APPENDIX H. ROADWAY CROSSING DESIGN FOR BICYCLES

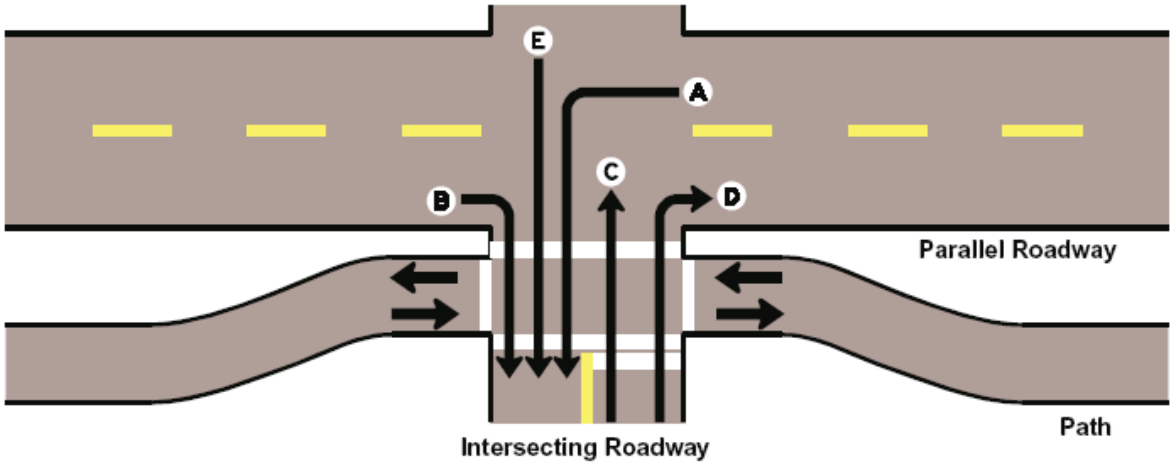
Traffic Control and Right-of-Way Assignment for Multi-purpose Trail Crossings

This section describes the policy on traffic control and right-of-way assignment for trail crossings. There are two primary categories of trail/roadway crossings. The first type of crossing is an intersection of two or more streets where the trail crosses at least one of the streets at the intersection. The second type of trail/roadway crossing is mid-block (e.g., typically at least 30 to 50 feet from an intersection).

Trail Crossings at Intersections

When trails cross roadways at intersections, the trail should generally be assigned the same priority as the parallel roadway. This applies at intersections with all types of traffic control. The AASHTO Bicycle Guide describes these types of intersections as "adjacent path crossings" (see figure H-1 below).

Figure H-1. Example of an adjacent path intersection depicting typical vehicle movements across the path



Source: AASHTO Guide for the Development of Bicycle Facilities, 1999

Signalized Intersections

At signalized intersections, if the parallel roadway has signals that are set to recall to green every cycle, the walk signals for the trail should also be set to recall to green. The walk interval should be maximized within the green interval:

WALK interval = Green Interval - Flashing Don't Walk Interval

Therefore, when the trail crosses the intersection parallel to a major street that has a long green interval, trail users will see WALK signals for a significant portion of each signal cycle. At locations where the parallel roadway has dedicated turn lanes, with protected signal turn phasing, the trail shall be given a red or don't walk signal during the protected phase to prevent conflicts between the trail and the turning vehicles. The trail signal should change to a walk or green signal as soon as the protected turn phase ends.

Where the parallel roadway is actuated, the trail crossing will also need to be actuated. For trail crossings, the minimum WALK interval should be 10 seconds. The USE PED SIGNAL sign (R9-5) should be used at trail crossings at signalized intersections. Countdown pedestrian signals should be installed at all signalized trail crossings as signal heads are replaced.

4-way Stop-controlled Intersections
Intersections with 4-way stops should generally be avoided. However, if trails cross at intersections with four way stops, additional stop signs should be added as needed to ensure that there is at least one appropriately-placed STOP sign at each trail approach.

Consideration should be given to removing stop signs for the trail and the parallel roadway leaving the intersection 2-way stop controlled for the intersecting roadway. An engineering study should be conducted before stop removing or adding any stop signs.

2-way Stop-controlled Intersections
At intersections with STOP signs controlling only one of the approaches, the trail should be assigned the same right-of-way as the parallel street. Stop signs should not be placed on the trail approaches to the intersecting roadway if the parallel street has no stop signs. The trail should have the same control as the parallel street.

If the two streets have the same roadway classification, and the stop signs face the intersecting street that is parallel to the trail, consideration should be given to reversing the stop sign placement, giving the right-of-way to the trail and the parallel street. Appropriate warning signs and markings should be placed on the trail and roadway.

Mid-block Trail Crossings

At mid-block trail crossings, traffic control should generally be one of the following:
- Traffic Signal
- Stop signs facing the trail
- Stop signs facing the roadway
- Yield signs facing the trail
- Yield signs facing the roadway

The decision of whether or not to use a traffic signal at a mid-block trail crossing should be primarily based on the installation criteria and procedures for pedestrian traffic signals found in SDOT's Director's Rule 04-01. All trail users (including bicyclists) should be included in calculating the "pedestrian volume" for the warrant procedure outlined in Rule 04-01. Since pedestrians are common trail users and they are generally the slowest trail users, the gap acceptance portions of the warrant procedure in Rule 04-01 should be used as well. When a trail crossing meets the warrants outlined in Rule 04-01, there may be other reasons why a signal is not necessary at the crossing. Engineering judgment should be applied in making the final decision of whether or not to install the signal.

Where a decision has been made not to install a traffic signal at a mid-block trail crossing, STOP or YIELD signs should be used to assign the right-of-way to the trail or the roadway. The assignment of priority at a shared-use path/roadway intersection should be assigned with consideration of the following:
- The relative importance of the trail and the roadway;
- The relative volumes of trail and roadway traffic; and

- The relative speeds of trail and roadway users.

The City of Seattle has four classifications of streets:
- **Principal Arterials**
- **Minor Arterials**
- **Collector Arterials**
- **Access Streets** (residential and commercial)

As part of the Seattle Bicycle Master Plan, two classifications of signed routes are proposed; regional signed routes and local signed routes. Major trails in the city will be included in the signed route system. As such, there are three proposed classifications for trails:
- **Regional Trails** (trails that are part of regional signed routes);
- **Local Through** Trails (trails that are part of the local signed route system); and
- **Minor Trails** (other trails including short connectors and trails in small parks).

The street and trail classifications described above make it possible to quantify the relative importance at each trail/roadway crossing. The following guidelines should be used to assign right-of-way.
- **Regional Trails** are effectively principal arterials for bicyclists, but trail user speed is generally lower than that on **Principal Arterial** streets. Therefore, **Regional Trails** should generally be given priority over **Minor Arterials, Collector Arterials,** and **Access Streets.** However, if the traffic volume on the street being crossed exceeds the traffic volume on the trail by 20% or more, the street should be given priority.
- **Local Through Trails** are like minor arterials for bicyclists, but trail user speed is generally lower than that on **Minor Arterial** streets. Therefore, **Local Through Trails** should generally given priority over **Collector Streets** and **Access Streets.** Again, if the traffic volume on the street being crossed exceeds the traffic volume on the trail by 20% or more, the street should be given priority.
- **Minor Trails** have roughly the same importance as Access Streets. Therefore, **Minor Trails** should normally not be given priority over any classification of **Arterial.** Where **Minor Trails** cross **Access Streets**, the priority should be assigned to the facility that has the most volume.

When new trails are built, they are often built in segments; so the trail user volume is low at first. Therefore, the right-of-way will likely need to be initially assigned to the streets that the trail crosses. However, as time goes on, the trail volumes will increase, perhaps changing the appropriate assignment of right of way. As such, trail/roadway crossings should be evaluated every few years to ensure that the right-of-way is assigned appropriately.

Pavement Markings
All trail crossing areas should be marked with a crosswalk according to the rules set forth in SDOT Director's Rule 04-01.

Advanced "TRAIL XING" word pavement markings should be utilized at all crossings where the trail crossing is determined to be unexpected.

Trail Warning Signs
All signs related to pedestrian/bicycle activity should be fluorescent yellow-green. It is recommended that the trail crossing warning sign be utilized at all trail crossings that are

uncontrolled for motorist. The crossing sign shall be supplemented with the downward arrow subplate (see Figure H-1).

Figure H-1. Trail Warning Signs

Advanced Warning Signs

It is recommended that the use of advanced warning signs be used at most crossing locations, especially those locations with restricted sight distance or areas where it is determined that the trail crossing would be unexpected. Advanced warning signs might not be used in highly urbanized situations where there are short blocks or where two or more marked crosswalks are close together. It is recommended that all advanced warning signs include the "distance ahead" subplate (W16-2a).

The subplates in Figure H-2 should be added to advanced warning signs.

Figure H-2. Advanced waning sign subplates.

Figure H-3. Example trail-roadway crossing with trail yield treatment

Selecting Appropriate Arterial Crossing Treatments for Bikeways

The following procedure should be used to select an appropriate crossing treatment when a minor street with a signed bike route or bicycle boulevard crosses an arterial street.

There are six possible design treatments that may result from this evaluation (see descriptions in previous section):

1. Mark crosswalk, no other improvements needed.
2. Curb extensions into the parking lane to narrow the crossing with for bicyclists (and pedestrians)
3. Raised median placed in center turn lane.
4. Raised median island created by tapering out the parking lane.
5. Traffic signal (possibly with curb extensions if on-street parking exists.
6. Raised island with 2-step traffic signal with off-set crosswalk markings (short section of sidewalk down the center of the median separates the crosswalks by at least 15 feet).

The set of charts below has been developed to assist the City in selecting the best crossing treatment for different types of roadway crossings. The following question should be used to determine which chart should be referenced:

QUESTION: How many travel lanes are being crossed?

- Two lanes, no center turn lane (see Chart 1)
- Two lanes, with center turn lane (see Chart 2) (note – a center turn lane can not be treated as a crossing island unless a formal crossing island is installed; without a crossing island, this is a three-lane arterial)
- Four or more lanes, undivided (see Chart 3)
- Four or more lanes, with continuous raised median or center turn lane (see Chart 4)

The charts require determining how many gaps in traffic are available for bicyclists to use to cross the roadway under [rush-hour conditions].

A crossable gap shall be calculated using the formula

W/10 + 6.5 + (n-1)2 = ___ Seconds

where *W* is the distance in feet from the curb, or the distance in feet from the curb to a raised refuge island (if the refuge island is a dependable source of protection). The value of 10 is the travel speed of slower bicyclists. The value of 6.5 includes 3 seconds of perception and reaction time in seconds plus 3.5 seconds which accounts for the length of a bicycle (6 feet) as well as acceleration time for a 10 mph cyclist who accelerates fairly slowly. The formula is based on the standard bicycle crossing time formula:

$$t_{cross} = t_r + v/2a + (w+l)/v$$

where:

- t_{cross} = time to cross the intersection
- t_r = reaction time (3 sec)
- v = bicyclist speed (mph) (10 mph to 20 mph)
- a = bicyclists acceleration (1.5 to 3 ft per second per second)
- w = width of crossing (ft)
- l = bicycle length (6 ft)

Chart 1: Two Lanes, No Center Turn Lane

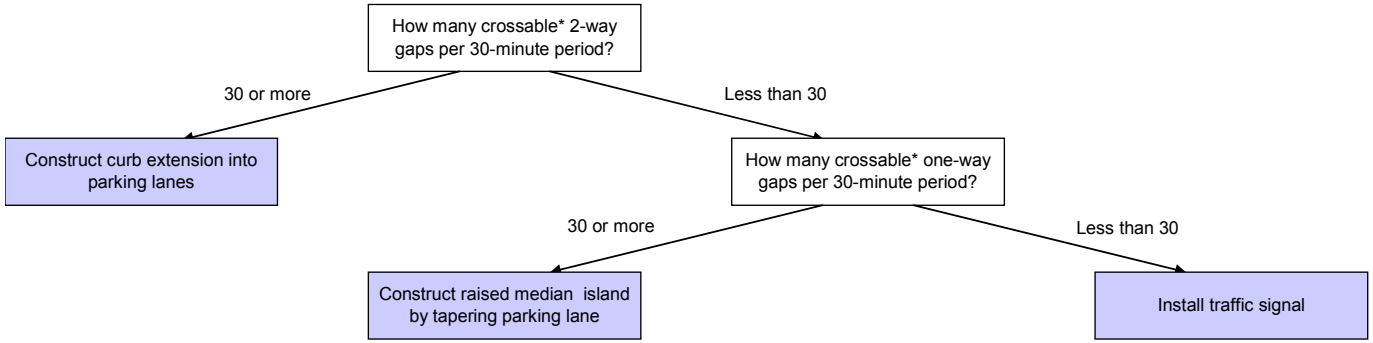
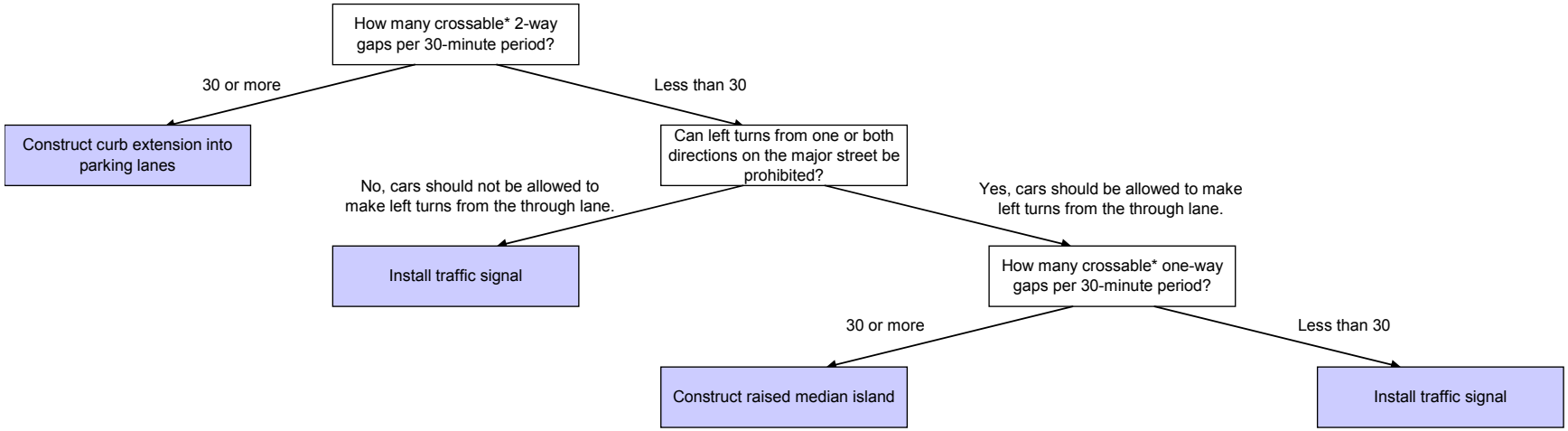


Chart 2: Two Lanes, With Center Turn Lane



*A crossable gap shall be calculated using the formula W/10 + 6.5 + (n-1)2 = ___ Seconds, where W is the distance in feet from the curb, or the distance in feet from the curb to a raised refuge island (if the refuge island is a dependable source of protection). The value of 10 is the travel speed of slower bicyclists. The value of 6.5 includes 3 seconds of perception and reaction time in seconds plus 3.5 seconds which accounts for the length of a bicycle (6 feet) as well as acceleration time for a 10 mph cyclist who accelerates fairly slowly.

Chart 3: Four or More Lanes, Undivided

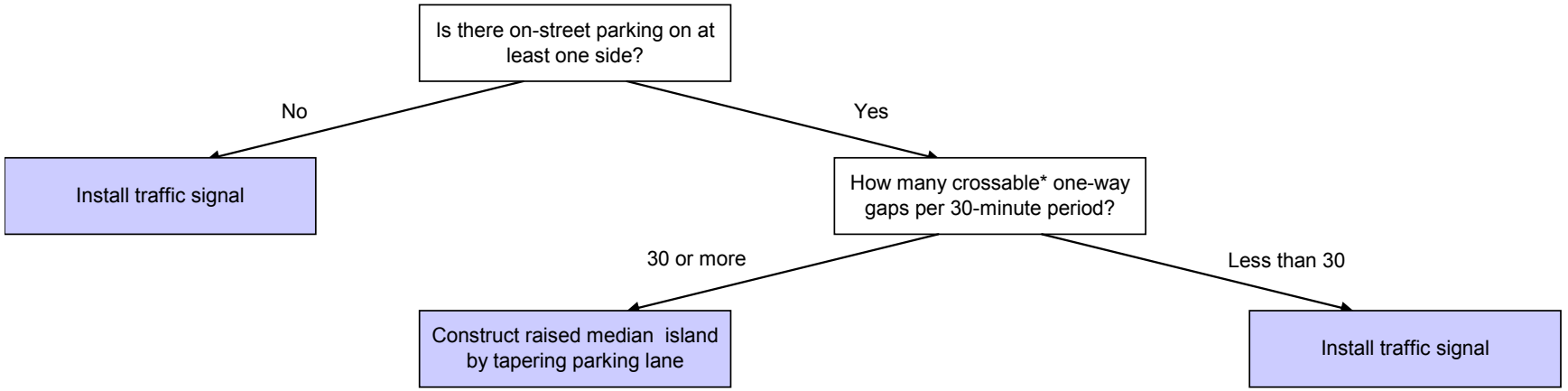
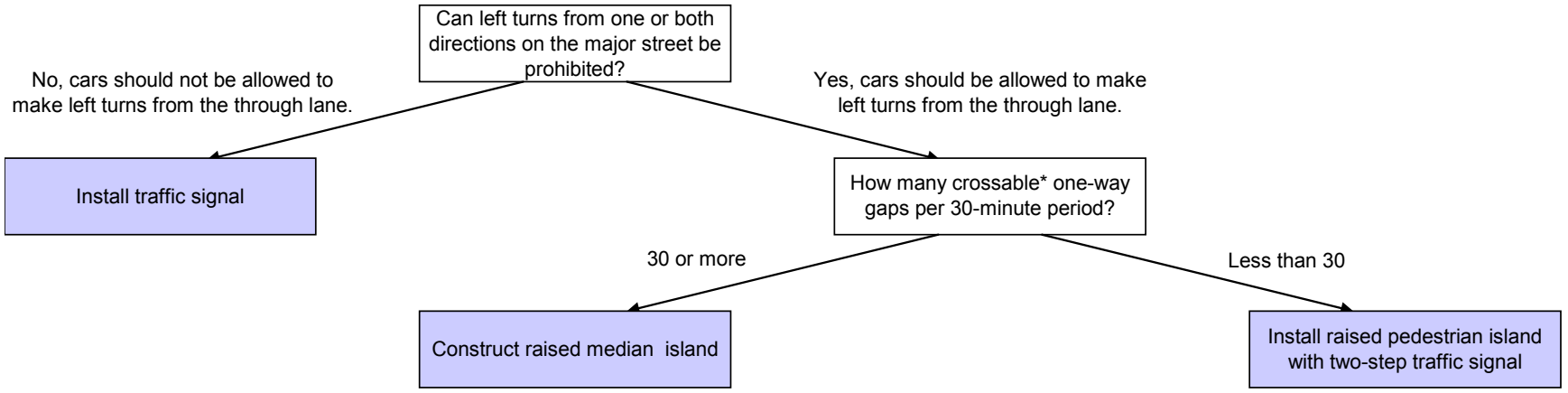


Chart 4: Four or more lanes, with continuous raised median or center turn lane



*A crossable gap shall be calculated using the formula W/10 + 6.5 + (n-1)2 = ___ Seconds, where W is the distance in feet from the curb, or the distance in feet from the curb to a raised refuge island (if the refuge island is a dependable source of protection). The value of 10 is the travel speed of slower bicyclists. The value of 6.5 includes 3 seconds of perception and reaction time in seconds plus 3.5 seconds which accounts for the length of a bicycle (6 feet) as well as acceleration time for a 10 mph cyclist who accelerates fairly slowly.