6 Intersection Design and Operations

The word *intersection* means more than just the meeting of two or more streets. It can also mean the intersection of two different modes of travel. It is where multiple modes of transportation (bike, pedestrian, auto, transit) converge, sometimes in conflict. It is because of this that intersections are often the most vital areas along a street. They are the point of most conflicts between vehicles, pedestrians, and bicycles.

Intersections must be designed with pedestrian safety and accessibility in mind.

If pedestrians are either prohibited from crossing or discouraged from crossing, walking as a mode of travel is hampered. The spacing of intersections or crossing points is also an important element in the creation of a supportive pedestrian environment.

6.1. General Considerations

- Pedestrians should be made as visible as possible because multiple conflict points for vehicles and pedestrians exist at intersections.
- Intersections that minimize pedestrian crossing distance and crossing time reduce the exposure to traffic and pedestrian/vehicular conflicts.
- Drivers traveling at a slower rate of speed have more time to process and react to pedestrian conflicts at intersections.

6.1.1 Intersection Control

Where two or more streets intersect, some form of traffic control is usually needed to define the ROW of the vehicles entering the intersection. This control can take the form of yield signs, stop signs on the minor street, all-way stop control, a traffic signal, or a roundabout.

6.2. General Principles

- Design intersections to be as compact as possible.
- Analyze Intersections as part of a network, not in isolation.
- Integrate time and space.
- Intersections are shared spaces.
- Utilize excess space as public space.

6.3. General Standards and Guidelines

- Streets are to intersect at 90-degree angles or as close as practicable.
- Two streets intersecting opposite sides of a third street are to have the same points of intersection or else their centerlines are to be separated by a minimum of 120 feet for local streets and a minimum of 200 feet for all other streets on the third street.
- Median breaks for intersections along major streets with other streets of collector or higher classification shall be no closer than 1,320 feet.
- Full access intersections of local streets with major streets should be kept to a minimum, and such intersections shall be at least 500 feet apart, measured between centerlines, and shall be farther apart where turn pockets dictate longer spacing. The need for left-turn storage may require a greater distance. Pedestrian access to transit and adjacent commercial uses should be considered in major street intersection spacing.
- Local streets should not intersect primary arterials.
- Maximum grade across intersections along local and two-lane sub-collector and two-lane collector streets shall not exceed 8 percent and along four-lane streets and greater shall not exceed 5 percent.
- Curb return radius should accommodate the expected amount and type of traffic and allow for safe turning speeds at intersections. Curb return radius shall be installed in accordance with Table 6–1.

	Local Residential	Collector	Major
Local Residential	15 ft.	20 ft.	30 ft.
Collector	20 ft.	25 ft.	30 ft.
Major	30 ft.	30 ft.	30 ft.

TABLE 6-1 CURB RETURN RADIUS

Note: Curb return radius for all other intersections not covered in Table 6-1 shall be determined by the appropriate reviewer.

- Sight distance at intersections must consider the following factors: grades, curvature, and superelevation.
- The minimum corner sight distance at an intersection of a street (public or private) or multiple dwelling residential/commercial/industrial driveway with a collector or higher classification street shall be in conformance with AASHTO Intersection Sight Distance Standards per AASHTO Greenbook.

- Adequate sight distances at intersections and along horizontal curves must be maintained. A sight distance easement that requires fences, monuments, signs, landscaping, walls, and slopes or any other obstruction at and beyond the ROW line to be eliminated, kept below 36 inches, or set back is only acceptable when relocation of the intersection or redesign of the curve does not permit adequate sight distance.
- The City Engineer or designee may prohibit parking at critical locations.
- The City Engineer or designee may control access along major streets at critical locations.
- All pedestrian street crossings in the City shall utilize Council Policy 200-07, "Marked Crosswalk Criteria at Uncontrolled Locations."
- All pedestrian street crossings must be accessible to persons with disabilities.
- Pedestrian facilities (including curb ramps, signal equipment, etc.) must comply with ADA standards and California Title 24 regulations and take into account the entire range of disability categories.
- Parking restrictions near crosswalks, within 20 ft of the vehicle approach side or within 15 ft of the vehicle approach side if a curb extension is present, is required to remove potential obstructions to the pedestrian's line of sight, particularly for young children and those in wheelchairs. Daylighting discussion per CVC 22500 (Assembly Bill 413, 2023) is further discussed in Sections 5.3.5.1 and 5.6.2.
- When street furnishings or other objects that obstruct view cannot be relocated, curb extension or other treatments should be considered.
- When deciding what type of control an intersection should have, follow Caltrans Intersection Control Evaluation (Traffic Operations Policy Directive 13-02). When expansion or addition of one type of traffic control is considered, this evaluation ensures a comparison with other types of traffic control and the no-build scenario on the basis of system impacts, safety and mobility benefits for all modes, and life-cycle costs.
- Stop signs and all-way stop controls are installed according to Council Policy 200-08 "Criteria for the Installation of Stop Signs". Traffic signals are installed according to Council Policy 200-06 "Criteria for Installation of Traffic Signals", except those references within Council Policy 200-06 to the latest version of the CA MUTCD. These Council policies prescribe warrants based on City, State of California, and federal standards. The warrants take into consideration vehicular and pedestrian volumes, accident history, traffic safety, the transportation system, and other relevant factors.
- Metal street name signs on metal posts are required at each intersection, at any point of street name change, and at midpoint in blocks over 2,000 feet in length, in conformance with the City's Standard Drawings. New street names and street name changes shall follow the procedures contained in the San Diego Municipal Code Chapter 12, Article 5, Division 11. A private street sign within public ROW shall be the same color as public street signs, with the letters *PVT* or the word *Private* written on it in place of the City logo.
- Schools, parks, community centers, or other high pedestrian generators have particularly high potential for vehicle and pedestrian conflicts. The major pedestrian routes to school should be identified and traffic controls should be structured so that the number of crossings at uncontrolled cross-streets is minimized, and pedestrians are directed to the most appropriate crossing locations. For both schools and parks, entrances tend to focus pedestrian street crossings at particular locations. These entrances can be made safer by combining them with roadway intersections so that the intersection's traffic control can also allocate right-of-way to pedestrians.

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6.3.1 New Development versus Retrofit

- Prior to improvements to an existing intersection, utilities (e.g., lighting, electrical, and storm drains) should be identified and either incorporated into the design or relocated.
- New intersections provide the opportunity to clarify new forms of traffic control that may create a more pedestrian-friendly setting.

6.4. Pedestrian Crossings

One of the most effective means of turning an important corridor into a community "spine" or "seam" rather than a community "divider" is providing for safe street crossings. Pedestrian crossings can be located at either controlled intersections such as stop signs and traffic signals, or in some cases uncontrolled intersections. Guidelines for installation of marked crosswalks at uncontrolled intersections and mid-block crossings are contained in Council Policy 200-07, "Marked Crosswalk Criteria at Uncontrolled Locations".

Mid-block Crossing Treatments will be discussed in Section 5.6.

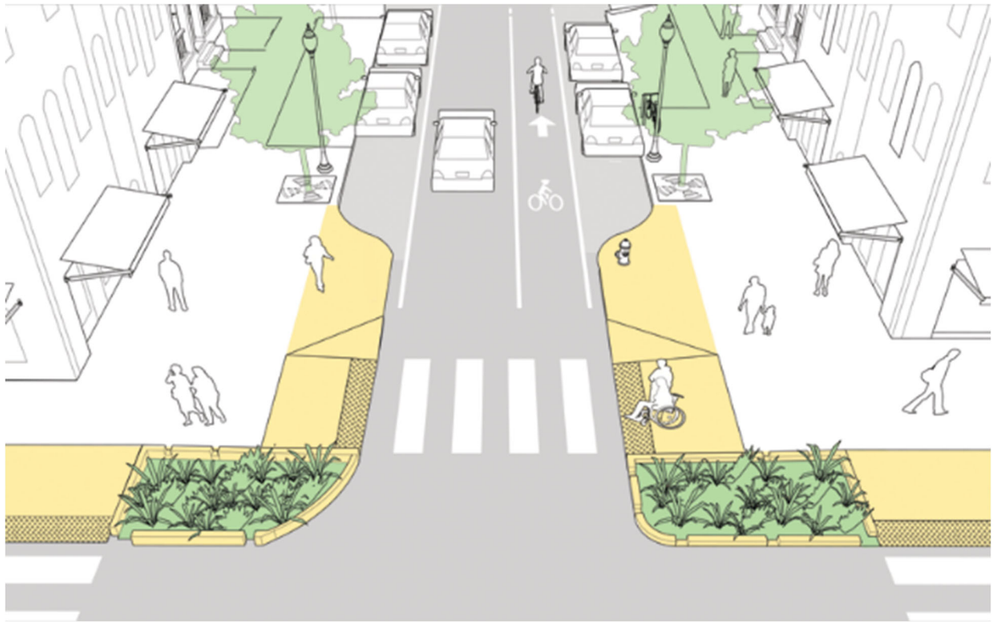

FIGURE 6-1 PEDESTRIAN CROSSING

Source: NACTO Urban Street Design Guide

Benefits:

- Marked crosswalks can help to reduce risk for pedestrians attempting to cross the road, as they provide a clearly defined crossing point where pedestrians are 'expected'. This improves safety for all road users.
- Marked crosswalks are useful in channelizing pedestrian crossing activity at specified locations.
- Marked crosswalks identify appropriate crossing locations for pedestrians and alert drivers to the possible presence of pedestrians.

Considerations:

The following are general issues that should be considered for pedestrian crossings, including residential street crossings and mid-block crosswalks:

- The width of the street, the geometry of the intersection, the timing of signalization, and the frequency of crossing opportunities all play important roles in achieving a pedestrian-friendly environment.
- Crossing opportunities should be provided at regular and convenient intervals.
- The use of marked crosswalks is generally considered appropriate at signalized intersections where pedestrian activity occurs.
- Street width and traffic speed can be reduced with the use of sidewalk pop-outs.
- Some pedestrians may become overconfident or be less aware of vehicles when crossing in a marked crosswalk; therefore, marked crosswalks should not be used indiscriminately.
- Transit stops that require pedestrians to cross the street should be provided with appropriate street crossings within proximity of the transit stop.

Standards and Guidelines:

- The installation of crosswalks shall conform to Council Policy 200-07 and in accordance with CA MUTCD.
- Marked crosswalks shall be provided at all signalized intersections where pedestrian crossing is allowed.
- Curb ramps shall be provided at all crosswalks. If a raised median extends into the crosswalk, the median nose should be relocated out of the crosswalk or an island passageway with truncated domes must be provided through the median.
- The width of all crosswalks shall be a minimum of 10 feet wide per SDM-116 or per dimensions specified by the ADA and PROWAG. Unless small-scale intersection conditions dictate otherwise, widths shall be increased where there is greater pedestrian activity. At diagonal curb ramps, the marked crossing shall extend 2 feet beyond the flares of the curb ramps.

- The number of pedestrian crossings should be maximized in order to prevent a street from becoming a barrier in the community.
- More frequent intersections along arterial roads (even if they only provide right-in and right-out access for cars, coupled with an overall interconnected system of roads within the grid of arterial streets should be built in new development. This will allow better transit coverage and pedestrian access as well as improved overall circulation and community aesthetics.
- Adequate lighting at the levels specified in Chapter 6.8, “Intersection Street Lighting”, should be present.
- See Section 1.5 for discussion regarding ADA and Designing for Various Disabilities and Ages.

6.4.1 Curb Ramps

Federal and State provisions require that a separate curb ramp is provided to serve each pedestrian crossing (marked or unmarked) when new curb ramps are being installed or where curb ramps are triggered by project improvements. Refer to the City's Curb Ramp Design Guidelines, supplemental policies, and City Standard Drawings.

Benefits:

- Provides access across intersections and inclusive design for all individuals.
- Provides a curb cut for pedestrians pushing bicycles, strollers, and other wheeled devices.
- Detectable warning surfaces placed at the base of the curb ramp make crosswalk destinations visible while also providing a tactile vibration for visually-impaired pedestrians.

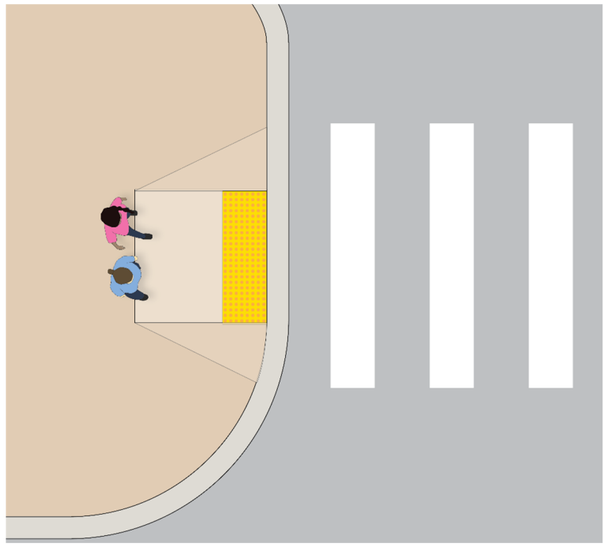

FIGURE 6-2 CURB RAMP PLAN VIEW

Considerations:

- A single, bi-directional ramp (one ramp diagonally at the corner) forces users to undertake a longer, more circuitous path of travel to the other side of the crossing. These curb ramps orient users to the center of the intersection where they risk greater exposure to vehicular traffic. Therefore, single diagonal curb ramps should be avoided at all cost.
- Installing two curb ramps serving two crossing at existing corners may be infeasible because of existing utilities and physical site-specific conditions, including street trees.
- Perpendicular curb ramps are preferred over parallel curb ramps to avoid the accumulation of water or debris at the base of curb ramps.

Standards and Guidelines:

- At new intersections, curb ramps shall be in line with the direction of crosswalks, with two curb ramps per corner to be considered to the maximum extent feasible unless existing constraints, conditions, or other extraneous circumstances deemed appropriate by the City Engineer prevent two-curb ramp design. If a single curb ramp or blended transition is allowed, it must be placed in the center to allow pedestrian access to either direction of the sidewalks. If crossing is allowed for only one direction, a single direction curb ramp can be installed.
- For existing intersections, City Standards require a curb ramp to be provided at each pedestrian crossing to the maximum extent feasible. If a curb return has two pedestrian crossings (marked or unmarked), then two curb ramps shall be installed at the curb return with one curb ramp serving each pedestrian crossing.
- Curb ramps shall be installed in accordance with the City's Standard Drawings.
- Curb ramps serving shared use paths shall be the same width as the width of the shared use path.
- Curb ramps at roundabouts shall be for exclusive use for pedestrians only. Bike ramps shall be provided for bike users. In cases where bicyclists must cross the crosswalks being used by pedestrians, then the crosswalks, median cut-throughs, and curb ramps shall comply with the Shared Use Path Accessibility guidelines.
- Curb ramps or full cut-throughs 60 inches in width minimum with truncated domes should be provided at channelization and island passageways. Refer to the City's Standard Drawings for additional information.
- Storm drainage inlets should be placed on the uphill side of the curb ramps to prevent standing water at corner.
- A modified directional curb ramp may be used in lieu of Type B and Type D curb ramps to the satisfaction of the City Engineer. See Figure 6-3 for more detail.
- Where pedestrian crossing is prohibited, curb ramps or blended transitions shall not be provided, and the pedestrian circulation path shall be either:
    - Separated from the roadway with landscaping or other non-prepared surface or
    - Separated from the roadway by a detectable vertical edge treatment with a bottom edge 15 inches maximum above the pedestrian circulation path.

- Curb ramps shall be installed at all legal crosswalks (marked or unmarked) at all intersections unless technically infeasible.

References:

- Curb Ramp Design Guidelines, City of San Diego Engineering and Capital Projects Department, 2022
- PROWAG (Shared Use Path Accessibility Guidelines), US Access Board, 2023
- Standard Drawings for Public Works Construction, City of San Diego, 2021

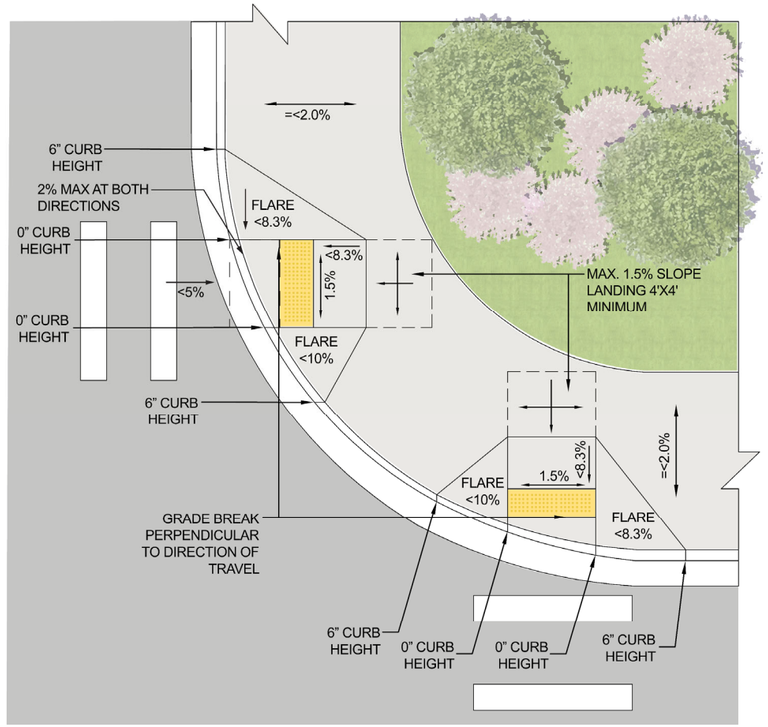

FIGURE 6-3 MODIFIED DIRECTIONAL CURB RAMP

6.4.2 Crosswalk Markings

Crosswalk markings delineate a preferred path for pedestrians to cross while also signaling to motorists to prepare to yield or stop. Markings improve and reinforce the pedestrian environment.

Benefits:

- Provides a direct, visible, and accessible path for pedestrians to cross the street.

- Improves and reinforces the pedestrian environment.
- Alerts motorists to stop or yield for pedestrian crossings.

Considerations:

- Marked crossings should be provided on all legs of a signalized intersection unless an intersection's unique geometry warrants restricting access for safety and visibility reasons.
- See City Engineer Memorandum "Extension of Pilot Program for Creative Crosswalks in Public Right-of-Way (ROW)" for installing creative crosswalks with decorative elements over the unpainted, paved surface between white continental crosswalk bars at certain intersections.

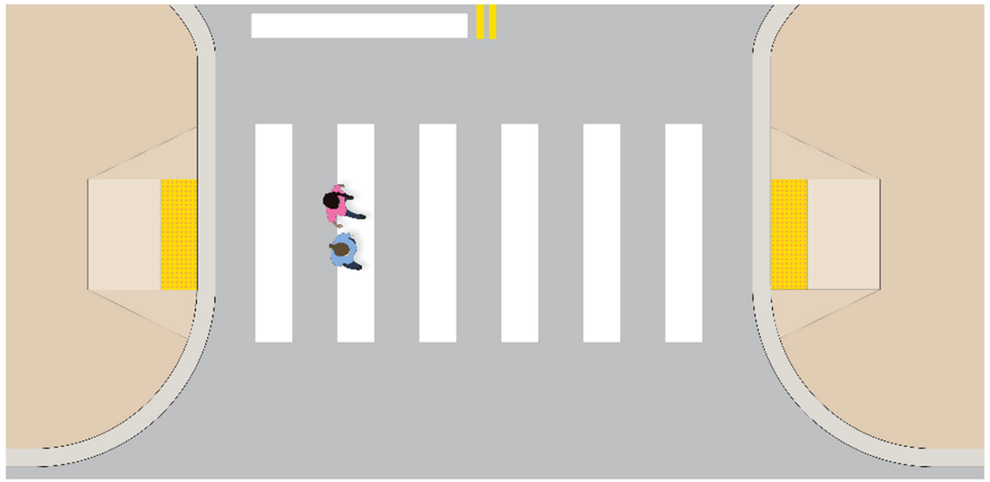

FIGURE 6-4 CROSSWALK MARKINGS PLAN VIEW

Standards and Guidelines:

- Council Policy 200-07 provides the requirements uncontrolled pedestrian crossings must meet in order to be considered for a marked crosswalk, how a crosswalk must be marked, and the process of removal, if necessary.
- Design standards for continental crosswalks are found in the City's Standard Drawings SDM-116.
- Marked crosswalks must be a minimum of 10 feet in width (the City's Standard Drawings SDM-116).
- Marked crosswalks shall be painted white. If the marked crosswalk is within 600 ft of a school or other
- Marked crosswalks should be provided on all intersection legs controlled by traffic signals unless pedestrian crossing is prohibited.
- Every crosswalk at a signalized intersection should be a continental crosswalk as per City Standard SDM-116 (Traffic Signal Design Guidelines).

- Limit lines for traffic signals and stop signs should be installed perpendicular to the traffic lane with the closest point at least 4 feet from the marked crosswalk.
- The following factors should be considered in determining whether a marked crosswalk should be used: vehicular approach speeds from both directions, vehicular volume and density, vehicular turning movements, pedestrian volumes, roadway width, day and night visibility by both pedestrians and motorists, desirable clarity of pedestrian routes for sighted or sight-impaired pedestrians, discouragement of undesirable pedestrian routes, consistency with marking at adjacent intersections or within the same intersection.

References:

- CA MUTCD Rev. 8 (Section 3B.18), Caltrans, 2024
- CA Vehicle Code (CVC 21368), Department of Motor Vehicles, n.d.
- Council Policy 200-07 "Marked Crosswalk Criteria at Uncontrolled Locations", City of San Diego, 2015
- "Extension of Pilot Program for Creative Crosswalks in Public Right-of-Way (ROW)" City Engineer Memorandum, City of San Diego, 2024
- Urban Street Design Guide, NACTO, 2013
- Standard Drawings for Public Works Construction, City of San Diego, 2021
- Traffic Signal Design Guidelines, City of San Diego Transportation Dept, 2018

6.4.3 Raised Intersection and Crosswalks

Raised intersections are created by raising the intersection to be level with the sidewalk. Similar to a speed table, this device has ramped edges on all approaches and exits and can incorporate textured paving materials on the flat intersection portion. Intersection tables force drivers to slow down upon entry and exit of the intersection. To distinguish between the road and sidewalk, bollards can be used to outline the sidewalk. This will serve to protect pedestrians by prohibiting vehicles from traveling on the sidewalk.

Raised crosswalks are similar to speed tables; however, they provide a marked pedestrian crossing. This device can be used at intersections or mid-block locations. Raised pedestrian crossing and bicycle lane are highly effective in areas with large volumes of pedestrian and bicycle traffic, such as schools or downtown business land uses.

Benefits:

- Provides accessible and convenient crossings for pedestrians, especially those with mobile and visual impairments, because they do not require vertically transitioning up and down a curb ramp.
- Improves motorists' visibility of pedestrians, especially at midblock crosswalks.
- Discourages motorists from speeding through crossings and intersections and signals the presence of pedestrians.
- Eliminates water ponding and debris collection at the base of typical curb ramps.

Considerations:

- Raised crosswalks should be avoided on wide multi-lane arterial roadways and on streets with steep grade changes and sharp curves.
- The impact of raised crosswalks on the operational needs of transit buses and emergency vehicles should be considered.
- The impact to drainage patterns should be examined to ensure that raised crossings properly accommodate the flow of water.

FIGURE 6-5 RAISED INTERSECTION

Source: NACTO Urban Street Design Guide

Guidelines:

- Where traffic speeds and conditions allow, raise the crosswalk crossings so they are flush with the connecting sidewalk and use special paving material to differentiate them from the roadway.
- Raised intersections shall have 3 feet of detectable warning surfaces along the flushed surfaces.
- Raised crosswalks may not be appropriate on streets with bus routes, because they can slow and impede the flow of bus traffic.
- Raised crosswalks should be 15’ to 20’ wide.
- Raised crosswalks should be wide enough (10’ minimum) that both the front and rear wheels of a passenger vehicle can sit atop the speed table at the same time when traveling over it.

References:

- Traffic Calming: State of the Practice, ITE/FHWA, 1999
- Traffic Calming Guide, Caltrans, 2023

6.4.4 Pedestrian Islands and Cut-Throughs

Pedestrian islands, also known as pedestrian refuge islands, allow for shorter crossing lengths for pedestrians as they wait to cross busy multi-lane streets with traffic traveling in both directions. These islands may include curbs, bollards, pedestrian push buttons or other features to protect people who are waiting. Pedestrian islands can have either cut-throughs or curb ramps if the walking surface is raised to sidewalk level. Cut-throughs refer to a lowered section of raised median that allows pedestrians to cross at the surface level.

FIGURE 6-6 PEDESTRIAN ISLAND

Location: 30th Street and Landis Street

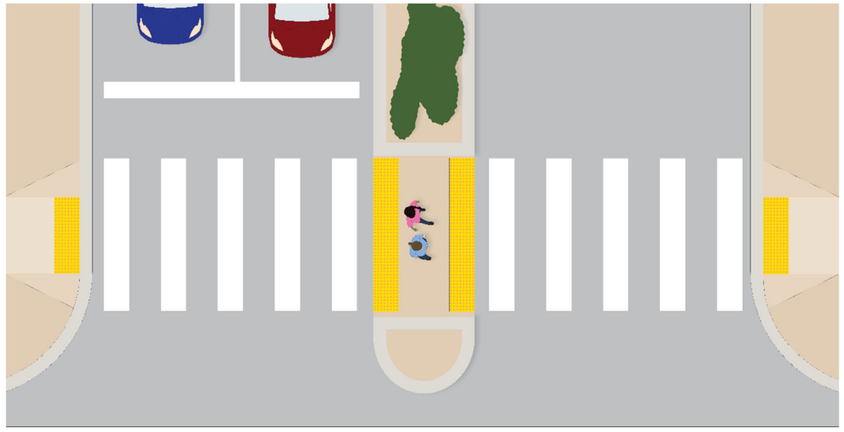

FIGURE 6-7 PEDESTRIAN ISLAND PLAN VIEW

Benefits:

- Allows pedestrians to cross wide streets in two stages, which benefits slower-walking pedestrians, seniors, children, or persons with disabilities.
- Allows pedestrians to focus on oncoming traffic in one direction at a time when crossing.
- Allows pedestrians to find gaps in traffic in order to cross at unsignalized crossings.
- Slows vehicle speeds when drivers are conscious of pedestrians waiting on the refuge island.
- Reduces risk of left turn collisions (at intersections) and vehicle head-on collisions (at the midblock).
- Provides low profile landscaping opportunities on the median next to the refuge island.

Considerations:

- Pedestrian safety islands may be enhanced using plantings or street trees. Plantings may require additional maintenance responsibilities and need to be maintained to ensure visibility.
- May impact underground utilities.
- Design must account for impact of raised median on emergency vehicle movement and access.
- In general, island passageways work best on wider streets with long pedestrian crossing times and exposure to vehicular traffic or on streets with speeds higher than 35 mph.
- Island passageways may be installed at intersections or mid-block locations deemed appropriate through engineering studies. They should be considered from the outset of design for intersections that are either complex, irregular in shape, excessively wide, or in areas where children and the elderly are expected to cross frequently.
- Pedestrian islands with cut-throughs and detectable warning surfaces are particularly useful for slower pedestrians such as the very young, the elderly, or persons with mobility disabilities. Where it is not possible to include ramps and waiting pads that meet accessibility requirements waiting areas should be at-grade with the roadway (channels).

- The use of island passageways should be considered where transit is “running” with the street ROW, particularly in station areas.

Standards and Guidelines

- Pedestrian islands shall be designed per the City’s Standard Drawings (SDG-139).
- Pedestrian islands should be well illuminated.
- Pedestrian refuge islands should be considered where crossing distances are greater than 50’.
- NACTO recommends that pedestrian safety islands have a minimum width of 6 feet, although a width of 8 to 10 feet is preferred.
- These medians can be landscaped to break up the sight line of the driver and enhance the aesthetics of the neighborhood.
- They should be located in places where pedestrians commonly cross, such as schools, large offices, retail destinations, senior housing, transit stations, and major midblock bus stops.
- They should have proper lighting, signage, reflectors, and drainage accommodations.
- On wider medians, the pedestrian island should be raised to provide more visibility for waiting pedestrians. Raised pedestrian islands should include curb ramp access, detectable warning surfaces on the curb ramps, and at least a 5’ wide level waiting area.
- At intersection crossings, median “noses” should be provided perpendicular to the crosswalk, at the tip of the median, pointed toward the intersection.

References:

- Traffic Calming Guidelines, City of San Diego Transportation Dept, 2010
- Standard Drawings for Public Works Construction (SDG-139), City of San Diego Engineering and Capital Projects Dept, 2021
- Urban Street Design Guide, NACTO, 2013

6.5. Intersection Treatments

Intersection treatments are a component of street design that enhance the safety, accessibility, and efficiency for all road users. These treatments encompass a range of physical and operational modifications aimed at improving the previously stated goals as well as promoting and facilitating active transportation. These treatments should be selected and designed based on the specific context and needs of each intersection.

6.5.1 Intersection Mural

Intersection murals add a supplemental placemaking component to neighborhoods and destinations. Painted murals are allowed at all controlled intersections on unclassified streets and two-lane classified collector streets (one travel lane in each direction) with a speed limit of 25 miles per hour or less, to the satisfaction of the City Engineer or his designee, but this does not apply to decorative crosswalks. See the

"Installation of Murals in Public Right-of-Way (ROW) Pavements and Sidewalks" Memorandum for more information.

Stamped concrete or other types of decorative paving will not be permitted at uncontrolled intersections to designate pedestrian crosswalks or at locations where it might appear to be a pedestrian crosswalk, in cross-gutters or gutters, or to be used to delineate pedestrian ramps. Stamped concrete and other types of decorative paving are permitted at other locations designated and marked as pedestrian crosswalks.

FIGURE 6-8 MURAL IN THE INTERSECTION

Source: San Diego Downtown Partnership, Ladies Who Paint
Location: 3rd Avenue and Cedar Street, Cortez Hill

References:

- Installation of Murals in Public Right-of-Way (ROW) Pavements and Sidewalks Memorandum, City of San Diego, 2018
- Mural Toolkit, Department of Cultural Affairs, n.d.
- Temporary Exhibit Toolkit, Department of Cultural Affairs, n.d.

6.5.2 Protected Intersections

Protected intersections have been implemented across North America as cities have expanded their protected bikeway networks. Also known as setback or offset intersections, this design keeps bicycles physically separate from motor vehicles up until the intersection, providing a high degree of comfort and safety for people of all ages and abilities. This design can reduce the likelihood of high speed vehicle turns, improve sightlines, and dramatically reduce the distance and time during which people on bikes are exposed to conflicts (see NACTO's Don't Give Up at the Intersection).

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Benefits:

- Protected intersections provide shorter, safer crossings for people walking. With low-speed vehicle turns and room for accessible pedestrian islands, people on foot and using personal mobility devices get many of the benefits of curb extensions.
- Protected intersections create shorter, simpler crossings, more predictable movements, and better visibility between people on bikes and people driving. As a result, the intersection is more comfortable and safer for people using the bikeway and the crosswalk.

Considerations:

- They are most commonly found on streets with parking-protected bike lanes or buffered bike lanes. Variants can be applied where there is no bike facility on the intersecting street, as well as streets with two-way protected bike lanes.
- Where no parking lane exists, a setback can be created by shifting the bikeway or motor vehicle lanes away from one another as they approach the intersection. This can be achieved through a buffer.

Guidelines:

- No Stopping/No Standing Zones: Zones should be long enough to allow approaching drivers and bike riders to see and recognize one another ahead of the intersection. Features that permit visibility, such as plants, seating, bike parking, and shared micromobility stations, can be placed here.
- Bike Yield Line & Bike Lane Crosswalk: Bike traffic should be expected to move forward to the stop bar on any signal phase, and pedestrian traffic should also be expected to cross to the island on any phase. This operation may be formalized with optional yield teeth on the bikeway before the crosswalk.
- Pedestrian Islands: Wider islands support high volumes of people walking and biking, raising the person-capacity of the intersection. Refer to Standard Drawing SDG-139 and Section 6.4.5 for standards and guidelines of pedestrian islands.
- Bike Queue Areas: Queue areas should be large enough for anticipated bicycle volumes, which often increase substantially after implementation of protected bike lanes. The bike queue area should be at least 6.5' deep, but dimensions of 10' or greater are desirable to accommodate trailers, cargo bicycles, and high bike volumes.
- Bikeway Setback: The bikeway setback distance determines most other dimensions of the protected intersection. A 10' setback, created in the shadow of the parking/loading lane, is shown. Where practical, a setback of 14-20' is preferred. If setbacks smaller than 12' are used, they should be accompanied by longer clear distances, and additional signal phasing or speed reduction strategies should be considered. Setbacks larger than 20' may increase turn speeds, and setbacks larger than 25' should be treated as a separate intersection.

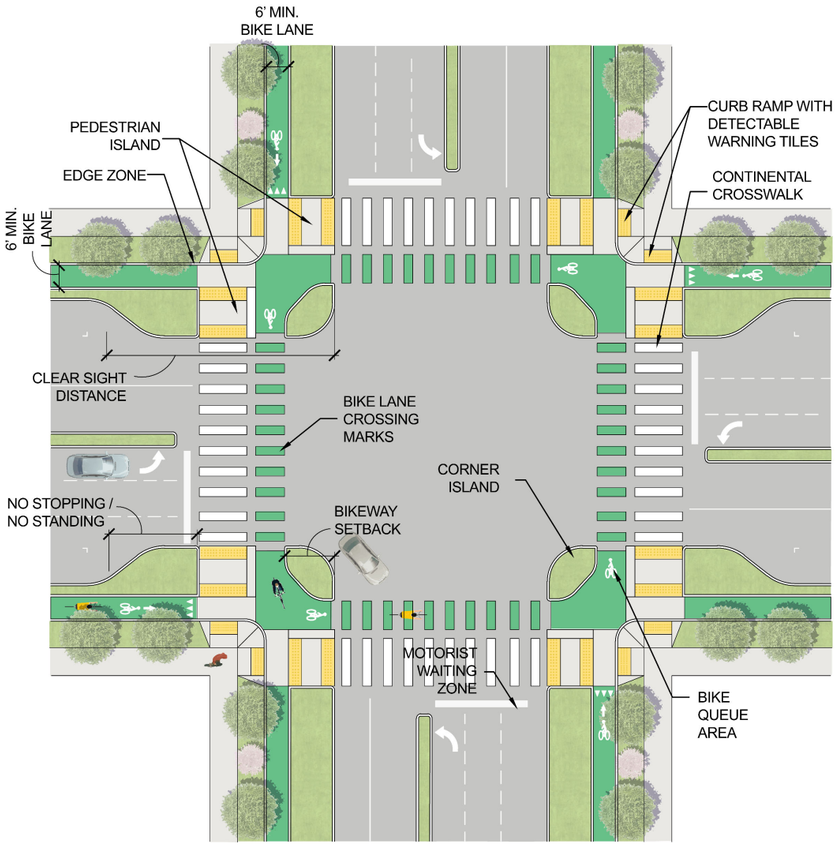

FIGURE 6-9 PROTECTED INTERSECTION

- Corner Island: Radii should be small enough that passenger cars are discouraged from turning faster than 10 mph. This is accomplished with an effective turn radius of less than 18', usually resulting from a 10' to 15' curb radius. Corner islands may have a mountable override area to accommodate large vehicles. Corner islands may also be implemented as channelization markings that are reinforced by mountable vertical elements such as modular speed bumps.
- Crossbikes/Intersection Crossing Markings: Crossbike markings can be marked with dotted bicycle lane line extensions and may be supplemented with green color or bike symbols between these lines.
- See CA MUTCD, PROWAG, other national guidance, and local standards for signal timing, signage and location guidance.

References:

- Don't Give Up at the Intersection, NACTO, 2019
- Improving Intersections for Pedestrians and Bicyclist: Informational Guide, FHWA, 2022

- Signalized Intersections Informational Guide, FHWA, 2013

6.5.3 Bicycle Accommodations at Intersections

6.5.3.1 Bend-In Bicycle Treatment

When a separated bike lane approaches an intersection with right-turning vehicles still positioned to the left of the separated bike lane, the designer may choose to either "bend-in" or "bend-out" the separated bike lane at the intersection to reduce the likelihood of conflicts with right-turning vehicles. To increase the visibility of bicyclists for turning vehicles, the bend-in design positions bicyclists adjacent to the vehicle turn lane. (Federal Highway Administration Separated Bike Lane Planning And Design Guide)

Benefits:

- Motorists on a side street can see bicycles and vehicles in a similar field of vision.
- Requires less space than bending out
- A bend-in design creates the opportunity to construct a curb extension to reduce pedestrian crossing distances. The design can create public space which could be used for:
    - Bike parking corrals
    - Bikeshare stations
    - Parklets
    - Public art exhibits
    - Bioswales/rain gardens

Considerations:

- Bicyclists may perceive less separation due to proximity of through vehicles.
- Bike lane symbols should be placed periodically to reduce the intrusion of pedestrians and motorists into the separated bike lanes. The words BIKE LANE may be used as an alternative to the bike symbol. Periodic maintenance will be required to ensure markings remain visible.

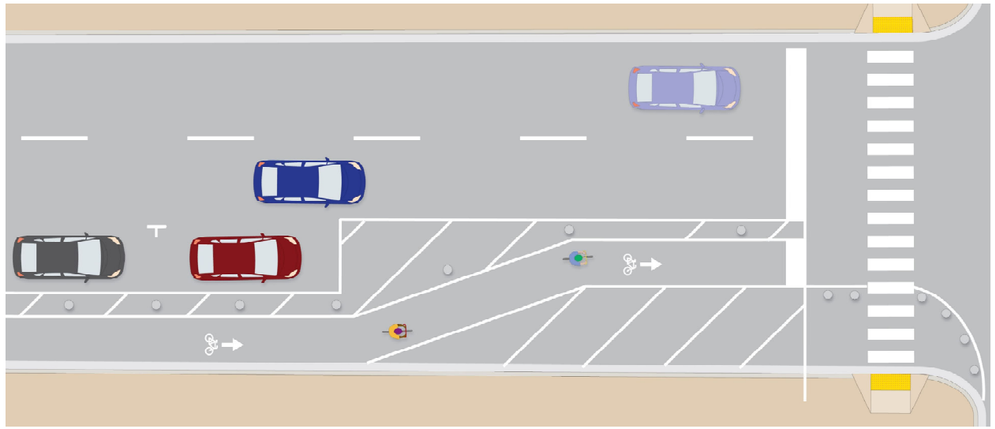

FIGURE 6-10 BEND-IN BICYCLE TREATMENT

Standards and Guidelines:

- Shift bicycle lane closer to motorized traffic so motorists and bicyclists can see each other better.
- A 'Turning Vehicles Yield To Bikes' sign may be placed on the mast arm.
- Guidance for parking space markings can be found in CA MUTCD Section 3B.19.
- For further guidance on typical signs and markings for separated bike lanes, see the Federal Highway Administration Separated Bike Lane Planning And Design Guide.

References:

- CA MUTCD Rev. 8 (Section 3B.19), Caltrans, 2024
- Separated Bike Lane Planning and Design Guide, FHWA, 2015

6.5.3.2 Bend-Out Bicycle Treatment

The bend-out design positions bicyclists downstream on the side street away from the intersection, allowing vehicles to complete turning movements before interacting with bicyclists. This design, which could be used on lower-volume side streets or driveways, provides space for a vehicle to yield to crossing bicycles without blocking through traffic on the main street. A Bicycle/Pedestrian Warning (W11-15) sign may be used as driveways approach separated bike lanes to alert drivers to be aware of bikes and pedestrians. (Federal Highway Administration Separated Bike Lane Planning And Design Guide)

Benefits:

- Allows vehicle traffic turning across separated bike lane to queue out of the way of through traffic and before the separated bike lane.
- Allows a queuing location for cyclists wanting to turn left.
- Raised crossing provides traffic calming for automobiles and can also slow bicyclists.

- Bend-out design provides opportunity for an ample pedestrian refuge between the separated bike lane crossing and the roadway crossing.

Considerations:

- Requires more space than Bend-in
- Less familiar design
- Adequate sight distance may be difficult for vehicles approaching on the side street.

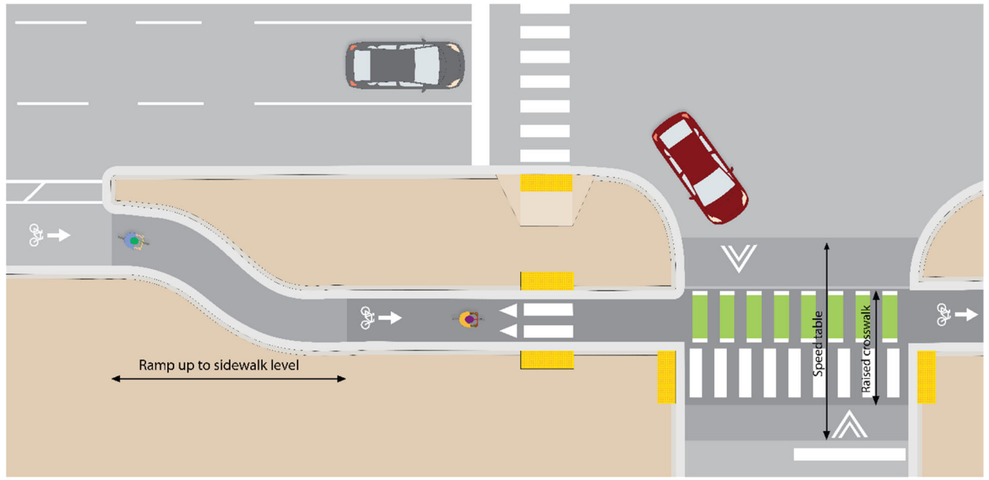

FIGURE 6-11 BEND-OUT BICYCLE TREATMENT

Guidelines:

- Separated bike lane and crosswalk may be raised to sidewalk level through the intersection, providing a traffic calming effect.
- A 'Turning vehicles yield to bikes' sign may be placed on the mast arm.
- For further guidance on buffer selection and installation and typical signs and markings for separated bike lanes, see the Federal Highway Administration Separated Bike Lane Planning And Design Guide.

References:

- Separated Bike Lane Planning and Design Guide, FHWA, 2015

6.5.4 Bicycle Pavement Marking Approaching an Intersection

Bicycle pavement markings alert bicyclists and motorists of each other's presence as they approach intersections.

Benefits:

- Maintains continuity of the bicycle facility.
- Guides bicyclist movements when approaching intersections.
- Alerts motorists to expect and yield to merging bicycle traffic.
- Signifies an appropriate location for motorists to safely merge across the bike lane into the right-turn lane.
- Reduces potential for conflicts between bicyclists and automobiles.

Considerations:

- If a full bike lane pocket cannot be accommodated, a shared bicycle/right turn lane can be installed that places a standard-width bike lane on the left side of a dedicated right-turn lane. This treatment may include signs advising motorists and bicyclists of proper positioning within the lane.
- In cases where there is insufficient roadway space to accommodate a bike lane pocket, the bicycle lane may have to be dropped altogether. However, sharrows provide an alternative option for marking a bikeway through an intersection where a bike lane pocket cannot be accommodated.

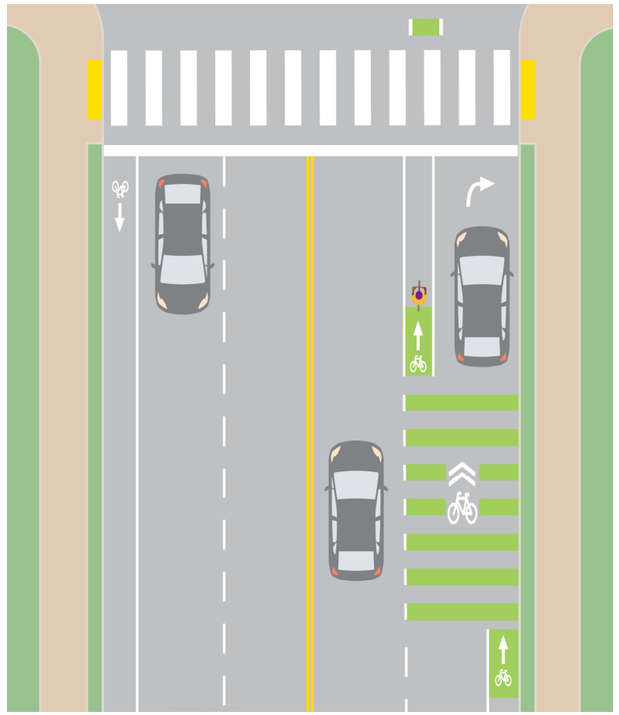

FIGURE 6-12 BICYCLE PAVEMENT MARKING APPROACHING AN INTERSECTION

Guidelines:

- Green colored pavement increases the visibility of conflict areas between bicyclists and vehicles (e.g., intersection approaches, driveways, and transitional zones).
- Apply dashed white lines (4" wide, 2' long) in the merging area at least 50' before the intersection or 100' if along a high speed/volume roadway.
- Bicycle lane pocket and through lane (next to a vehicular right turn pocket) should be 4' minimum but 6' preferred.
- Include signage (CA MUTCD 2B.20) to force vehicle in right turn lane to turn right.
- Consult CA MUTCD Part 9 for guidance regarding traffic control for bicycle facilities.
- Merging across two lanes exceeds the comfort zone of most bicyclists. Double right turn lanes or an inside through/right combination lane should be avoided on routes with heavy bicycle use. To prevent vehicles in the outside right turn lane from turning into a bicyclist it is important to encourage proper lane positioning for the bicyclist. This can be accomplished by providing a bicycle lane to the left of the outside turn lane with a bicycle lane. This design positions bicyclists using a bicycle lane to the outside of a double right-turn lane. This treatment should only be considered at locations where the right most turn lane is a pocket at the intersection. In this instance, the bicyclist would only have to merge across one lane of traffic to reach the bicycle lane. While non-standard colored bicycle lanes may also help distinguish the bicycle lane in the merging area, bicyclists should not be expected to merge across two lanes of traffic to continue straight though an intersection.

References:

- CA MUTCD Rev. 8, Caltrans, 2024
- Guide for the Development of Bicycle Facilities, AASHTO, 2012
- Highway Design Manual, 7th ed., Caltrans, 2020
- Urban Bikeway Design Guide, NACTO, 2014

6.5.5 Bicycle Pavement Markings Through an Intersection

Bicycle pavement markings, also known as bicycle lane extensions, provide a clear boundary to help guide bicyclists safely through intersections.

Benefits:

- Raises awareness for both bicyclists and motorists to potential conflict areas within the intersection.
- Guides bicyclists through an intersection in a straight and direct path.
- Alerts motorists to not veer into the path of bicyclists also passing through the intersection.
- Relieves bicyclist stress by delineating clear travel paths.
- Reduces conflicts between bicyclists and motorists.

Considerations:

- Striping may not be required for every signalized intersection and should be evaluated and implemented on a case-by-case basis.

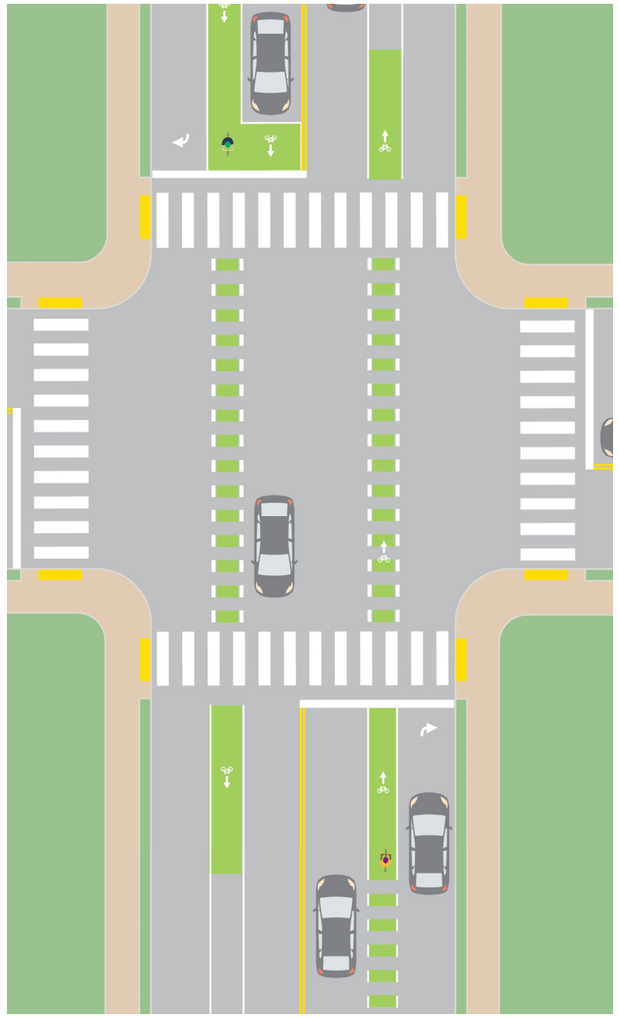

FIGURE 6-13 BICYCLE PAVEMENT MARKINGS THROUGH AN INTERSECTION

Guidelines:

- Striping width shall be a minimum of 6" (Standard Plans A20D Detail 40) adjacent to motor vehicle travel lanes and/or should otherwise match the striping dimensions and lateral positioning of the

leading bike lane. Green-colored pavement may be used in-between the bike lane extension striping.
- Bicycle lane markings may be extended through intersections consistent with the provisions of the CA MUTCD Section 3B.08.
- Bicycle lane markings as shown in Figure 9C-106 (CA MUTCD) may be used within the boundaries of bicycle lane extensions.

References:

- CA MUTCD Rev. 8 (Section 9C.04 and Figure 9C-106), Caltrans, 2024
- Guide for the Development of Bicycle Facilities, AASHTO, 2012
- Standard Plans (A20D), 7th Ed., Caltrans, 2022
- Urban Bikeway Design Guide, NACTO, 2014

6.5.6 Bicycle Box

A bicycle box is generally right-angle extension to a bicycle lane at the head of a signalized intersection. Bicycle boxes give bicyclists a clear, designated space in front of queued vehicles while waiting for a green light at intersections. Motorists must stop behind the white limit line at the back end of the bicycle box and are restricted from making a right turn on a red light at the intersection. Bicycle boxes allow bicyclists to safely position themselves before shifting into their desired travel lane.

Benefits:

- Improves visibility of bicyclists.
- Allows bicyclists to safely position themselves at the front of the queue and establish position in the intersection when the light turns green.
- Reduces signal delay for bicyclists.
- Allows bicyclists to avoid breathing in exhaust fumes from queued vehicles.
- Facilitates ideal positioning for bicyclist left turns on a two-lane roadway with traffic in each direction, or at offset/jogged intersections.
- Reduces conflicts between bicyclists and motorists, especially where collisions occur when vehicles turn right.

Considerations:

- Colored pavement surface may be costly to maintain.
- Placement of markings between tire tracks will reduce wear.
- Bicycle boxes may extend across multiple travel lanes to facilitate bicyclist left turn positioning. A two-stage turn queue box may be an alternative approach to facilitating left turns where there are multiple vehicle through lanes.

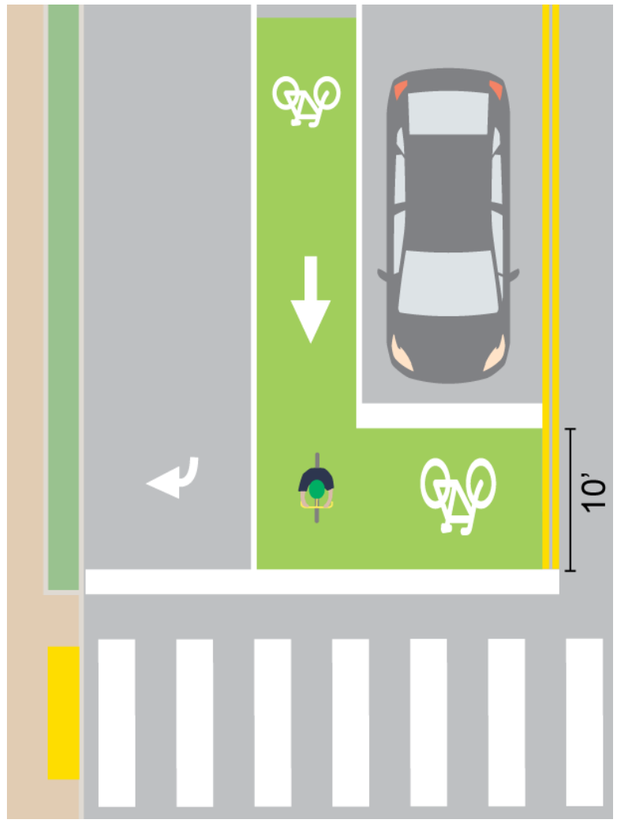

FIGURE 6-14 BICYCLE BOX

Guidelines:

- The bicycle box shall be 10’ deep to allow for bicycle positioning with a pronounced stop line (MUTCD 9E.12) at the back edge as a buffer from vehicles.
- Signage should be present to prevent ‘right turn on red’ and to indicate where the motorist must stop (CA MUTCD 2B.54).
- A “Wait Here” marking can also be used to supplement the intent of the stop line.
- Where right-turn-only lanes for motor vehicles exist, bicycle lanes should be designed to the left of the turn lane. If a right-turn-on-red is desired, consider ending the bicycle box at the edge of the bicycle lane to allow motor vehicles to make this turning movement.

References:

- CA MUTCD Rev. 8 (Section 2B.54), Caltrans, 2024
- Manual on Uniform Traffic Control Devices for Streets and Highways, 11th ed., FHWA, 2023
- Urban Bikeway Design Guide, NACTO, 2014

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6.5.7 Two-Stage Turn Queue Box

A two-stage turn queue box, or a “Copenhagen left turn,” helps facilitate bicyclist left turns at multi-lane signalized intersections. When bicyclists enter the intersection from a right-side bicycle lane, they can wait in a queue box that allows them to reposition their bike and complete their original left turn at the next green light.

Benefits:

- Improves bicyclist ability to make left turns safely and comfortably.
- Provides a formal queuing space for bicyclists making a two-stage turn.
- Reduces turning conflicts between bicyclists and motor vehicles.
- Prevents conflicts arising from bicyclists queuing in a bike lane or crosswalk.
- Separates turning bicyclists from through bicyclists.

Considerations:

- There are various queue box configurations to consider depending on roadway geometry. These include a cycle track buffer configuration, a parking lane configuration, a crosswalk setback configuration, a bike box configuration, a T-intersection parking lane configuration, and a T-intersection “jughandle” sidewalk configuration. More information can be found in NACTO’s Urban Bikeway Design Guide.
- While two stage turns may increase bicyclist comfort in many locations, this configuration typically results in increased delay for bicyclists. Bicyclists now need to receive two separate green signal indications (one for the through street, followed by one for the cross street) to turn. At unsignalized intersections this configuration may also increase delay for bicyclists due to the need to wait for appropriate gaps in crossing motor vehicle traffic.
- On Trolley routes, use two-stage turn queue boxes to encourage bicyclists to cross tracks at a safe angle. (MTS Designing for Transit)

Guidelines:

- See Section 9E.11 of the FHWA MUTCD for standards and guidelines for the optional Use of Two-Stage Bicycle Turn Boxes within an intersection.
- A queue box shall be designated to hold queuing bicyclists and formalize two-stage turn maneuvers.
- Pavement markings shall include a bicycle stencil and a turn arrow to clearly indicate proper bicycle direction and positioning.
- The queue box shall be placed in a safe, designated area that does not conflict with the path of motor vehicle travel. Typically, this is between the bicycle lane and the pedestrian crosswalk within the intersection. Colored paving inside of the queuing area should be used to further define the bicycle space.
- Markings across intersections should be used to define through bicyclist positioning.

- In cities that permit right turns on red signal indications, a "No Turn on Red" sign shall be installed overhead to prevent vehicles from entering the queuing area (CA MUTCD 2B.54).

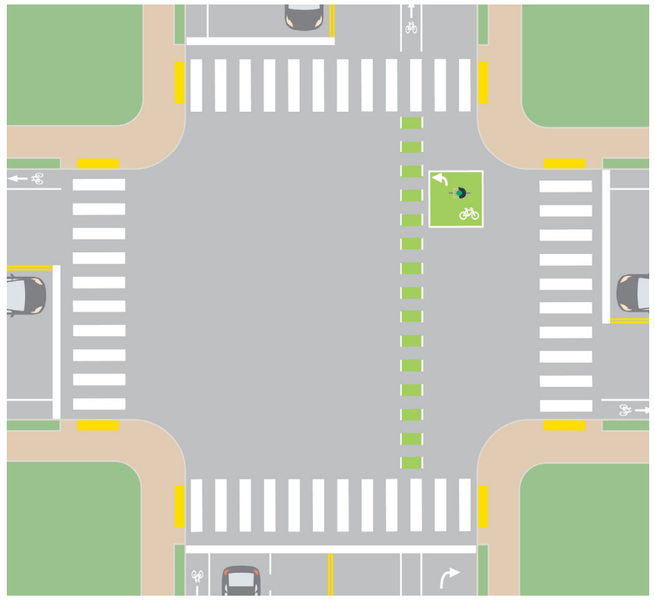

FIGURE 6-15 TWO-STAGE TURN QUEUE BOX

- In cases where a constrained roadway geometry or right of way prevents the creation of a dedicated two stage turn queue box in a protected location:
    - The pedestrian crosswalk may be adjusted or realigned to enable space for a queue box.
    - A bike box may be provided behind the pedestrian crossing to serve the same purpose. This configuration should only be considered if pedestrian volumes are low, as bicyclists must yield to pedestrians in the crosswalk before entering the queue.

References:

- CA MUTCD Rev. 8 (Section 2B.54), Caltrans, 2024
- Designing for Transit, MTS, 2018
- Urban Bikeway Design Guide, NACTO, 2014

6.5.8 Bicycle-Only Left Turn Pockets

A bicycle-only left turn pocket grants exclusive left turn access to bicyclists from the center turn lane. At locations with jogged and T-intersections, bicyclists can enter a left turn pocket in the center turn lane and wait for a gap in traffic before continuing left onto the intersecting local street.

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Benefits:

- Provides route continuity for bicycle travel along local streets that have jogged or offset intersections.

Considerations:

- If traffic volumes are moderate to high, restricting vehicular left turns (at offset intersections where bicycle left turn pockets are present) may reduce conflicts between bicyclists and vehicles.

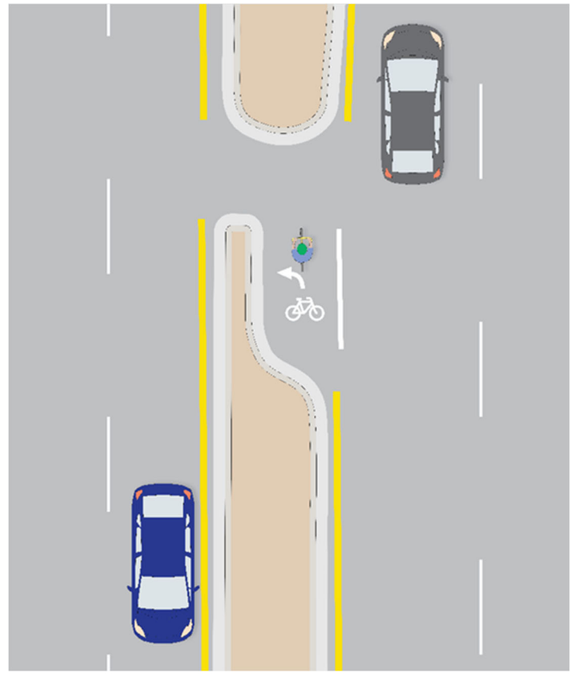

FIGURE 6-16 BICYCLE-ONLY LEFT TURN POCKET

Guidelines:

- The bicycle left turn pocket should be 4' minimum in width, with 5' preferred.
- Signs and raised median design restrictions should be provided that prohibit motorists from turning, while allowing access to bicyclists.
- Bicycle only signal heads may also be used at busy or complex intersections.
- The left turn pocket should be protected by a raised curb, but the pocket may also be defined by striping if necessary.

6.6. Signalized Intersections

Traffic signals are electrically operated traffic control devices that provide indication for roadway users to advance their travels by assigning right-of-way to each approach and movement. Traffic signals are a common form of traffic control to address roadway operations and safety issues. They allow the shared use of road space by separating conflicting movements in time and allocating delay and can be used to enhance the mobility and safety of some movements. (FHWA Signalized Intersections Informational Guide).

Traffic signals can be designed to improve pedestrian safety at intersections. Pedestrians can be given lead time so they can enter an intersection before vehicles; as a result, they'll be more visible to drivers. Meanwhile, shorter signal cycles can reduce the amount of time that pedestrians wait to cross; this can reduce delays and discourage people from crossing against the light. Traffic signals that prevent vehicles from turning right on red also may help prevent conflicts between drivers and pedestrians at crowded intersections. Traffic signals furthermore can be aligned with transit headways; this can help prioritize crossing for pedestrians.

Different technologies can be utilized such as a fiber optic network or a wireless traffic signal interconnect. Fiber optic network could be a good solution for an area with wide communication infrastructure that can serve all proposed and future ITS needs. Wireless traffic signal interconnect system can provide communication between two or more traffic signal controllers which are part of an interconnected traffic signal system using radio.

6.6.1 Pedestrian Signals and Phasing

Pedestrian signals provide an indicator to pedestrians for when they should cross at an intersection.

6.6.1.1 Exclusive Pedestrian Phase

An exclusive pedestrian phase, or pedestrian scramble, allows intersection crossings in all directions (including diagonally) while vehicles are stopped.

Benefits:

- Allows pedestrians to cross in any direction, negating the need to cross twice to reach destinations diagonally across the intersection (when diagonal crossings are employed).
- Reduces conflicts between motorists and pedestrians by isolating movements for each to occur in separate signal cycles.

Considerations:

- Exclusive pedestrian phases should be reserved for locations that have extremely high pedestrian volumes throughout the day. Leading pedestrian intervals (LPI) are typically a better choice for most locations.
- The tradeoff to safer, multi-directional crossings afforded by an exclusive pedestrian phase is increased wait times for all intersection users.
- This treatment may potentially confuse visually impaired pedestrians who rely on traffic sounds to decide when and where to cross.
- This treatment may affect the ability to synchronize timing at adjacent traffic signals.

FIGURE 6-17 EXCLUSIVE PEDESTRIAN PHASE

Location: Market Street and 5th Avenue

References:

- CA MUTCD Rev. 8 (Section 2B.54, 3B.18), Caltrans, 2024
- Proven Safety Countermeasures, FHWA, n.d.
- PROWAG (Section R308.3.2.2), US Access Board, 2023
- Steps to a Walkable Community: A Guide for Citizens, Planners, and Engineers, AmericaWalks, 2012

6.6.1.2 Lead Pedestrian Interval

Lead Pedestrian Intervals (LPI) at Traffic Signals enable pedestrians to establish themselves in the crosswalk before concurrent traffic movements get a green indication. This reduces conflicts between pedestrians and turning vehicles.

Benefits:

- LPIs increase the visibility of crossing pedestrians and give them priority within the intersection.
- LPIs typically require adjustments to existing signal timing that are relatively low cost compared to other countermeasures.

Considerations:

- This treatment may potentially confuse visually impaired pedestrians who rely on traffic sounds to decide when and where to cross. Non-visual format such as audible tones, speech messages, and/or vibrating surfaces should be provided.
- This treatment may affect the ability to synchronize timing at adjacent traffic signals.

FIGURE 6-18 LEAD PEDESTRIAN INTERVAL

Location: Aero Drive and Convoy St/Linda Vista Road

Guidelines:

- Accessible Pedestrian Signals are required with an LPI implementation.

- Leading pedestrian intervals grant pedestrians a walk signal 3 to 7 seconds before a green light is given to vehicles traveling in the same direction or turning left at the intersection. Additional time can be
- To increase the effectiveness of an LPI and improve the visibility of pedestrians, a curb extension could be installed at the intersection corners.
- "NO TURN ON RED" signs and "NO RIGHT TURN ON RED" blank-out signs should be considered with LPIs. Refer to Section 5.8.9.1 "Turn Restrictions".

References:

- CA MUTCD Rev. 8, Caltrans, 2024
- General Plan, City of San Diego, 2024
- Traffic Safety Bulletin 21-01: LPI Implementation Guidelines, Caltrans, 2021
- Urban Street Design Guide, NACTO, 2013

6.6.1.3 Accessible Pedestrian Signal

Accessible Pedestrian Signals (APS) are devices that communicate information about pedestrian timing in nonvisual format such as audible tones, verbal messages, and/or vibrating surfaces. APS is required at all new and major modified traffic signals.

Benefits:

- Improve ability of pedestrians with hearing and visual impairments to cross the street safely.
- Allow pedestrians to more accurately judge beginning of "WALK" interval.
- Reduce crossings begun during "DON'T WALK" phase.

Considerations:

- Audible signals can be heard six to twelve feet from the push button. Volumes become louder or softer in response to level of traffic noise.
- Passive detection and automatic pedestrian signals reduce the need for those with limited mobility to contact a pushbutton.

Guidelines:

- All new and major alterations of traffic signal require the installation of APS.
- Pedestrian push button shall be located to comply with PROWAG and CA MUTCD.
- APS should be installed at every signalized intersection and pedestrian hybrid beacon.
- APS detectors may be push buttons or passive detection devices.
- APS is typically integrated into the pedestrian detector (push button), so that the audible tones and/or messages come directly from the push button housing.
- They should have a push button locator tone and tactile arrow and can include audible beaconing and other special features.
- The tone of the walk signal should be distinct from the push button locator tone.

- When accessible pedestrian signals are located as close as possible to where pedestrians are waiting to cross the street, they provide the clearest and least ambiguous indication of which pedestrian crossing is served by a device.
- See the "Whitebook" Section 700-4.5 for required elements for Accessible Pedestrian Traffic Signals.

FIGURE 6-19 ACCESSIBLE PEDESTRIAN SIGNAL

Location: India Street and Broadway

References:

- CA MUTCD Revision 8 (Sections 4E.09, 4E.10, 4E.11, 4E.12, and 4E.13), Caltrans, 2024
- Designing Sidewalks and Trails for Access Part II of II: Best Practices Design Guide, FHWA, 2001
- PROWAG, US Access Board, 2023
- The "Whitebook", City of San Diego Engineering and Capital Projects Dept, 2021

6.6.1.4 Pedestrian Countdown Displays at Traffic Signals

Pedestrian Countdown Displays at Traffic Signals let pedestrians know how much crossing time remains.

Benefits:

- Helps pedestrians judge whether there is sufficient time to cross.
- Provides certainty as regards the duration of the flashing DON'T WALK phase.
- Especially helpful to mobility-challenged, elderly pedestrians, and adults accompanying small children.

Considerations:

- May not be easily understood by children or other persons with limited counting ability.
- Does not benefit vision-impaired pedestrians unless the signal is equipped with an audible pedestrian signal.
- Countdown signal technology will not currently work for railroad-preempted traffic signals (i.e. at signalized crossings near rail lines).

FIGURE 6-20 PEDESTRIAN COUNTDOWN DISPLAY

Location: India St and Broadway

Guidelines:

- Pedestrian signal heads provide special types of traffic signal indications exclusively intended for controlling pedestrian traffic. These signal indications consist of the illuminated symbols of a WALKING PERSON (symbolizing WALK) and an UPRAISED HAND (symbolizing DON'T WALK).
- Engineering judgment should determine the need for separate pedestrian signal heads (see CA MUTCD Section 4D.03).
- All pedestrian signal heads used at crosswalks where the pedestrian change interval is more than 7 seconds shall include a pedestrian change interval countdown display in order to inform pedestrians of the number of seconds remaining in the pedestrian change interval.
- See CA MUTCD 4E.06 for pedestrian walk and clearance time guidance.
- See CA MUTCD 4E.07 for guidance on countdown pedestrian signals.

References:

- CA MUTCD Rev. 8 (Section 4C and 4E), Caltrans, 2024
- General Plan, City of San Diego, 2024
- PROWAG, US Access Board, 2023

6.6.2 Bicycle Signals and Phasing

6.6.2.1 Bicycle Signals

A bicycle signal head is a traffic control device at intersections that facilitates bicycle movements separately from cars.

Benefits:

- Separates bicycle movements from conflicting motor vehicle, streetcar, light rail, or pedestrian movements.
- Provides priority to bicycle movements at intersections (e.g., a leading bicycle interval).
- Accommodates bicycle-only movements within signalized intersections (e.g., providing a phase for a contra-flow bike lane that otherwise would not have a phase). Through bicycle travel may also occur simultaneously with parallel auto movement if conflicting automobile turns are restricted.
- Protects bicyclists in the intersection, which may improve real and perceived safety at high-conflict areas.
- Improves operation and provides appropriate information for bicyclists (as compared to pedestrian signals).
- Helps to simplify bicycle movements through complex intersections and potentially improve operations or reduce conflicts for all modes.

Considerations:

- Bicycle signal heads require the same maintenance as standard traffic signal heads, such as replacing bulbs and responding to power outages.

Guidelines:

- Bicycle signal lenses should be 8" in diameter and have yellow housing, yellow visors, and yellow backplates.
- The use of a bicycle signal face is optional. However, such use shall be limited to situations where bicycles moving on a green or yellow signal indication in a bicycle signal face are not in conflict with any simultaneous motor vehicle movement at the signalized location, including right (or left) turns on red. See Chapter 4H of the FHWA MUTCD for additional standards and guidelines.
- Bicycle signal heads typically use standard three-lens signal heads in green, yellow, and red with a stencil of a bicycle.

- A Bicycle Signal (R10-10b) sign shall be installed immediately adjacent to every bicycle signal face that is intended to control only bicyclists, including signal faces that are comprised of all bicycle symbol signal indications, all arrow signal indications, and every combination thereof.
- The purpose of the sign is to inform any motor vehicle drivers who can also see the signal face that these signal indications are intended only for bicyclists.

FIGURE 6-21 BICYCLE SIGNAL HEAD

Location: 5th Avenue and Market Street

References:

- CA MUTCD Rev. 8 (Sections 4C.102 and 4D.104), Caltrans, 2024
- Manual on Uniform Traffic Control Devices for Streets and Highways, 11th ed., FHWA, 2023
- Urban Bikeway Design Guide, NACTO, 2014

6.6.2.2 Bicycle Only Phase

Bicycle-only phases can be used to increase safe turning for bicycles at certain intersections. Generally, bicycle signal faces (bicycle signal heads) are installed to indicate to cyclists when it is their turn to travel, as well as which directions are permitted during that phase.

Benefits:

- A bicycle only signal phase at high-volume intersections for both bicyclists and vehicles may increase bicycle safety due to a lower number of bicycle/vehicle conflicts.

Considerations:

- One of the biggest issues designers face with a bicycle only phase is that it does not permit any conflicting vehicle turn movements when the bicycle signal is green or yellow. This restriction can limit the application of bicycle signals because of the need to prohibit conflicting turning movements such as left or right turns (including turns on red) during the green bicycle signal phase.
-

FIGURE 6-22 BICYCLE ONLY PHASE

Location: Russell Boulevard and Sycamore Lane, Davis, CA
Source: NACTO

Guidelines:

- The minimum duration of the yellow change interval shall be 3 seconds, while the maximum duration of the yellow change interval should be 6 seconds.
- If the bicycle signal is used to separate bicycle movements from right turning vehicles, then right turn on red shall be prohibited when the bicycle signal is active. This can be accomplished with the provision of a traffic signal with red, yellow, and green arrow displays. An active display to help emphasize this restriction is recommended.
- Bicycle signal faces shall not be used to provide a bicycle phase that stops all motorized vehicles and pedestrians at the signalized location to allow multiple bicycle movements from multiple conflicting directions. (FHWA MUTCD: Chapter 4H)

References:

- "Benefit-cost analysis of added bicycle phase at existing signalized intersection", Korve and Niemeier, 2002
- Manual on Uniform Traffic Control Devices for Streets and Highways, 11th ed., FHWA, 2023
- Urban Bikeway Design Guide, NACTO, 2014

6.6.2.3 Bicycle Green Wave

A green wave is when traffic signals are deliberately timed to coordinate successive green lights along a corridor. Therefore, bicyclists that travel along a green wave street at moderate speeds benefit from not having to intermittently stop at intersections.

Benefits:

- Reduce the amount of stops along a corridor.
- Provides for a continuous flow of bicycle traffic at the target speed.
- Lessens the physical demands of bicycling, especially for younger, older, and/or newer riders.
- May encourage vehicular drivers to decrease their speeds in order to reap the benefits of the green wave.
- Slower car speeds improve safety conditions for both pedestrians and bicyclists.

Considerations:

- Before making traffic signal timing modifications, the presence of major transit routes and their ability to meet on-time performance goals should be evaluated on potential green wave streets.

Guidelines:

- The appropriate signage should be posted to let bicyclists know they are traveling on a street with a green wave.

FIGURE 6-23 GREEN WAVE SIGNAGE

Source: ITE/SFMTA

References:

- Urban Street Design Guide, NACTO, 2013

6.6.2.4 Bicycle Loop Detector

A bicycle loop detector notifies traffic signals to change when bicyclists are waiting at a red light. When a bike is positioned squarely on top of the designated pavement marking (where the loop detector lies underneath), it will be picked up and trigger a green light at the next available signal phase for the bicyclist.

Benefits:

- Improves efficiency and flow of bicycle traffic.
- Reduces delay for bicyclists.
- Increases convenience and safety of bicycling.
- Affords bicyclists the same technology given to motorized vehicles.
- Provides more time for bicyclists to clear the intersection by prolonging the green light phase.
- Discourages red light running by bicyclists, which reduces the risk of collisions with motorized vehicles.

Considerations:

- Loop detector sensitivity settings need to be monitored and adjusted over time.
- Higher car speeds and wider intersections may warrant specific signal timing consideration for bicyclists.

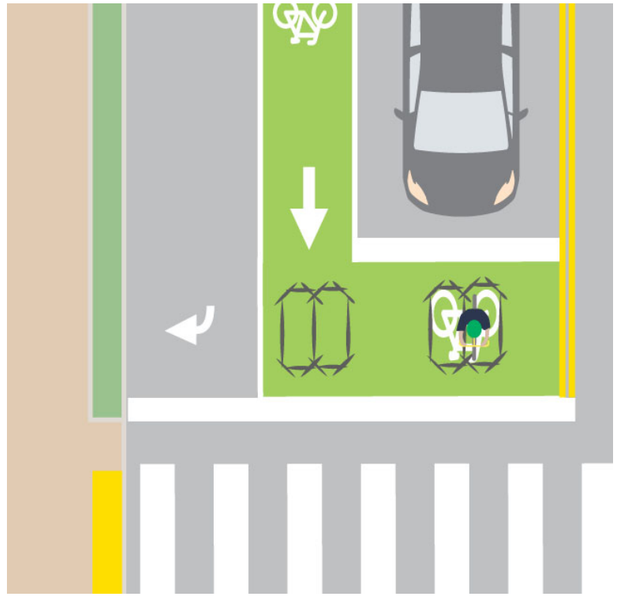

FIGURE 6-24 BICYCLE LOOP DETECTOR

Guidelines:

- Section 4D.105(CA MUTCD) and Figure 4D-111 (CA MUTCD) contain information on bicycle detectors and their locations.
- Loop detectors shall be designed in accordance with the City's Standard Drawings SDE-104 and any other applicable City standards.
- A symbol (see CA MUTCD Figure 9C-7) may be placed on the pavement indicating the optimum position for a bicyclist to actuate the signal.
- An R10-22 sign (see CA MUTCD Section 9B.13 and Figure 9B-2) may be installed to supplement the pavement marking.

References:

- CA MUTCD Rev. 8 (Section 4D.105 and 9C.05), Caltrans, 2024
- CA Vehicle Code (CVC 21450.5), Department of Motor Vehicles, n.d.
- Standard Drawings for Public Works Construction, City of San Diego, 2021
- Standard Plans (ES-5B), 7th Ed., Caltrans, 2024

- Urban Bikeway Design Guide, NACTO, 2014

6.6.3 Transit Signal Prioritization

Transit signal prioritization allows transit vehicles to shorten red lights or extend green lights at signalized intersections with minimal impact to the traffic signal system.

Benefits:

- Reduces delay for transit vehicles.
- Improves transit reliability and travel times.

Considerations:

- Signal coordination should not increase delay for all modes (including transit itself), and should take into consideration the acceleration rates and speeds of bicyclists.

Guidelines:

- Transit signal prioritization requires the installation of specialized equipment at an intersection's traffic signal controller and on the transit vehicle.
- Transit signal priority (TSP) projects are more effective when bus stops are placed at the far side of signalized intersections.
- A corridor's traffic signals can also be programmed to achieve a green wave for transit vehicles by timing the signals to match a bus's average operating speed instead of an automobile's average speed.

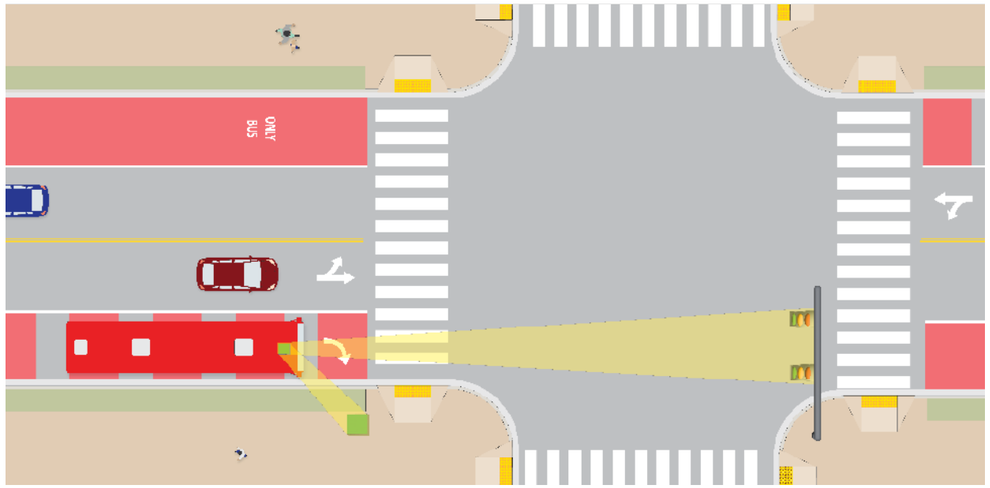

FIGURE 6-55 TRANSIT SIGNAL PRIORITIZATION

References:

- Transit Street Design Guide, NACTO, 2016

6.6.3.1 Queue Jumps

Queue Jumps are design elements with two distinct features: the bypass lane and the traffic signal transit phase. A queue jump is a phase insertion treatment intended to exclusively serve transit vehicles stopped at a red signal and positioned at a near-side stop in a right-turn lane. During the red phase, passengers may board and alight the transit vehicle. The vehicle is then given a green signal in advance of the adjacent lanes, allowing the vehicle to merge back into a through travel lane ahead of the queued traffic in the adjacent lanes. Typically, the time for this phase is allocated from the parallel general traffic movement and lasts three to four seconds. The treatment is also possible at far-side stop locations, where it would be located in the curbside through-movement lane.

Benefits:

- A bus head start can significantly improve bus performance by routing vehicles through congested intersections ahead of traffic.
- As congestion increases, bus queue jumps and bypasses become more effective.

Considerations:

- Queue jumps are most useful at traffic bottleneck locations and don't need to be tied to bus stops.
- If vehicle right-turn volumes are high enough for right-turn queues to occur with regularity, right turns should be accommodated separately from transit in a turn pocket.

Guidelines:

- Separate signals must be used to indicate when transit proceeds and when general traffic proceeds. Transit signals should be a transit specific signal head.
- A transit phase may not be needed if there is a receiving lane for the bus on the far side of the intersection.
- If provided as a shared right-turn/queue jump, a protected right-turn signal may be used with a sign indicating RIGHT TURN SIGNAL and EXCEPT BUSES.
- See the CA MUTCD for guidelines on preferential lanes and signal faces.

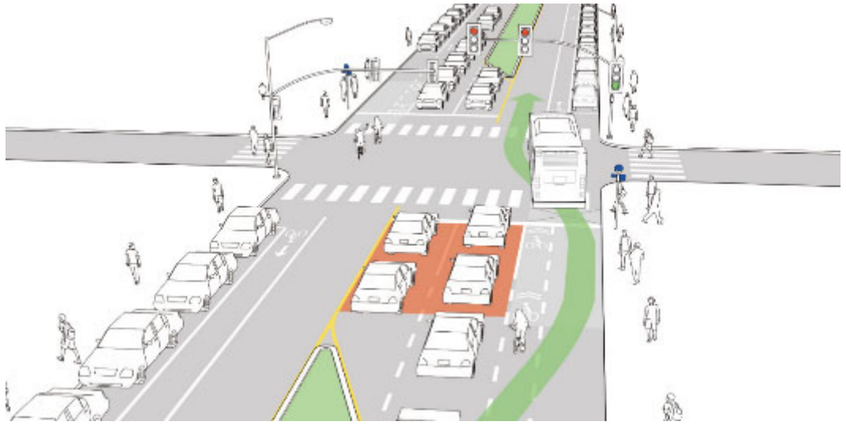

FIGURE 6-26 QUEUE JUMP

Source: NACTO Transit Street Design Guide

FIGURE 6-27 QUEUE JUMP WITH TRANSIT SIGNAL

Location: Ash Street and 1st Avenue

References:

- CA MUTCD Rev. 8, Caltrans, 2024
- Transit Street Design Guide, NACTO, 2016

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6.7. Unsignalized Intersections

Unsignalized intersections are those at-grade junctions of two or more public roads where the control of right-of-way is determined by the presence of a YIELD or STOP sign, or no sign at all (uncontrolled).

6.7.1 Stop Signs

The stop sign is used to assign right of way at an intersection and to make sure that traffic flows smoothly and predictably.

Benefits:

- Lower in cost than traffic signals, both to install and maintain.
- Decreases the speed at which vehicles enter the intersection, reducing potential crash severity particularly at intersections with low visibility.
- Provide for the orderly movement of traffic.

Considerations:

- STOP signs should not be used for speed control.
- STOP signs should be installed in a manner that minimizes the numbers of vehicles having to stop. At intersections where a full stop is not necessary at all times, consideration should be given to using less restrictive measures such as YIELD signs.
- Once the decision has been made to install two-way stop control, the decision regarding the appropriate street to stop should be based on engineering judgment. In most cases, the street carrying the lowest volume of traffic should be stopped.
- A STOP sign should not be installed on the major street unless justified by a traffic engineering study.
- STOP signs should be used if engineering judgment indicates that one or more of the following conditions exist:
    - Intersection of a lower volume road with a main road where application of the normal right-of-way rule would not be expected to provide reasonable compliance with the law;
    - Street entering a through highway or street;
    - Unsignalized intersection in a signalized area; and/or
    - High speeds, restricted view, or crash records indicate a need for control by the STOP sign.

FIGURE 6-28 STOP-CONTROLLED INTERSECTION

Location: Brookhaven Road and Deep Dell Road

Standards and Guidelines:

- Refer to Council Policy 200-08 for the installation of stop signs within the public ROW.
- When it is determined that a full stop is always required on an approach to an intersection, a STOP (R1-1) sign shall be used.
- The STOP sign shall be an octagon with a white legend and border on a red background.
- Secondary legends shall not be used on STOP sign faces.
- At intersections where all approaches are controlled by STOP signs (see Section 2B.07), an ALL WAY supplemental plaque (R1-3P) shall be mounted below each STOP sign. The ALL WAY plaque (see Figure 2B-1) shall have a white legend and border on a red background.
- The ALL WAY plaque shall only be used if all intersection approaches are controlled by STOP signs.
- Supplemental plaques with legends such as 2-WAY, 3-WAY, 4-WAY, or other numbers of ways shall not be used with STOP signs. See CA MUTCD Section 2B.05-2B.07 for additional guidance.

References:

- CA MUTCD Rev. 8 (Section 2B.05-2B.07), Caltrans, 2024
- Council Policy 200-08 "Criteria for the Installation of Stop Signs", City of San Diego, 1997

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6.7.2 Roundabouts

Roundabouts are circular intersections with specific design and traffic control features. These features include yield control of all entering traffic, channelized approaches, and appropriate geometric curvature to ensure that travel speeds on the circulatory roadway are typically less than 30 mph.

The design standards in the following sections apply within the boundaries of roundabouts, mini-roundabouts, and traffic circles. If the volume on any leg of an intersection is greater than 3,000 vehicles per day, a roundabout is recommended over a traffic circle, and must be designed following the standards described in this chapter to ensure that it embodies the fundamental Safe Systems principles of redundancy for human mistakes and low crash energy for human vulnerability. NCHRP has released the most recent version of roundabout guidance (Research Report 1043). It must be followed except when there is a conflict with City of San Diego guidance, which supersedes.

Benefits:

- The physical shape of roundabouts eliminates crossing conflicts that are present at conventional intersections, thus reducing the total number of potential conflict points and the most severe of those conflict points.
- When operating within their capacity, roundabouts typically have lower overall delay than signalized and all-way stop-controlled intersections. The delay reduction is often most significant during non-peak traffic periods.
- Roundabouts often provide environmental benefits by reducing vehicle delay and the number and duration of stops compared with signalized or all-way stop-controlled alternatives.
- Because roundabouts can facilitate U-turns, they can be a key element of a comprehensive access management strategy to reduce or eliminate left-turn movements at driveways between major intersections.
- Roundabouts can have traffic calming effects on streets by reducing vehicle speeds using geometric design rather than relying solely on traffic control devices.

Considerations:

- A roundabout may reduce the amount of widening needed on the approach roadways in comparison to alternative intersection forms. While signalized or stop-controlled intersections can require adding lengthy left-turn and/or right-turn lanes, a roundabout may enable maintaining a narrower cross section in advance of the intersection. However, roundabouts usually require more space for the circulatory roadway, central island, and sidewalks than the typically rectangular space inside traditional intersections. Therefore, roundabouts often have greater right-of-way needs at the intersection quadrants compared with other intersection forms.
- Pedestrians with vision impairments may have more difficulty crossing roundabouts, which can be mitigated with adequate design. Look to the design guidelines below and to the NCHRP Research Report 1043 “Guide for Roundabouts” for more information on making roundabouts accessible.

General Guidelines:

- Signs, striping, and markings at roundabouts are to comply with the CA MUTCD.
- The design of landscaping should consider lines of sight for motorists approaching and traveling around the roundabout. Sufficient sight triangles should be provided to allow for adequate visibility.
- The radius of roundabouts should take into account the design speed for turning vehicles.
- Roundabouts must adhere to the California Highway Design Manual (Chapter 400).
- Roundabouts must adhere to City of San Diego CFC Section 503 for emergency vehicle access.
- For single lane entries, entering fastest paths must be 25 mph or less, constrained by three concrete curbs that provide sufficient entry deflection, and measured using the City of San Diego's fastest path method.
- For two lane entries, entering fastest paths must be 30 mph or less, constrained by three concrete curbs that provide sufficient entry deflection, and measured using the City of San Diego's fastest path method.
- For two lane entries, the outside entry lane must not be close to parallel with the inside circulating lane, maintain a Phi angle of 20-40 degrees for each entry lane (measured using the City of San Diego's Phi Angle method)
- Center, splitter, and curb-extension islands must all be present and raised if volume on that leg is greater than 3,000 vehicles per day.
- For multi-lane approaches, the crosswalk must be raised or include a Rectangular Rapid Flashing Beacon.
- Curbs designed to accommodate long truck off-tracking must be at least 2.5 inches above the roadway surface, and no more than 3.5 inches above it.
- The offset between the face of curb and the design vehicle tire (not vehicle envelope) is:
    - 6 inches for mountable curb with no gutter
    - 12 inches for non-mountable curb with no gutter
    - 18 inches for curb with gutter

Guidelines for Accessible Pedestrian Design with Roundabouts:

- Buffers must be included between the sidewalks and the circulating roadway. The buffer discourages pedestrians from crossing to the central island or cutting across the circulatory roadway of the roundabout, and it helps guide pedestrians with vision impairments to the designated crosswalks.
- A buffer width of 5 ft (minimum 2 ft) or greater may include planting low shrubs, grass, or non-walkable surface in the area between the sidewalk and curb to maintain sight distance needs.
- Crosswalks must be oriented perpendicular to traffic so that pedestrians have maximum cones of hearing and vision no matter which direction they are crossing. If a pedestrian refuge is present, the crosswalk must have an angle point in the center of the refuge.
- Crosswalks must be one car length (20 ft) away from the circulating roadway on each leg that has more than 3,000 vehicles per day (two-way volume).

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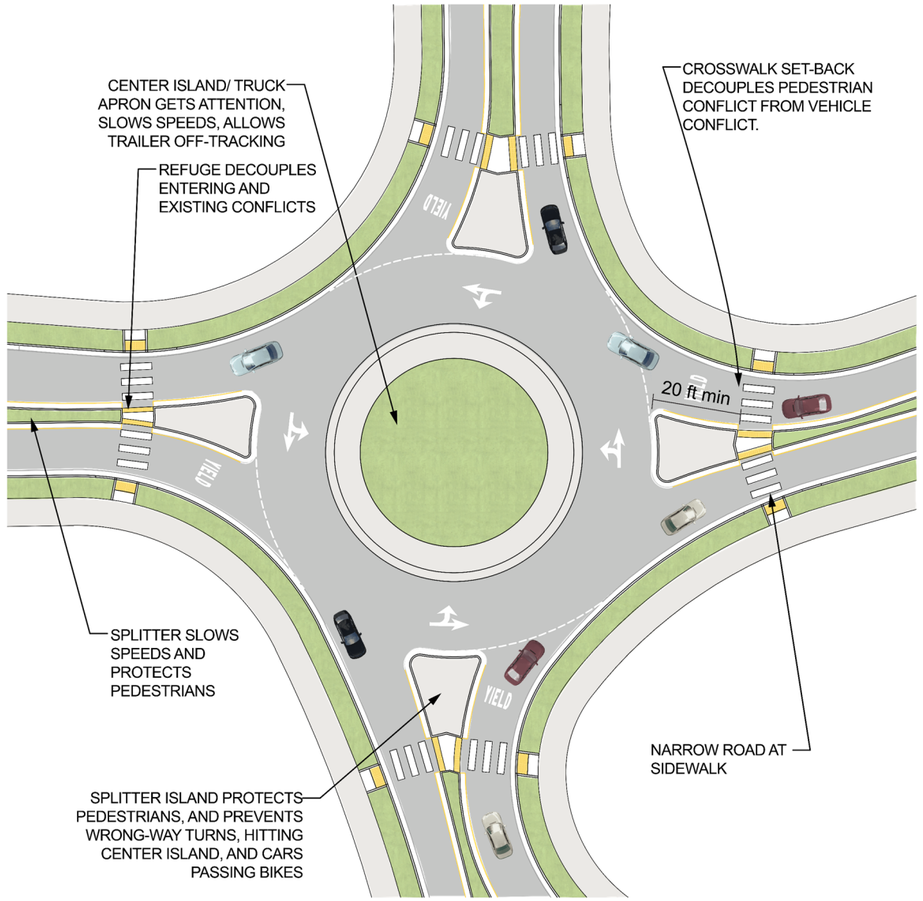

FIGURE 6-29 ROUNDABOUT

- Crosswalks should be located in vehicle-length increments away from edge of the circulatory roadway.
- The pedestrian refuge island must be present between entering and exiting vehicles on each leg that has more than 3,000 vehicles per day (two-way volume).
- Pedestrian refuge islands must be at least 6 feet wide at their narrowest point, with 2 ft of truncated domes aligned with the crosswalks on both sides and at least 2 feet between the domes.
- The pedestrian refuge islands must have an angle point in the center and the edges of the refuge must reflect this angle point in the center.
- If there is no pedestrian refuge island, the crosswalk must not have an angle point and must be as perpendicular as possible to both entry and exit vehicle traffic.
- Pedestrian curb ramps must not have flares so their edges can be used for orientation.

- Bicycle ramps must not resemble pedestrian curb ramps and shall not merge with the curb ramp top landings.
- At some roundabouts, it may be desirable to place the crosswalk two or three car lengths (45 ft or 70 ft) back from the edge of the circulatory roadway. This longer setback is typically used in situations with relatively high volumes of pedestrian crossings that may cause queues on the exit roadway to frequently extend into the circulatory roadway.

Guidelines for Bicycle Facilities within Roundabouts:

- Bicycle lanes the exterior of the circulatory roadway is an impractical solution that is to be avoided, as it creates overlap between bicycle movements and exiting vehicular movements.
- Where bicycle lanes or shoulders are used on approach roadways, they should be terminated in advance of roundabouts. Bicyclists may choose to merge with traffic and travel like other vehicles, or they may choose to exit the roadway onto the sidewalk (or shared use path) and travel as pedestrians. Sufficient sidewalk width for mixed traffic should be provided unless the lane only turns right and is separated from circulating vehicles with raised channelization.
- If a right turn bypass lane for cyclists is provided, it must be separated from the circulating roadway with raised curb to prevent cyclists from proceeding straight into the circle.
- The full width bicycle lane should normally end at least 100 feet before the edge of the circulatory roadway. An appropriate taper (a rate of 7:1 is recommended) should be provided to narrow the combined travel lane and bike lane width down to the appropriate width necessary to achieve desired motor vehicle speeds on the roundabout approach.
- Because some bicyclists may not feel comfortable traversing some roundabouts in the same manner as other vehicles, bicycle ramps can be provided to allow access to the sidewalk or a shared use path at the roundabout.
- Provide bicycle ramps for cyclists to access the shared sidewalks and to return to their lane on the roundabout exits when a driveway is not close enough to serve this purpose.
- Bicycle ramps must align with bicycle lanes and include an angle point to control bicycle speeds.
- Directional indicators may be used to guide visually-impaired to help them stay on the sidewalk.
- In general, bicycle ramps should only be used where the roundabout complexity or design speed may result in less comfort for some bicyclists. Ramps may not be needed at urban one-lane roundabouts, as the low-speed and lower-volume environment will typically allow cyclists to navigate as comfortably as vehicles.

References:

- CA MUTCD Rev. 8, Caltrans, 2024
- California Fire Code (Section 503), California Building Standards Commission, 2022
- FPB Policy A-14-1 "Fire Access Roadways", City of San Diego Fire-Rescue Dept, 2015
- Highway Design Manual, 7th ed., Caltrans, 2020
- Improving Intersections for Pedestrians and Bicyclist: Informational Guide, FHWA, 2022
- NCHRP Research Report 1043: Guide for Roundabouts, National Academies of Sciences, Engineering, and Medicine, 2023
- PROWAG, US Access Board, 2023

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6.7.3 Mini-Roundabouts

Mini-roundabouts are a type of roundabout characterized by a small diameter and traversable islands (central island and splitter islands). Mini-roundabouts offer most of the benefits of regular roundabouts with the added benefit of a smaller footprint. As with roundabouts, mini-roundabouts are a type of intersection rather than merely a traffic calming measure, although they may produce some traffic calming effects. They are best suited to environments where speeds are already low and environmental constraints would preclude the use of a larger roundabout with a raised central island.

Benefits:

- A mini-roundabout can often be developed to fit within existing right-of-way constraints.
- A mini-roundabout may provide less delay for a critical movement or for an overall intersection in comparison to other intersection alternatives.
- Mini-roundabouts have been used successfully in the U.K. to improve safety at intersections with known crash problems, with reported crash rate reductions of approximately 30 percent as compared to signalized intersections.
- Designed properly, a mini-roundabout reduces speeds and can be implemented as part of a broader traffic calming scheme.
- Because of the traversable design of the central island and splitter islands, emergency vehicles are unlikely to have significant difficulty negotiating a mini-roundabout.

Considerations:

- Mini-roundabouts cannot provide the same level of speed reduction as their larger counterparts and thus are less suited for roadways with speeds exceeding 30 to 35 mph.
- Pedestrians are accommodated at pedestrian crosswalks around the perimeter of the mini-roundabout. The splitter islands at mini-roundabouts typically do not provide the same degree of refuge as those at other roundabouts, thus typically requiring pedestrians to cross the street in one stage (as with many conventional intersections).
- Mini-roundabouts are generally located in environments where bicyclists are comfortable negotiating the roundabout as a motor vehicle. In the event a bicyclist desires to navigate the intersection as a pedestrian, sidewalks and crosswalks are provided.
- High volumes of trucks will significantly reduce the capacity of a mini-roundabout, as trucks will occupy most of the intersection when turning. Additionally, high volumes of trucks overrunning the central island may lead to rapid wear of the roadway markings.

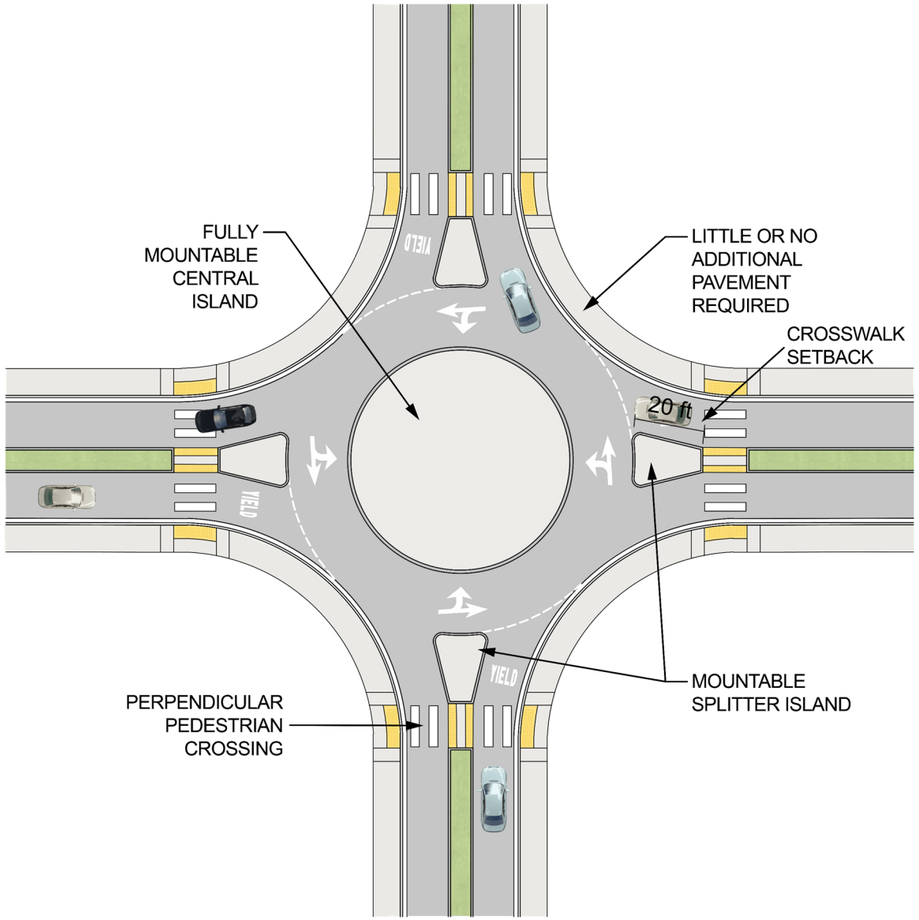

FIGURE 6-30 MINI-ROUNDABOUT

Guidelines:

- A mini-roundabout inscribed circle diameter generally should not exceed 90 ft.
- The central island should be domed using 5 to 6% cross slope, with a maximum height of 5 inches.
- The advanced entrance line into the circulatory roadway should be placed at least 2 ft outside of the vehicle paths.
- Splitter islands at least 6 ft in width should be provided as deflection and as refuge island for pedestrian crossings.
- Reflective signage should be placed within the center island and reflective paint should be used on the curb.
- Sidewalks should be set back from the edge of the circulatory roadway by at least 5 ft so that pedestrians with visual impairments can clearly follow designated crossing paths.

- Signage and detectable warning plates should be provided to delineate pedestrian crossing paths and signal drivers to yield.

References:

- CA MUTCD Rev. 8, Caltrans, 2024
- NCHRP Research Report 1043: Guide for Roundabouts, National Academies of Sciences, Engineering, and Medicine, 2023
- PROWAG, US Access Board, 2023

6.7.4 Traffic Circle

Traffic circles are circular medians placed in the center of an intersection. Traffic flows around the median counter-clockwise through the intersection. Drivers yield to vehicles already circulating within the intersection. These devices may reduce speeds through neighborhoods and the frequency of collisions. Due to the horizontal deflection, vehicles must slow to maneuver around the device. The circular median can be landscaped to help beautify a neighborhood. Traffic circles are appropriate on 25 mph or slower local streets, often within residential neighborhoods rather than in urban centers.

Benefits:

- Traffic circles produce a traffic calming effect.
- Traffic circles can create a landscaping opportunity.

Considerations:

- If medians are raised, traffic circles may impact large vehicles' turns.
- As with all roundabout types, traffic circles do not provide explicit priority to specific users such as trains, transit, or emergency vehicles.
- If the volumes on all legs of an intersection are less than 3,000 vehicles per day, a traffic circle may be used, which may or may not include raised splitter islands on some or all legs or a truck apron.
- They may impact emergency response time.

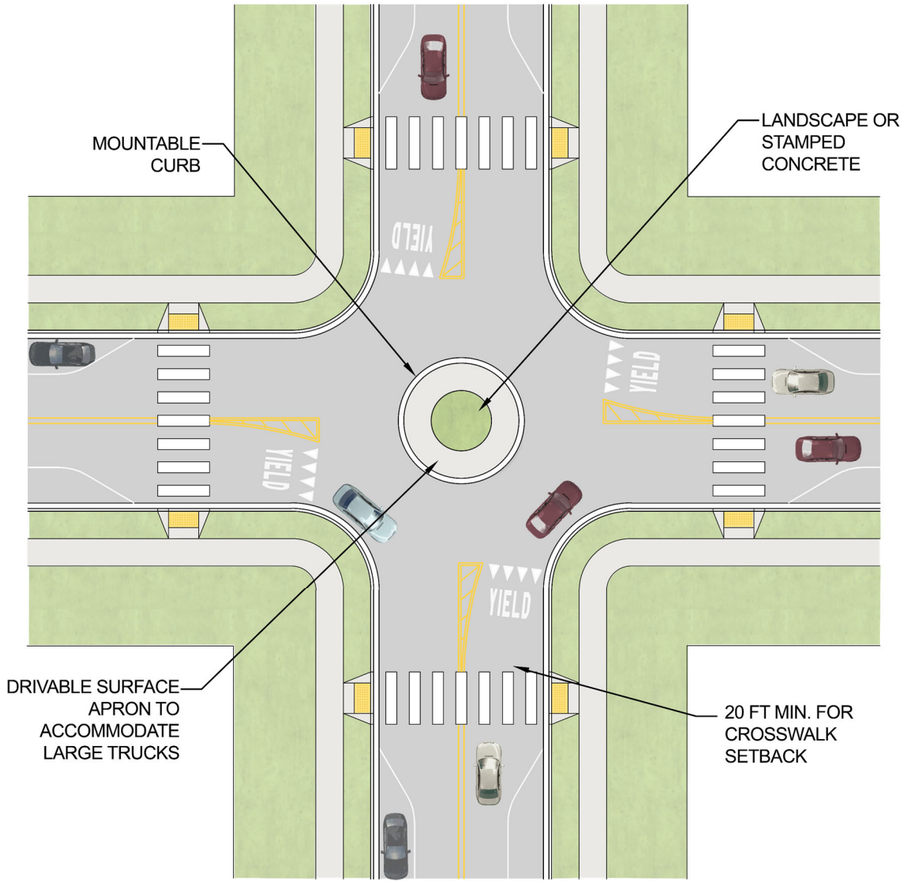

FIGURE 6-31 TRAFFIC CIRCLE

Guidelines:

- Where feasible, landscaping should be incorporated.
- Compared to mini-roundabouts and roundabouts, in which yield control is used on all entries, traffic circles can use stop control or be uncontrolled on one or more entries.

References:

- Traffic Calming Guidelines, City of San Diego Transportation Dept, 2010

6.7.5 Pedestrian Crossings at Uncontrolled Intersections

A marked crosswalk or pedestrian warning sign can improve safety for pedestrians crossing the road, but at times may not be sufficient for drivers to visibly locate crossing locations and yield to pedestrians. To enhance pedestrian conspicuity and increase driver awareness at uncontrolled, marked crosswalks, transportation agencies can install a pedestrian actuated Rectangular Rapid Flashing Beacon (RRFB) or pedestrian hybrid beacons (PHB/HAWKs) to accompany a pedestrian warning sign.

More discussion of these treatments are discussed in Sections 5.6.3 and 5.6.4.

6.8. Intersection Street Lighting

Increased visibility at intersections at nighttime is important since various modes of travel cross paths at these locations. Intersection lighting should be based on factors such as a history of crashes at nighttime, traffic volume, the volume of non-motorized users, the presence of crosswalks and raised medians, and the presence of transit stops and boarding volumes.

Benefits:

- Intersection lighting can reduce pedestrian crashes up to 42% (USDOT FHWA).

Considerations:

- Selecting the most appropriate lighting system is best done through lighting design and calculation on a per-project basis as opposed to using a one-size-fits-all approach.
- Most new lighting installations are made with breakaway features, shielded, or placed far enough from the roadway to reduce the probability and/or severity of fixed-object crashes. Modern lighting technology gives precise control with minimal excessive light affecting the nighttime sky or spilling over to adjacent properties.

Guidelines:

- Lighting shall be installed at all street intersections. Lighting at non-signalized intersections shall conform to Table 6-2.
- Street Lighting at Signalized Intersections shall conform to Caltrans' Roadway Lighting Manual (2021).
- Street Lighting Standards, arms, bases, and mounting heights shall conform to the City of San Diego Standard Drawing (SDE-101) for intersection and mid-block lighting.
- All signalized intersections shall utilize cobra head style luminaires on Type 15 standards per City requirements. Operation of the street light systems shall be network controlled unless otherwise noted.

- See the City's Standard Drawings and City of San Diego Whitebook, Part 7: Street Lighting And Traffic Signal Systems, for required street lighting material requirements, construction requirements, and design guidance.

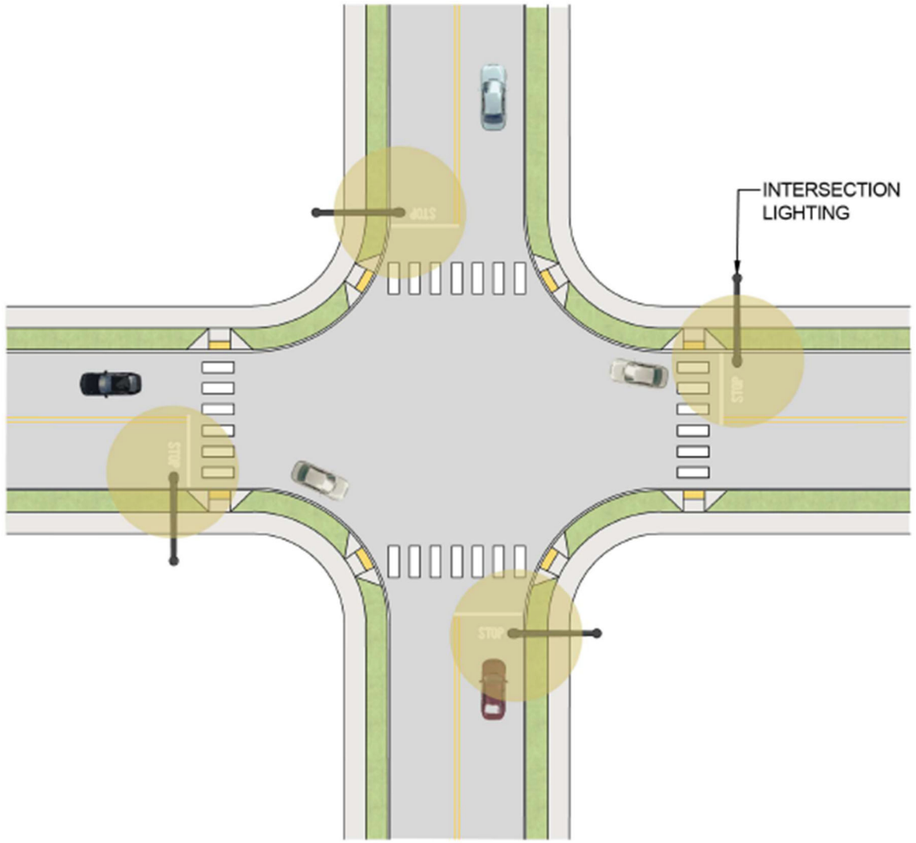

FIGURE 6-32 INTERSECTION LIGHTING

References:

- Approved Materials List for Street Lighting, City of San Diego, 2020
- CA MUTCD Rev. 8 (Part 4), Caltrans, 2024
- Lighting Handbook, FHWA, 2023
- Roadway Lighting Manual, 1st ed., Caltrans, 2021
- Standard Drawings for Public Works Construction, City of San Diego, 2021
- The "Whitebook", City of San Diego Engineering and Capital Projects Dept, 2021

Street B / Street A	B1 Local residential streets (any width) and collector or higher streets up to and including 40 feet wide, curb to curb	B2 Collector or higher streets greater than 40 feet and up to and including 52 feet wide, curb to curb	B3 Collector or higher streets greater than 52 feet wide, curb to curb
A1 Local residential streets (any width) and collector or higher streets up to and including 40 feet wide, curb-to-curb	**A1 to B1** Install (1) pole with a Type Y-INT luminaire on one far right corner of the wider street	**A1 to B2** Same as A2 to B1	**A1 to B3** Same as A3 to B1
A2 Collector or higher streets greater than 40 feet and up to and including 52 feet wide, curb-to-curb	**A2 to B1** Install (2) poles with a Type Z-INT luminaire on both far right corners of the wider street	**A2 to B2** Same as A2 to B1	**A2 to B3** Same as A3 to B2
A3 Collector or higher streets greater than 52 feet wide, curb-to-curb	**A3 to B1** Install (2) poles with a Type Z-INT luminaire on both corners of the wider street and (2) poles with a Type Y-INT luminaire on both corners of the narrower street.	**A3 to B2** Install (4) poles with a Type Z-INT luminaire on each corner.	**A3 to B3** Same as A3 to B2

TABLE 6-2 STREET LIGHTING AT NON-SIGNALIZED INTERSECTIONS

Luminaire Type	Min. Required Luminaire	Street Light Distribution
Type X	3500 Lumens, Min.	Type II
Type Y-INT	6500 Lumens, Min.	Type III
Type Y-MID	6500 Lumens, Min.	Type II
Type Z-INT	11000 Lumens, Min.	Type III
Type Z-MID	11000 Lumens, Min.	Type III

TABLE 6-3 LUMINAIRE REQUIREMENTS