A

DESIGN GUIDELINES

These Design Guidelines are intended to broaden the range of design options for streets in the Tulsa region, recognizing that streets and public rights-of-way comprise a significant portion of a city's area and as such must maximize the public benefit they offer.

As in other cities and communities, streets in Tulsa and the surrounding cities have always served multiple functions. In the nineteenth and early twentieth centuries, they were the primary component of local transportation infrastructure, allowing people and goods arriving by rail to reach local destinations throughout the city. This led to a variety of street users, and accordingly led to a variety of problems for safety and circulation in the streets. As automobile ownership and use increased dramatically in the decades that followed, the city had to accommodate the trend within the space for streets that had already been established.

Over time, street design focused primarily on motor vehicle movement, and the emerging discipline of traffic engineering worked to safely integrate cars and trucks into pre-existing urban forms. While there were clear benefits to accommodating automobile movement through the city, the negative effects have become increasingly evident over the last forty years. The focus on automobiles has resulted in a different form of land development patterns, namely emphasizing vehicle access, and not person access, to buildings and property. This access comes at the expense of other uses of the street and other transportation choices.

The intent of this appendix is to allow the region to choose a different direction for its future and recreate a system of streets that prioritize community-serving functions while still accommodating the automobile mobility needs that streets have traditionally had.

Pedestrian Realm

Sidewalks

Sidewalks are one of the most vibrant and active sections of the overall right-of-way. Throughout the region, sidewalks play a critical role in the character, function, enjoyment and accessibility of neighborhoods. People in the region value the walkability of their city and neighborhoods and wish to see this quality preserved and enhanced. The function and design of the sidewalk significantly impacts the character of each street. Extending from curb to building face or property line, sidewalks are, of course, the place typically reserved for pedestrians, but they also accommodate street trees and other plantings, stormwater infrastructure, street lights, bicycle racks, and transit stops. They are a place of transition and economic exchange as restaurants engage the public space and retailers attract people to their windows and shops.

In many ways, each community has two types of cities in one. Downtown and the neighborhoods in the historic core portion of the city reflect a traditional urban pattern characterized by a regular grid of streets. The grid distributes traffic well and offers many different routing options for pedestrians and travelers using a variety of different modes. Mixed land uses are common in these areas with some residences within walking distance of retail, commercial, community and green space amenities.

In the outlying areas of the city and farther out into the county, many streets have a more typical suburban development pattern and curve through quiet residential areas with little cut-through automobile traffic. The land use is generally of lower intensity with greater separation and more open space. Sidewalk network coverage on these local streets varies from community to commuity, and curvilinear streets create atypically shaped intersections with increased crossing distances and decreased pedestrian visibility. These neighborhood residential streets are set within an arterial grid of high-volume, high-speed streets that present barriers to pedestrian travel, especially those without sidewalks present.

Sidewalk Zones

Sidewalks are not a singular space, but are comprised of distinct usage zones. Sidewalks typically are located in the right-of-way that extends from the curbline to the property line behind it. They can be broken up into three primary zones, each of which performs a unique function in the overall operation of the street and interface with adjacent private property uses. Although boundaries between zones may blur and blend, their overall function of each zone generally remains consistent.

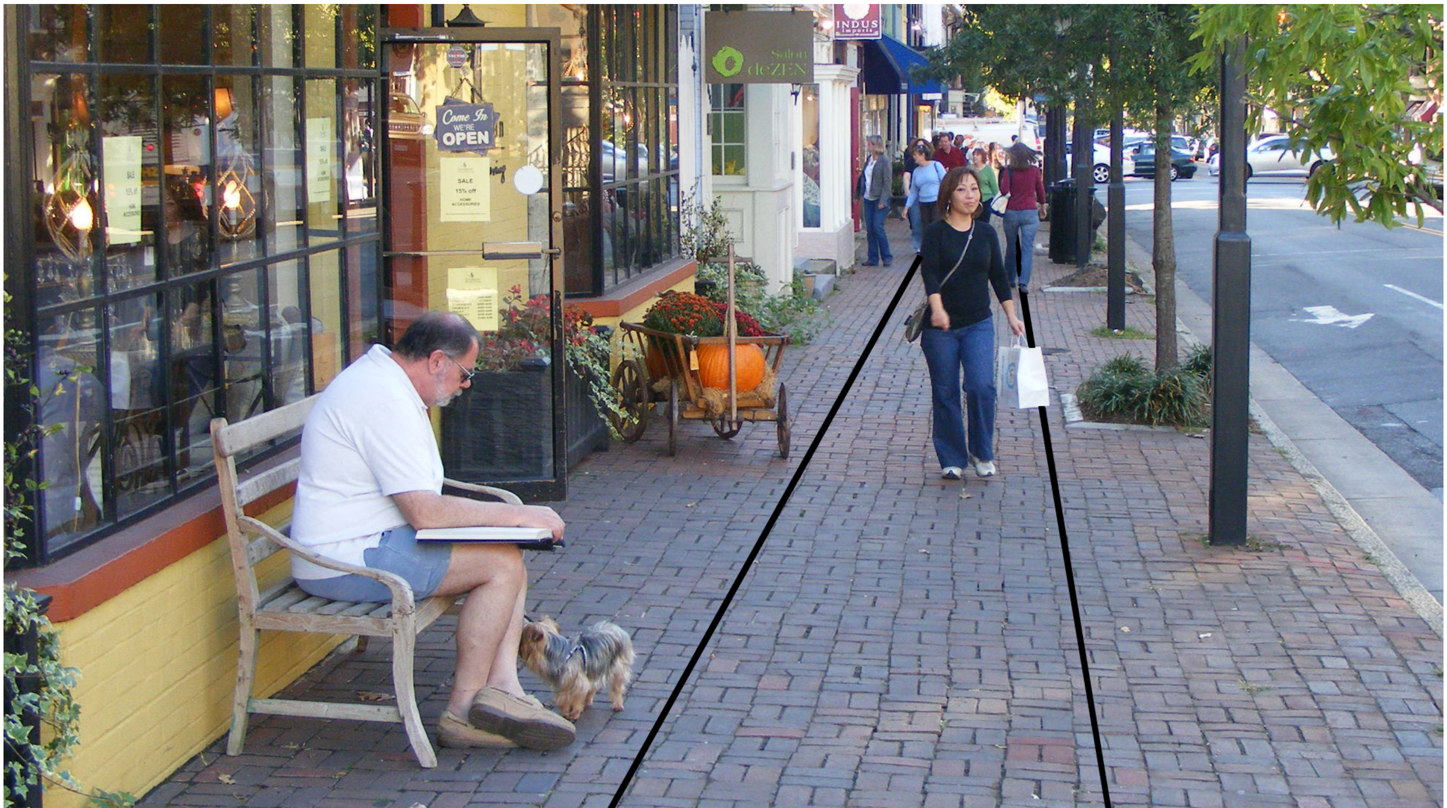
A. Frontage Zone

The Frontage Zone is the area of sidewalk that immediately abuts the private property along the street. In residential areas, the Frontage Zone may be occupied by front porches, stoops, lawns, or other landscape elements that extend from the front door to the sidewalk edge. The Frontage Zone of commercial properties may include architectural features or projections, outdoor retailing displays, café seating, awnings, signage, and other encroachments into or use of the public right-of-way. Frontage Zones may vary widely in width from just a few feet to several yards.

B. Pedestrian Clear Zone

Also known as the "walking zone," the Pedestrian Clear Zone is the portion of the sidewalk space used for active travel. For it to function, it must be kept clear of any obstacles and be wide enough to comfortably accommodate expected pedestrian volumes including those using mobility assistance devices, pushing strollers or pulling carts. To maintain the social quality of the street, the width should accommodate pedestrians passing singly, in pairs, or in small groups as anticipated by density and adjacent land use.

The Pedestrian Clear Zone should have a smooth surface, be well lit, provide a continuous and direct path with minimal to no deviation, and meet all applicable accessibility requirements. Although



Frontage Zone	Pedestrian Zone	Amenity Zone
• Door swings • Awnings • Cafe seating • Retail signage and displays • Building projections	• Zone should be clear of any and all fixed obstacles. Clear space for pedestrian travel only.	• Street lights, street trees, and utility poles • Bicycle racks • Parking meters • Transit stops • Street furniture and signage
2' to Several yards	6' Minimum	6' Minimum

currently legal throughout most of the region, bicycling on sidewalks is generally discouraged to decrease conflicts with pedestrians.

C. Amenity Zone

The Amenity Zone, or "landscape zone," lies between the curb and the Pedestrian Clear Zone. This area occupied by a number of street fixtures such as street lights, street trees, bicycle racks, parking meters, signposts, signal boxes, benches, trash and recycling receptacles, and other amenities. In commercial areas, it is typical for this zone to be hardscape pavement, pavers, or tree grates. In residential or lower intensity areas, it is commonly a planted strip.

Preferred Widths for Sidewalk Zones

The width of the various sidewalk zones will vary given the street type, the available right-of-way, and the intensity and type of uses expected along a particular street segment. A balanced approached for determining the sidewalk width should consider the character of the surrounding area and the anticipated pedestrian activities.

For example, is the street lined with retail that encourages window shopping that stops pedestrian travel, or does it connect a residential neighborhood to a commercial area where pedestrians frequently need to pass one another?

The width of the sidewalk should also relate to the street width and the height of adjoining buildings. If sidewalks are too wide, the street may feel empty and pedestrians may seem out of place, lost on a sea of sidewalk. If sidewalks are too constrained, friction may result between the sidewalk zones, leaving less space for healthy tree growth, limited access to parking meters or other fixtures, and a lower pedestrian level of service as pedestrians struggle to travel at their preferred pace.

Many streets in the region have considerable right-of-way constraints. Preferred sidewalk zone widths may not always be possible and design judgment must be used to achieve a comfortable and functional balance. Traditionally, right-of-way has been allocated from the inside out, starting with the needs of motor vehicles first and then dividing the remaining right-of-way among all other street users. Certain streets will require a paradigm shift: street design should allocate right-of-way from the outside in, prioritizing needs in the sidewalk zone and meeting pedestrian needs first.

- Fixtures in the Amenity Zone must be installed a minimum of 2′ from the front of curb (or 18″ into the Amenity Zone)
- The Americans with Disabilities Act requires a minimum 3′ clear width while the draft Proposed Right Of Way Accessibility Guidelines (PROWAG) recommend 4′ clear width in the Pedestrian Zone. However, in the the region, sidewalks are typically 5′ at a minimum.

Street Trees

Trees play an important role in making streets comfortable, delightful, memorable, and sustainable. Used appropriately, they can help define the character of a street.

Trees provide shade that reduces energy use and mitigates the urban heat island effect. Their leaves capture rainwater and evaporation cools the ambient urban air temperature. Trees sequester carbon dioxide and thus contribute to the mitigation of climate change associated with the greenhouse effect. Trees capture gaseous pollutants and particulates in the tree canopy surface, removing as much as 60 percent of the airborne particulates at street level.

Trees are part of the urban forest contributing to natural diversity. They provide habitat for a range of living creatures in the urban context, including people. Psychologically, trees have been found to reduce stress and improve concentration. This may partly explain why studies have found that tree lined retail corridors do better than counterparts lacking street trees: consumers are likely to spend more time on tree-lined streets which can lead to spending more money there as well. Research has also found that trees on streets and in front yards increase property values, with increases generally in the range of 7 percent for homes in areas with good tree cover.

Street Trees and Urban Design

Street trees are both a transportation and urban design tool. As vertical elements in the streetscape, trees help to frame and define the street wall, accentuate spaces and focus view corridors. Canopy trees provide an enclosure to the street that reinforces the sense of intimacy and scale. This enclosure can have positive effects in slowing traffic and increasing driver awareness.

Street trees improve walkability by providing necessary shade and filtered light. They provide interest and intrigue to pedestrians walking along a block face. Street trees are an opportunity to express the image of a community through plant selection and arrangement. Trees also provide seasonal interest and variation.

Selecting the Right Tree

Trees come in a wide variety of shapes and sizes. The biodiversity of the urban forest is an increasingly important aspect of maintaining healthy tree coverage. Using a range of tree species beyond those typically found on the City's streets is strongly encouraged.

In order to select an appropriate street tree for a specific street, the species must have the appropriate scale and form for the context of the street and the adjacent land uses and, most importantly, the appropriate amount of soil volume to thrive. Other considerations include: sun exposure and culture; whether the trees growth might interfere with sidewalks surfaces, site distances, or other site amenities; if overhead and subsurface utilities might impede growth; the desired quality of light and shade; mature canopy size in relation to adjacent buildings; and frequency of curb-running vehicles such as buses.

Design

- Tree species must remain constant along the entire length of a block face.
- Exposed surface area of tree wells should be a minimum of 4' by 10'. Larger dimensions may be required if deemed appropriate where part of a development of masterplanned area or required as part of the site plan process.

Shaded sidewalks make walking an enjoyable experience.

Suggested Street Tree Species

Large Trees

- Ginko (male)
- Common Hackberry
- Black Oak
- Bur Oak
- Northern Red Oak
- Shumard Oak
- Southern Red Oak
- Swamp White Oak
- Water Oak
- White Oak
- London Planetree
- American Sycamore
- Tulip Tree

Medium Trees

- Green Ash (Urbanite)
- White Ash
- Chittimwood
- Kentucky Coffeetree (male)
- Lacebark Elm
- Cedar Elm
- Goldenrain Tree (Panicled)
- Eastern Hophornbeam
- Thornless Honey Locust
- Shantung Maple
- Sugar Maple
- White Mulberry (male)
- Chinquapin Oak
- English Oak
- Sawtooth oak
- Callary Pear
- Chinese Pistache
- Japanese Zelkova

Small Trees

- Japanese Cherry
- Crapemyrtle (standard)
- Washington Hawthorn
- Deciduous Holly
- Sweet Mockorange
- Eastern Redbud
- Oklahoma Redbud
- Chinese Fringetree
- Common Smoketree

- Tree wells should support a subsurface tree trench large enough to provide sufficient arable soil volume and adequate moisture for individual trees. and shall hold a minimum volume of 300 cubic feet per tree. Continuous trenches which link individual wells shall be provided where possible.
- Planting strips for existing conditions should be a minimum of 2.5', in continuous width. New development shall be minimum of 4' in continuous width.
- Planting strips and tree wells should be planted with hardy evergreen ground cover or grass sod or covered with a tree grate. The grate's size, shape, material and design should be approved be the City where part of a development of masterplanned area.
- In densely urban areas or those with limited sidewalk width, tree grates are preferred.
- As street trees mature, they must be limbed up to a height of 7' from finished grade in order to provide clearance for pedestrians.
- Ornamental trees should be specified where overhead utilities are present to avoid conflicts.
- Evergreen trees are not to be used as street trees.
- Large street trees that mature over 60' in height should be spaced at least 35' on center.
- Medium street trees that mature from 30- 60' in height should be spaced at least 25' on center.
- Small street trees that mature under 30' in height should be spaced at least 15' on center.

Maintenance

For established street trees, standard maintenance consists of structural pruning on a regular cycle (typically every 3-5 years depending on the species, size, and location of the tree) and regular inspection by a certified arborist (recommended every 1-2 years) to assess the condition of the tree and determine the presence of any disease or damage that could lead to failure of the tree. Seasonal maintenance includes watering to ensure establishment of plant material; mulching to minimize water use, discourage weeds and protect against erosion; and pruning low shrubs and groundcover to control overgrowth onto sidewalks as overgrowth can reduce effective sidewalk width below ADA standards.

Street Lights

Street lights add comfort and safety to the street, while providing character and scale. Street lighting is typically oriented into the vehicle or pedestrian travel ways, however additional street lighting can highlight public art, architectural features or be an artistic expression itself.

Street lighting can also be an expression of street type. Higher activity commercial streets typically have a higher level of overall street lighting while lower intensity areas such as residential streets and parkways will generally have less frequent street lights and lower lighting levels.

Lighting lower than 20' brings the scale of the street down to the pedestrian level.

Highway-style lights (above left) serve to illuminate the automobile travel way but do not serve the sidewalk well. Parking lot lights (above right) should not be relied upon to provide sidewalk illumination.

Lighting levels should be consistent along the street without pools of light and dark. Lighting should be managed to reduce energy consumption and light pollution. The spectrum of light should ideally mimic sunlight as possible as this is more pleasing to the human eye.

Design

- In general, lighting should reflect the character and urban design of the street type to create a recognizable hierarchy of roads and spaces.
- Comply with lighting requirements in areas with existing design guidelines.
- Lighting is typically located in the Amenity Zone of the street. Depending on conditions, lighting may be permitted in medians, however this is less common and often restricted.
- Light poles are typically located 18" off the front of curb.
- Lighting should be oriented toward travelers both in the roadway and on the sidewalk. Adequate lighting at intersections and crossings is essential.
- Pedestrian scale lighting (lower than 20') should be used alone or in combination with roadway scale lighting in high-activity areas to encourage nighttime use and as a traffic calming device.
- Critical locations such as ramps, crosswalks, transit stops and seating areas that are used at night must be visible and lit.
- Lighting may alternate on either side of a street or be arranged in parallel. Parallel arrangements are more formal and common in retail corridors.
- Lighting should be located in concert with street trees – often alternating trees and lights – so that trees do not block the illumination.
- Light poles should not impede the pedestrian clear zone.

Access Management

A major challenge in street design is balancing the number of access points to a street. There are many benefits of well-connected street networks, but on the other hand, most conflicts between users occur at intersections and driveways. The presence of many driveways in addition to the necessary intersections creates more conflicts between vehicles entering or leaving a street and bicyclists and pedestrians riding or walking along the street. When possible, new driveways should be minimized and old driveways should be eliminated or consolidated. Raised medians should be used where possible and placed to limit left turns into and out of driveways.

Access management through limiting driveways and providing raised medians has many benefits:

- The number of conflict points is reduced, especially by replacing center-turn lanes with raised medians since left turns by motorists account for a high number of crashes with bicyclists and pedestrians.
- Pedestrian crossing opportunities can be enhanced with a raised median.
- Universal access for pedestrians is easier, since the sidewalk is less frequently interrupted by driveway slopes.
- Fewer driveways result in more space available for higher and better uses.
- Improved traffic flow may reduce the need for road widening, allowing part of the right-of-way to be recaptured for other users.
- Reference TRB Access Management Manual for in-depth guidance regarding access managment.

Possible Negatives of Access Management

The following possible negative effects of management should be considered and addressed:

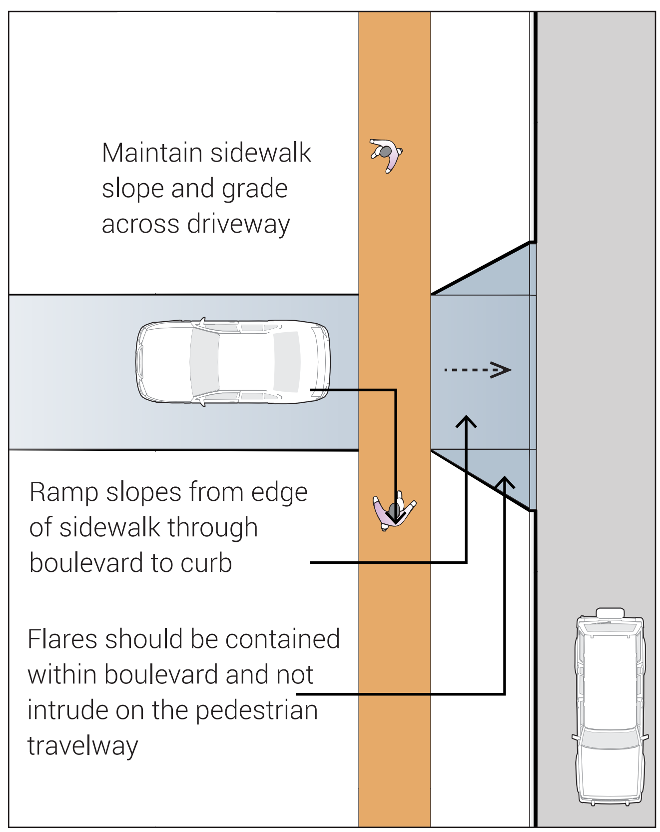
- Streamlining a street may increase motor vehicle speeds and volumes, which can be detrimental to other users.
- Reduced access to businesses may require out-of-direction travel for all users, including pedestrians and bicyclists.
- Concrete barriers and overly-landscaped medians act as barriers to pedestrian crossings. Medians should be designed with no more than normal curb height and with landscaping that allows pedestrians to see to the other side.
- Adjacent land uses can experience decreased access. This can impact businesses as well as residents.

Where angle parking is proposed for on-street parking, designers should consider the use of reverse-in angle (or head-out) parking in lieu of front-in angled parking. Drivers exiting a front-out angled parking space can better see the active street they are entering. This is especially important to bicyclists. Moreover, people exiting cars do so on the curb side and aren't likely to step into an active travel lane.

Driveways

Driveways occur wherever there are land uses that require vehicle access from the street network. Driveways often cross sidewalks, bike and parking lanes and affect moving traffic. These crossings can create conflicts between various users. To the extent possible:

- The number of driveways should be minimized, particularly along commercial corridors, in order to minimize conflicts.
- As an access management principle, driveways should be avoided within the functional area of an intersection to reduce the potential for conflicts with turning vehicles and pedestrians in the crosswalk.



The continuous pavement treatment above alerts drivers to expect pedestrian cross traffic.

Design

As a general rule, driveways should be designed to look like driveways, not roadway intersections, and incorporate the following principles:

- Sidewalks should be continuous across driveways at a continuous grade and cross-slope and the driveways flares should be contained within the boulevard space and not intrude on the pedestrian travel way.
- The pedestrian zone should be consistent with ADA guidelines to ensure that all pedestrians using wheeled mobility devices can safely cross the driveway.
- A standard driveway has a 4' flare on each side to prevent high speed turning movements, and this minimum should be a goal in areas of high pedestrian traffic or those where the city wants to encourage pedestrian traffic. Outside these areas, large flares are standard.
- Driveway width should be minimized to the extent appropriate for traffic conditions, use, type and location.
- Driveways should be located outside the functional area of the intersection, with an absolute minimum of 100 feet from intersections in commercial corridors and 40 to 60 feet in residential corridors.

Medians can provide space for street trees, gateway treatments (such as planters) and utilities (such as fire hydrants.)

  - The functional area of an intersection includes areas upstream and downstream of the intersection. In contrast with the physical area of an intersection, the functional area varies depending on several site specific variables including: amount of queuing at an intersection; distance traveled during perception-reaction time; and declaration distance.
  - In locations where a driveway must function as a leg of an intersection, it should be designed with pedestrian safety features such as crosswalks, small corner radii, and pedestrian signal indications if part of a signalized intersection.
- Truncated domes should not be used where driveways cross the sidewalk zone unless the driveway is functioning as a leg of an intersection and curb ramps are present.
- Site obstructions (signs, landscaping, decorative fencing, signal boxes, building features etc.) should be carefully located to maximize visibility between turning motorists and pedestrians at driveway.

Medians

Medians used on urban streets provide access management by limiting left turn movements into and out of abutting development to select locations where a separate left turn lane or pocket can be provided. The reduced number of conflict points decreases risk of vehicle crashes. Medians provide pedestrians with a refuge as they cross the road and provide space for landscaping, lighting, and utilities. These medians are usually raised and curbed. Landscaped medians enhance the street or help to create a gateway entrance into a community.

Medians can be used to create tree canopies over travel lanes, contributing to a sense of enclosure. Recommended widths depend on available right-of-way and function. Because medians require a wider right-of-way, the designer must weigh the benefits of a median with the issues of pedestrian crossing: distance, speed, context, and available roadside width.

Crossing Treatments

Curb Extensions

Curb extensions, also known as neckdowns, bulb-outs, or bump-outs, are created by extending the sidewalk at corners or mid-block. Curb extensions are intended to increase safety, calm traffic, and provide extra space along sidewalks for users and amenities. They shorten crossing distances (exposure time) and increase visibility between roadway users: the waiting pedestrian can better see approaching traffic and drivers can better see pedestrians waiting to cross the road. Curb extensions have a variety of potential benefits including:

- Additional space for pedestrians to queue before crossing
- Improved safety by reducing motor vehicle speeds and emphasizing pedestrian crossing locations
- Less pedestrian exposure to motor vehicles by reducing crossing distances
- Space for ADA-compliant curb ramps where sidewalks are too narrow
- Enhanced visibility between pedestrians and other roadway users
- Restricting cars from parking too close to the crosswalk area
- Space for utilities, signs, and amenities such as bus shelters or waiting areas, bicycle parking, public seating, street vendors, newspaper stands, trash and recycling receptacles, and planting, and landscape elements

Design

- Curb extensions should be considered only where parking is present or where motor vehicle traffic deflection is provided through other curbside uses.
- Curb extensions are particularly valuable in locations with high volumes of pedestrian traffic, near schools, at unsignalized pedestrian crossings, or where there are demonstrated pedestrian safety issues.
- A typical curb extension extends the approximate width of a parked car, or about 6' from the curb.
- The minimum length of a curb extension is the width of the crosswalk, allowing the curvature of the curb extension to start after the crosswalk which should deter parking; NO STOPPING signs should also be used to discourage parking. The length of a curb extension can vary depending on the intended use (i.e., stormwater management, transit stop waiting areas, restrict parking).

Curb extensions can be a valuable space for placing streetside amenitites such as bike parking.

- Curb extensions should not reduce a travel lane or a bicycle lane to an unsafe width.
- Curb extensions at intersections may extend into either one or multiple legs of the intersection, depending on the configuration of parking.
- Street furniture, trees, plantings, and other amenities must not interfere with pedestrian flow, emergency access, or visibility between pedestrians and other roadway users.
- Curb extensions may be located at corners or midblock locations.

Considerations

- The turning needs of larger and emergency vehicles should be considered in curb extension design.
- Care should be taken to maintain direct routes across intersections aligning pedestrian desire lines on either side of the sidewalk. Curb extensions often make this possible as they provide extra space for grade transitions.
- Consider providing a 20' long curb extension to restrict parking within 20' of an intersection.
- In order to move traffic more efficiently, curb extensions should not be installed on arterials with peak hour parking restrictions.
- When curb extensions conflict with turning movements, the width and/or length should be reduced rather than eliminating the extension wherever possible.
- Emergency access is often improved through the use of curb extensions as intersections are kept clear of parked cars.
- Curb extension installation may require the relocation of existing storm drainage inlets and above ground utilities. They may also impact underground utilities, parking, delivery access, garbage removal, and street sweepers. These impacts should be evaluated when considering whether to install a curb extension.
- Curb extension installation may require the relocation of existing storm catch basins which can increase costs substantially. Catch basins should be centered at least 5 feet from the beginning of the bump out.

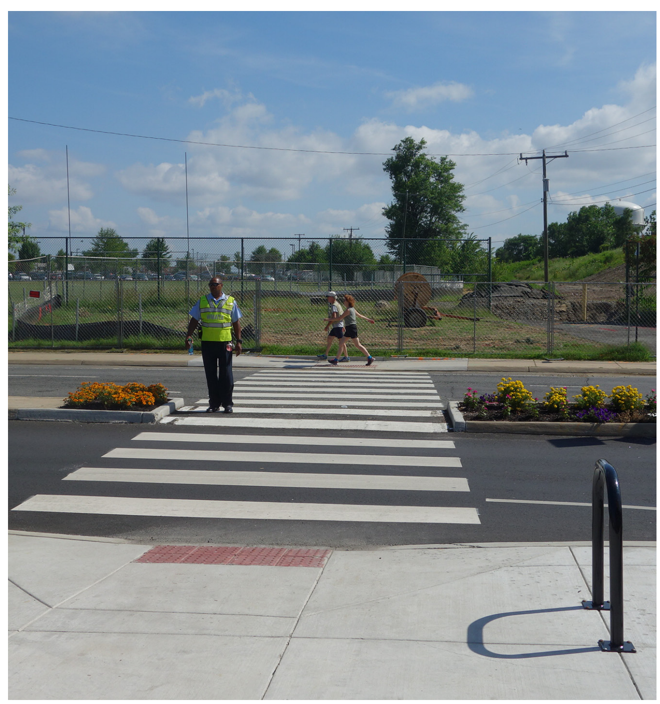
Crossing Islands

As the number of travel lanes increases, pedestrians feel more exposed and less safe entering the intersection. Crossing islands are raised islands that provide a pedestrian refuge while crossing multilane roadways enabling pedestrians to find gaps in traffic and allowing a two stage crossing movement. At mid-block crossings where width is available, islands should be designed with a stagger, or in a "z" pattern, encouraging pedestrians to face oncoming traffic before progressing through the second phase of the crossing.

Design

Crossing islands should:

- Be installed where there is a demand for pedestrians to cross the road, but where the numbers of pedestrians are not high enough to warrant a signalized pedestrian crossing.



Crossing islands enable pedestrians to cross the street in two stages.

- Include at-grade pedestrian cut-throughs as wide as the connecting crosswalks, detectable warnings, and be gently sloped to prevent standing water and ensure adequate drainage.
- Be at least 6′ wide, preferably 8–10′. Where a 6′-wide median cannot be attained, a narrower raised median is still preferable to nothing. The minimum protected width is 6 feet, based on the length of a bicycle or a person pushing a stroller. The refuge is ideally 40 feet long.
- Accommodate turning vehicles. Crossing islands at intersections or near driveways may affect left-turn access.
- All crossing islands at intersections should have a "nose" which extends past the crosswalk. The nose protects people waiting on the crossing island and slows turning drivers.
- Safety islands should include curbs, bollards, or other features to protect people waiting.
- Be illuminated or highlighted with street lights, signs, or reflectors to ensure that motorists see them.
- Crossing islands may be enhanced using plantings or street trees. Plantings may require additional maintenance responsibilities and need to be maintained to ensure visibility.

Considerations

- Crossing islands should be considered where crossing distances are greater than 50′.
- To guide motorists around crossing islands, consider incorporating diverging longitudinal lines on approaches to crossing islands.
- If there is enough width, center crossing islands and curb extensions can be used together to create a highly visible pedestrian crossing and effectively calm traffic.
- Where possible, stormwater management techniques should be used on crossings islands with adequate space. Plantings should be low growing to maximize visibility, and ideally involve minimum maintenance.

Raised Crossings and Intersections

Raised crossings and intersections create a safe, slow-speed crossing and public space at minor intersections. Raised crossings are created by raising the crosswalk to same level as the sidewalk. Raised intersections are a similar concept to raised crossings but are applied to the entire area of an intersection. These treatments provide an array of benefits especially for people with mobility and visual disabilities because there are no vertical transitions to navigate.

Raised crossings and intersections:

- Make it physically more difficult for drivers to go through crossings and intersections at unsafe speeds.
- Improve drivers' awareness by prioritizing pedestrian crossings and helping define locations where pedestrians are expected.
- Eliminate standing water and debris collection at the base of ramps.
- Increase visibility between drivers and pedestrians by raising pedestrians in the motorists' field of view and giving pedestrians an elevated vantage point from which to look for oncoming traffic.
- Create pedestrian crossings which are more comfortable, convenient and accessible since transitioning between the sidewalk and roadway does not require negotiating a curb ramp.

Design

- Raised crossings and intersections are appropriate in areas of high pedestrian demand. They should also be considered in school zones and locations where pedestrian visibility and motorist yielding have been identified as concerns.
- Raised crossings should be considered across free-flowing right turn slip lanes to slow automobiles in preparation for yielding to pedestrians.

Raised crossings can include pavement markings on the approach ramps that make it more evident to drivers that a grade change is present. Contrasting paving treatments in the crossing also call attention to pedestrian cross traffic.

- Care should be taken to maintain direct routes across intersections aligning pedestrian desire lines on either side of the sidewalk.
- Raised crossings can be provided across side streets of major thoroughfares to slow traffic entering the neighborhood.
- Raised crossings should provide pavement markings for motorists and appropriate signage at crosswalks per the MUTCD.
- Design speeds and emergency vehicle routes must be considered when designing approach ramps.
- Raised crossings and intersections require detectable warnings at the curb line for persons with visual disabilities.

Considerations

- Raised crossings are particularly valuable at unsignalized mid-block locations, where drivers are less likely to expect or yield to pedestrians.
- Raised intersections and crossings can be used as gateway treatments to signal to drivers when there are transitions to a slower speed environment that is more pedestrian-oriented.
- High-visibility or textured paving materials can be used to enhance the contrast between the raised crossing or intersection and the surrounding roadway.
- Designs should ensure proper drainage. Raised intersections can simplify drainage inlet placement by directing water away from the intersection. If the intersecting streets are sloped, catch basins should be placed on the high side of the intersection at the base of the ramp.

Crosswalk Design

Well-designed crosswalks are an important component of a pedestrian friendly city. Safety for all pedestrians, especially for those with limited mobility and disabilities, is the single most important criteria informing crosswalk design.

Legal crosswalks exist at all locations where two streets cross, including T-intersections, regardless of whether pavement markings are present. In other words, drivers are legally required to yield to pedestrians at intersections even when there are no pavement markings.

Marked crosswalks help guide pedestrians to locations where they should cross the street as well as inform drivers of pedestrian movements. In addition to intersections, marked crosswalks are used in locations where pedestrians may not be expected, such as at mid-block crossings or uncontrolled crossings (crossings where motorists do not have signals or stop signs).

Crosswalks should be marked only at locations where significant pedestrian activity is occurring or anticipated to help ensure that drivers associate crosswalks and pedestrian activity. In order to create a convenient, connected, and continuous walking network, the first step is identifying the location for marked crosswalk. Begin by identifying desire lines and destinations such as schools, parks, civic buildings, retail areas, and transit stops. Then, identify where it is safest for people to cross. These observations should inform location and prioritization of crossing improvements.

As with any installation of traffic control devices, the most essential tool for crosswalk installation is the use of engineering judgment. Engineering judgment should be used and, if applicable, an engineering study performed when considering the marking of crosswalks.

Ladder style crosswalks provide greater visibility for approaching drivers.

Standard Crosswalks

The typical crosswalk throughout the Tulsa region is the standard style, with 8" wide white stripes parallel to the path of travel. Textured pavement and colored crosswalks are discouraged except as special treatments in defined districts, as they often fade over time and lack sufficient retro-reflectivity.

For areas with high pedestrian traffic and locations with unsignalized crossings, crosswalks should be the high visibility ladder treatment. These would have the current parallel bars, but then add perpendicular 24" bands every 24".

Design

- Crosswalks should be at least 10' wide or the width of the approaching sidewalk if it is greater. In areas of heavy pedestrian volumes, crosswalks can be up to 25' wide.
- Crosswalks should be aligned with the approaching sidewalk and as close as possible to the parallel street to maximize the visibility of pedestrians while minimizing their exposure to conflicting traffic.
- Designs should balance the need to reflect the desired pedestrian walking path with orienting the crosswalk perpendicular to the curb; perpendicular crosswalks minimize crossing distances and therefore limit the time of exposure.
- ADA-compliant curb ramps should direct pedestrians into the crosswalk. The bottom of the ramp should lie within the area of the crosswalk (flares do not need to fall within the crosswalk).
- Textured crossings should be constructed and maintained to ensure a regular surface that is traversable by those in wheelchairs.
- Stop lines at stop-controlled and signalized intersections should be striped no less than 4' and no more than 30' from the approach of crosswalks.

Marked Crosswalks at Signal-Controlled Locations

Intersection controls are one of the most important factors in intersection design. The goal of controlling intersections is to provide the safest, most efficient means to move people across an intersection, whether walking, riding a bicycle, taking transit, or driving. Specific attention should be given to vulnerable users, such as pedestrians and bicyclists.

Engineering judgment should be used to establish the most appropriate controls on a site-specific basis. The following factors should be considered when determining intersection controls:

- Vehicular, bicycle, and pedestrian traffic volumes on all approaches
- Number and angle of approaches
- Approach speeds
- Sight distance available on each approach
- Reported crash experience

Depending on the type of intersection and the selected control devices, it may not always be appropriate to mark crosswalks at all legs of an intersection. Alternate treatments may be necessary to optimize safety and visibility, which are discussed in the sections that follow.

Marked Crosswalks at Stop-Controlled Locations

Stop-controlled approaches are easiest for pedestrians to cross because motorists and bicyclists must stop and yield the right of way to pedestrians. Stop-controlled intersections also help reduce pedestrian delay. However, the use of stop signs must balance safety with efficient traffic flow for all modes, including bicyclists and transit vehicles. Stop sign installation requires specific warrants be met as determined by the MUTCD.

For neighborhood residential streets, marked crosswalks should be used at locations where pedestrian crossings are more frequent, such as school walking routes, park entrances, or other locations. Stop lines should be striped at stop-controlled intersections no less than 4' and no more than 30' from the approach of crosswalks, unless determined otherwise by an engineering study.

Marked Crosswalks at Uncontrolled Locations

As with other locations, crosswalks should be marked at mid-block uncontrolled locations where pedestrian volumes are high. In all cases, they should be accompanied by signage at the road edge or in the street, and in many cases, they should be combined with other treatments outlined in this section. On higher speed streets, advance yield markings and signage may be desirable to alert drivers early enough to ensure adequate stopping distance.

Advance yield markings on this multi-lane street alert drivers to expect pedestrian crossings ahead.

Rectangular Rapid-Flashing Beacons (RRFBs)

At some uncontrolled crossings, particularly those with four or more lanes, it can be difficult to achieve compliance with laws that require motorists to yield to pedestrians. Vehicle speeds and poor pedestrian visibility combine to create conditions in which very few drivers are compelled to yield.

One type of device proven to be successful in improving yielding compliance at these locations is the Rectangular Rapid Flash Beacon (RRFB). RRFBs are a pedestrian crossing sign combined with an intensely flashing beacon that is only activated when a pedestrian is present. RRFBs are placed curbside below the pedestrian crossing sign and above the arrow indication pointing at the crossing. They should not be used without the presence of a pedestrian crossing sign. The light-emitting diode (LED) flash is a "wig-wag" flickering pattern at a rate of 190 flashes per minute. The beacons are activated by a call button for pedestrians or bicyclists.

Another LED panel should be placed facing the pedestrian to indicate that the beacon has been activated. The pushbutton and other components of the crosswalk must meet all other accessibility requirements.

Design

- The design of RRFBs should be in accordance with FHWA's Interim Approval 11 (IA-11) for Optional Use of Rectangular Rapid Flashing Beacons issued July 16, 2008 and the Interpretation Letter 4(09)-41 (I) - Additional Flash Pattern for RRFBs issued July 25, 2014.

- RRFBs can be used when a signal is not warranted at an unsignalized crossing. They are not appropriate at intersections with signals or STOP signs.

- RRFBs are installed on both sides of the roadway at the edge of the crosswalk. If there is a pedestrian refuge or other type of median, an additional beacon should be installed in the median.

Considerations

- RRFBs are considerably less expensive to install than mast-arm mounted signals. They can also be installed with solar-power panels to eliminate the need for a power source.

- RRFBs should be limited to locations with critical safety concerns, and should not be installed in locations with sight distance constraints that limit the driver's ability to view pedestrians on the approach to the crosswalk.

- RRFBs should be used in conjunction with advance yield pavement lines and signs, which are discussed on the previous page.

- Usually implemented at high-volume pedestrian crossings, but may also be considered for priority bicycle route crossings or locations where bike facilities cross roads at mid-block locations.

Push buttons are located on the sign post of the RRFB which must be supplied with an electrical connection.

HAWK Signal

"HAWK" stands for High-intensity Activated Crosswalk and is also referred to as a pedestrian hybrid beacon. A HAWK signal is a push button-activated pedestrian signal that increases pedestrian safety at crossings while stopping vehicle traffic only as needed. The following describes how a HAWK signal works:

1. Signal remains dark until a pedestrian activates the walk indication by pushing a button.
2. Signal will then flash yellow to warn drivers that a pedestrian will be entering the crosswalk.
3. Steady yellow indication follows advising drivers to stop if safe to do so.
4. Signal then turns solid red, requiring vehicles to stop at the stop line. Pedestrian sees the walk indication and proceed into the crosswalk.
5. Once walk time is completed, the signal will flash red. This lets the driver know that once they come to a complete stop they may proceed through the intersection if there are no pedestrians in the crosswalk.
6. HAWK will return to the dark or "off" position until the push button is activated again.

HAWK signals may be used at mid-block crossings (including off-street path crossings) and should be considered where high traffic volumes and speeds (typically based on study of 35mph or less, per MUTCD) make it difficult for pedestrians to cross the street at locations that do not meet traffic engineering warrants for a conventional signal. HAWK signals provide a protected crossing while allowing vehicles to proceed through a pedestrian crossing as soon as it is clear, thus minimizing vehicle delay.

Design

HAWK signals must be accompanied by the following crossing treatments:

- Crosswalk pattern to match the intensity of the crossing, likely a higher-visibility crosswalk
- Advanced stop bar placed 20 to 50 feet from crosswalk
- MUTCD R10-23 signs mounted both on the mast arm and the supporting pole.

The HAWK signal indicates a preferred crossing location and thus does not improve crossing at all quadrants of an intersection as a signalized intersection would. It does not improve movement through the intersection for cyclists in on-street lanes as they are subject to motor vehicle indications.

HAWKs are particularly useful in multi-lane contexts like the one pictured here where a multiple threat crash risk exists.

Signalized Intersections

The design of signalized intersection should attempt to prioritize the safety, comfort, and convenience of all users. All signalized intersections should contain indications for motor vehicles and pedestrians, and signals for bicyclists and transit where appropriate. By optimizing signal phasing and timings, multiple modes are able to safely move through the intersection with limited conflicts, low delay, and more comfort.

Signal Timing for Pedestrians

Signal timing for pedestrians is provided through the use of pedestrian signal heads. Pedestrian signal heads display the three intervals of the pedestrian phase:

1. The Walk Interval, signified by the WALK indication—the walking person symbol—alerts pedestrians to begin crossing the street.
2. The Pedestrian Change Interval, signified by the flashing DON'T WALK indication—the flashing hand symbol accompanied by a countdown display—alerts pedestrians approaching the crosswalk that they should not begin crossing the street. The countdown display alerts pedestrians in the crosswalk how much time they have left to cross the street.
3. The Don't Walk Interval, signified by a steady DON'T WALK indication—the steady upraised hand symbol – alerts pedestrians that they should not cross the street. The beginning of the Don't Walk Interval is called the Buffer Interval, which should be displayed for a minimum of a three seconds prior to the release of any conflicting motor vehicle movements.

The total time for the pedestrian change interval plus the buffer interval is called the pedestrian clearance time, or the time it takes for a pedestrian to clear the intersection leaving at the onset of the DON'T WALK indication.

Pedestrian signal heads should be provided at all signalized intersections for all crosswalks. Additionally, it is highly recommended to install crosswalks on all legs of a signalized intersection unless it is determined to be unnecessary due to pedestrian travel patterns. Signal timing for pedestrians should be provided at all newly constructed signalized intersections and incorporated into all signalized intersection improvements.

The following design goals can help improve pedestrian crossing safety and comfort at signalized intersections:

- Reduce vehicle speeds
- Minimize crossing distance
- Minimize delay for WALK indication
- Minimize conflicts with turning vehicles
- Provide sufficient signal time to cross the street

Design

- Pedestrian signals should allocate enough time for pedestrians of all abilities to safely cross the roadway. The MUTCD specified pedestrian walking speed is 3.5 feet per second to account for an aging population and is endorsed by the City. The pedestrian clearance time, which is the total time for the pedestrian change interval plus the buffer interval, is calculated using the pedestrian walking speed and the distance a pedestrian has to cross the street.
- Countdown pedestrian displays inform pedestrians of the amount of time in seconds that is available to safely cross during the flashing Don't Walk Interval. All pedestrian signal heads should contain a countdown display provided with the DON'T WALK indication.
- In areas with higher pedestrian activity, such as near transit stops, along Main Streets, and in neighborhood centers, pedestrian push-button actuators may not be appropriate. Pedestrians should expect to get a pedestrian cycle at every signal phase, rather than having to push a button to call for a pedestrian phase.

- At more complex intersections (e.g., where there is more than one signal phase for each direction), where pedestrian volumes are lower, or uneven or variable volumes of users, push buttons should be provided. The responsiveness of the actuated signal should be as prompt as possible (as low as 5 seconds) based on the necessary transition time for approaching motorists to come safely to a stop.
- Along corridors where traffic signals are synchronized, they should be designed to meet target speeds to maintain safe vehicular travel speeds and discourage speeding.

Considerations

- One of primary challenges for traffic signal design is to balance the goals of minimizing conflicts between turning vehicles with the goal of minimizing the time required to wait at the curb for a WALK indication.
- Intersection geometry and traffic controls should encourage turning vehicles to yield the right-of-way to pedestrians.
- Requiring pedestrians to wait for extended periods can encourage crossing against the signal. The 2010 Highway Capacity Manual states that pedestrians have an increased likelihood of risk-taking behavior (e.g., jay-walking) after waiting longer than 30 seconds at signalized intersections.
- Opportunities to provide a WALK indication should be maximized whenever possible. Vehicular movements should be analyzed at every intersection in order to utilize non-conflicting phases to implement Walk Intervals. For example, pedestrians can always cross the approach where vehicles cannot turn at a four-leg intersection with the major road intersecting a one-way street when the major road has the green indication.

Leading Pedestrian Interval

The Leading Pedestrian Interval (LPI) initiates the pedestrian WALK indication three to seven seconds before motor vehicles traveling in the same direction are given the green indication. This technique allows pedestrians to establish themselves in the intersection in front of turning vehicles, increasing visibility between all modes.

Design

- Installation of new LPIs or retrofits should prioritize intersections with high volumes of pedestrians and conflicting turning vehicles, and locations with a large population of elderly or school children who tend to walk slower.
- The LPI should be at least three seconds to allow pedestrians to cross at least one lane of traffic to establish their position ahead of turning traffic.
- A lagging protected left arrow for vehicles may be provided to accommodate the LPI.
- Newly-installed LPIs should provide accessible pedestrian signals to notify visually-impaired pedestrians of the LPI. Without an accessible pedestrian signal, visually-impaired pedestrians may begin to cross with the vehicular movement when motorists less likely to yield to them.

Pedestrian signal timing should prioritize the safety, comfort, and convenience of all users.

Traffic Calming

Traffic calming is the combination of mainly physical measures that:

- Reduce the negative effects of motor vehicle use - changing the role and design of streets to accommodate motorists in ways that reduce the negative social and environmental effects on individuals, neighborhoods, districts, retail areas, corridors, downtowns, and society in general (e.g., reduced speeds, reduced sense of intrusion/dominance, reduced energy consumption and pollution, reduced sprawl, and reduced automobile dependence).
- Alter driver behavior - the street design helps drivers self-enforce lower speeds, resulting in less aggressive driving and increased respect for non-motorized users of the streets.
- Improve conditions for non-motorized street users - promoting walking and bicycling, changing expectations of all street users to support equitable use of the street, increasing safety and comfort (i.e., the feeling of safety), improving the aesthetics of the street, and supporting the context of the street.

The definition of traffic calming is broad enough to apply to myriad contexts and situations, but specific enough to have independent meaning so that it is not confused with other street design elements and design approaches.

Through design, traffic calming aims to slow the speeds of motorists to the "desired speed" (usually 20 mph or less for residential streets and 25 to 35 mph for boulevards and avenues) in a context-sensitive manner. Traffic calming is acceptable on all street types where pedestrians are allowed.

The greatest benefit of traffic calming is increased safety. Compared with conventionally designed streets, traffic calmed streets typically have fewer collisions and even higher reductions in injuries and fatalities. These dramatic safety benefits are mostly the result of slower speeds for motorists

Traffic calmng features are especially applicable in commercial areas where most visitors arrive by automobile. Drivers are signaled by street features that they have arrived in the commercial district, and they are induced to slow travel speeds in this area with higher pedestrian traffic.

that result in greater driver awareness, wider fields of vision, shorter stopping distances, and less kinetic energy during a collision. At 20 mph or less, chances are very high that a motorist will not kill or severely injure a pedestrian in a collision. Other contributing factors to these superior safety results include a more legible street environment and design advantages for pedestrians and cyclists. Bulb-outs on corners of intersections, for example, allow pedestrians to see past parked cars prior to crossing the street.

Design

There are both physical and visual elements that can help slow vehicle traffic. Visually narrowing a street, or changing its aesthetics can be effective traffic calming techniques, and can be more widely applicable than geometric measures. Treatments include:

- Curb and gutter, which defines the traveled part of the roadway
- Sidewalks, which indicate that motorists should expect to see pedestrians
- Outdoor cafes or other activities in the pedestrian zone, such as street furniture
- Street trees, which create a sense of enclosure
- On-street parking, which creates an activity zone to which drivers must pay attention
- Pavement type and road striping
- Buildings that are closer to the street (i.e., no parking or drive-through between the street and adjacent buildings)
- Bump outs, either at intersections or mid-block crossings, which also shorten pedestrian crossing distances
- Reduction in curb radii, in order to slow turning movements
- Lane diets or roadway diets, which reduce the number of lanes or amount of lane space and can result in slowed vehicle travel

Creating vertical or horizontal deflection of the vehicle path is a very effective way to slow traffic, and may be appropriate on residential streets. Horizontal deflection is typically most effective. Treatments include:

- Bump outs, either at intersections or mid-block crossings.
- Traffic circles, which force drivers to slow at intersections and yield to users approaching from the left.
- Speed humps provide a gentle rise on the roadway.
- Chicanes force drivers and bicyclists to navigate a narrowed "s" shaped pathway along the street created by the placement of bump outs that alternate from one side of a street to the other, typically in groups of three.

Traffic Calming Intersection Treatments

Blocking or restricting access is highly effective, but can have the unintended effect of creating traffic problems on neighboring streets. Treatments include:

- Diverter Median Barriers, which restrict a driver's ability to cross an intersecting street.
- Diverter Islands restrict turn or through movements for vehicle traffic, and may allow bicycle and pedestrian traffic in all directions. Diverter islands are typically used at intersections to deter heavy vehicle volumes and eliminate cut-through traffic. They should be part of a larger traffic calming strategy that evaluates and handles accessibility through the adjacent street network and considers emergency vehicle response times. Effects are generally limited to the intersection; the street may require additional traffic calming in addition to the intersection treatments to be effective.
- Right In/Right Out restrictions, which restrict left turns into and left turns out of a street.

Considerations

Traffic calming measures that may be applied depend on the context of the street. Special consideration should be given to:

- Street classification
- Traffic operational analysis
- Mix of traffic, including consideration of bus, bike or truck routes
- Adjacent land uses
- First responder vehicle needs
- Effect on on-street parking

Speed Humps

Speed humps are a roadway design feature that consists of raised pavement approximately 3 to 4 inches high at their center, which extend the full width of the street. The height of a speed hump tapers near the drain gutter to allow unimpeded bicycle travel. Speed humps should not be confused with speed bumps commonly found in parking structures.

Speed humps may be considered on low volume neighborhood streets in order to control vehicle speeds. Streets that have high traffic volumes, are transit routes or have frequent freight travel are typically not good candidates for speed humps.

Design

- Speed humps should have a smooth leading edge, a parabolic rise, and be engineered for a speed of 25 to 30 mph, so they can be negotiated by large vehicles.
- Speed humps should be clearly marked with reflective markings and signs.
- Typically speed humps are 22 feet in length, with a rise of 6 inches above the roadway and should extend the full width of the roadway. They should be tapered at the edges to the gutter to accommodate drainage.
- Grade should be considered; do not use on roadways with greater than 5 percent grade.
- Do not use on collector or arterial streets.

Diverter islands can allow for two-way bicycle access to a street while restricting automobile access at one end.

Speed hump locations are often indicated with signage to further alert drivers to slow speeds.


Chicanes divert traffic horizontally and may be designed to create a one-lane street that necessitates driver yielding.

- Parking must be restricted adjacent to humps.
- A speed study showing 85th percentile at least 5 mph over the speed limit required prior to implementation.

Chicanes

Chicanes can take the form of curb extensions, center islands, or staggered on-street parking. These traffic calming features slow vehicles by compelling them to shift laterally or pass through a narrowed section of roadway.

Chicanes may be considered on residential streets where:

- There is a high volume of high-speed cut through traffic
- Children frequently walk or bicycle to and from school
- A comprehensive neighborhood traffic calming program is present
- Other traffic calming measures have been implemented.

Design

- The size of chicanes will vary based on the targeted design speed and roadway width, but must be 20 feet wide curb to curb at a minimum to accommodate emergency vehicles.
- Can incorporate stormwater treatment and low growing landscaping.
- Parking may be affected to a greater extent than other traffic calming measures.

Curb Radii

Curb returns or radii are the curved connection of curbs at the corners formed by the intersection of two streets, which guide vehicles in turning corners. The shape of a corner curb radius has a significant effect on the overall operation and safety of an intersection.

The shape and dimensions of curb radii vary based on street type, transportation context, and design vehicle (vehicle type used to determine appropriate turn radius at an intersection). Smaller corner radii increase pedestrian safety by shortening crossing distances, increasing pedestrian visibility, and decreasing vehicle turning speed. Smaller corner radii also provide better geometry for installing perpendicular curb ramps for both crosswalks at each corner, resulting in simpler, more appropriate crosswalk placement, in line with the approaching sidewalk. Factors to consider when designing curb radii:

- Curb radius: the actual radius proscribed by the curb line at an intersection.
- Effective radius: The radius available for the design vehicle to make the vehicle turn, accounting for the presence of parking, bike lanes, medians, or other features.

Curb radii can be designed:

- To allow for the selected design vehicle to complete a turn fully within its designated travel lane or lanes.
- To accommodate a vehicle turn by allowing for a particular vehicle type to complete a turn with some latitude to partially use adjacent or opposing lanes on the origin or destination streets.

Tighter curb radii are particularly appropriate in downtown Main Street contexts.

Design

The effective turning radius (rather than the actual curb radius), should typically be used to determine the ability of vehicles to negotiate a turn. Determination of the design vehicle should consider and balance the needs of the various users of a street--from pedestrians and bicyclists to emergency vehicles and large trucks--considering the volume and frequency of these various users. The design vehicle should be selected according to the types of vehicles using the intersection with considerations to relative volumes and frequencies. The designer should balance designing for a larger vehicle versus accommodating the needs of large vehicles, which may allow encroachment into another lane. A typical curb radius of 20 feet (smaller radii may be considered) should be used wherever possible including where:

- There are higher pedestrian volumes
- There are few larger vehicles
- Bicycle and parking lanes create a larger effective radius.

Factors that may affect the curb radii must be taken into consideration:

- The street type
- The angle of the intersection
- Bump outs
- The number and width of receiving lanes
- Large vehicles
- Effective turning radius

Where there are high volumes of large vehicles making turns- inadequate curb radii could cause large vehicles to regularly travel across the curb and into the pedestrian waiting area.

1. On corners along bus routes, intersections should accommodate allowing a transit vehicle using the entire roadway, similar to an emergency vehicle.
2. Because emergency vehicles have sirens and flashing lights and other vehicles must pull over, they can typically use the full right-of-way without encountering opposing vehicles. On busier streets, the ability of emergency vehicles to swing wide may be limited by queued traffic which may not be able to pull over.
3. Freight corridors should be designed for WB-50 trucks. WB-60 and larger trucks may also be present on city streets, particularly on designated state highways, truck routes and in industrial areas. These may need to be accommodated in certain instances, though they generally do not fit well on the existing street network in most of the Tulsa region.

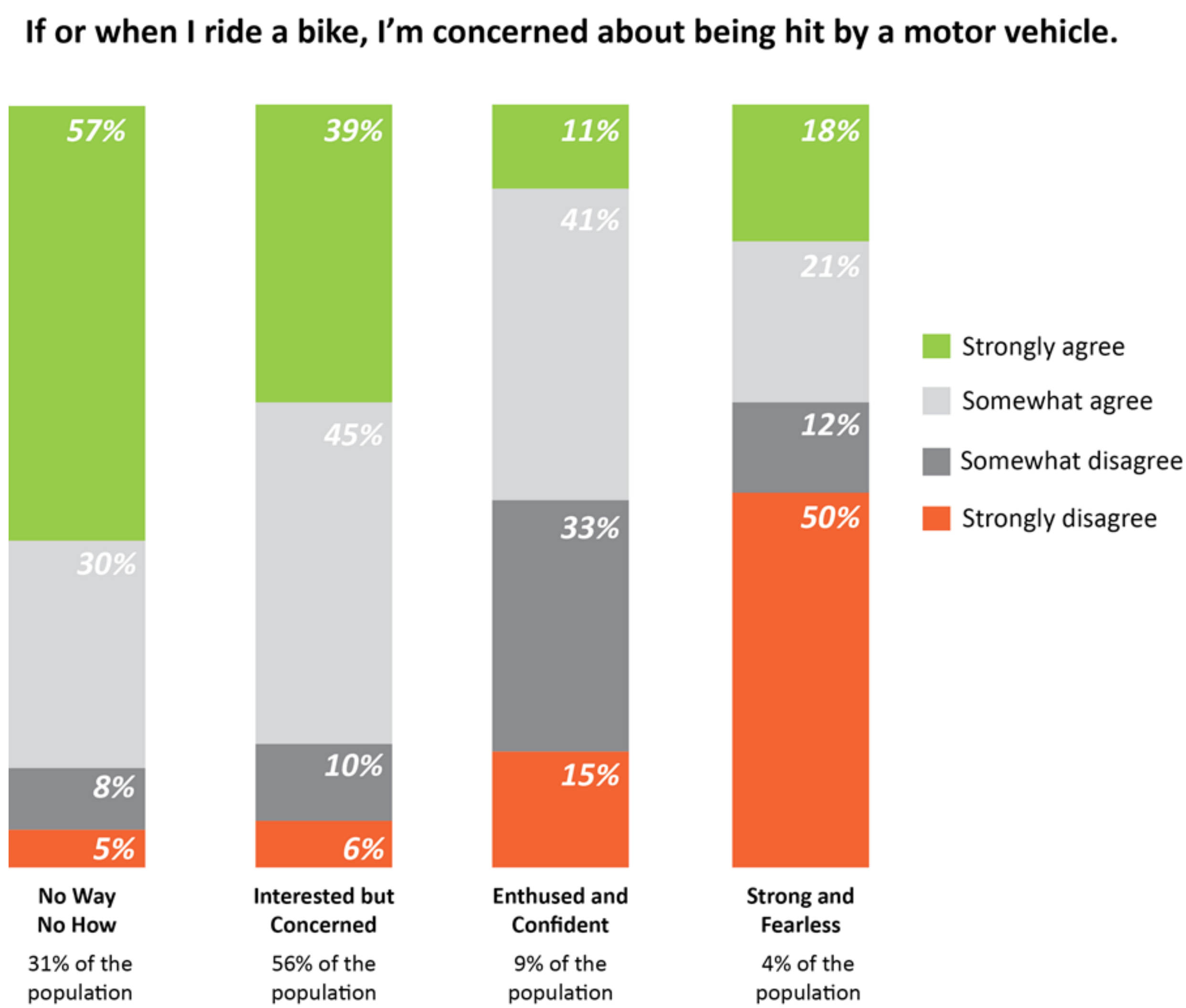
A variety of strategies can be used to maximize pedestrian safety while accommodating large vehicles including:

- Adding parking or bicycle lanes to increase the effective radius of the corner
- Varying the actual curb radius (i.e., compound curb radii) over the length of the turn so that the radius is smaller as vehicles approach a crosswalk and larger when making the turn. Compound radii effectively shorten crossing distances and make pedestrians visible while accommodating larger vehicle turns; because they allow more sweeping turns and they do not slow turning vehicles.
- Painting a median: Where there is sufficient lane width on the destination street, a painted median can enable a large vehicle to complete a turn without turning into opposing traffic.
- Restricting access: Where there is a desire to keep curb radii small, restrictions on large vehicles making the turn may be considered. This should be considered in light of the overall street network.
- Installing advance stop lines on the destination street to increase the space available for large vehicles to make a turn by enabling them to swing into opposing lanes on the destination street while opposing traffic is stopped.

Bicycle Facilities

These recommendations are built off of the adopted 1999 Trails Master Plan, the findings from the Tulsa Go Plan analysis, and from on-the-ground analysis of the existing facilities and conditions. Most importantly, these recommendations build off of the engaged bicycle community in the Tulsa region that have participated in the Go Plan's public engagement process. The planning process for the future bicycle network considered the needs, skills, and desires of a range of bicyclists. Generally, bicycle planning professionals accept that there is a large percentage of the American population that is interested in cycling for transportation purposes, but do not currently cycle for a variety of reasons. People typically have positive memories of bicycling in their youth and associate bicycling with expanded personal freedom and adventure. But as they have grown older, most have come to view bicycling as a recreational activity that is safest on trails; riding on the street network is perceived to be unsafe and unappealing. Conversations during the plan development process revealed similar attitudes in the Tulsa region, so the bicycle facility network recommendations are designed to meet this broader demographic of users.

Research focused on bicycle transportation has historically been very limited as has the collection of data regarding the use and safety of treatments, such as bike lanes, designed to improve bicycling. Over the last 5 -15 years, an increasing focus has been placed on understanding the desires and needs of bicyclists. Research identifying reasons



Survey response results from 2012 Portland study relating fear of being hit by motorist to bicyclist classification shows strong correlation between bicyclist classification and safety concerns operating in close proximity to traffic.

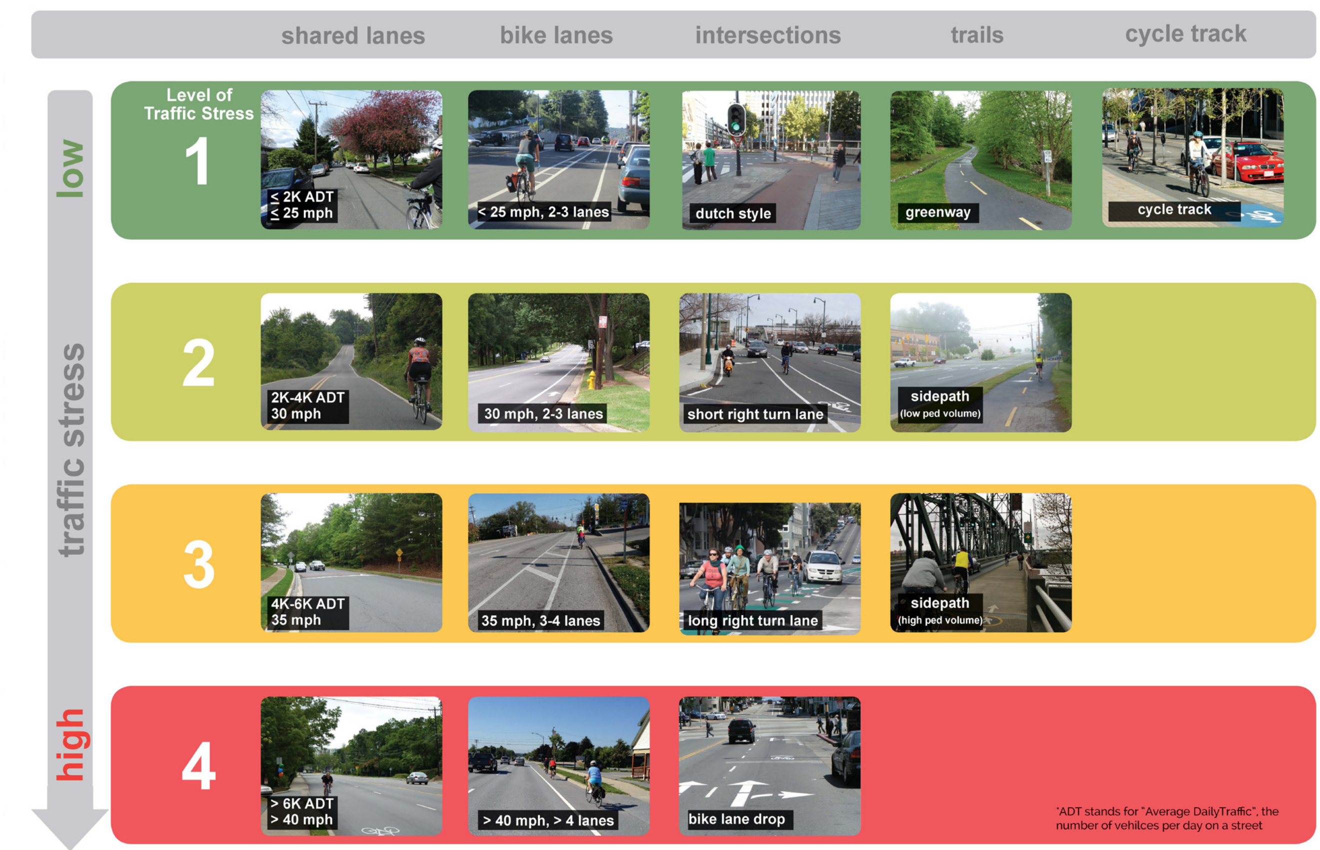
people choose other modes of transportation over bicycling consistently find people cite perceived risk, weather, topography, trip distance and support facilities (showers, bike parking) as primary discouragements to bicycling. Of these issues, perceived risk is the most critical and challenging barrier to overcome to increase rates of bicycling for transportation purposes.

A number of research studies have shown a bicyclist's perception of their personal safety riding on a roadway is greatly influenced by their proximity to and interaction with motorized traffic. At low-volumes and speeds of traffic, many people feel safe and comfortable sharing the roadway with traffic. As traffic speed and volume increase, their perception of safety degrades significantly resulting in a feeling of increased stress and discomfort on the roadway.

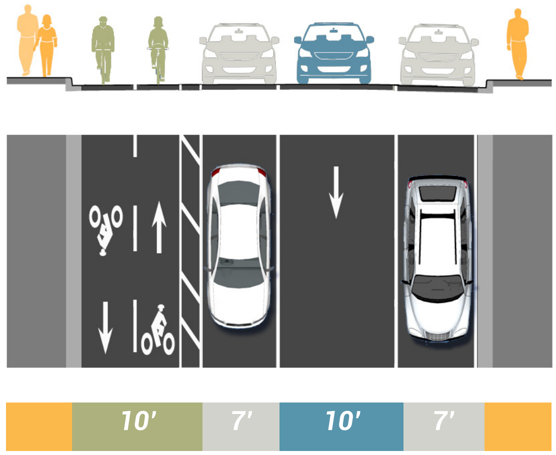
The degree to which people experience this stress is likely to vary by bicycling experience, health, age, and trip purpose (commuting vs. recreational family ride). A seminal 2012 survey in Portland, OR questioned residents about their level of comfort riding on various street types with and without bicycle facilities, signs or pavement markings. Respondents were then sorted into four categories based upon which correlated their stated comfort level riding on various street types with their concern about being hit by a motor vehicle. The results are summarized in the graphic below.

Priority Routes via Low-Stress Bicycling Concept

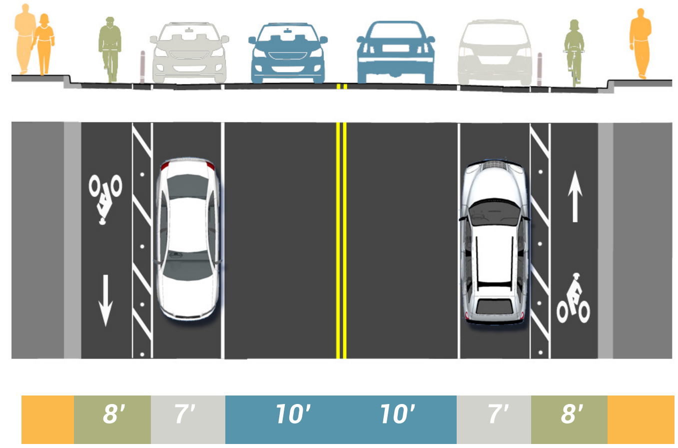
In looking at the current conditions of many of streets in the Tulsa region, it was clear that many of them are either over-built and have great potential in being reimagined to have bike facilities on them, or they are so heavily trafficked that major actions would have to occur to make them feel comfortable to ride on. The low-stress bicycling concept is premised on the experience of the Dutch who have focused on building a connected bicycle network that minimize bicyclists interaction with motorized traffic. Their approach



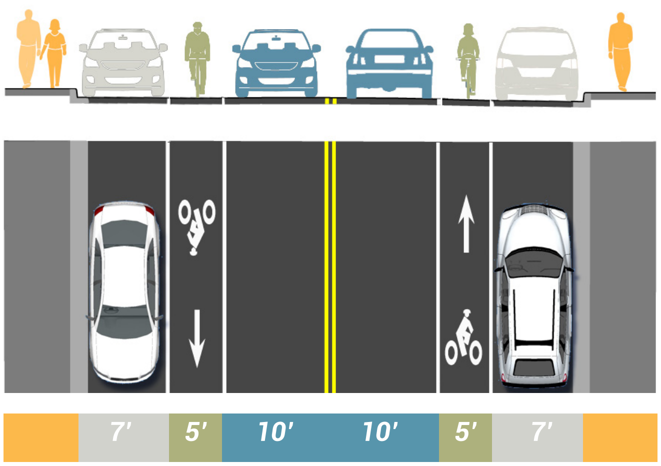
Level of Traffic Stress takes bicycle facility type, traffic speed and traffic volume into account to determine the bicyclist's level of stress experienced while traveling along that street or pathway.



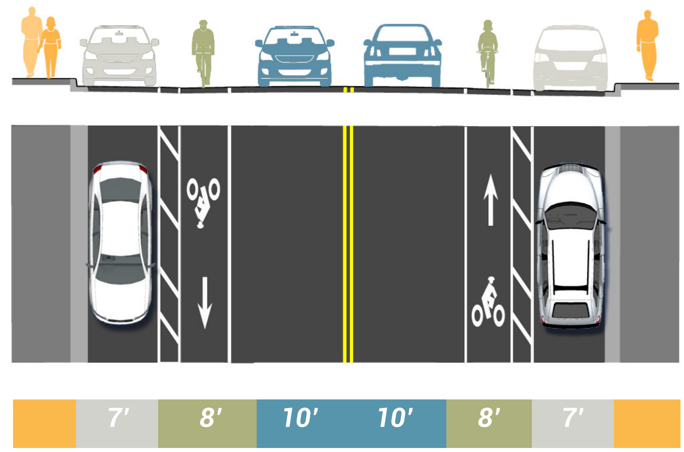
Two-way Cycle Track



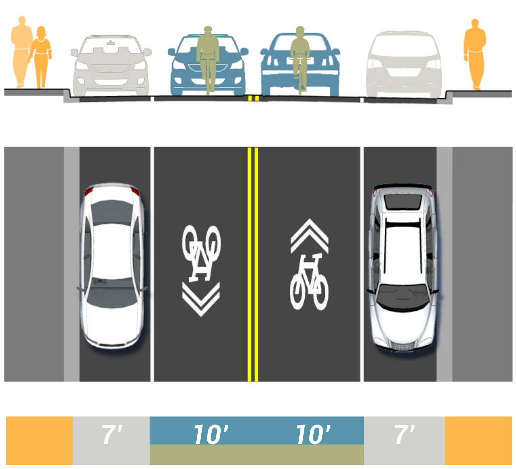
One-way Cycle Tracks



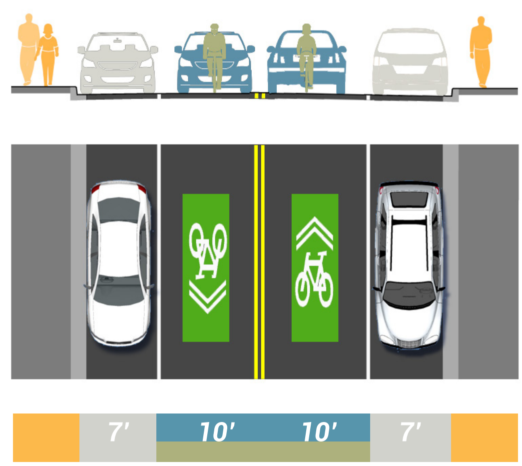
Bike Lanes



Buffered Bike Lane



Shared Lane Markings



Priority Shared Lane Markings

These cross sections indicate minimum facility and lane widths for on-street bicycle facilities. Widths are further detailed in each of the facility type write-ups in this section.

Automobile travel lane widths should adhere to the Context Sensitive Capacity-Volume-Geometrics table developed jointly by INCOG and the City of Tulsa engineering department. For instance, if a transit lane is located on a street, the lane for bus travel must be 11'. This table is included as the last page of this appendix.

targets mainstream adult bicyclists (Interested but Concerned population) by providing the following types of facilities:

- Shared lanes on low-volume, low speed, local streets
- Bicycle lanes on moderate-volume & moderate-speed streets
- Cycle tracks (cycle tracks) on high-volume or high-speed streets

For bicycling to be an appealing transportation choice for the Interested but Concerned population, the streets need to be less stressful to bike on, and the bicycle network should get people from point A to point B without significant additional mileage or delay.

A primary goal of the priority bicycle network for the Tulsa Go Plan was to identify and plan for a connected system of low stress routes which appeal to the Interested but Concerned population. These key routes were identified to link the existing and proposed trail system and provide direct north-south and east-west travel through the multimodal district. These routes also connect major destinations including parks and schools. Plus they are some of the only routes to cross the Arkansas River or provide access under Interstate 244 and 44. Many of the facilities recommended are self-explanatory and are designs that have been recommended before, but there are a few that are unique to the Go Plan and serve a greater purpose than just moving bicycles.

Sidepaths and Trails

Sidepath and trails are two facilities that provide off-street space intended for use by bicyclists and pedestrians. Both may be designated for one-way or two-way travel. Most off-street paths accommodate both bicyclists and pedestrians within the same space and are sometimes referred to as shared-use paths. Off-street facilities for exclusive bicyclist use are discussed in the following section, "Cycle Tracks."

A defining feature of off-street paths is that they place bicyclists and pedestrians in an off-street location, where they become subject to all applicable laws pertaining to pedestrian movement at intersections and driveways.

The difference between sidepaths and trails for the purposes of this plan and set of guidelines is their location in relation to a street right-of-way. Sidepaths are located in a right-of-way and place bicyclists and pedestrians in parallel travel paths to the on-street automobile traffic.

Trails are located off-street through open land, often, in the Tulsa region, along watercourses or former rail lines. They interact with streets through at-grade and grade-separated crossings. Where space is available, some trails are constructed with dual cartways: one for pedestrians and one for bicyclists.

Similar design principles and considerations apply to both facility types. However, sidepath design must consciously address driveway crossings and a higher frequency of street crossings to ensure path users and drivers are aware of potential conflicts.

Design

- Off-street paths are desirable along high volume or high speed roadways, where accommodating bicyclists within the roadway in a safe and comfortable way is impractical.
- Off-street paths typically have a lower design speed for bicyclists than in-street facilities do and may not provide appropriate accommodation for cyclists who desire to travel at greater speeds. In addition, greater numbers of driveways or intersections along a sidepath corridor can decrease bicycle travel speeds and traffic signals can increase delay for bicyclists on off-street paths compared to cyclists using in-street bicycle facilities such as bike lanes.
- Many bicyclists express a strong preference for separation from motorized vehicles provided by off-street paths when compared with on-street bike lanes. This may be especially true of less experienced or slower bicyclists. Off-street paths should not be considered a substitute to accommodating bicycles within the roadway.

- Off-street paths have a relationship with roadways similar to that of sidewalks to roadways, in that they function as parallel facilities located in close proximity to vehicle travel lanes. Conflicts with vehicles turning across the path of bicycles and pedestrians at driveways and intersections are an inherent drawback of off-street paths. Off-street paths are commonly used along recreational corridors, scenic corridors, or parkways, and may be part of a regional trail system.
- Off-street paths may be used to provide two-way bicycle and pedestrian travel adjacent to one-way roadways.
- Off-street paths should be a minimum of 10 feet wide ideally. Sidepaths in constrained locations with lower pedestrian volumes may be as narrow as 8 feet.

Considerations

- Off-street paths intended for use by bicyclists should be designed to meet adopted guidelines. This includes widths, clearance, design speed, stopping and sight distance.
- Off-street paths intended for use by pedestrians must meet accessibility requirements under the Americans with Disabilities Act (ADA). Grades may meet but not exceed the grade of the adjacent roadway.
- Crossings must be designed in a way that facilitate sight distance for drivers, bicyclists, and pedestrians, provide stacking room for vehicles waiting to enter the roadway or cross the off-street path, and allow bicyclists and pedestrians to anticipate and react to vehicular turning movements.
- Off-street paths should be designed to maintain constant cross slope and running slope through driveways.
- The desired buffer width between the off-street path and the roadway is a minimum of 5 feet, with a desired minimum of 6 feet, and may be a planted boulevard.
- One-way paths may be used in park settings to minimize conflicts between users where there are high volumes of bicyclists or pedestrians. Because pedestrians walk at relatively slow speeds, one-way pedestrian paths are generally not encouraged.
- When one-way paths for bicycles are desired, consideration should be given to discourage wrong way cycling.
- When one-way paths for bicycles are provided within roadway corridors, the paths in opposite directions should be provided in pairs. Generally a pair of one-way off-street paths will be provided on opposite sides of the roadway to allow bicyclists to travel adjacent to motorized traffic in the same direction.

Sidepaths are located along roadways and are shared by bicyclists and pedestrians.

Trails are located in their own off-street alignment and are shared by bicyclists and pedestrians.

- On a one-way path, an off-street facility may transition to an on-road bike lane or cycle track configuration in advance of an intersection or driveway. This allows cyclists to take advantage of the comfort of off-street paths in mid-block locations with the operational benefits of in-street cycling at intersections.
- Enhanced traffic control devices such as bike signals at intersections may be appropriate in some locations.
- At intersections with low-volume minor roadways, the crossing of an off-street path and/or sidewalk may be raised, in the form a raised crosswalk to serve as a traffic calming feature for motor vehicles. Raised paths through intersections are more difficult to construct and maintain as grade present issues for ADA compliance and drainage.
- Sidepath design may be complicated along corridors with pinch points that limit right-of-way where the path may be located. Roadway edge demands such as utility locations and driveways can impact location and design of these facilities.

Cycle Tracks

Cycle tracks, also known as separated or protected bike lanes, are exclusive bicycle facilities physically separated by a vertical element from the adjacent motor vehicle lanes. Separation can be achieved through a vertical curb, a parking lane, flexposts, plantings, removable curbs or other measures. Buffered bike lanes that do not include a vertical element are not considered cycle tracks.

There are four basic configurations for cycle tracks:

- Sidewalk level bike lanes
- Bike lanes constructed at an intermediate level between the sidewalk and the street
- Street level bike lanes separated from traffic or parking by a curb
- Street level bike lanes separated from traffic or parking by a vertical object

Cycle tracks dramatically increase rider comfort and decrease stress. They are usable by a broad spectrum of bicyclists including very young riders and more cautious bicyclists. Cycle tracks may be used on many different street types and are especially welcome on higher speed, higher volume roadways. Studies show that bicyclists prefer separation from motor vehicles on most types of roadways and can contribute to expanding bicycle mode share. Cycle tracks can be one-directional or two-directional; may be provided on both sides of two-way streets or on one side of one-way streets.

Design

Cycle tracks are appropriate on streets with operating speeds of 25 mph and higher, and volumes that exceed 4,000 vehicles per day.

Cycle tracks can be useful on-streets that provide connections to off-street trails, since bicyclists on these streets may be more accustomed to riding in an area separated from traffic.

Intersection design for cycle tracks is complex and requires careful attention to conflicts with turning vehicles.

- Dimensions are for bike lane only and do not include sidewalk or street buffer.
- Typical minimum bike lane width of 5′ will not accommodate passing. 6.5′ is required on a one-way facility for two bicyclists to pass one another, and 4′ in each direction on a two-way facility. Edge conditions impact the ability to comfortably pass or ride two abreast. The minimum width is discouraged when a separated bike lane is located between raised curbs. If width is constrained, designer should consider options that allow bicyclists to use the buffer space to pass another user.
- Passing may occur in opposing lane.

Adjacent to on-street parking, a minimum 2′ to 3′ buffer should be provided between parking and the separated bike lane; the buffer serves as a pedestrian loading and unloading zone and helps keep bicyclists out of the door zone of parked vehicles.

Cycle tracks can be designed to be two-way facilities on a one-way street. Signage and pavement markings are provided at driveway crossings to alert drivers to the presence of two-way bicycle cross traffic.

Considerations

- Cycle tracks require increased parking restrictions approaching intersections compared to standard bicycle lanes to provide for visibility at intersection transitions.
- Vertical curb separation should be considered where on-street parking is not present. Stormwater drainage will need to be considered with this option. Street level cycle tracks may be combined with islands at corners and crossings.
- At transit stops, cycle tracks should be routed between the stop passenger waiting area and the sidewalk to reduce conflicts while passengers are boarding and alighting. Signage and/or markings may be added to alert transit riders and bicyclists of the conflict zone as pedestrians cross the bike lane from the sidewalk to the transit stop.
- Ensure gutter seams, drainage inlets and utility covers are flush with the roadway surface. Where possible, these features should be kept out of the bike lane.
- The presence of drainage and utility structures along the curb may reduce the effective width of a separated bike lane.
- Maintenance should be considered, including street sweeping.

Standard Bike Lanes

Bike lanes provide an exclusive space for bicyclists in the roadway. Bike lanes are established through the use of lines and symbols on the roadway surface. Bike lanes are for one-way travel and are normally provided in both directions on two-way streets and/or on one side of a one-way street. Bicyclists are not required to remain in a bicycle lane when traveling on a street and may leave the bicycle lane as necessary to make turns, pass other bicyclists, or to properly position themselves for other necessary movements. Bike lanes may only be used temporarily by vehicles accessing parking spaces and entering and exiting driveways and alleys. Stopping, standing and parking in bike lanes is prohibited.

Design

- Bike lanes can be used on one-way or two-way streets with single or multiple lanes.
- Bike lanes may be placed adjacent to a parking lane or against the curb if there is no parking. Conventional bicycle lanes are located on the right side of the roadway.
- Bike lanes are typically installed by reallocating existing street space (i.e., narrowing other travel lanes, converting travel lanes and/or reconfiguring parking lanes).
- The minimum width of bike lanes is 5' next to a curb and, if working in very constrained locations, 4' on a street with no curb. Bicycle lanes may be 6', but if more street width is available, the street should be evaluated for other treatments.
- When bike lanes are adjacent to parking, the combined width (from face of curb) of parking and bicycle lane should be at least 12'.
- Bike lanes are indicated by a solid white line along the left side of the lane. Use dotted or dashed line marks to indicate areas of bicycle/vehicle conflict.
- Bicycle lane word and/or symbol and arrow markings (MUTCD Figure 9C-3) shall be used to define the bike lane and designate that portion of the street for preferential use by bicyclists.

Considerations

- Bike lane design should consider parking configurations and turnover, the presence of medians, the continuity of the facility and the configuration and complexity of turning movements at intersections.
- If bike lanes are adjacent to guardrails, walls or other vertical barriers, additional bicycle lane width is desired to account for bicyclist "shy" distance from the edge. Similarly, provide additional space if bicycle lanes are at sidewalk level and adjacent to the curb and travel lanes.
- Ensure gutter seams, drainage inlets and utility covers are flush with the roadway surface. Where possible, these features should be kept out of the bike lane.
- Where wider lanes are possible, consider providing a buffered bike lane, discussed next.
- On constrained corridors with high parking turnover, consider designing pavement markings to guide bicyclists outside of the door zone of parked vehicles. Treatments include installing a buffer on the parking side of the bicycle lane, door zone, hatch marks, or using parking T's instead of a longitudinal parking line.
- Consider using colored pavements to highlight areas where conflicts might occur, such as at intersection and driveway crossings.
- It is critical that bike lanes receive the same treatment as the remainder of a street surface with regard to cleaning. In addition, bike lanes need to have regular cleaning of storm drains, especially during spring and autumn seasons when fallen leaves or other tree debris may collect in drains and cause pooling or flooding of stormwater in curbside bike lanes.

Bike lanes are marked with a bicyclist symbol and arrow indicating direction of travel.

Buffered Bike Lanes

Buffered bicycle lanes are created by painting or otherwise creating a flush buffer zone between a bicycle lane and the adjacent travel lane. While buffers are typically used between bicycle lanes and motor vehicle travel lanes to increase bicyclists' comfort, they can also be provided between bicycle lanes and parking lanes in locations with high parking turnover to discourage bicyclists from riding too close to parked vehicles.

Buffered bicycle lanes are distinct from separated bicycle lanes in that they have no vertical barrier between travel lanes and/or parking. Like separated bicycle lanes, buffered bicycle lanes have been found to dramatically increase bicycling comfort for a wide range of community bicyclists.

Design

- The recommended minimum width of a buffer is 2'; however width may vary depending upon the available space and need for separation. Total assembled width of bicycle travel way (lane) and buffer should be at least 7'.
- Buffered bicycle lanes are typically installed by reallocating existing street space (i.e., narrowing other travel lanes, converting travel lanes and/or reconfiguring parking lanes).
- Buffers should be painted with solid white lines and channelization markings.
- Bicycle lane word and/or symbol and arrow markings (MUTCD Figure 9C-3) shall be used to define the bike lane and designate that portion of the street for preferential use by bicyclists.
- Buffers can be useful on multi-lane streets with higher speeds, but are not required in these locations.

Considerations

- Where only one buffer can be installed on a constrained corridor with on-street parking, the buffer should typically be placed between the bicycle lane and parking lane, depending upon roadway speeds and parking turnover.
- Generally speaking, there is no upper limit for buffer width and buffers of 5' to 6' are common where travel lanes are converted to buffered bicycle facilities, however, wide buffers without vertical separators may invite illegal use for vehicle travel. In this case, buffer space should be divided and placed on either side of the bike lane as opposed to all on one side.
- Ensure gutter seams, drainage inlets and utility covers are flush with the roadway surface. Where possible, these features should be kept out of the bike lane.
- Because they do not require construction of a separating element, buffered bicycle lanes may be established through simple street resurfacing and may enable trial or phasing prior to the installation of separated facilities.
- Buffered bicycle lanes, like cycle tracks, may transition at intersections to provide adequate visibility and safety.
- Buffered bike lanes can easily be converted to cycle tracks in the future through using vertical elements such as flexposts or rubber curbing.

Buffered bike lanes provide greater shy distance between motor vehicles and bicyclists.

Shared Lane Markings

Marked shared lanes are indicated by specific bicycle symbols called shared lane markings or sharrows. Sharrows markings are two chevrons positioned above a bicycle symbol.

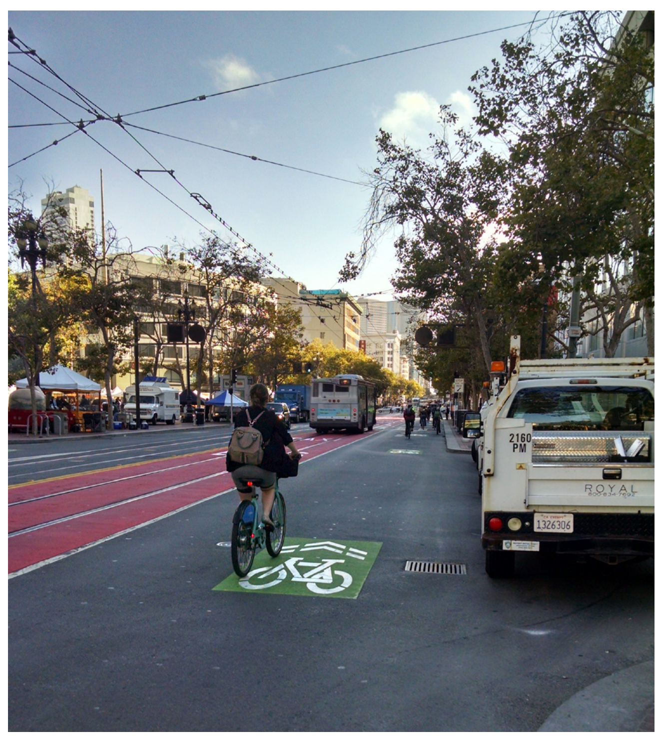
In general, this is a design solution that can only be used in locations where a standard bike lane or separated bike lane is not feasible due to space constraints. On streets with narrow travel lanes, shared lane markings direct the bicyclist to the correct and most conspicuous position on the road: the middle of the travel lane. This marked "lane within the lane" can reduce conflicts by encouraging (though not requiring) vehicles to use inside lanes and reserve the outside lane for bicyclists. Markings also altert drivers to the presence of bicyclists on the roadway.

Shared lane markings should be placed in such a manner to direct bicyclists to ride in the most appropriate location on the roadway. They can also be used in multiple lanes to position bicyclists for turning movements.

Design

- Shared lane markings are not a preferred facility type except in locations with low traffic speeds and volumes (operating speeds less than 25 mph, volumes less than 4,000 vehicles per day).
- On streets that fall outside of these design parameters, shared lane marking can be used as an interim (retrofit) design solution, however they should not be used on streets with speed limits above 35 mph and are generally not appropriate on roadways with more than four travel lanes (two-way) or more than three travel lanes (one-way).
- Refer to the MUTCD for additional design guidance on the use of shared lane markings.
- On narrow travel lanes adjacent to on-street parking, shared lane markings should be placed in a location that is outside of the door zone of parked vehicles (such as the center of the travel lane).
- Shared lane markings should be supplemented by SHARE THE ROAD signs, and BICYCLES MAY USE FULL LANE signs where appropriate.

Shared lane markings indicate bicyclists' presence to drivers and appropriate placement on the roadway.



Green-backed priority shared lane markings are more visible and spaced more closely than normal sharrows.

Considerations

- Marked shared lanes should be provided after considering narrowing or removing travel lanes, parking lanes and medians as necessary to provide an exclusive bicycle facility.
- Shared lanes can be used as an interim solution to complete connections between bicycle lanes and other facilities.

Priority Shared Lanes

On multi-lane streets, marked shared lane symbols, or sharrows, can be enhanced with a green colored backing. These priority shared lane markings are also placed at greater frequency than standard shared lane markings to further emphasize the presence of bicyclists on the street. They are particularly appropriate for application in commercial areas with high bicyclist volumes and complex vehicle movements as drivers stop and start in the course of accessing on-street parking.

Design

- Priority shared lanes can be an appropriate retrofit solution on multi-lane one-way and two-way streets where roadway space is not available for separate bicycle facilities. They should not be used in locations with higher operating speeds (35 mph or greater).
- Shared lane markings can be supplemented by SHARE THE ROAD signs, and BICYCLE MAY USE FULL LANE signs where appropriate.

Considerations

- Priority shared lanes should be provided after considering narrowing or removing travel lanes, parking lanes, or medians as necessary to provide an exclusive facility.

Neighborhood Bikeway, Neighborways or Bike Boulevards

What most influences the way people drive isn't the speed limit, a caution sign, or the threat of a ticket. Rather, drivers take their cues from the design of the street. Narrower lanes, trees, wayfinding signage, pavement markings, people walking and biking give the impression that pedestrians and bicyclist are a priority, so drivers slow down.

Neighborhood slow streets are a network of quiet, often residential streets that are designed for slower speeds. These streets are designed to give priority to pedestrians and bicyclists. They are excellent places to play, walk a dog, or ride a bicycle that connect across neighborhoods and the city.

Urban signed routes provide a local street route that is an alternative to traveling on a high-volume, high-speed arterial. Most of these routes will need crossing treatments at intersections as described earlier in this appendix, and can range from curb extensions and marked crosswalks to raised crossings and signals. These signed routes are very similar to neighborhood slow streets and may be further enhanced with the addition of traffic diverters and traffic calming.

Design

- Design features that reduce operating speeds are used to maintain low speeds (20 mph or less) on neighborhood slow streets.

Many jurisdictions have used large bike symbols to indicate bicycle boulevards.

- Neighborhood slow streets are best accomplished in neighborhoods with a grid street network (where motor vehicle through-traffic can be directed to parallel routes), but can also be accomplished by combining a series of road and trail segments to form one continuous route.
- Ideally, neighborhood slow streets should not carry more than 1,000 motor vehicles per day to be comfortable for pedestrians and bicyclists. Traffic management devices are typically used to discourage motor vehicle through-traffic while still enabling local traffic access to the street.
- Neighborhood slow streets should be long enough to provide connectivity between neighborhoods and common destinations such as schools or parks.

Considerations

- At major street crossings, neighborhood slow streets may need additional treatments other than marked crosswalks for pedestrians and bicyclists. Treatments can include signage, median refuge islands, curb extensions, advisory bike lanes, rapid flash beacons, pedestrian-actuated signals and/or bicycle signal heads.
- Many local street connections are offset across major arterial crossings. Some are signalized at one leg, and in these situations, bicyclists should be directed to cross at the signalized leg. A short stretch of sidepath is required to connect the non-signalized leg to the signal. In situations without signalization, a HAWK or RRFB should be installed to create greater yielding behavior by drivers.

Bicycle Accommodations at Intersections

The majority of motor vehicle crashes involving bicycles in urban areas occur at intersections. In Oklahoma, on-street bicycles are operating vehicles and are required to follow the same rules of the road as motorists. Good intersection design makes bicycling more comfortable and attractive, reduces conflicts with motor vehicles and pedestrians, and contributes to reduced crashes and injuries. The following principles are applied to intersection design in order to accommodate bicyclists:

- Provide a direct, continuous facility to the intersection
- Provide a clear route for bicyclists through the intersection
- Reduce and manage conflicts with turning vehicles
- Provide signal design and timing to accommodate bicyclists, based on an engineering study.
- Provide access to off-street destinations.

Intersection improvements for bicycles should be considered during all roadway improvement projects, street redesign, and safety improvements or upgrades.

Bicycle Lanes at Intersections

Bicycle lanes provide a dedicated space for bicyclists to predictably ride along roadways and through intersections. When designing intersections for bicyclists, the approaches should be evaluated and designs should maintain continuity of bicycle facilities to the maximum extent feasible.

Streets with dedicated bicycle lanes should continue striping through unsignalized and complicated intersections to provide additional guidance and safety measures for bicyclists. This design principle is especially important at intersections where there are conflicting vehicular movements, unsignalized crossings, and/or crossings of more than four travel lanes. Signalized intersections may not require striping through each intersection, and should be evaluated on a case-by-case basis.

Design

- Standard details for bicycle lane markings at intersections are provided in the NACTO Urban Bikeway Design Guide. Additional guidance can also be found in the MUTCD and AASHTO "Bike Guide."
- Dedicated bicycle lanes should be provided on intersection approaches where space is available.
- At intersections with a dedicated right turn lane, bicycle lanes should be provided to the left of the right turn only lane unless bicycle signals and dedicated phasing is provided.

Considerations

- Bicycle lane markings, including green-colored pavement, shared lane markings, dashed bicycle lane lines, and signage may be provided through intersections per engineering judgment.
- Selective removal of parking spaces may be needed to provide adequate visibility and to establish sufficient bicycle lane width at approaches to intersections.
- Shared lane markings may be used where space is not available for bicycle lanes at intersections, however this should only be done if no other design is possible.
- Although the minimum recommended width of a bicycle lane within the intersection is 5', 4' bicycle lanes can be provided in extremely constrained conditions.
- Bicycle lanes at the entrance and exit of a circular intersection should allow direct access to a shared use bicycle/pedestrian path around the perimeter of the intersection via curb ramps; ramps should be provided for bicyclists to mount the sidewalk prior to the intersection. Designs should also enable bicyclists to mix with traffic and proceed through the intersection.

Bicycles at Signalized Intersections

Bicycles have different operating characteristics than motor vehicles and special consideration is necessary in designing traffic signals that accommodate both motorists and bicyclists. Bicyclists have the disadvantage of slower acceleration rates than motorists, and traffic signal design should include adjustment of minimum green intervals, clearance time and extension time to account for tthis. Signal progression should be designed in order to balance the needs of all users, with appropriate design speeds and traffic signal coordination settings. Appropriate signal timing also can reduce delay, discourage bicyclists from running red lights and help minimize conflicts.

The AASHTO Guide for the Development of Bicycle Facilities provides a specific formula to estimate minimum green time for bicycles from a standing

Striping bike facilities through intersections highlights the bicyclist's path of travel.

position. It is based on the average adult bicyclists who can operate at 10 miles per hour. A slower speed or extended time may be appropriate at locations with young children, such as near schools.

Design

Where actuated signals are present, the signal system should automatically detect bicycles as well as motor vehicles. The City of Tulsa and some other communities have some loop detectors at actuated or semi-actuated intersections, but they are the only ones in the region. In order for bicyclists to prompt the green phase at these intersections, bicycle detection devices should be installed.

Detection devices can also include:

- Video, infra-red or microwave detection
- Magnetometers (special locations such as on or under bridges)
- Detection devices should be located within bicycle lanes or bicycle boxes, marked with a bicycle detector symbol, and supplemented by appropriate signage.
- When it is not feasible for the detection device to be located within the bicycle lane or bicycle box, detection devices should be located prior to the stop bar and span an appropriate distance to provide for left, though, and right turning bicyclists.

Considerations

- Reference the latest edition of the AASHTO Bike Guide and the NACTO Urban Bikeway Guide for more details on the signal timing needs of bicycles at intersections. The AASHTO Bike Guide provides the technical information necessary to calculate minimum green time and other aspects of signal design to accommodate bicycles. The NACTO Urban Bikeway Design provides less technical detail, but provides information regarding bike signal heads
- Where right-turn-only lanes for motor vehicles exist, bicycle lanes should be designed to the left of the turn lane.
- Special attention should be given to signal timing at locations with higher vehicular speeds and longer crossing distances. At these locations, bicyclists are more likely to have different signal timing needs than motorists, such as extending the green time to allow bicyclists to clear the intersection before the yellow/red phases. The AASHTO Bike Guide contains detailed guidance for bicyclists' signal timing needs at wide intersections.
- Bicycle signal heads provide dedicated signal indications to bicyclists and should be positioned to maximize visibility to bicycle traffic. They should be coordinated with pedestrian and non-conflicting vehicular movements to increase safety and minimize overall delay.
- Bicycle detection devices, particularly loop detectors, need regular testing to ensure the equipment is working correctly.

Bike Boxes

A bicycle box is dedicated space located between the crosswalk, and the motor vehicle stop line used to provide bicyclists a dedicated space to wait during the red light at signalized intersections. Placing bicyclists ahead of stopped vehicular traffic at a red light improves visibility and reduces conflicts among all users. They also

Bicyclists wait in a bike box in Chicago, which increases their visibility and reduces their signal delay.

provide bicyclists a head start to get through the intersection, which aids in bicyclists making difficult turning movements and improves safety and comfort due to the difference in acceleration rates between bicycles and motor vehicles. Bicycle boxes also provide more space for multiple bicyclists to wait at a red light as opposed to being constrained to a 5' wide bicycle lane. In all cases, the bicycle box allows a bicyclist to be in front of motor vehicles, which not only improves visibility and motorists awareness, but allows bicyclists to "claim the lane" if desired.

Design

- In locations with high volumes of turning movements by bicyclists, a bicycle box should be used to allow bicyclist to shift towards the desired side of the travel way. Depending on the context of the bicycle lane, left or right side, bicyclists can shift sides of the street to align themselves with vehicles making the same movement through the intersection.
- In locations where motor vehicles can continue straight, or turn right crossing a right side bicycle lane, the bicycle box allows bicyclists to move to the front of the traffic queue and make their movement fi rst, minimizing conflicts between the right turning motorist and the bicyclist. Where designs place bicycle boxes in front of a vehicle lane that may turn right on red, NO TURN ON RED signs must be provided.

Considerations

- When bike boxes are implemented, they are typically to be painted green, and area minimum of 13' in depth.
- Bicycle box design should be supplemented with appropriate signage according the latest version of the MUTCD.
- Where right turn only lanes for motor vehicles exist, bicycle lanes should be designed to the left of the turn lane. If 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.

Wayfinding

The ability to navigate through a region is informed by landmarks, natural features, signs, and other visual cues. Wayfinding is a cost-effective and highly visible way to improve the bicycling environment by familiarizing users with the bicycle network, helping users identify the best routes to destinations, addressing misperceptions about time and distance, and helping overcome a barrier to entry for infrequent cyclists (e.g., "interested but concerned" cyclists).

A bikeway wayfinding system is typically composed of signs indicating direction of travel, location of destinations, and travel time/distance to those destinations; pavement markings indicating to bicyclists that they are on a designated route or bike boulevard and reminding motorists to drive courteously; and maps providing users with information regarding destinations, bicycle facilities, and route options.

General Principles

- Messages must be clear and concise
- Related signs should be combined to limit visual clutter, and signs should be limited in number and content as to not overpower the reader
- Signs should be placed in such a way that primary regulatory signs are not overlooked
- Groups of wayfinding signs should have a graphically standardized appearance
- Signs must be maintained to ensure current information and adequate condition
- Destination names will be kept generic to the extent possible to avoid advertising
- Private campus areas, such as a college campus, may provide a system of wayfinding to facilitate internal site circulation. These systems are developed independently from City wayfinding systems within the public right-of-way.

General Wayfinding

Primary signing may be accomplished through street name signs. Street name signs follow MUTCD standards. Street name signs are posted on one of the quadrants at residential intersections. At collector and arterial street intersections signs are posted on diagonally opposite corners. Signs may be mounted on stand-alone posts, light poles, or on signal mast arms. The signs list the street name, generalized street address range for that block and, if on a bike route, a bike symbol. Street signs are installed in conjunction with street reconstruction and are replaced to maintain good visibility.

Design

Refer to MUTCD standards for sign installation, such as mounting height, lateral placement from edge of path or roadway and other guidance.

- Mounting height should generally be above the eye of the intended user.
- Size of font should be legible to intended user
- Signs should be combined horizontally or vertically, where possible
- Lines of sight and visibility should be reviewed when placing signs
- A sign should be as simple and as short as possible to convey the intended message
- Pavement markings can also be used to assist with wayfinding in some locations and can also be a placemaking tool
- Wayfinding may be part of a broader district wayfinding/ branding initiative.
- Pedestrian wayfinding is primarily provided near major attractions, such as theaters or event centers.
- Pedestrian wayfinding may be useful in areas where large volumes of pedestrians may be walking to transit stops.
- Signs should meet all needs for public accessibility

Bicycle Route Wayfinding

This guidance is appropriate for on-street bicycle routes or sidepaths adjacent to roadways.

- Route identification signs may be placed generally every ½ mile, at the far side of intersections with major bike routes and at decision points.
- Use D11-1c series Bicycle Route Signs with route name, such as "RIVER BIKEWAY," in place of "BIKE ROUTE" or M1-8 series signs to identify bicycle routes.
- Place decision signs in advance of intersections with other major bike routes and at decision points.
- Decision signs should include destinations and directional arrows, and may include distance to destination
- D1-3 series Destination Supplemental Signs should be used and, where feasible, consolidated with route identification signs to minimize size and clutter.

Bicycle wayfinding typically includes destination, distance and direction.

- Destinations should be listed with the closest destinations towards the top of a sign assembly, with a maximum of three destinations used on any single sign.

Trail Wayfinding

This guidance is appropriate for trails located on independent rights-of-way.

- Where bikeways managed by multiple agencies or from multiple systems share a common segment, wayfinding signs for either agencies or systems may be used.
- Wayfinding or route identification signs should be posted at all major decision points along the trail (feeder trail intersections, forks in the trail, etc.) and after all roadway crossings (local streets and arterials).
- Street name signs should be installed at all locations where trails intersect streets. This type of sign should have a sign blade for both the street name and the trail name.
- Wayfinding signs may be part of a larger regional network and/ or branding system.

INCOG Context Sensitive Capacity-Volume-Geometrics Table

Recommended Standards for Arterial Street Improvements

Roadway Description	LoS D Range	LoS D Mid-point	FHWA/AASHTO Recommended Geometrics
2-Lane Arterial	11,900 - 15,300	13,600	14 FT Curb lane With Bike Sharrow (IF Curb Exists)
			13 FT Curb lane With Bike Sharrow (IF No Curb)
			11 FT Minimum outside lane for streets with Transit
			5 FT Min for a striped Bike lane (With Curb); 4 FT Min (No Curb)
			All Other Cases: Share the Lane (Bike & Auto) - Signed Route
3-Lane Arterial - Center Left (TWLTL)	14,000 - 18,000	16,000	14 FT Curb lane With Bike Sharrow (IF Curb Exists)
			13 FT Curb lane With Bike Sharrow (IF No Curb)
			11 FT Minimum outside lane for streets with Transit (through lane)
			5 FT Min for a striped Bike lane (With Curb); 4 FT Min (No Curb)
			All Other Cases: Share the Lane (Bike & Auto) - Signed Route
			10 FT Minimum for TWLTL (Center Left)
4-Lane Arterial (Undivided)	22,800 - 30,600	27,200	14 FT Curb lane With Bike Sharrow (IF Curb Exists)
4-Lane Arterial (Divided)	26,600 - 34,200	30,400	13 FT Curb lane With Bike Sharrow (IF No Curb)
			11 FT Minimum outside lane for streets with Transit
			10 FT Minimum inside lane with 11 FT Outside Lane
			5 FT Min for a striped Bike lane (With Curb); 4 FT Min (No Curb)
			All Other Cases: Share the Lane (Bike & Auto) - Signed Route
5-Lane Arterial - Center Left (TWLTL)	25,200 - 32,400	28,800	14 FT Curb lane With Bike Sharrow (IF Curb Exists)
			13 FT Curb lane With Bike Sharrow (IF No Curb)
			11 FT Minimum outside lane for Transit use (through lane)
			10 FT Minimum inside lane with 11 FT Outside Lane
			5 FT Min for a striped Bike lane (With Curb); 4 FT Min (No Curb)
			All Other Cases: Share the Lane (Bike & Auto) - Signed Route
			10 FT Minimum for TWLTL (Center Left)

Notes:

LoS D Traffic Volume Range is based on the Capacity Table used for INCOG Travel Demand Models approved by INCOG, Fast Forward Plan, also used in City of Tulsa Capital Improvement Project determination.

Roadways with traffic volumes above the mid-point of LoS D are discouraged from any roadway lane-configuration change. Any changes may require additional pavement/RoW or involve moving curbs, or a policy change with regard to the Roadway. Level of Service at or above this level is considered volatile based on truck traffic, number of curb-cuts, number of bus-stops, variation in travel speed. Traffic Volume above this level may approach breakdown/gridlock if any of the exacerbating factors are present.

Roadway Geometrics are recommended practice as recognized by AASHTO & FHWA guidelines. They should be adhered to in any reconfiguration of lanes, if under study for consideration.

Sources:

1. A Policy on Geometric Design of Highways and Streets, 6th Edition, AASHTO, 2011
2. The 13 Controlling Criteria, FHWA, U.S. Department of Transportation
3. Guide to Bicycle Facilities, 4th Edition, AASHTO, 2012
4. INCOG, ACOG & ODOT Roadway Capacity Table