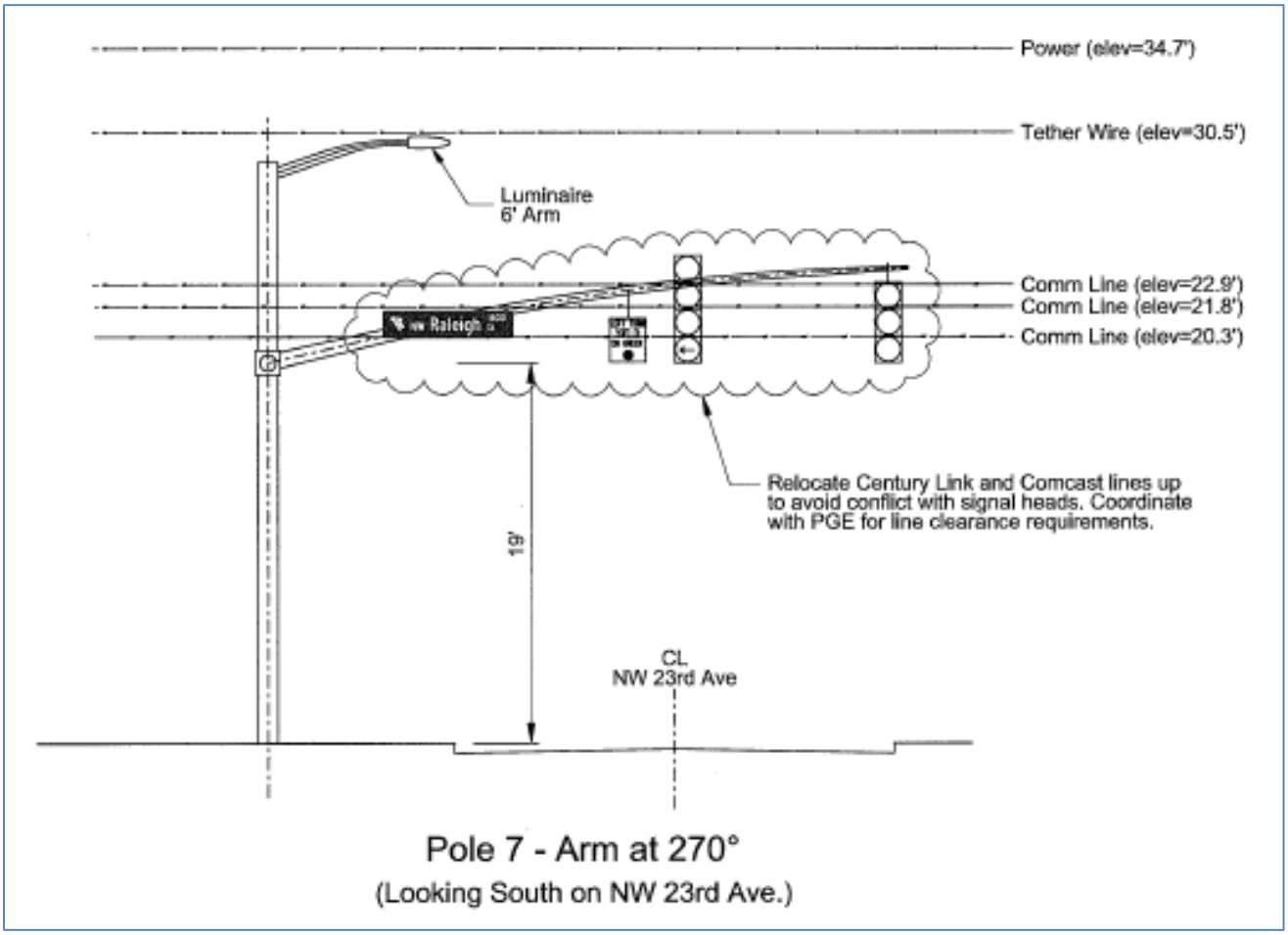


Figure 9-5 Example Pole Elevation Detail

10 REMOVALS

See Chapter 10 of the ODOT *Traffic Signal Design Manual* for guidance on when a removal plan is required, and what information should be provided. Use PBOT standard drafting practices for the removal sheet.

For most signal modifications that are not removing or replacing all signal poles, the removals can usually be shown on the Signal Plan, rather than providing a separate Removal Plan. Where all, or a significant number, of the poles or conduit runs will be removed and/or replaced, a Removal Plan should be provided.

The traffic signal legend code in Appendix B includes the appropriate callout symbols and legend text for removals.

Appendix A
Plan Requirements and Drafting Standards

PLAN SETS

Information to be included in traffic signal and street lighting plan sets is outlined below. The plan sheet requirements outlined generally follow how they would be ordered in the set, beginning with the Notes and Legend sheet. Signal Plans should be numbered TS-1, TS-2, TS-3, etc. Street Lighting Plans should be numbered IL-1, Il-2, IL-3, etc.

- General (all sheets):
  - ☐ PBOT Standard title block with applicable signature approval lines including SSL PBOT Principal Engineer PE number under approval signature (53882PE)
  - ☐ Intersection ID # in title block (signal plans only) – if new signal, PBOT will provide the intersection ID.
  - ☐ Review stamp with date (if not final)

Traffic Signal Plans

- Notes and Legend sheet
  - ☐ Signal, Interconnect and Street Lighting Legend, as applicable (see Appendix B)
  - ☐ General Notes (request these from the SSL District Engineer as they are design specific)
  - ☐ List of applicable PBOT and/or ODOT Standard Drawings
- Signal Plan – See Chapter 5
  - ☐ 1”=10’ scale at full size (22”x34”)
  - ☐ Included base drawing info (curb, sidewalk, striping, signal equipment excluding loops, utilities, etc.)
  - ☐ Centerline and stationing (or dimension pole location from curb lines)
  - ☐ Standard signal equipment and labeling symbology from CADD Cell library
  - ☐ Pole numbering convention – See bellow
  - ☐ Signal head, pedestrian signal head numbering – See bellow
  - ☐ Phase diagram
  - ☐ Pole entrance chart – See Chapter 9
  - ☐ North arrow and scale bar
  - ☐ Lane use arrows, including bike lanes and bike paths (diagonal movements from trails)
  - ☐ Mast arm clearance calculations (or on Notes and Legend sheet or separate detail sheet if space is constrained) – See Chapter 9
  - ☐ Street name sign details (or on Notes and Legend sheet if space is constrained)
- Detection Plan – See Chapter 6
  - ☐ 1”=20’ scale at full size (22”x34”), unless directed otherwise
  - ☐ Included base drawing info
  - ☐ North arrow
  - ☐ Scale bar
  - ☐ Show striping, stop bars, bike lane stencils from striping plan
  - ☐ Any necessary loop placement details, if not standard
  - ☐ Detection for all modes (vehicle, pedestrian, bicycle, railroad, light rail, streetcar, etc.)

  - ☐ Detection diagrams (loop wiring, etc.)
- Wiring Plan – See Chapter 9
  - ☐ Wiring Diagram using standard PBOT symbols from CADD Cell library
  - ☐ Pole terminal cabinet diagrams
  - ☐ Street names
  - ☐ North arrow
- Interconnect/ITS Plan – See Chapter 7
  - ☐ 1”=40’ scale at full size (22”x34”), unless directed otherwise
  - ☐ Splice diagrams
  - ☐ Included base drawing info
  - ☐ North arrow
- Plan Details – See Chapter 9
  - ☐ Add sheets to the set as necessary, to include non-standard details or to fit information that will not fit on the signal or detection sheet because of space constraints.
  - ☐ Pole elevation drawings – may be needed where overhead utilities constrain the location of the pole and/or mast arm, and additional detail is needed to ensure proper clearances are provided.
- Removal Plan
  - ☐ See Chapter 10
  - ☐ Standard signal equipment and labeling symbology from CADD Cell library

Street Lighting Plans

- Notes and Legend sheet
  - ☐ Street Lighting Legend, including legend of street lighting symbols.
  - ☐ General notes (request these from the SSL District Engineer as they are design specific).
  - ☐ Typical street light pole placement and wiring detail (if applicable).
  - ☐ List of applicable PBOT and/or ODOT Standard Drawings.
- Street Lighting Plan
  - ☐ 1”=20’ scale at full size (22”x34”)
  - ☐ Included base drawing info (curb, sidewalk, striping, signal poles, utilities, etc.). Distinguish between existing and proposed roadway, curb, sidewalk and other features using grayscale for existing features.
  - ☐ Show existing and proposed (as applicable) street light poles, conduit routing, pull boxes, and service panels using PBOT standard symbols from the CADD cell library. Identify the power source location from the utility company.
  - ☐ Use PBOT standard symbols to identify poles, conduits, conductors, panels, photocell location, etc. on plan sheet.
  - ☐ Identify tree type for all trees located closer than 25’ from lights (this can be provided separately on a civil or landscape plan).
  - ☐ Centerline and stationing (or dimension pole location from curb lines).
  - ☐ North arrow and scale bar.

- Street Lighting Details
  - ☐ Street lighting service panel schematic wiring diagram (also required if adding or modifying circuits in an existing service panel).
  - ☐ Street lighting circuits schematic diagram(s).
  - ☐ Street Light Pole Table, when required for clarity. Includes pole locations (station/offset), pole and fixture type, mounting height, foundation detail, notes, and other applicable information as necessary.

DRAFTING STANDARDS

PBOT maintains CADD Cell libraries which include standard signal and street lighting symbols, details, CADD annotation bubbles, and standard signal and street lighting legend text. Contact the SSL Division Engineer for information on obtaining the CADD Cell libraries.

Plan views that include both existing and proposed equipment should differentiate between the two by differing the lineweights. Proposed equipment and conduit should be shown "bold", while existing equipment and conduit runs should be shown with a lesser lineweight. Existing curbs, sidewalks, utilities, and other roadway features should be shown in a greyscale to reduce visual clutter.

Plan callout bubbles should be organized on the plan sheet in a manner that best reduces visual clutter. Bubbles organized in vertical lines on either side of the plan view help create a more legible plan. Bubbles should not overlap with other linework, and leader lines should be provided such that it is clear what plan elements they are pointing to. Leader lines should not cross.

Text and Dimensions

In the days of hand drafting, text was placed by a dedicated drafter with either excellent hand writing, or with aide of a Leroy Lettering Set. A single font and only a few text heights were available.

These days, computer programs supply a variety of font resource files and an infinite possibility of text heights. To make Signals and Street Lighting drawings consistent, PBOT has standardized on MicroStation Font 001 (the AutoCAD equivalent is Romans.shx font) with and minimum text height of 0.08 inches high when plotted half size. Uppercase letters should be used except in instances where lengthy paragraphs are placed. One exception to this standard is for street names which should be in italics (slant of 10° - 15°) with a text height of 0.125 inches when plotted half size.

Dimensions should use an Open Arrow and the size of the dimensions should follow the minimum text height for the page.

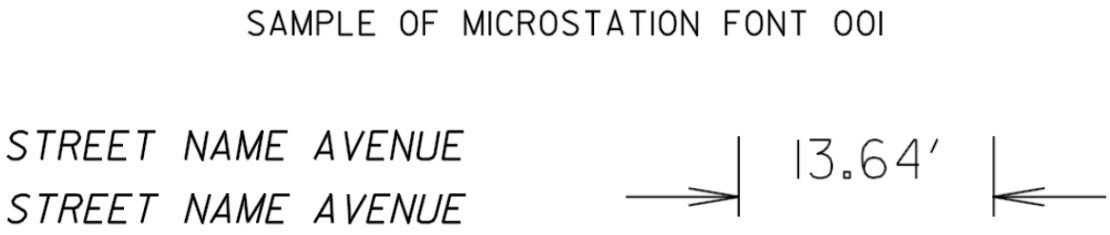


Figure A-1 Examples of Text and Dimensions

Signal Head and Pole Numbering

PBOT standard practice is to number vehicle and pedestrian signal heads on the plan, which are referenced to the wiring diagram and terminal cabinet details elsewhere in the plan set. Figure A-1 below illustrates the typical intersection movement numbers and signal head numbering convention for PBOT signals.

Signal poles, including pedestrian signal poles, pushbutton pedestals, and street light poles powered by the signal service, are numbered as shown in Figure A-2.

When numbering poles, signal heads, etc., on plan sheets, the numbering generally begins in the northwest corner of the intersection and proceeds clockwise around the intersection.

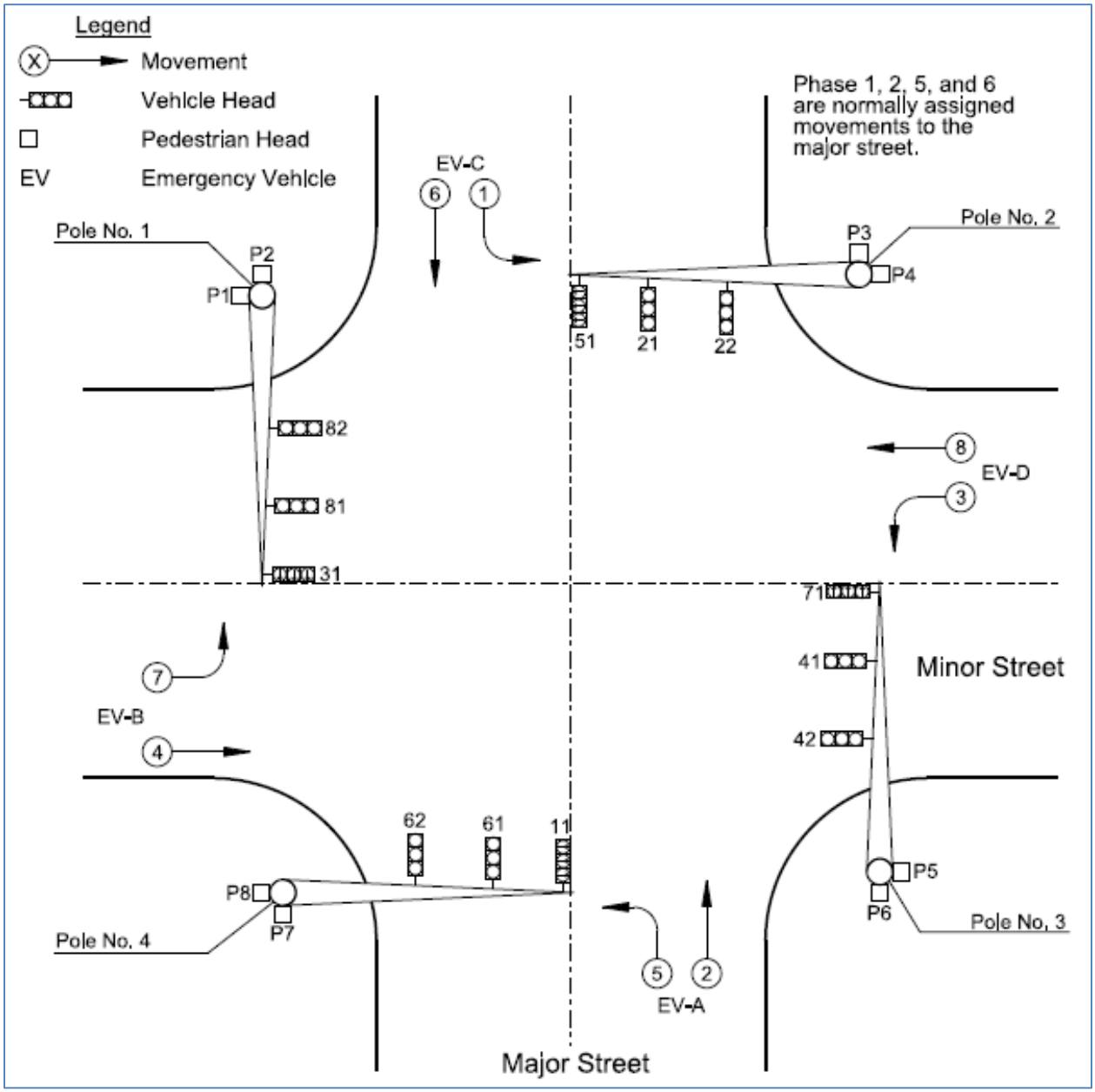
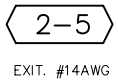
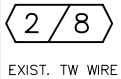
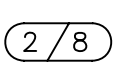
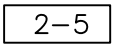
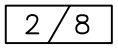
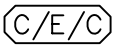


Figure A-2 Typical Intersection Movements and Signal Head Numbering

Appendix B
PBOT CADD Symbols and Signal Legend

(NOT TO SCALE) REV. 4/04/2007

PLAN CELL LIBRARY LIST

	1	2	3	4	5	6	7	8	9	10	
1	 EXISTING	 EXISTING	 EXIST. CONDUIT	 EXIT. #14AWG AC=PL04	 EXIST. TW WIRE AC=PL05	 INSTALL	 INSTALL	 INST. CONDUIT	 INSTALL	 INSTALL AC=PL10	10
11	 INSTALL	 REMOVE	 REMOVE	 REMOVE	 REVISE	 REVISE	 REVISE AC=PL17	 SONIC DET. AC=PL18	 MICRO. DET. AC=PL19	 6' LOOP AC=PL20	20
21	 L.T.YIELD SIGN AC=PL21	 AC=PL22	 AC=PL23	 AC=PL24	 AC=PL25	 AC=PL26	 AC=PL27	 AC=PL28	 L.TURN SIGNAL AC=PL29	 AC=PL30	30
31	 AC=PL31	 AC=PL32	 AC=PL33	 AC=PL34	 AC=PL35	 AC=PL36	 AC=PL37	 AC=PL38	 AC=PL39	 AC=PL40	40
41	AC=PL41	12–12–12	12–12–8	12–8–8	8–12–12	8–8–12 AC=PL46	8–8–8 AC=PL47	12–12–12/A	12–12–12PVS	12–12–12PVS/A	50
51	4–12" PVS	8" Y Flash AC=PL53	12" Y Flash AC=PL54	8" R Flash AC=PL55	12" Y Flash AC=PL56	SIGN	DOGHOUSE	OPTICOM AC=PL58	12–12–8Yf	8–8–8Yf AC=PL60	60
61	QUADRIPOLE	4' LOOP	6' LOOP	PULLBOX A AC=PL64	PULLBOX B AC=PL65	STEEL POLE AC=PL66	WOOD POLE AC=PL67	CONTROL. 337 AC=PL68	CONTROL. 332 AC=PL68	PED. ROUND AC=PL68	70
71	PED. ROUND AC=PL71	FIRE SIGNAL AC=PL72	PED. SQUARE AC=PL73	12R–12Y–12Yf–12G AC=PL75	PED. SQUARE AC=PL75	PEDESTRIAN NEON AC=PL76	PED. NEON AC=PL77	TRAFFIC CAMERA AC=PL78	NEON PED./SIGN AC=PL79	NEON PED./SIGN AC=PL80	80
81	POWE. MANHOLE	DRINK. FOUNTAIN AC=PL82	TELEPHONE AC=PL83	SLP & TRAIN AC=PL84	ORNAMENTAL STREET L. POLE	PIPE POST AC=PL86	FIRE HYDRANT AC=PL87	FIRE ALARM/PP AC=PL88	SIDEWALK RAMP AC=PL89	STREET LIGHT AC=PL90	90
91	TREE, DECIDUOUS	TREE EVERGREEN AC=PL92	MASTARM POLE AC=PL93	MAST ARM/SLP	THRU ARROW AC=PL95	LEFT TURN AC=PL96	T/L ARROW AC=PL97	DIAMOND SIGN AC=PL98	BIKE SIGN AC=PL99	DIMENS. ARROW AC=PL_100	100
101	PHASE	PH. ROTATION AC=PL102	SIGNALIZATION AC=PL_103	DETECTOR AC=PL_104	DIMENSION PLAN AC=PL_105	REMOVAL PLAN AC=PL_106	WIRING DIAGRAM AC=PL_107	INDEX OF SHEET AC=PL_108	POLE ORIENTATION AC=PL_109	POLE ENTRANCE AC=PL_110	110
111	MAST ARM CALCULA.	POLE ENTRANCE AC=PL_112	8R–8Y–12GTA AC=PL_113	8R–8Y–12GLA AC=PL_114	P.P.D DETECTOR AC=PL_115	P.M.S DETECTOR AC=PL_116	LIGHT RAIL SIG. AC=PL_117	TRAIN ONLY AC=PL_118	NORTH AC=PL_119	HAWK SIGNAL AC=PL_120	111
121	RED LIGHT VIOL. AC=PL_121	RED L. CAMERA AC=PL_122	RED L. PHOTO AC=PL_123	CONTRUCT. NOTE AC=PL_124	12R–8Y–8G–12GLA AC=PL_125	BIKE–PED SIGN AC=PL_126	ROAD STRIP. TAG AC=PL_127	GENERIC REF. SIGN AC=PL_128	KEYNOTE DIAM.TAG AC=PL_129	TRAFFIC SIGNAL STATION DATA AC=PL_130	121
	LOOP DIAGRAM AC=L	1 – LOOP AC=L01	2 – LOOP AC=L02	3 – LOOP AC=L03	4 – LOOP AC=L04	2 – 2 LOOP AC=L05	3 – 2 LOOP AC=L06	1(U) & 1(L) LOOP AC=L07	2(U) & 2(L) LOOP AC=L08	BIKE SIGNAL AC=PL_131	

WORKING UNIT : FT, INCH, 12, 1000

SIGNALIZATION : ELEMENT, CELLS, FILE, ATTACH, T:\PDOTNT\Ustation, CELLIBS, CELL LIBRARIES–SSL (MicroStation Cell, All File)
SIG_PLAN.cel., SIG_WIRING.cel, STL_PLAN.cel, LEGEND.cel or DETAIL.cel (NOT Use Shared Cells)
RC = SIG_PLAN.cel, AC = PL(Number), AC = PL_(Number) or AC=L, AC=L(Number)

SCALE: 1 = 1–00 OR 1 = 3–00

WIRING DIAGRAM CELL LIBRARY LIST

	1	2	3	4	5	6	7	8	9	10	
1	 AC=W1	 8"–8"–8"	 8"–8"–8"	 8"–8"–8"	 8"–8"–8"	 8"–8"–8"	 8"–8"–8"	 8"–8"–8"	 PED. P1 & P2	 PED. P3 & P4	10
11	 PED. P5 & P6	 PED. P1 & P2	 12"–8"–8"	 12"–8"–8"	 12"–8"–8"	 12"–8"–8"	 AC=WD17 12"–8"–8"	 AC=WD18 12"–8"–8"	 AC=WD19 12"–8"–8"	 AC=WD20 12"–8"–8"	20
21	 8"–8"–12"	 8"–8"–12"	 8"–8"–12"	 8"–8"–12"	 AC=WD25 8"–8"–12"	 AC=WD26 8"–8"–12"	 AC=WD27 8"–8"–12"	 AC=WD28 8"–8"–12"	 12"–12"–12"	 12"–12"–12"	30
31	 12"–12"–12"	 12"–12"–12"	 AC=WD33 12"–12"–12"	 AC=WD34 12"–12"–12"	 AC=WD35 12"–12"–12"	 AC=WD36 12"–12"–12"	 IN/OUT 3–12" PVS	 3–12" PVS	 IN/OUT 3–12" PVS	 3–12" PVS	40
41	AC=WD41 3–12" PVS	AC=WD42 3–12" PVS	AC=WD43 3–12" PVS	AC=WD44 3–12" PVS	AC=WD45 3–12" PVS/A	AC=WD46 3–12" PVS/A	AC=WD47 3–12" PVS/A	AC=WD48 3–12" PVS/A	RIGH ARROW.	SCHOOL CROSSWALK	50
51	AC=WD51 OPTICOM DETEC.	AC=WD52 STEEL POLE	AC=WD53 WOOD POLE	AC=WD54 PIPE POST	AC=WD55 UNMETER SERV.	AC=WD56 PULL BOX	AC=WD57 CONTROLLER	AC=WD58 CONDUIT	AC=WD59 STUB. CONDUIT	AC=WD60 10/C CONDUCTOR	60
61	AC=WD61 7/C CONDUCTOR	AC=WD62 5/C CONDUCTOR	AC=WD63 2/C CONDUCTOR	AC=WD64 OPTICOM CABLE	AC=WD65 LOOP LEAD	AC=WD66 SHIELD PAIR	AC=WD67 ARROW	AC=WD68 CURBLINE	DOGHOUSE SIG.	DOGHOUSE SIG.	70
71	TERM. CABINET	TERM. CABINET	TERM. CABINET	COLOR CODE	AC=WD75 8"–8"–12"A	AC=WD76 8"–8"–12"A	8"–8"–12"A	8"–8"–12"A	AC=WD79 12"A–12"A–12"A	AC=WD80 12"A–12"A–12"A	80
81	12"A–12"A–12"A	12"A–12"A–12"A	MICROWAVE D.	SONIC DETEC.	NEON PED.	NEON PED.	AC=WD87 PUSH BUTTON	AC=WD88 PUSH BUTTON	AC=WD89 ARROW	8"–8" TRAIN	90
91	SQUARE LENS	PED. ROUND	PED. SQUARE (SINGLE)	3–12" – 2–12"A	AC=WD95 12"–12"–8"	12–12–12YfA–12GA	AC=WD97 12–12–12YfA–12GA	12"–12"–8"f	12"–12"–8"f	12"–12"–8"	100
101	12"–12"–8"	12"–12"–8"	8"Y flash	AC=WD_104 8"R flash	12"R flash	AC=WD_106 12"Y flash	NORTH				110
111	CROSSWALK	BIKE & PERSON SIGN	AC=WD113 NO LEFT TURN	NO TURN ON R.	AC=WD95 LEFT ARROW	AC=WD_116 THRU & RIGHT	AC=WD_117 BIKE SIGNAL SIGN	AC=WD_118 BIKE	AC=WD_119 WIRING DIAGRAM	AC=WD_120 PED. ROUND	120

WORKING UNIT : FT, INCH, 12, 1000

SIGNALIZATION : ELEMENT, CELLS, FILE, ATTACH, T:\PDOTNT\Ustation, CELLIBS, CELL LIBRARIES (ALL FILE)

SIG_WIRING.cel, SIG_PLAN.cel, STL_PLAN.cel, LEGEND.cel or DETAIL.cel (NO Use Shared Cells)

RC = SIG_WIRING.cel, AC = WD(NUMBER) or AC = WD_(NUMBER)

RC = LEGEND.cel, AC = (Number)S or (Number)L

RC = DETAIL.cel, AC = D (Number) or Detail Name

SCALE: 1 = 1–00 or 1 = 3–00

(NOT TO SCALE) REV.4/04/2007

Appendix C
Signals and Street Lighting Early Assistance Checklists

Public Works Permitting
Signals Design Report

Early Assistance / Inquiry Meeting

- ☐ Identify scope of work required
  - ☐ All Signals – provide info as required
    - ☐ Identify Phasing
    - ☐ Identify phase rotation
    - ☐ Should street lights be added or replaced?
    - ☐ Opticom required?
    - ☐ Interconnect requirements
    - ☐ Will painting of poles be required?
    - ☐ Detection required
  - ☐ Remodeled signals only
    - ☐ Provide record drawings to consultant
    - ☐ Identify scope of remodel
      - ☐ How much is shown on the plans?
      - ☐ Are any materials reusable?
      - ☐ Which materials need to be returned to Albina Yard?
  - ☐ Special design considerations
    - ☐ Temporary signals
    - ☐ Unique pedestrian and bicycle facilities
    - ☐ Light rail or streetcar issues
    - ☐ Transit pre-emption
    - ☐ Rail pre-emption
    - ☐ Other_____
- ☐ Identify required sheets
  - ☐ Signalization Plan
  - ☐ Detection Plan
  - ☐ Wiring Diagram
  - ☐ Removal Plan
  - ☐ Loop Diagram
  - ☐ Standard Details
- ☐ Identify other elements required on plan set
  - ☐ Pole Entrance Chart
  - ☐ Mast Arm Clearance Calculations
  - ☐ Color Code
  - ☐ Wiring at Terminal cabinets and Pole bases
- ☐ Identify where consultant can find information on PBOT design standards, details, typical notes, sample plan sheets, etc…
- ☐ Identify any materials that will be provided by PBOT
- ☐ Address any other items requested by consultant

Public Works Permitting
Street Lighting Design Report

Early Assistance / Inquiry Meeting

- ☐ Option B
  - ☐ Direct consultant accordingly.
- ☐ Option C - Design District
  - ☐ Identify design district / standards
  - ☐ Identify specific pole, mast arm length (when applicable), and fixture
  - ☐ Identify spacing or layout requirements
    - ☐ Patterned District
    - ☐ Not Patterned District
  - ☐ Will photometric analysis be required?
  - ☐ Identify color if painted district
- ☐ Option C - Not a Design District
  - ☐ Identify options for poles and fixtures
  - ☐ Identify design lighting levels and uniformity
  - ☐ Photometric analysis required?
  - ☐ Identify Pole finish
- ☐ Is an existing Option B system impacted?
  - ☐ PGE disconnects power, contractor to remove pole and repair S/W
- ☐ Provide direction on existing on-site materials:
  - ☐ Which materials will be reusable on-site by contractor
  - ☐ Which materials should be delivered to Albina Yard.
- ☐ Identify availability (or lack of) existing power source (panel) for project.
- ☐ Identify any spacing requirements:
  - ☐ Between lights and trees
  - ☐ Between lights and top of driveway wings (5’ minimum)
- ☐ Identify where consultant can find information on PBOT design standards, details, typical notes, sample plan sheets, etc…
- ☐ Are off-site improvements required?
- ☐ Are there signal impacts?
- ☐ Address any other items requested by consultant

Appendix D
Signal and Street Lighting Design Checklists

Public Works Permitting

Concept Development (30%)

Requirements – Signals Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

Permit No.	Project/Improvement Name	
Engineer of Record	Phone	Email

SIGNALS DESIGN / DRAFTING REQUIREMENTS:

Req'd	Done	
☐	☐	Show proposed lights, driveways, hydrants, trees, vaults, and other physical features that impact the placement of signal poles, controllers, and conduits on signal sheets.
☐	☐	Identify any vaulted sidewalk areas (new and existing)
☐	☐	Identify any overhead obstructions (such as canopies) that may impact pole placement
☐	☐	Identify Phasing and Phase rotation
☐	☐	Show proposed placement of major signal components on plans o All Poles o Controller
☐	☐	Additional Comments:

I acknowledge that I have addressed all above, applicable items:

_____ _____

Engineer Signature *Date*

_____

Engineer Printed Name

COP Use Only

☐ Accepted

☐ Rejected By:_____ Date:_____

If rejected Manager Signature:

Reason for Rejection:

Public Works Permitting

Design Development (60%)

Requirements – Signals Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

Permit No.	Project/Improvement Name	
Engineer of Record	Phone	Email

SIGNALS DESIGN / DRAFTING REQUIREMENTS:

Req'd	Done	
☐	☐	Address all comments from 30% design level
☐	☐	Use standard engineering scale (typically 1"=10' or 1"=20') for full size (22"x34") Signal drawings.
☐	☐	Provide Signalization Plan / Dimension Plan o All signal devices, signage, luminaire arms, sidewalk boxes o Phase diagram and rotation o Interconnect drawings o Special notes as required o Pole entrance chart o Mast arm clearance calculations
☐	☐	Provide Detection Plan o Show and dimension all loop locations o Loop wiring diagram o Phase diagram (matching that on Signal sheet) o Notes as applicable
☐	☐	Provide Wiring Diagram o Schematic showing wiring of all components o Detailed wiring at each terminal cabinet and pole base o Color code
☐	☐	Provide Removal Diagram
☐	☐	Connect the 'dots' (signal poles, controller, panel, sidewalk boxes, etc.) showing proposed conduit routing between sidewalk boxes and each pole.
☐	☐	Use PBOT standard symbols to identify poles, conduits, conductors, panels, etc. on plan sheet.
☐	☐	Provide legend that matches symbols used on drawing; do not include symbols that are not used.
☐	☐	Identify power source for new panels: o Provide utility junction box adjacent to panel o Identify PGE/PP&L work request number
☐	☐	Verify pole foundation types and provide supporting materials o PBOT Standard Foundations (areas without underground conflicts) o Special Design (vaulted areas) o Provide Proposed design detail o Provide supporting calculations stamped and signed by an Engineer
☐	☐	Additional Comments:

Public Works Permitting

Design Development (60%)

Requirements – Signals Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

I acknowledge that I have addressed all above, applicable items:

_____ _____

Engineer Signature *Date*

_____

Engineer Printed Name

COP Use Only
☐ Accepted ☐ Rejected By:_____ Date:_____ If rejected Manager Signature:
Reason for Rejection:

Public Works Permitting

Plan Review (90%)

Requirements – Signals Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

Permit No.	Project/Improvement Name	
Engineer of Record	Phone	Email

SIGNALS DESIGN / DRAFTING REQUIREMENTS:

Req'd	Done	
☐	☐	Address all comments from the 30% and 60% review level
☐	☐	Provide Standard Drawings and Special Details
☐	☐	Title Block (signal sheets only) – top signature line is "Division Manager" #53882, and bottom signature line is "City Engineer" #51538, unless directed otherwise.
☐	☐	Provide special provisions and signature sheet
☐	☐	Additional Comments:

I acknowledge that I have addressed all above, applicable items:

_____ _____

Engineer Signature *Date*

_____

Engineer Printed Name

COP Use Only

☐ Accepted

☐ Rejected By:_____ Date:_____

If rejected Manager Signature:

Reason for Rejection:

Public Works Permitting

Final Plans (100%)

Requirements – Signals Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

Permit No.	Project/Improvement Name	
Engineer of Record	Phone	Email

SIGNALS DESIGN / DRAFTING REQUIREMENTS:

Req'd	Done	
☐	☐	Address all comments from 30%, 60%, and 90% review level.
☐	☐	Finalize special provisions and signature sheet
☐	☐	Provide electronic copy (DWG or DGN) of lighting sheets on CD
☐	☐	Additional Comments:

I acknowledge that I have addressed all above, applicable items:

_____ _____

Engineer Signature *Date*

_____

Engineer Printed Name

COP Use Only

☐ Accepted

☐ Rejected By:_____ Date:_____

If rejected Manager Signature:

Reason for Rejection:

Public Works Permitting

Concept Development (30%)

Requirements – Street Lighting Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

Permit No.	Project/Improvement Name	
Engineer of Record	Phone	Email

STREET LIGHTING DESIGN / DRAFTING REQUIREMENTS:

Option B Systems – City Owned / Utility Maintained

Req'd	Done	
☐	☐	Show all existing utility poles on, across from, and near impacted frontages and identify any existing lighting.
☐	☐	Identify if utilities will be overhead or underground (so lighting options can be identified at the 30% meeting).

Option C Systems – City Owned/City Maintained

Req'd	Done	
☐	☐	Pole type and placement identified correctly on plans (patterned district)
☐	☐	Vaulted sidewalk areas (new and existing) clearly identified

All Lighting Systems

Req'd	Done	
☐	☐	Photometric analysis demonstrating target lighting levels and uniformity are met (generally for new subdivisions, streets, and atypical lighting designs). o Photometric analysis and pole layout on plans to match o Provide printed version of all inputs and outputs using analysis software. o Provide average horizontal illuminance level (footcandles) o Provide uniformity ratios (avg:min and max:min) o Provide output drawing showing illuminance levels point-by-point
☐	☐	Additional Comments:

I acknowledge that I have addressed all above, applicable items:

_____ _____

Engineer Signature *Date*

_____

Engineer Printed Name

COP Use Only

☐ Accepted

☐ Rejected By:_____ Date:_____

If rejected Manager Signature:

Public Works Permitting

Concept Development (30%)

Requirements – Street Lighting Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

Reason for Rejection:

Public Works Permitting

Design Development (60%)

Requirements – Street Lighting Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

Permit No.	Project/Improvement Name	
Engineer of Record	Phone	Email

STREET LIGHTING DESIGN / DRAFTING REQUIREMENTS:

Option B Systems – City Owned / Utility Maintained

Req'd	Done	
☐		For areas with underground utilities, identify choice of lighting system:
	☐	o Wood Utility Poles (lighting Installation by PGE, contractor coordinated)
		o Other PGE type from PGE standard materials list (contractor installs pole, arm fixture, and lamp. PGE installs underground system).
	☐	o Fiberglass Poles _____
	☐	o Aluminum Poles _____
☐	☐	Provide notes specific to installation of Option B lighting system (typically shown on Civil Sheets).
☐	☐	Identify all existing and proposed mast arms and luminaires on existing wood utility poles and proposed 'Street Light Only' SLO poles.

Option C Systems – City Owned / City Maintained

Req'd	Done	
☐	☐	Show lighting work on separate lighting sheets.
☐	☐	Use standard engineering scale (typically 1"=20') for full size (22"x34") lighting drawings.
☐	☐	Use PBOT standard symbols to identify poles, conduits, conductors, panels, etc. on plan sheet.
☐	☐	Provide legend that matches symbols used on drawing; do not include symbols that are not used.
☐	☐	Identify tree type for all trees located closer than 25' from lights (this can be on a civil or landscape plan).
☐	☐	Provide a sidewalk box in the furnishing zone adjacent to every light unless approval to omit them has been granted.
☐	☐	Connect the 'dots' (lights) showing conduit routed between sidewalk boxes and each pole. Preferred conduit routing is under the sidewalk (outside of tree wells), typically 24" from back of sidewalk. Alternate location is in street.
☐	☐	Provide voltage drop calculations using City approved method and one-phase system.
		o Size wire such that a maximum voltage drop of 3% is not exceeded.
		o Minimum allowable wire size is #10awg and maximum is #2awg.
☐	☐	Identify photocell location, and provide power using 3-#10awg conductors
☐	☐	Identify power source
☐	☐	For new panels:
		o Provide utility junction box adjacent to panel
		o Size the panel appropriately
		▪ 100A panel is connected with 3 - #2awg
		▪ 60A panel is connected with 3 - #6awg
		▪ 20 A panel (Type A only) is connected with 3 - #8awg

Public Works Permitting

Design Development (60%)

Requirements – Street Lighting Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

		○ Verify load on each breaker is less than 80% of rated size
		○ Provide panel schematic specific to project
☐	☐	Identify PGE/PP&L work request number and contact person
☐	☐	Provide pole charts (when required for clarity)
☐	☐	Verify pole foundation types and provide supporting materials
		○ PBOT Standard Foundations (areas without underground conflicts)
		○ Special Design (vaulted areas)
		○ Provide Proposed design detail
		○ Provide supporting calculations stamped and signed by an Engineer
☐	☐	Select and add special street lighting notes as applicable to plans
All Lighting Systems		
☐	☐	Address all comments from 30% design level
☐	☐	Show proposed lights, driveways, hydrants, trees, vaults, and other physical features that impact the placement of lights, panels, and conduits on lighting sheets.
☐	☐	Identify lights to be removed by project
☐	☐	Additional Comments:

I acknowledge that I have addressed all above, applicable items:

_____ _____

Engineer Signature *Date*

_____

Engineer Printed Name

COP Use Only

☐ Accepted

☐ Rejected By:_____ Date:_____

If rejected Manager Signature:

Reason for Rejection:

Public Works Permitting

Plan Review (90%)

Requirements – Street Lighting Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

Permit No.	Project/Improvement Name	
Engineer of Record	Phone	Email

STREET LIGHTING DESIGN / DRAFTING REQUIREMENTS:

Option C Systems

Req'd	Done	
☐	☐	Title Block (lighting sheets only) – top signature line is "Division Manager" #53882, and bottom signature line is "City Engineer" #51538, unless directed otherwise.
☐	☐	Provide standard lighting details
☐	☐	Provide special provisions and signature sheet

All Lighting Systems

Req'd	Done	
☐	☐	Address all comments from the 30% and 60% review level
☐	☐	Additional Comments:

I acknowledge that I have addressed all above, applicable items:

_____ _____

Engineer Signature *Date*

_____

Engineer Printed Name

COP Use Only

☐ Accepted

☐ Rejected By:_____ Date:_____

If rejected Manager Signature:

Reason for Rejection:

Public Works Permitting

Final Plans (100%)

Requirements – Street Lighting Design & Drafting – for plan sets

Engineer of record to complete this form and sign. Submit with plans

Permit No.	Project/Improvement Name	
Engineer of Record	Phone	Email

STREET LIGHTING DESIGN / DRAFTING REQUIREMENTS:

Option C Systems

Req'd	Done	
☐	☐	Finalize special provisions and signature sheet
☐	☐	Provide electronic copy (DWG or DGN) of lighting sheets on CD

All Lighting Systems

☐	☐	Address all comments from 30%, 60%, and 90% review level.
☐	☐	Additional Comments:

I acknowledge that I have addressed all above, applicable items:

_____ _____

Engineer Signature *Date*

_____

Engineer Printed Name

COP Use Only

☐ Accepted

☐ Rejected By:_____ Date:_____

If rejected Manager Signature:

Reason for Rejection: