Appendix D: Bicycle, Pedestrian and Intersection Treatment Toolkit

As discussed in the main body of the master plan, a series of potential improvements that seek to create more walkable environments, both in between developments on Concord Pike as well as connecting to and within the surrounding neighborhoods. The following pages provide suggestions and illustrations of best practices for the development of walking and bicycling infrastructure throughout the study area. Also included are various possible treatments at signalized intersections to allow for striking a better balance between vehicular traffic and better non-motorized traffic movement.

It is worth noting that not all of the items in the toolkit are currently consistent with national or Delaware policies or manuals. Therefore some suggestions may need to be further researched or piloted prior to extensive implementation being considered.

SHARED USE PATHS

Shared use paths provide two-way travel for walking, bicycling, jogging and skating. They may be built independent from the road network or alongside a roadway.

Benefits

- Intended for shared use by a variety of groups, including pedestrians, bicyclists, scooters, and joggers.
- Physically separate users from motor vehicles.

Standard Dimensions

- Adequate widths to enable side-by-side travel and passing, typically at least 10 feet wide.
- Separation of modes in areas with existing or anticipated higher levels of activity, including a 10-foot (minimum) bikeway and a 5-foot (minimum) walkway.
- A minimum of a 2-foot graded area with clearance from obstructions, such as bushes, large rocks, bridge piers, abutments and poles.
- minimum 1-foot clearance from “smooth” features, such as bicycle railings or fences with appropriate flaring and treatments. Ideally, a graded shoulder area of 3 - 5 feet, with a 5-foot minimum buffer from traffic.
- Crossings with major roads should include signals and refuge islands.

Typical Application

- Shared use paths may be used adjacent to roadways where bicycle travel is desirable, but roadway traffic and speeds are unsafe for cyclists.
- Shared use paths may be used independent from the roadway network in greenways, along waterways, and to improve the connectivity of on-street bicycle facilities.

Considerations

Shared use path design requires:

- High-quality construction and maintenance that avoids pavement cracking and buckling.
- Asphalt is the preferred surface material.
- Intuitive and safe intersection crossings.
- Removal of poles, trees or other obstructions that are present in many existing sidepath locations.
- Adequate lighting for nighttime use.

Off-Street Path Connections

Path connections provide pedestrians and bicyclists with shorter, more direct routes. Connections between trails, shared use paths, and sidewalks ensure a robust pedestrian and bicyclist network. Path connections must be built to ADA standards with smooth surfaces, adequate width, and curb ramps. Path connections must be at least 8 feet wide to accommodate bicycle travel.

SEPARATED BIKE LANES

Separated bike lanes (along side streets) are vertically separated from motor vehicle traffic by a curb, flex posts, and/or parking, and distinct are from the sidewalk.

Benefits

- Provide greater comfort to pedestrians by separating them from bicyclists.
- Prevent motor vehicles from driving, stopping or waiting in the bikeway.
- More attractive to a wider range of bicyclists than striped bikeways on higher volume and faster speed roads.

Standard Dimensions

- One-way separated bike lanes should have a minimum width of 5 feet. 7 feet is preferred.

Separated bike lanes have different levels of separation:

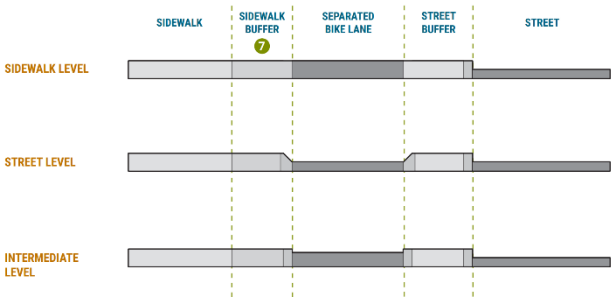
- Flexible delineator posts (often called “flex posts”) offer the least separation. Posts are placed in the middle of the buffer area of 3 feet wide.
- On-street parking offers a high-degree of separation but may require raised buffer treatments at intersections.
- Raised buffers provide the greatest level of separation from traffic but often require road reconstruction.

Typical Application

- On roadways with operating speeds greater than 30 mph or greater than 6,000 vehicles per day.
- Preferred in higher density areas, adjacent to commercial and mixed-use development, and near major transit stations or locations where observed or anticipated pedestrian volumes will be higher.

Considerations

- Separated bike lanes may be at sidewalk level, street level, or intermediate height.
- Separated bike lanes can be designed to accommodate one-way or two-way travel.Consider curbside conflicts, large vehicle use, low-stress network gaps, and high peak hour volumes.
- Parking may be present between the buffer and travel lane.
- Bicycle signals, signs, and markings can improve safety at intersections and driveways.
- Transitions to trails and other bicycle facilities should be clear and intuitive.



BUFFERED BIKE LANE

Buffered bike lanes are conventional bike lanes paired with a designated buffer space separating the bike lane from the adjacent motor vehicle travel lane and/or parking lane to increase the comfort of bicyclists.

Benefits

- A painted buffer increases horizontal separation between bicyclists and motor vehicles.
- Buffers increase space between bicyclists and hazards such as passing traffic or car doors.

Standard Dimensions

- Desirable width is 6 feet. Minimum buffered bike lane width, exclusive of buffer, is 5 feet
- Minimum buffer width is 2 feet. There is no maximum.
- Buffer is marked with two solid white lines. Diagonal crosshatching should be used for buffers less than 3 feet wide. Chevron crosshatching should be used for buffers greater than 3 feet wide.
- Buffers should be broken along curbside parking to allow cars to cross the bike lane.

Typical Application

- On roadways with more than 3,000 vehicles per day or posted speed limits greater than 25 mph.
- Where standard bike lanes are being considered.
- On streets with high travel speeds and/or high traffic volumes.
- On roadways with on-street parking, a buffer can be placed between the bike lane and the parking lane.

Considerations

- Preferable to conventional bike lanes when used as a contra-flow bike lane on one-way streets.
- Can be used on one-way or two-way streets.
- If there is sufficient width and a separated bike lane is not being considered, buffers may be installed on both sides of the bike lane.
- Allow bicyclists to ride side by side or to pass slower moving bicyclists.

CONVENTIONAL BIKE LANES

A conventional bike lane (along side streets) is a portion of a side street designated for bicycles and distinguished from traffic lanes by signing and a solid white line.

Benefits

- Provide designated space for bicyclists.
- Reduce the need for bicyclists and motor vehicles to negotiate for space on the roadway.

Standard Dimensions

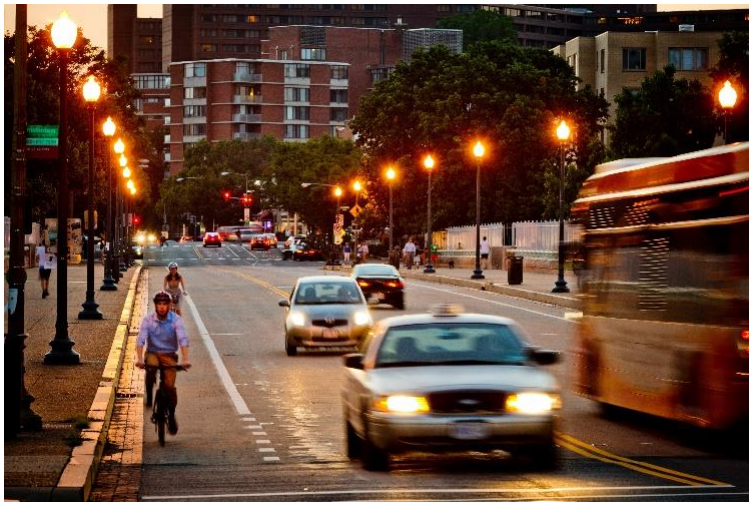
- The preferred width of a bike lane is 6 feet. The minimum width is 5 feet.
- Pavement markings (two solid white lines) and signs designate bike lane.
- Parking Ts or hatch marks can highlight the vehicle door zone on constrained corridors with high parking turnover to guide bicyclists away from doors.

Typical Application

- On roadways with more than 3,000 vehicles per day or posted speed limits greater than 25 mph.
- On streets with high transit vehicle volume.

Considerations

- Can be used on one-way or two-way streets.
- Contra-flow bike lanes may be used to allow two-way bicycle travel on one-way streets for motorists, improving bicycle network connectivity.
- Stopping, standing and parking in bike lanes may be problematic in areas of high parking demand and deliveries, especially in commercial areas.
- Wider bike lanes or buffered bike lanes are preferred at locations with high parking turnover.
- Bike lanes should be striped at intersection approaches and through intersections.
- Bike lanes should meet minimum width requirements exclusive of the gutter pan.



BIKE BOULEVARDS

A street with low traffic volumes and speeds, designed to give bicyclists travel priority. Often in residential neighborhoods with additional traffic calming measures to reduce motor vehicle volumes. Also known as a neighborhood greenway.

Benefits

- Prioritize bicyclist travel and safety.
- Minimize bicyclist delay.
- Create safe and convenient crossings for bicyclists and pedestrians, especially at crossings of busy arterial streets.

Standard Design

- Bike boulevards include wayfinding signs and shared lane markings at a minimum.
- Traffic calming measures create a comfortable bicycling experience and communicate bicyclist priority. Elements may include:
    - Speed humps
    - Traffic circles
    - Curb extensions
    - Chicanes

Typical Application

- Ideally placed on streets with speeds 25 mph or less with average daily traffic less than 3,000 vehicles per day.
- On streets parallel to high-volume major roads.
- On roadways where it is infeasible to install bike lanes, separated bike lanes, or sidepath, but it is desirable to communicate bicyclists priority within a shared lane.

Considerations

- Bicycle boulevards may have partial street closures to physically block motor vehicles from traveling one direction. Partial closures allow for emergency access but may increase violation of traffic laws by traveling the wrong way.
- Bicycle boulevards can be part of low-stress bicycle networks if safe crossings of arterial roads are provided

BICYCLE PARKING

On-street or on-sidewalk facilities that allow bicyclists to store their vehicle safely while accessing nearby destinations.

Benefits

- Provide quick access to destinations in a convenient and secure way.
- Reduces the occurrence of bicycles being locked to trees, sign posts, and street furniture.

Standard Dimensions

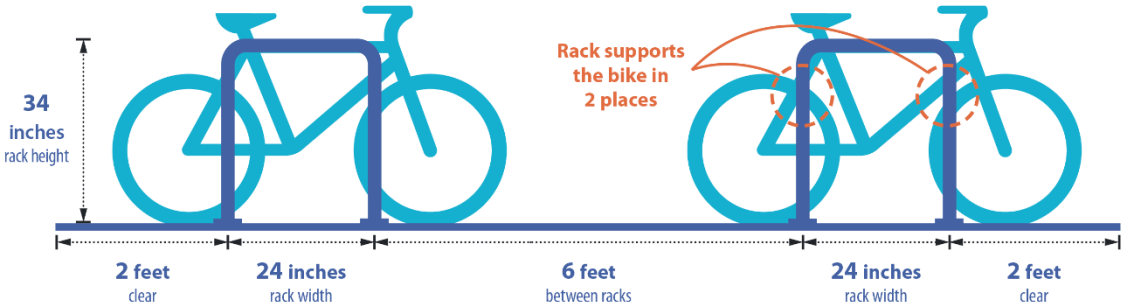
- Standard bicycle racks include the inverted U-rack and post and ring.
- The rack should be a minimum of 32 inches tall. Standard inverted U-racks measure approximately 34 inches high by 24 inches wide.
- Bicycle racks should be durable and securely anchored, thin enough to allow a standard U-lock to be used, but thick enough so that the rack cannot be cut with bolt cutters.

Typical Application

- Bicycle racks may be placed on the sidewalk but should not impede pedestrian travel.
- Bicycle racks may be placed on the street. On-street corrals are designated through striping and can be installed with flex posts. A bike corral that replaces an on-street parking space can provide parking for 6 to 12 bikes in place of one car.
- For private rights-of-way, short-term bicycle parking should be located in highly visible locations near building entrances.
- Bicycle racks should be located along the bicycle network and near popular destinations.
- A corral can also be placed in locations where parking is not allowed, such as 30 feet from an intersection or marked crosswalk. This helps make the crosswalk safer by ensuring no one parks their car illegally and blocks visibility of the crosswalk or intersection, while also adding parking spaces for people on bikes.

Considerations

- Bicycle racks should always allow a bicycle to be locked to the rack in two places (typically the bicycle frame and one wheel) to prevent theft.
- Sheltered bicycle parking protected bicycle from the elements.
- Consider providing bike racks with additional space for bicycles with trailers.
- Bicycle racks should have adequate clearance from driveways, curb ramps, transit loading areas.



WAYFINDING

Wayfinding provides travel information through signage and maps. Signage points bicyclists to key routes and destinations.

Benefits

- Provide information such as routes and distances to different destinations. Destinations can include parks, neighborhoods, business districts, schools, shared-use paths and transit stations.
- Confirm that bicyclists are on a designated route.
- Increase awareness of bicyclists to motorists.
- Familiarizes users with the bicycle network.
- Increases comfort for infrequent bicyclists.

Standard Design

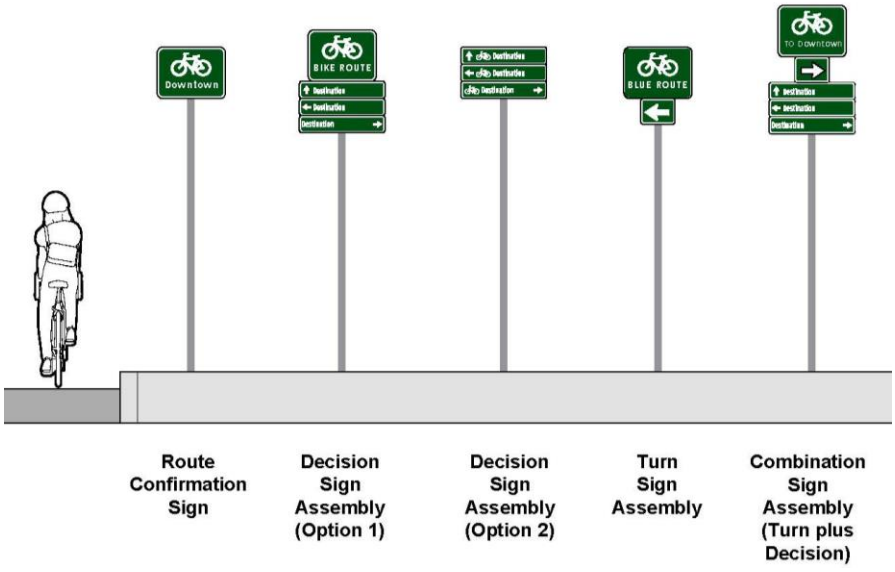
- Signage must be accessible and easy to understand.
- Consult MUTCD standards (Section 9B.01 – Application and Placement of Signs).

Typical Application

- Along roadways that are part of the bicycle network.
- Along roadways comfortable for bicycle travel.
- Important at turns and junctions where bicyclists must make wayfinding decisions.

Considerations

- Consider type of information communicated when considering placement of sign.
- Pavement markings may be used to reinforce routes and signage.
- Color and other branding can reinforce sense of place and identify different routes.
- Wayfinding should be done at a systematic level to ensure cohesive set up and design.



SIDEWALKS

Sidewalks provide space along a street for pedestrian travel. Sidewalks provide the greatest benefit to people when they are wide enough for two people to walk side-by-side, maintained in good condition with few bumps or cracks, kept clear of debris and overgrowing plants, and built with curbs.

Benefits

- Improve safety and comfort of people walking by separating pedestrians from people moving faster on bikes or in cars.
- Provide space for utilities, signs, and amenities such as bus shelters or waiting areas, bicycle parking, public seating, public art, newspaper stands, trash and recycling receptacles, and landscaping elements.
- Make walking an easy choice between destinations by creating a network for pedestrian travel throughout the city.

Standard Design

- Sidewalks should be a minimum of 5 feet. The widths of sidewalks will vary based on context and expected pedestrian volumes.
- Most sidewalks should be designed with curbs to elevated pedestrians from the roadway.
- A buffer zone between the street and the sidewalk separates drivers from pedestrians. Utilities, traffic control devices, trees, and furniture can be placed in this buffer zone.
- All new sidewalks and curb ramps shall comply with ADA regulations.

Typical Application

- Sidewalks should be present along all streets.

Considerations

- Sidewalks must be wide enough to comfortably accommodate different types of pedestrians, including those using mobility assistance devices, pushing strollers, or pulling carts.
- Sidewalks must include an accessible pathway that is free of obstructions, such as light poles, traffic signals, trees, utilities, and furniture.
- To indicate pedestrian priority at driveways, consider extending the sidewalk’s material across the driveway.
- Sidewalks should, as much as possible, follow the natural path of pedestrian travel parallel to the street. Crosswalks should be aligned with sidewalks to maintain the most direct path of travel.

MARKED CROSSWALKS

Marked crosswalks are used to raise driver awareness of people crossing the street and to direct people who are walking to the best place to cross the street. High visibility crosswalks are marked in a way that increases motorist visibility of the crosswalk.

Benefits

- The continental striping pattern is more visible to drivers than narrow parallel lines.
- Help guide pedestrians to locations where they should cross the street.
- Increase motorist awareness of crosswalk location.

Standard Dimensions

- Install with curb ramps.
- Crosswalks should be at least as wide as the sidewalk or sidepath, with a minimum width of 6 feet. On roadways with a posted speed limit of 40 mph or at locations with high pedestrian activity, crosswalks should be 10 feet wide.
- At signalized intersections, install a stop bar in advance of the crosswalk.
- Uncontrolled intersections should meet requirements in MUTCD Section 3B.18.

Typical Application

- All controlled crossings and relevant uncontrolled crossings.
- All legs of intersections.

Considerations

- High visibility crosswalks should be convenient for pedestrian access.
- Parking should be restricted in advance of a crosswalk to provide adequate sight distance.

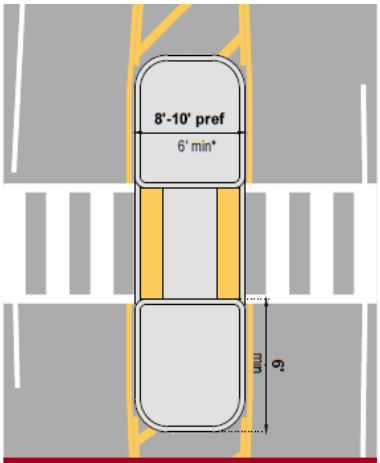
Refuge islands (also called pedestrian refuges or center islands) are delineated or raised areas that separate opposing directions of motor vehicle traffic. Refuge islands are used as a supplement to a crosswalk.

Benefits

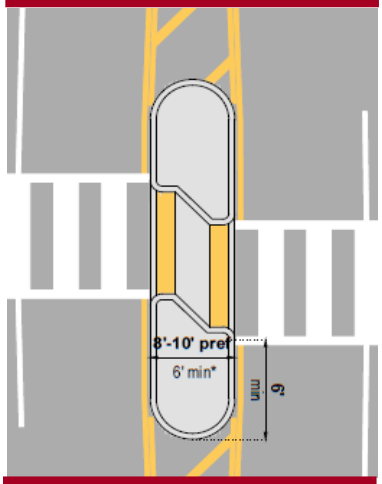
- Provide a designated place for people walking and biking to wait for an opportunity to cross each half of the street.

CENTER REFUGE MEDIAN

- Reduce pedestrian crossing distance.
- Provide space for additional lighting at crossing.
- Reduce speeding as drivers approach the crossing through visual narrowing of the travel lane.



Straight



Offset

Standard Dimensions

- Refuge islands should be a minimum of 6 feet wide. To provide bicyclist refuge or for high pedestrian volumes, refuge islands should be a minimum of 8 feet wide.
- The refuge is ideally 40 feet long.
- Ramps or island cut-throughs are required for accessibility. They should be the full width of the crosswalk.

Typical Application

- Intersections and midblock crossings where it is difficult to cross the street due to long crossing distances or few gaps in traffic.
- Where motor vehicle speeds are above 30 mph and average motor vehicle volumes are above 9,000 vehicles per day.
- There must be adequate width (a minimum of 6 feet) in the middle of the road to install the refuge island. Generally, streets with a two-way center turn lane or few or no left turns by people driving provide opportunities to install a refuge island.

Considerations

- Pedestrians may get caught on the crossing island if motorists do not yield or signal timing is too short.
- Crossing islands at intersections may restrict left turning.
- Emergency vehicles may need to travel in lanes of opposing direction of travel.
- Wide medians increase the pedestrian crossing distance.
- Can be installed with an active warning beacon at midblock crossings.
- Temporary crossing islands can be constructed with temporary curbing or flex posts.

TIGHTER CORNER RADII

A wide curb radius allows motorists to turn right at high speeds and increases risk of collisions with pedestrians. Truck aprons and other measures that reduce the corner radius force motorists to slow down to take the sharper turn. While not a popular practice Nationwide this still may be deployed as a pilot program if warranted.

Benefits

- Decrease the effective radius available for motor vehicle turn movements by forcing sharper turns.
- Reduce vehicle turning speeds.
- Reduce crossing distance for pedestrians.
- Provide flexibility for curb ramp placement.

Standard Design

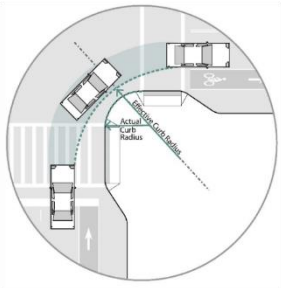
- Implementation should be tailored to the largest design vehicle size that frequently uses the intersection. This effective turning radius should determine actual curb radius.

Typical Application

- Most intersections, especially with fast turning movements or common turning conflicts.
- Do not use on intersections with high truck or bus volumes.

Considerations

- Corner radii that are too small may encourage motor vehicles to drive over the curb and onto sidewalks and bikeways.
- May affect on-street parking and bike lanes.
- Large vehicles may encroach on the opposing travel lane when turning.



Truck Aprons

A small curb radius has adverse safety effects if the rear wheel of a truck travels over pedestrian queueing areas. Mountable truck aprons are a solution that can reduce turning speeds for passenger vehicles while accommodating the turning movements of larger vehicles that require the large corner radii.

Mountable truck aprons are raised 2 – 3 inches above the street. The surface should be visually different from the adjacent travel way and pedestrian areas.

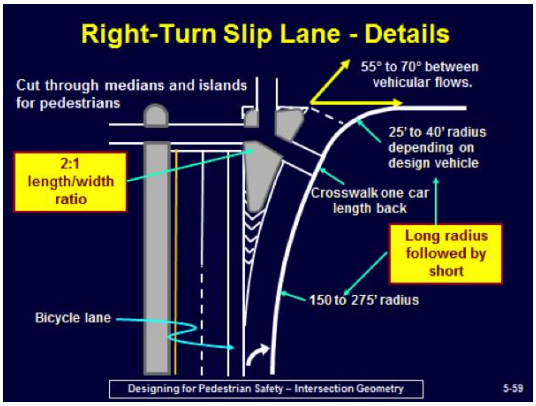
Truck aprons can also be used on roundabouts around the inner circle.

PEDESTRIAN-FRIENDLY SLIP LANES

Well-designed slip lanes slow down motor vehicles and reduce pedestrian exposure compared to standard designs. The island is large enough to accommodate pedestrians waiting to cross.

Benefits

- Encourage drivers turning right to yield to pedestrians crossing and to traffic on the cross street.
- Optimize sightlines to the crosswalk for motorists
- turning right.
- Reduce the complexity of intersection.
- Reduce the crossing distance for pedestrians.
- Reduce motor vehicle speeds and thus conflict severity.



Standard Design

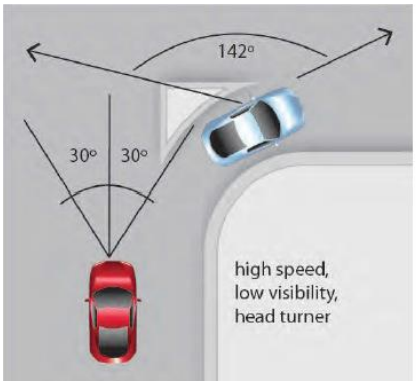
- Motorists approach the slip lane at a gradual angle (150 to 275 degrees radius). Any crossing pedestrians can be seen straight ahead of the motorist.
- Motorists exit the slip lane at a sharper angle to the cross street (25 to 40 degrees radius). This angle does not require motorists to turn their head a lot to see traffic on the cross street.
- Refuge island has a 2:1 length to width ratio.
- Orient the crosswalk 90 degrees to the slip lane.
- Allow for queuing space before and beyond the crosswalk where motorists wait before yielding.

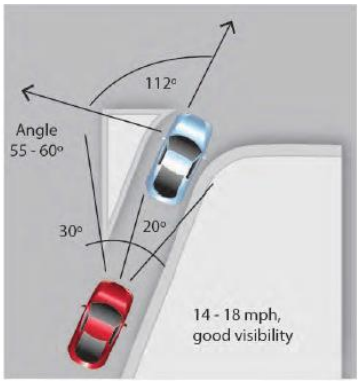
Typical Application

- Locations with existing higher speed channelized right turns.

Considerations

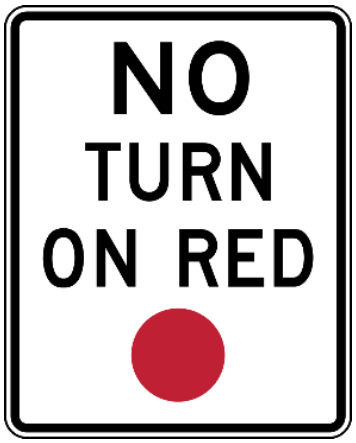
- May be used in conjunction with signage and high-visibility crosswalks.
- Providing a raised crosswalk in the slip lane further reinforces pedestrian priority.





NO TURN ON RED RESTRICTIONS

Right turn on red restrictions prevent drivers from legally turning right while the traffic signal is red. Restricting this movement reduces conflicts with pedestrians crossing in front of turning motorists.



Benefits

- While traffic law requires motorists to stop at a red light prior to turning right, motorists often do not fully stop.
- When turning right on red, motorists normally are looking left at oncoming traffic and do not look to their right at pedestrians crossing.
- Reduces conflict between right turning vehicles and pedestrians and bicyclists traveling straight.

Standard Design

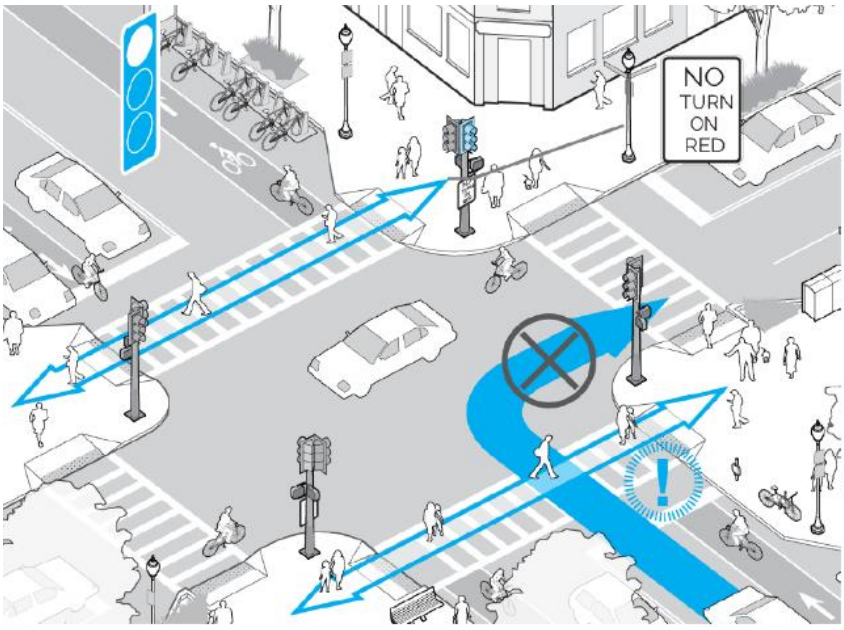
- Install No Turn on Red signs (MUTCD R10-11) on each approach. Signs should be clearly visible to turning motorists.
- Dynamic electronic signs can be used to restrict right turns to certain times of day or during certain signal phases.

Typical Application

- Intersections with an exclusive pedestrian phase or an LPI.
- Intersections with poor sight distances.
- Intersections with high volumes of right-turning vehicles and high volumes or bicyclists or pedestrians.

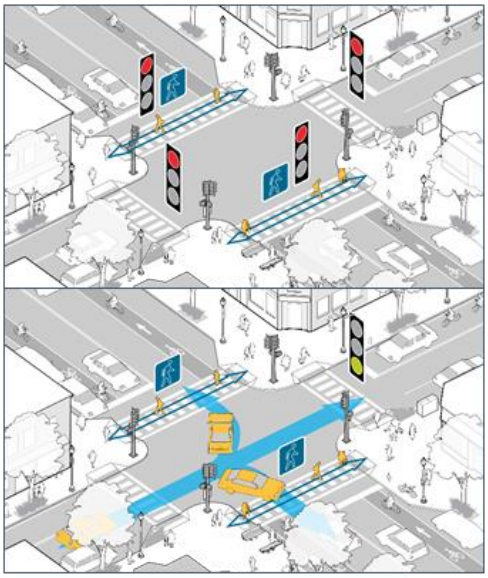
Considerations

- Restricting right turns on red during times of high-volume traffic may be sufficient.
- May increase the number of right turn on green conflicts.



LEADING PEDESTRIAN INTERVALS

Leading Pedestrian Intervals (LPI) starts the pedestrian WALK signal three to seven seconds before motorists traveling in the same direction are given the green indication. This allows pedestrians to enter the intersection prior to turning motorists, increasing visibility between all modes.



Benefits

- Give pedestrians a head start to establish themselves in the intersection before the green phase.
- Prioritize pedestrian safety and convenience at intersections.
- Increase visibility of crossing pedestrians.
- Reduce conflicts between pedestrians and motorists.
- Increase compliance of motorists yielding to pedestrians.
- LPIs especially benefit slower pedestrians, including people with disabilities, seniors, and children by providing additional crossing time.

Standard Design

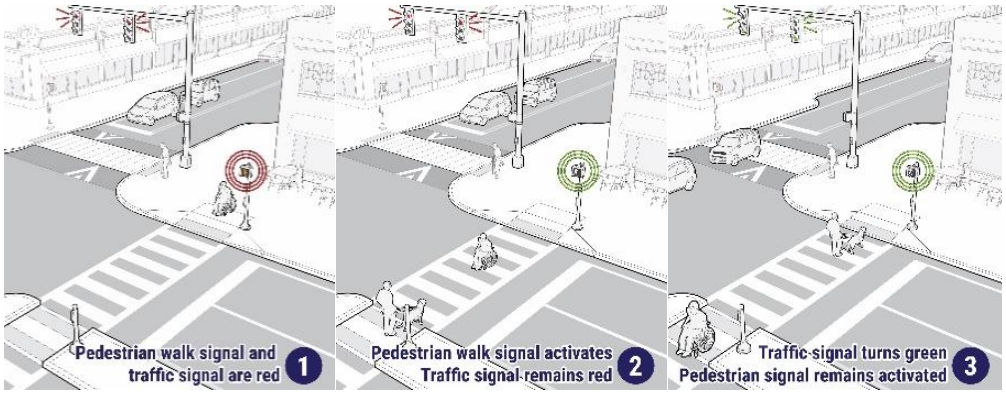
- Install with high visibility crosswalk markings, curb ramps, and accessible pedestrian signals.
- LPI may be accompanied with an audible noise for visually impaired pedestrians.

Typical Application

- LPIs are most effective at intersections with high volumes of pedestrians and conflicting motorist turning movements.

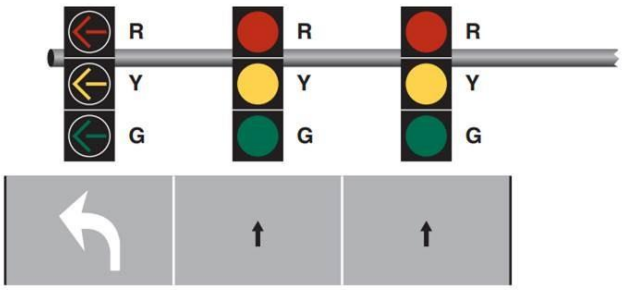
Considerations

- LPIs can be provided automatically or provided only when actuated. Active detection requires an accessible pushbutton.
- LPI can be lengthened based on particularly high bicycle or pedestrian volumes.
- No Right Turn on Red signs should be considered with LPIs.



SIGNAL PHASING / TIMING STRATEGIES

Traffic signals are used to convey the right-of-way to intersection users to provide for the orderly and efficient movement of traffic. Signal phasing and timing strategies can be used to reduce the potential for crash-producing conflicts between motorists, pedestrians, and bicyclists and can provide improved safety for pedestrians.



Benefits

- Coordinated signal timing set for a desirable progression speed can dictate the speed of motor vehicles along a corridor.
- Shorter cycle lengths in the off-peak can reduce delay for all users and may decrease instances of pedestrians crossing against the signal.
- Pedestrian recall and Rest in Walk for the coordinated pedestrian phases yield longer pedestrian walk intervals and may decrease instances of pedestrians crossing against the signal.
- Protected-only left-turns (i.e. green arrow only) reduce potential conflicts between pedestrians crossing with the signal and left turning drivers who are usually focused on gaps in on-coming traffic.
- Flashing yellow arrow for right-turns may increase driver yielding to crossing pedestrians.

Standard Design

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- Pedestrian recall and Rest in Walk should be provided for the coordinated pedestrian phases.

Typical Application

- Signal timing can be adjusted at all signalized intersections, with a priority for locations with medium to high pedestrian volumes.
- Signal timing adjustments are most effective on long corridors with:
  - Infrequent crossing opportunities,
  - Short pedestrian phases, or
  - High pedestrian or bicyclist volumes.

Considerations

- Signal timing operations must account for motor vehicle volumes, turning movement volumes, and average and 95th percentile motor vehicle queue lengths compared to the available storage length.

ACCESSIBLE BUS STOPS

All transit trips begin and end with walking. Bus stops need appropriate pedestrian infrastructure to facilitate access from the bus stop to the final destination, as well as the other side of the street for return trips.

Benefits

- Increase access to and visibility of transit stops.
- May increase transit ridership by increasing safety, convenience, and comfort.
- Accommodate transit users of all abilities and ensure ADA accessibility.

Standard Design

- Accessible bus stops should have lighting, trash receptacles, and transit route information.
- To improve access to bus stops, install wide sidewalk connections, marked crosswalks, and, pedestrian signals at intersections.
- Sidewalks must be wide enough to accommodate wheelchair lifts. A paved platform should be installed for the bus ramp.
- At high volume locations, shelters and seating improve comfort for those waiting.

Typical Application

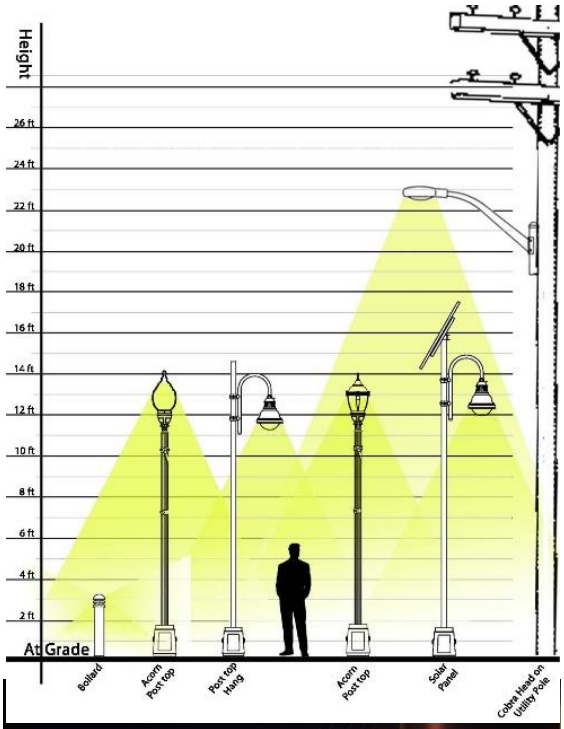
- All bus stops.

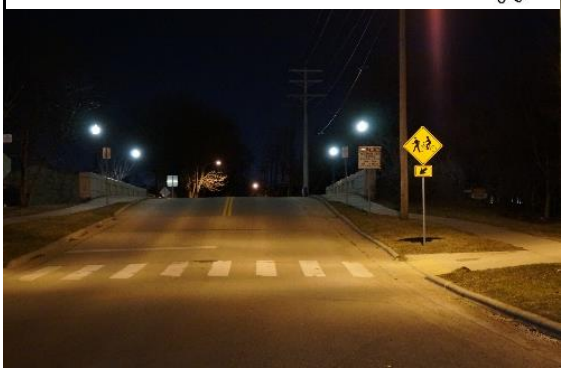
Considerations

- Bus stop should accommodate distance between front and rear bus doors.
- Placement of the bus stop should be near intersections if possible, with marked crossing locations, ideally at the far side to:
    - Allow pedestrian view of approaching traffic,
    - Increase visibility of pedestrians using transit,
    - Encourage pedestrians to cross behind the bus, and
    - Minimize conflict between buses and motor vehicles turning right.
- At the midblock, place bus stop behind midblock crossing.
- When locating bus stops, consider curbside space, sidewalk condition, on street parking, bicycle facilities, and crosswalks.

LOCAL STREET LIGHTING

Scaled lighting along side streets and local roads are an essential element in street design. It is used to increase the visibility and safety of people walking, biking, and driving at night and during dawn/twilight hours. Guidelines for placement, size, and wattage of lighting is a key element of creating pedestrian-friendly streets.





Benefits

- When implemented at intersections, increases visibility of pedestrians crossing to people driving.
- Highlights certain locations and elements in a neighborhood as focal points or landmarks which provides wayfinding support.

Standard Design

- Lighting should be consistent and uniform. Uniform lighting can suggest pedestrian use and create a sense of enclosure.
- To avoid creating a silhouetting effect, lighting at crosswalks should be placed to illuminate crossing pedestrians from the side instead of overhead.

Typical Application

- Beneficial at intersections in areas with high volumes of pedestrians, such as commercial or retail areas.
- Controlled and uncontrolled intersections.
- On crossing approaches.
- Along sidewalks.
- Near schools, parks, and recreation centers.
- On both sides of arterial streets.

Considerations

- Installation of lighting along regional shared-use paths should begin and end at logical locations to avoid creating intermittently dark sections.
- Consider energy usage and environmental impacts.
- Consider quality and color of light.