

9. *Design Guidelines*

These design guidelines should be consulted when planning new facilities, reconstructing or modifying existing facilities, and updating city and design standards.

Topics:

- 9.1 Key Factors for Pedestrians
- 9.2 Key Factors for Bicyclist Travel
- 9.3 Travel Along Road Corridors
- 9.4 Developing Complete Street Cross Sections
- 9.5 Transitions Between On and Off-Road Bicycle Facilities
- 9.6 Modifying Existing Facilities
- 9.7 Travel Across the Road Corridor
- 9.8 Neighborhood Connectors
- 9.9 Bike Route Signs and Wayfinding
- 9.10 Bike and Pedestrian Boulevards and Neighborhood Greenways
- 9.11 Off-Road Trails
- 9.12 Gateway Transitions
- 9.12 Commercial Centers
- 9.13 Land Use Planning

9.1 Key factors for Pedestrians

Travel time and continuity of travel path are key factors that influence the likelihood of a person attempting a trip on foot, versus in the car or on a bike. The average speed for a pedestrian is 3 to 4 mph. This speed varies greatly according to age, trip purpose and fitness level. Pedestrians, like drivers, are significantly affected by the number of traffic signs and signals encountered. The number of traffic signs and signals significantly affect travel time for pedestrians, as well as motor vehicles, and can slow them down and add to the time of their trip.



The buffer between the sidewalk and the street as well as the degree of exposure in the crosswalks has a significant impact on the pedestrian's experience

Because walking is such a comparatively slow method of transportation, most trips that are taken by pedestrians are limited to short distances. Nationally 44% of trips taken by foot are for personal or family business, with social and recreational trips close behind at 35%. Earning a living only counts for 7% of pedestrian trips. The percentage of people who will choose walking as a form of transportation drops off significantly for trips of over a mile-and-a-half and is negligible for trips over 3 miles. Pedestrians generally take the shortest possible route available, and are not willing to go far out of their way. For example, many pedestrians will make a dash across a busy street if they must walk more than a typical downtown city block to a signalized intersection.

Perhaps the most important factor influencing the nature of a pedestrian trip is exposure to motor vehicles and the speed at which the motor vehicles are moving. For both safety and aesthetic reasons, the quality of a pedestrian's journey is much different when walking along a tree-lined path versus along a busy five-lane road with heavy truck traffic and no vegetation for shade. Also, it is much safer and more pleasant to walk along a street where the speed limit is 25 mph versus a street where the speed limit is 45 mph. National statistics show that a pedestrian's probability of death if hit by a motor vehicle increases from 15% when the car is going 20 mph to 85% if the car is going 40 mph.

Most likely, for a trip of any length, a pedestrian will need to cross a roadway. The availability and convenience of mid-block and signalized crossings as well as the nature of the roadway been crossed strongly influence the decision to walk, the safety of the walk and the decision to make that walk again in the future.

Pedestrian Quality/Level of Service

In order to make recommendations on appropriate for pedestrians, the pedestrian quality of service model that was developed by Sprinkle Consulting, Inc. was utilized. The model is based on data gathered from a wide cross section of users who evaluated numerous real world scenarios. A simplified version of this model has been incorporated in the 2010 Highway Capacity Manual's multi-model level of service evaluation. The following summarizes the key factors for pedestrians.

Key Factors (in order of statistical significance):

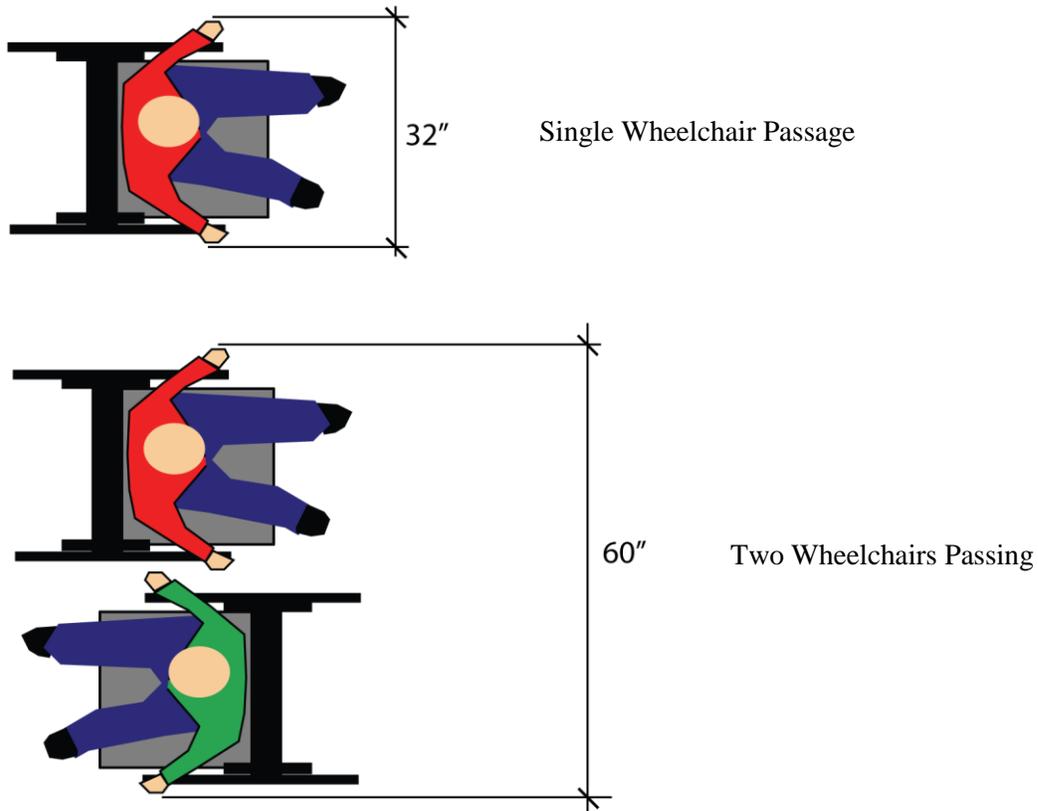
1. Presence of a sidewalk
2. Amount of lateral separation between pedestrians and motor vehicles
3. Presence of physical barriers (such as trees) and buffers (including parking) between pedestrians and motor vehicles
4. Motorized vehicle volume
5. Motorized vehicle speed

Pedestrian Spatial Requirements and Sidewalk Width

Pedestrian spatial requirements vary greatly given the variety of pedestrians. More significant than the size differential between individuals, the various mobility aids utilized have a major impact on how much space is required. Pedestrians who use crutches, walkers, wheel chairs, scooters or guide dogs require more space than pedestrian not using any of those aids. 2'-6" (30") is generally considered the bare minimum necessary for a person using a wheel chair. Thus 3' (36") is considered the narrowest a sidewalk should be at any point and only then for short distances. 4' (48") is required for a person with a guide dog.

For two pedestrians to comfortably walk side by side or pass each other, a five foot wide sidewalk is required. This is reflected in AASHTO Guidelines. With an aging population and the fact that most pedestrians will use some type of mobility aid at some time, sidewalk widths should accommodate the ability for two people to comfortably pass each other, even if they are using some type of mobility aid. Thus, a 6' wide sidewalk is considered more appropriate, especially when along collector and arterial streets where there is more pedestrian traffic. This has the added advantage of an adult walking with a child or someone walking a dog being able to pass another adult without having to do so single file. Where occasional bicycle traffic is to be encountered, an eight foot wide sidewalk is a more appropriate width and this is typically used along primary roads.

Figure 9.1A Wheelchair Spatial Requirements



Providing Seating

Providing benches and other seating options along collectors and arterials help make longer trips manageable for some pedestrians. The seating should be located in as pleasant a place as possible and shaded from the summer sun. Businesses and residents should be encouraged to provide and maintain benches for use by the general public.

9.2 Key Factors for Bicycle Travel

One of the most controversial issues with regard to accommodating bicyclists within the road right-of-way is whether they are better accommodated in the roadway itself or on a path alongside the road. Also, if bicycles are to be accommodated within the roadway, should a portion of the roadway be officially designated for bicycles? When addressing these issues, legal rights, safety, travel efficiency, nationally accepted guidelines and conflicts with pedestrians need to be considered.

Legal Rights

Bicyclists, for the most part, are granted the same rights and subject to the same regulations as motorists. There are some exceptions, such as their use being restricted from freeways, and some special rules regarding their operation.

Safety

While it may seem that bicyclists would be safer on a Sidewalk Bikeway than riding in the roadway, the inverse is actually true in most cases for experienced adult cyclists. This is due primarily to the bicycles traveling at a high rate of speed in an area where the drivers of turning vehicles are not looking. This is illustrated in Fig. 2.2A *Bicycle Lane visibility Vs. Sidewalk Visibility* illustration on the next page. The more frequent and busy the road and driveway intersections are the more chances there are for conflicts.

Travel Efficiency

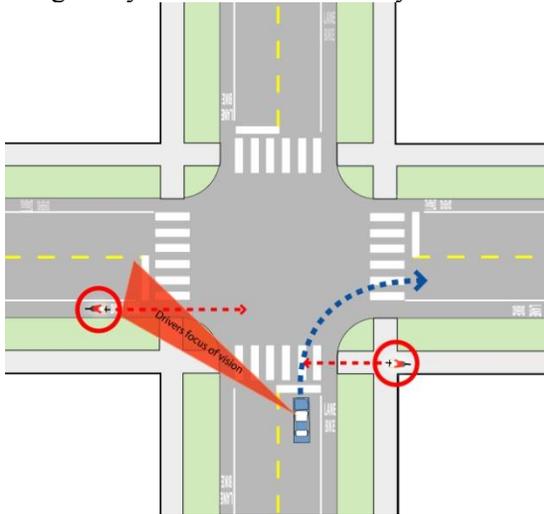
One of the most significant drawbacks to bicycling on sidewalks as opposed to bicycling in the roadway is the loss of right-of-way when traveling along collectors and arterials. When riding in the roadway of a major road, the vehicular traffic on side streets that do not have a traffic light generally yield to the bicyclists on the main road. If riding on a sidewalk, the bicyclist generally ends up yielding at those same side streets. In addition, the cyclist must approach every driveway with caution due to the visibility issues cited in the previous section and the fact that drivers rarely give right-of-way to a bicyclist on sidewalks. As well, the placement of many push-buttons used to trigger walk signals are often inconveniently placed for a cyclist.

Bicyclists are also required by law to yield to all pedestrians when riding on a sidewalk and provide an audible signal of their approach. As the number of pedestrians increase, a bicyclist's progress can be impeded.

The location of sidewalks is often such that when a vehicle on an intersecting driveway or roadway is stopped and waiting for traffic to clear on the through road, their position blocks the sidewalk. This requires difficult and often dangerous maneuvering to ride around the stopped vehicle. As a result of all of the above factors, bicyclists who are using their bike for utilitarian purposes infrequently use sidewalks because they essentially have to yield to all other users in the road corridor. Although separate facilities are appropriate in most cases, shared facilities will continue to be a preferred facility by some bicyclists in some cases.

Fig. 9.2A. Bicycle Lane Visibility Vs. Sidewalk Visibility

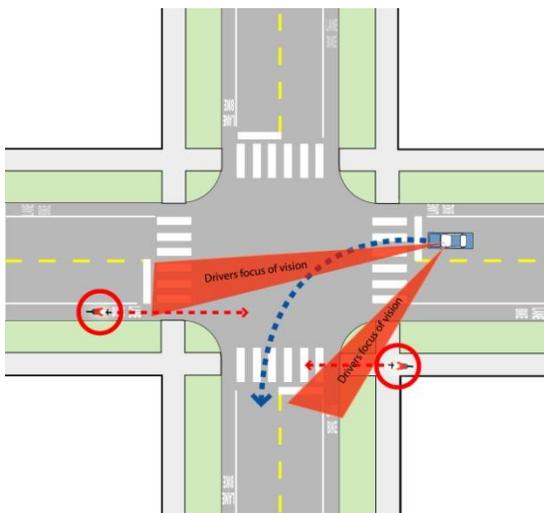
Bicycles traveling in the opposite direction of traffic on sidewalks have significantly greater chance of being hit by a vehicle because they are outside of the driver’s typical field of view.



Car turning right

Bicyclist in Bike Lane is in the driver’s focus of vision as they scan oncoming traffic and is easily seen.

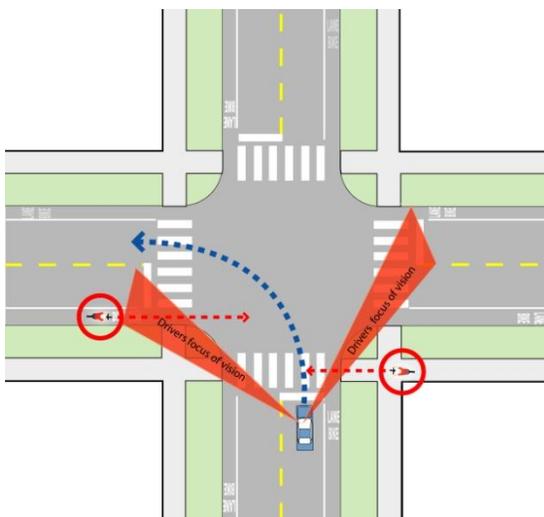
Bicyclist on Sidewalk Bikeway/Sidewalk is not in the driver’s focus of vision and can’t easily be seen until just before impact.



Car turning left

Bicyclist in Bike Lane is in the driver’s focus of vision as he/she scans oncoming traffic and is easily seen.

Bicyclist on Sidewalk Bikeway/Sidewalk is not in the driver’s focus of vision and can’t easily be seen until they are in crosswalk.



Car turning left

Bicyclist in Bike Lane is in the driver’s focus of vision and is easily seen.

Bicyclist on Sidewalk Bikeway/Sidewalk is not in the driver’s focus until just before impact.

Graphics based on those prepared by Richard Moeur, P.E. for his Good Bicycle Facility Design Presentation available at <http://www.richardcmoeur.com/docs/bikepres.pdf>

Pedestrian Conflicts

As the number of bicyclists and pedestrians increase on a shared facility, the number of conflicts increase and pedestrians' comfort decreases. Pedestrians typically travel 2 to 4 miles per hour and bicyclists travel between 8 and 20 miles per hour. The speed difference is significant and the stealthy nature of a bicycle means that pedestrians generally have little to no audible warning of a bicycle approaching from behind. Pedestrians and bicyclists can both be severely injured in bicycle / pedestrian crashes.

Nationally Accepted Guidelines

The American Association of State Highway and Transportation Officials (AASHTO) publishes *A Policy on Geometric Design of Highways and Streets* that is also known as "The Green Book." This set of guidelines is the primary reference for street design used by federal, state, county and local transportation agencies. For guidance on how to accommodate bicycles, The Green Book references AASHTO's *Guide for the Development of Bicycles Facilities*. Federal and most state sources of funding require that bicycle projects conform to these guidelines. AASHTO's guidelines specifically discuss the undesirability of Sidewalks as Shared Use Paths. Sidewalk Bikeways are considered unsatisfactory for the all of the reasons listed above. Only under certain limited circumstances do the AASHTO guidelines call for Sidewalk Bikeways to be considered. On page 20 of the guidelines these circumstances are spelled out as:

- a) *To provide bikeway continuity along high speed or heavily traveled roadways having inadequate space for bicyclists, and uninterrupted by driveways and intersections for long distances.*
- b) *On long, narrow bridges. In such cases, ramps should be installed at the sidewalk approaches. If approach bikeways are two-way, sidewalk facilities also should be two-way.*

Bicycle Quality/Level of Service

In order to make recommendations on appropriate bike lane widths, the bicycle quality of service model that was developed by Sprinkle Consulting, Inc. was utilized. The model is based on data gathered from a wide cross section of users who evaluated numerous real world scenarios. A simplified version of this model has been incorporated in the 2010 Highway Capacity Manual's multi-model level of service evaluation. The following summarizes the key factors for bicyclists.

Key Factors (in order of statistical significance):

1. Presence of bicycle lane or paved shoulder
2. Proximity of bicyclists to motorized vehicles
3. Motorized vehicle volume
4. Motorized vehicle speed
5. Motorized vehicle type (percent truck/commercial traffic)
6. Pavement condition
7. The amount of on-street parking

Bicycle Spatial Requirements

Bicycle spatial requirements vary greatly given the variety of bicycle styles out there. Tricycles, tandems, recumbent all have different special requirement. For a typical two wheel bicycle, a stationary bicyclist is only about 2' wide. But when in motion, the bicyclist requires 5' of width to operate. The extra space is required for essential maneuvering and to provide a comfortable lateral clearance. Thus, a path that is capable of having two bicyclists comfortably pass each other needs to be 10' wide.

Additional Considerations

Children Riding on Sidewalks – Young children will most likely continue to ride bicycles on sidewalks even if on-road facilities are provided. The risks previously mentioned still hold true, but factors such as unfamiliarity with traffic and the limited depth perception typical of young children should also be considered when choosing the most appropriate facility to use. Also, young children, in general, may be riding at lower speeds than adults.

Adults Riding on Sidewalks – Even with the presence of on-road bicycle facilities, many adults will not feel comfortable riding in the roadway in some or all situations. It should be recognized that the choice to ride in the road or on a sidewalk will vary with each individual's skills, weather and roadway conditions.

Transition Points – One of the difficulties in creating a system where bicycle travel is accommodated within a patchwork of on- and off-road facilities is the transition from one facility to the other. The point where the bicyclist leaves the sidewalk to join the roadway is especially difficult at intersections.

Redundancy of Facilities – Bicyclists are not restricted from riding in most roadways, nor is it likely that bicyclists will ever be required to ride on a Sidewalk Bikeway given their known safety issues. Therefore, the presence of bicycles in the roadway should be anticipated. Any off-road facilities that are constructed should be viewed as supplemental to accommodations within the roadway.

Driver and Bicyclist Behavior – There is ample room for improvement to the behavior of bicyclists and motorists alike in the way they currently share (or don't share) the roadway. Community education programs coupled with enforcement programs are the best approach for addressing this issue.

Passing on the Right – In a shared roadway scenario, it is dangerous for a bicyclist to pass a line of cars on the right. Bike lanes have the important advantage of allowing bicyclists to safely pass a line of cars waiting at an intersection. Much like the rewards for carpoolers traveling in a high occupancy vehicle lane, a bike lane gives bicyclists preference in moving through congested areas. Bikes can move to the front of an intersection more easily, allowing for better visibility and safer integration among motor vehicles, as well faster travel.

9.3 Travel Along Road Corridors

Our roadway network has been designed primarily to move cars safely, efficiently, and with minimal disruption. This network includes major arterial streets that place cars in multiple lanes moving at high speeds for long distances. These major transportation corridors usually present tremendous challenges when we try to retrofit them with non-motorized facilities. There are two primary types of non-motorized movements related to road corridors:

- Travel Along the Road Corridor (Axial Movements) that utilizes sidewalks, shoulders, and bikeways.
- Travel Across the Road Corridor (Cross-corridor Movements) that utilizes intersections, crosswalks, and grade-separated crossings such as bridge overpasses or tunnel underpasses.

Pedestrian travel along road corridors is accommodated by sidewalks or shared-use paths.

Bicycle travel along road corridors is accommodated by Bike Lanes, shared roadways, and shared-use paths. Restricting bicycles to a path along a roadway—while potentially a legal option—is fraught with safety concerns. This diminishes the attractiveness of using a bicycle for transportation.

Multi-Modal Corridor Width Requirements

While primary roads are classified as Principal Arterials, Minor Arterials, and Collectors, there is not always in practice a direct relationship between a road's classification and the number of lanes or lane width. Factors such as the available right-of-way, existing infrastructure and context have a significant influence in a road's design.

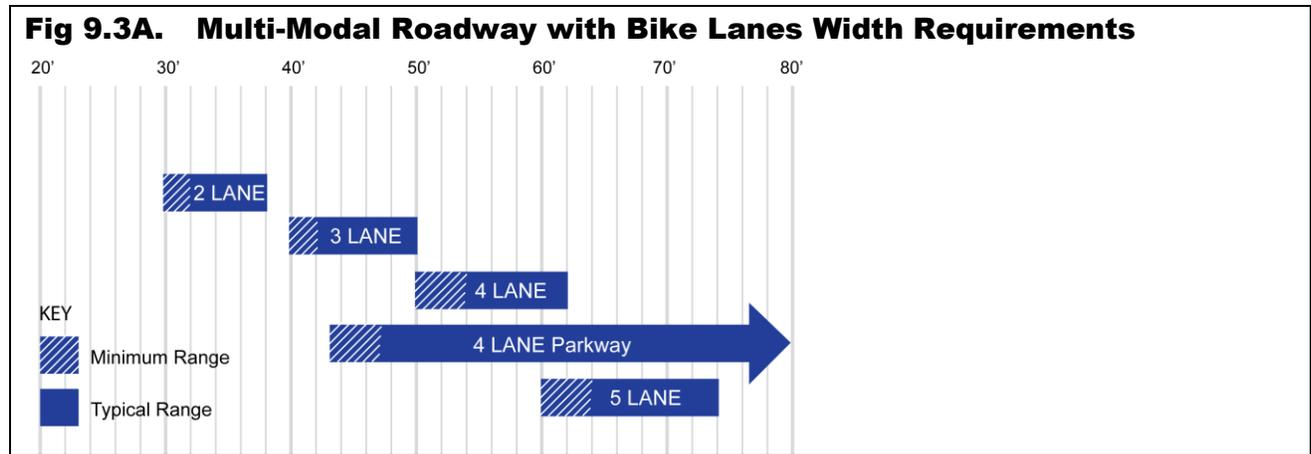
Multi-Modal Roadway Widths

There are various configurations of overall road widths depending on individual lane widths. For instance, a road may have anywhere from ten to twelve foot travel lanes and five to eight foot Bike Lanes. Variation in any or all of these widths has an impact on overall road width.

Also affecting roadway widths are:

- Parking – adds approximately seven feet to each side of the road and increases roadway width requirements.
- Speed – wider motor vehicle lanes generally increase speed of motor vehicles. With high speed roads, wider Bike Lanes are desirable to increase the lateral separation between motor vehicles and bicycles.

Fig 5.3A, Multi-Modal Roadway Width Requirements, illustrates the range of widths for typical multi-modal road types. The Minimum Range is based on AASHTO minimum guidelines. The Typical Range begins based on generally preferred minimums. The upper range is based on the maximum dimensions that would typically be encountered for motor vehicle and Bike Lanes.



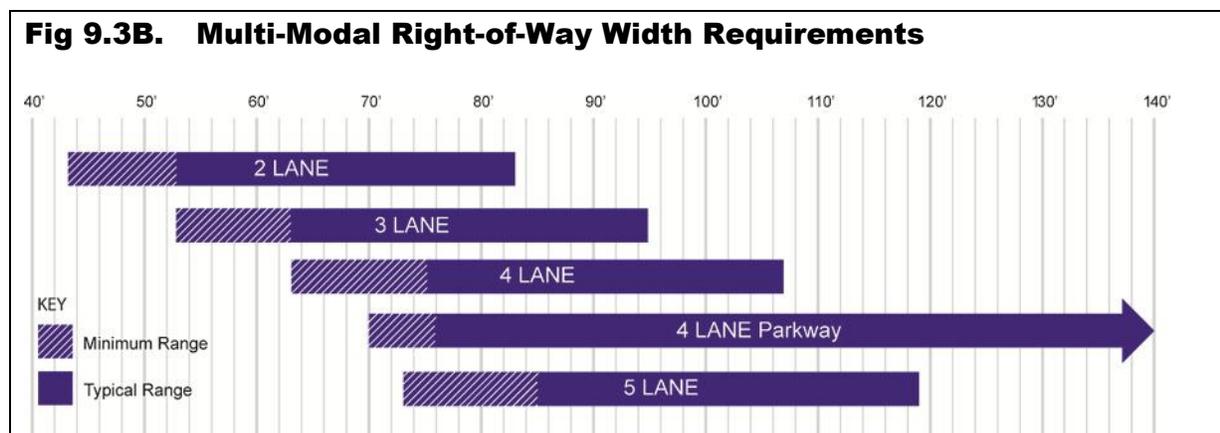
Multi-modal ROW Widths

In addition to the road, the ROW contains sidewalks/path, the buffer area between the sidewalk and the road and space for a median if any. There is tremendous variation within some variables such as the buffer and the median distance.

Fig 9.3B, Multi-Modal ROW Width Requirements, illustrates the range of widths for typical multi-modal ROWs. If ROW is greater than any of the given scenarios, then all those that fall within that width are feasible. For instance, a ROW of 66' is capable of accommodating a two or three lane road. The two lane road would simply have more opportunities for flexibility than the three lanes. Note that it is not always preferable to go to the maximum allowable ROW width. Bigger is not necessarily better. The best width will depend on contextual circumstances in a given a situation. Special circumstances, however, may make it necessary to make maximum use of the ROW.

Other issues that have a bearing on ROW widths include:

- Parking – parallel on-street parking adds approximately seven feet to each side of the road and increases ROW requirements, though in some circumstances the space would be deducted from the buffer.
- Speed – as noted under Multi-Modal Roadway Widths, higher speeds generally increase the need for a wider road. Higher speeds also make a wider buffer more desirable.



9.4 Developing Complete Street Cross Sections

Integrating bicycle and pedestrian facilities into existing roadways takes into account the road's context, the type of road, the desired motor vehicle speeds, the anticipated amount of motor vehicle traffic and the available ROW. Roadways that are designated as having a focus on bicycle and pedestrian traffic should be designed such that motorists naturally travel the roadway at the desired speed range of 30 to 35 MPH. This may be accomplished by the combination of narrow motor vehicle travel lanes, street trees close to the edge of the roadway and introducing elements into the roadway such as medians and crossing islands that interrupt long straight stretches of roadway.

The following is an overview of the key design of each segment of roadway. More information regarding road corridor cross sections may be found in the Appendix.

Sidewalk Guidelines

- Sidewalks should be a minimum of 5' wide as per AASHTO guidelines. 4' wide sidewalks may be used if a 5' wide passing spaces for wheelchair users are provided at reasonable intervals but this is not recommended.
- If sidewalk is placed at the back of a curb (curb-attached sidewalk) then the sidewalk should be a minimum of 6' wide, providing at least a 5' clear path taking into consideration signs and utility poles.
- It is recommended that all sidewalks along all Arterial and Collector roadways be at least 6' wide. In certain circumstances, such as completing a gap between two existing 5' sidewalks and where valuable trees and easements restrict the space, a 5' sidewalk may be used.
- It is recommended that at least one sidewalk along all Arterials and Collectors be at least 8' wide and that the location of the wider sidewalk/road side pathway be consistent from segment to segment.
- It is recommended that when a sidewalk/road side pathway is used as a link in a regional trail system, that it conform to AASHTO guidelines for Shared-Use Paths having a minimum width of 10' with 2' shoulders.

Buffer Width

- Buffers should be a minimum of 2' on Collectors and 5' on Arterials as per AASHTO Guidelines.
- A 5' wide buffer is generally considered the minimum to accommodate street tree plantings.
- A 6' wide buffer is considered the desirable minimum with along Collector roadways.
- A 9' wide buffer is considered the desirable minimum along Arterial roadways.

Buffer Plantings/Street Trees

- Tree spacing should be approximately 30' on center.
- Trees should be placed a minimum 5' back from the face of curb on Arterials and a minimum of 2' back from the face of curb on Collectors. The trees should also be placed a minimum of 2' back from the edge of sidewalk.
- Tree spacing/alignment should be varied as necessary to permit good visibility at crosswalks and intersections.

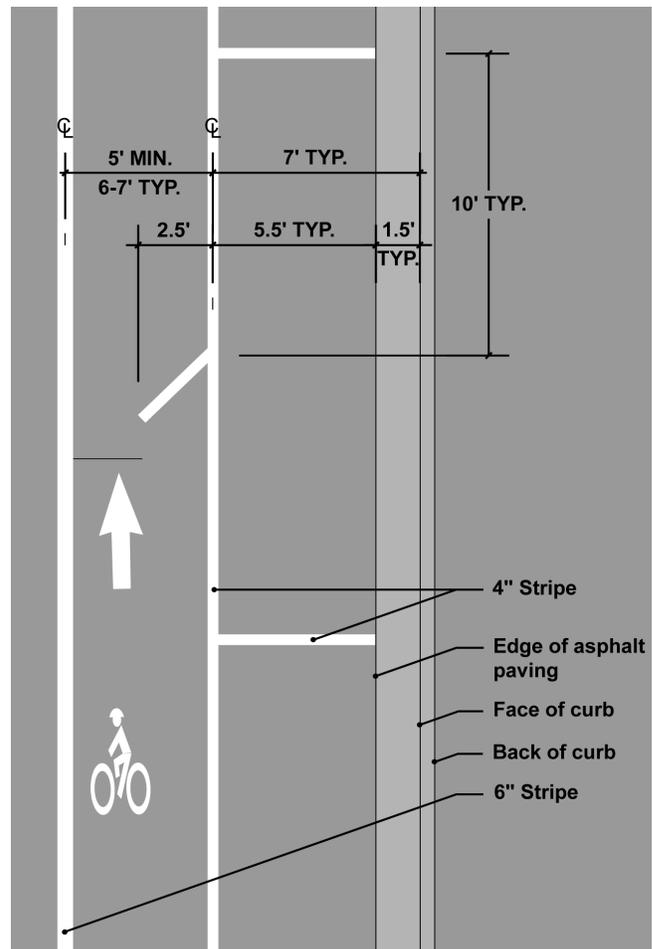
Bike Lane:

- Generally roads with ADT’s below 3,500 vehicle per day do not require bike lanes as the traffic flow is such that motorists can generally pass bicyclists without waiting for oncoming traffic to clear.
- 5’ minimum as measured from face of curb to edge line with a minimum of 3’ rideable surface outside of the gutter plan.
- If the seam between the gutter pan and the road surface is not smooth than a minimum of 4’ of rideable surface should be provided.
- 4’ minimum as measured from the edge of pavement to the edge line when no curb is present.
- Bike Lanes may be located on either side of a one-way road. For consistency sake, the right hand side should be the default choice. If, however there are numerous bus stops with frequent bus service the left and side of the road may be preferable. If there is on-street parking on one side of the road, the bicycle lane should generally be located on the opposite side of the road than the on-street parking.



On-Street Parking:

- When adding parking the parking lane should be set at 7’ measured from face of curb and the bike lane width should be a minimum of 5’ wide.
- Additional width for bike lanes is desirable due to opening doors of parked cars infringing on the bike lane width.
- A 4” stripe should mark the edge of the parking lane to encourage parking as close to the curb as possible.
- The parking lane should always remain at 7’. Any additional room should be allocated toward the Bike Lane first, then to the travel lane adjacent to the bike lane.
- Bike Lanes wider than 5’ may have the “door zone” cross-hatched to encourage bicyclists to ride a safe distance away from the parked cars. The bicycle symbol and arrow should be placed to the outside of the bicycle lane to encourage safe bicycle lane position. Please note that cross hatching in the “door zone” is NOT a standard marking included in the MUTCD. To utilize this marking a request need to be made to the FHWA asking for permission to conduct an experiment with this marking.



Shared Lane Markings:

- Used on primary roads with speeds 35 MPH or lower generally where the right-of-way is too narrow for designated bike lanes.
- Pavement markings direct bicyclists to move with traffic and outside of the reach of opening car doors.
- Markings indicate to motor vehicles to expect bicycles in the roadway.
- If used on a street with parallel on-street parking, shared lane markings should be placed so that the centers of the markings are at least 11 feet from the face of the curb, or from the edge of the pavement where there is no curb



Sub-standard Bicycle Lanes and Edge Striping

There will be places where it will be impossible to reconfigure a roadway to accommodate even the minimum width of bicycle lane as described in AASHTO. In such cases it may be desirable to place a bike lane of a slightly narrower width in order to provide continuity of on-road facilities. At an absolute minimum, a bicycle lane next to a standard curb and gutter should have 3' of rideable surface (measured to the centerline of the lane stripe). In a case where that is not possible, a standard 4" edge stripe may be considered without the standard bicycle lane markings and signs.



Paved Shoulder

Paved shoulders are generally added to arterial and collector roadways in rural areas as a designated space in the roadway to accommodate bicycle and pedestrians. In order to be usable for bicyclists they need to be a minimum of 4' wide as measured from the edge of pavement to the edge of line when no curb is present. Generally, paved shoulders do not have bike lanes signs and/or pavement markings except at intersections where a designated right turn lane is present, than a paved shoulder should be transitioned to a standard bike lane pavement marking to avoid conflicts with right turning vehicles. A paved shoulder may be signed as a bike route or with a Share the Road Sign.



Motor Vehicle Lane Width

A 2007 Transportation Research Report, *Relationship of Lane Width to Safety for Urban and Suburban Arterials*, which included evaluation of roads in Oakland County, found that there is no discernable safety difference between roads that have lane widths of 10 and 11' when compared to a comparable road with a 12' lane width. This was especially the case for two and three lane roads. The Oakland County data indicated that there may be concerns when going below 11' lanes on 5 lane roads.

Sidewalk/Roadside Pathway Marking and Signing

In instances where existing sightlines and visibility are limited use an advanced warning sign to notify walker and bicyclist of an approaching subdivision entrance or busy drive. Only use a stop sign at the drive on extreme cases where warranted.

Fig 9.4A Urban Multi-Modal Roadway Design Guidelines

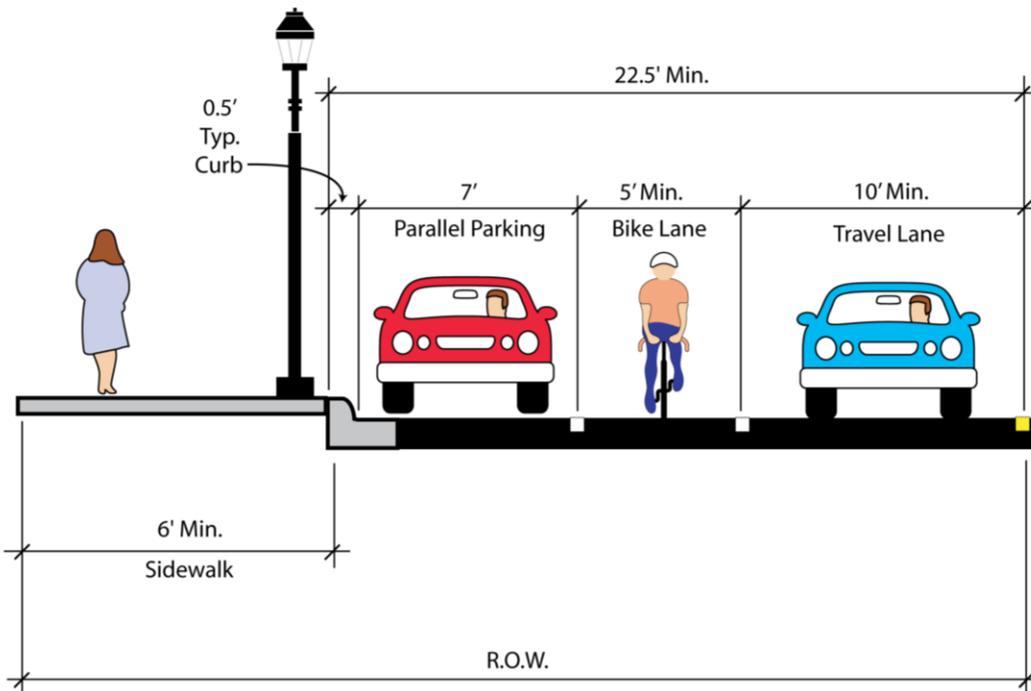
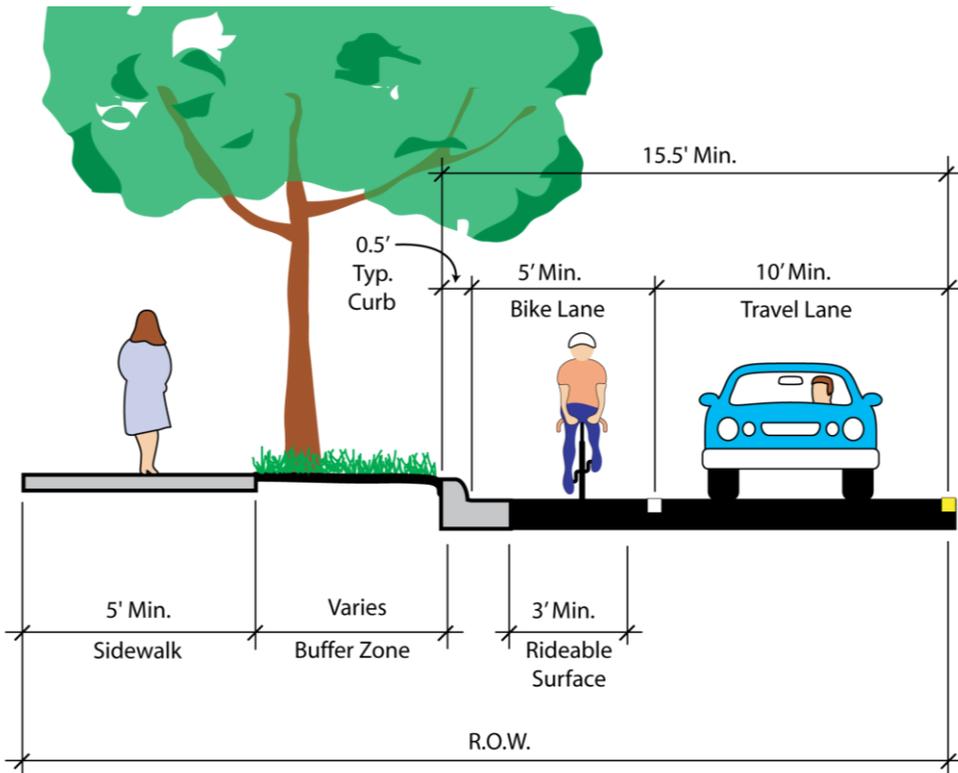


Fig 9.4B Urban Bike Lane Sizing Chart

The following chart indicates the minimum bike lane width necessary to maintain a bicycle quality/level of service of C or above.

12' Travel Lanes											
	Urban 2 Lane Road:					Urban 4 Lane Road:					
No. of Lanes	2	2	2	2	2	4	4	4	4	4	4
Design ADT	3,500	5,000	10,000	15,000	20,000	15,000	20,000	25,000	30,000	35,000	40,000
25 mph	5	5	5	5	5	5	5	5	5	5	5
30 mph	5	5	5	5.5	6	5	5	5.5	5.5	5.5	6
35 mph	5	5	5.5	6	6.5	5	5.5	5.5	6	6	6
40 mph	5	5	5.5	6	6.5	5.5	5.5	6	6	6.5	6.5
45 mph	5	5.5	6	6.5	6.5	5.5	6	6	6.5	6.5	6.5
50 mph	5	5.5	6	6.5	7	6	6.5	6.5	6.5	6.5	7
55 mph	5	5.5	6	6.5	7	6	6.5	7	7	7	7

11' Travel Lanes											
	Urban 2 Lane Road:					Urban 4 Lane Road:					
No. of Lanes	2	2	2	2	2	4	4	4	4	4	4
Design ADT	3,500	5,000	10,000	15,000	20,000	15,000	20,000	25,000	30,000	35,000	40,000
25 mph	5	5	5	5.5	5.5	5	5	5	5.5	5.5	5.5
30 mph	5	5	5.5	6	6.5	5	5.5	6	6	6	6.5
35 mph	5	5	6	6.5	6.5	5.5	6	6	6.5	6.5	6.5
40 mph	5	5	6	6.5	7	6	6	6.5	6.5	7	7
45 mph	5	5.5	6.5	7	7	6	6.5	6.5	7	7	7
50 mph	5	5.5	6.5	7	7.5	6	6.5	7	7	7	7.5
55 mph	5	6	6.5	7	7.5	6.5	6.5	7	7	7.5	7.5

10' Travel Lanes											
	Urban 2 Lane Road:					Urban 4 Lane Road:					
No. of Lanes	2	2	2	2	2	4	4	4	4	4	4
Design ADT	3,500	5,000	10,000	15,000	20,000	15,000	20,000	25,000	30,000	35,000	40,000
25 mph	5	5	5	6	6	5	5	5.5	6	6	6
30 mph	5	5	6	6.5	7	5.5	6	6.5	6.5	6.5	7
35 mph	5	5.5	6.5	7	7	6.5	6.5	6.5	7	7	7
40 mph	5	5.5	6.5	7	7.5	6.5	6.5	7	7	7.5	7.5
45 mph	5	6	7	7.5	7.5	6.5	7	7	7.5	7.5	7.5
50 mph	5	6	7	7.5	8	6.5	7	7.5	7.5	7.5	8
55 mph	5	6.5	7	7.5	8	7	7	7.5	7.5	8	8

Notes

1. Size is based on an 18” wide gutter pan. If the gutter is only 1’ wide or there is no gutter the width may be reduced by 0.5’.
2. Bike lane sizing is based on 3% truck traffic. For every 1% increase in heavy vehicles add approximately 8” to 9” of additional bike lane width.
3. In urban areas, where there is a demand for on-street parking and none exists, bike lanes 7’ and over may experience illegal parking.

Fig 9.4C Rural Multi-Modal Roadway Design Guidelines

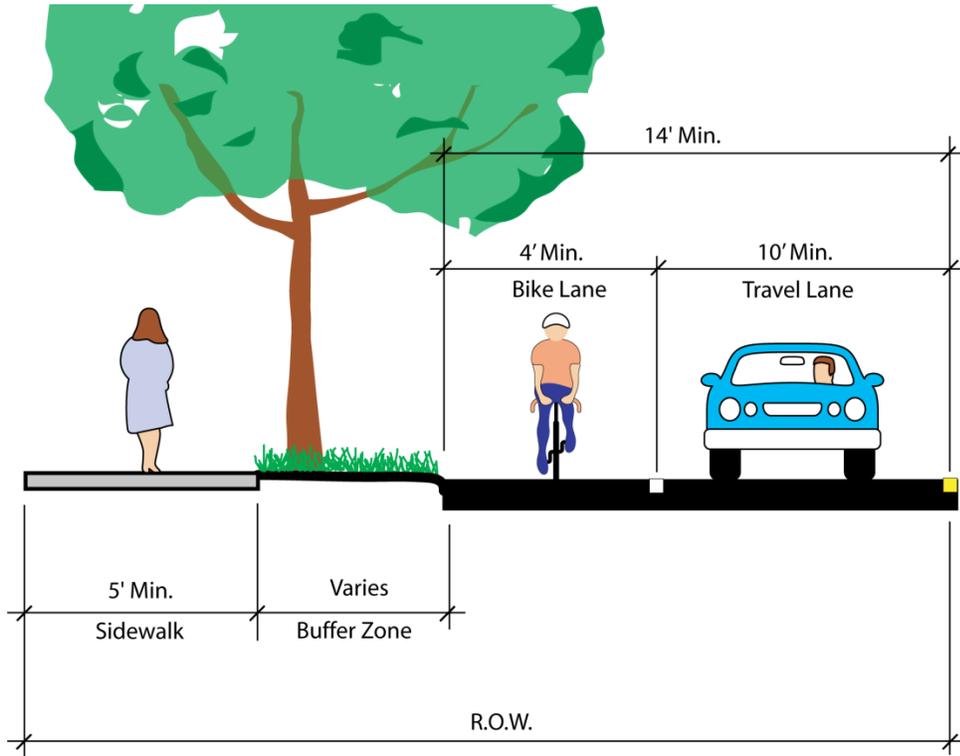


Fig 9.4D Rural Bike Lane Sizing Chart

The following chart indicated the minimum bike lane width necessary to maintain a bicycle quality/level of service of C or above.

12' Travel Lanes											
	Rural 2 Lane Road:					Rural 4 Lane Road:					
No. of Lanes	2	2	2	2	2	4	4	4	4	4	4
Design ADT	3,500	5,000	10,000	15,000	20,000	15,000	20,000	25,000	30,000	35,000	40,000
25 mph	4	4	4	4	4	4	4	4	4	4	4
30 mph	4	4	4	4	4.5	4	4	4	4	4	4.5
35 mph	4	4	4	4.5	5	4	4	4	4.5	4.5	4.5
40 mph	4	4	4	4.5	5	4	4	4.5	4.5	5	5
45 mph	4	4	4.5	5	5	4	4.5	4.5	5	5	5
50 mph	4	4	4.5	5	5.5	4.5	5	5	5	5	5.5
55 mph	4	4	4.5	5	5.5	4.5	5	5.5	5.5	5.5	5.5

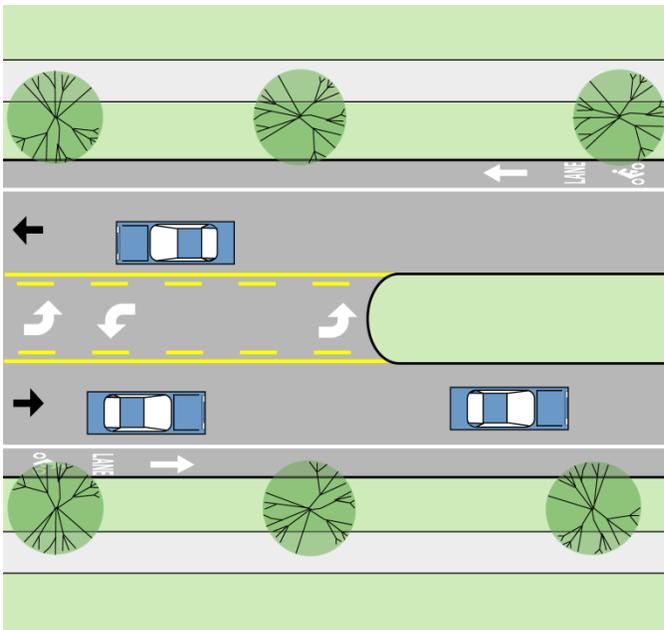
11' Travel Lanes											
	Rural 2 Lane Road:					Rural 4 Lane Road:					
No. of Lanes	2	2	2	2	2	4	4	4	4	4	4
Design ADT	3,500	5,000	10,000	15,000	20,000	15,000	20,000	25,000	30,000	35,000	40,000
25 mph	4	4	4	4	4	4	4	4	4	4	4
30 mph	4	4	4	4.5	5	4	4	4.5	4.5	4.5	5
35 mph	4	4	4.5	5	5	4	4.5	4.5	5	5	5
40 mph	4	4	4.5	5	5.5	4.5	4.5	5	5	5.5	5.5
45 mph	4	4	5	5.5	5.5	4.5	5	5	5.5	5.5	5.5
50 mph	4	4	5	5.5	6	4.5	5	5.5	5.5	5.5	6
55 mph	4	4.5	5	5.5	6	5	5	5.5	5.5	6	6

10' Travel Lanes											
	Rural 2 Lane Road:					Rural 4 Lane Road:					
No. of Lanes	2	2	2	2	2	4	4	4	4	4	4
Design ADT	3,500	5,000	10,000	15,000	20,000	15,000	20,000	25,000	30,000	35,000	40,000
25 mph	4	4	4	4.5	4.5	4	4	4	4.5	4.5	4.5
30 mph	4	4	4.5	5	5.5	4	4.5	5	5	5	5.5
35 mph	4	4	5	5.5	5.5	5	5	5	5.5	5.5	5.5
40 mph	4	4	5	5.5	6	5	5	5.5	5.5	6	6
45 mph	4	4.5	5.5	6	6	5	5.5	5.5	6	6	6
50 mph	4	4.5	5.5	6	6.5	5	5.5	6	6	6	6.5
55 mph	4	5	5.5	6	6.5	5	5.5	6	6	6.5	6.5

Notes

1. The reduction in width in comparison to the Urban Bike Lane Sizing Chart is due to the lack of curb.

Fig 9.4E Use of Medians



A planted median should be considered whenever a turn lane is not needed. The planted median improves the aesthetics of the roadway, reduces the impervious surfaces and can act as an informal crossing island for dispersed mid-block crossings. Medians have also been shown to be less expensive to construct and maintain than paving in the long run. The median may also be constructed in a manner that will mitigate storm water run-off.

9.5 Transitions Between On and Off-Road Bicycle Facilities

The recommended approach to accommodating bicycles along arterials and collectors is with a bicycle lane. However, there will be places, especially in the near-term, where that may not be possible. This presents a situation where some bicyclists will prefer to continue bicycling in the roadway and others will prefer to leave the roadway and use a sidewalk bikeway. Given the significant variances in bicyclist's abilities, trip purposes, and cycling speeds, forcing all cyclists into a single solution is inappropriate. The solution then is to accommodate both preferences.

The transition points between sidewalk bikeways and bike lanes, presents a number of challenges. This underscores the importance of making the non-motorized system as consistent as possible. When bringing bicyclists into the roadway as shown in Fig 9.5A (next page), the entrance point needs to be protected. Unlike merging points between motor vehicles, the speed differential between bicyclists and motor vehicles may be significant with the potential for hit-from-behind crashes if the merging area is not protected.

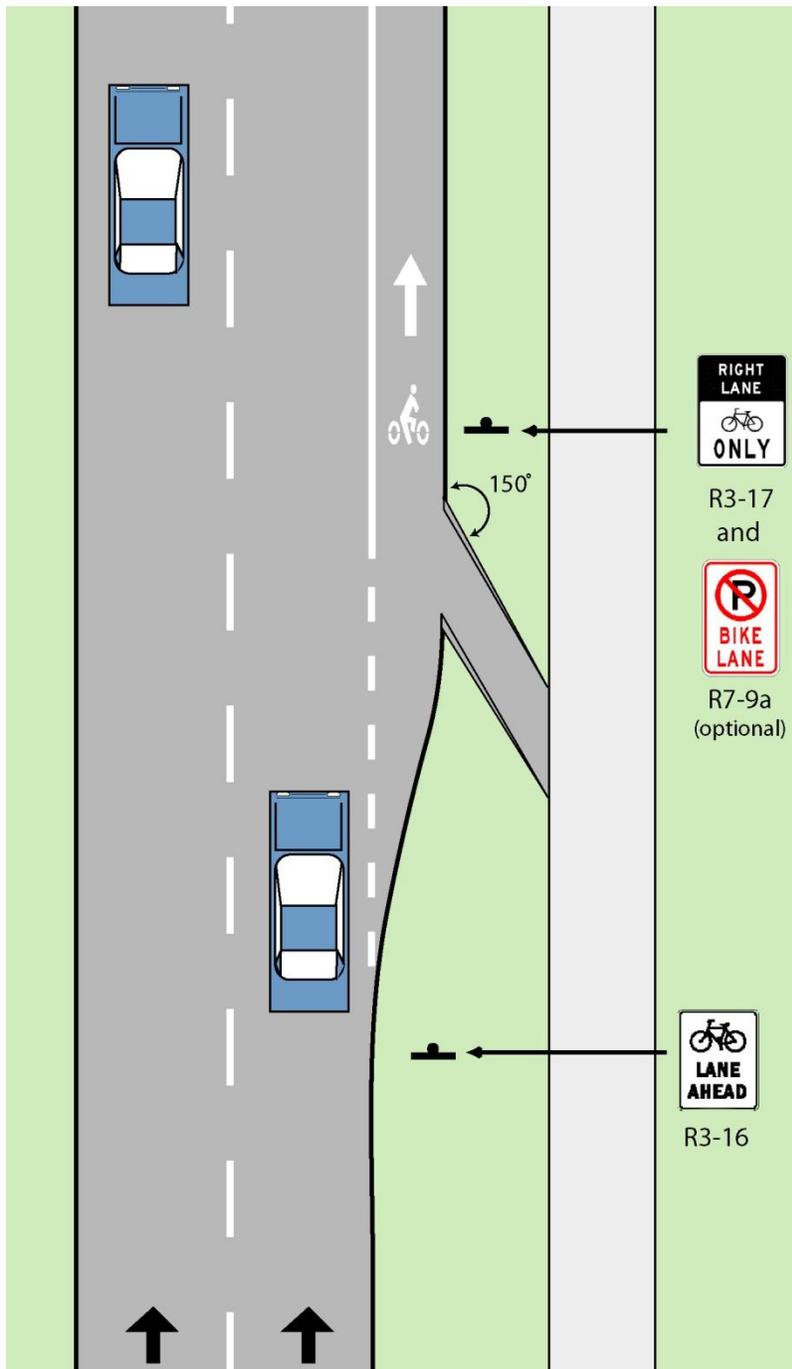
When bringing bicycles onto a pathway, there is the potential for conflicts with pedestrians and bicyclists already on the pathway. Trying to segregate bicycles and pedestrians on a single 8 – 10 feet wide path is not feasible. Each direction for bicycle use requires 4 feet. Some busy shared-use paths have a dashed yellow line down the center to separate path users by direction of travel. While these tend to work to a degree in busier off-road pathways they are rarely used in sidewalk bikeway situations.

The solution does not differentiate between the sidewalk bikeways that are adjacent to a bike lane from a typical sidewalk. A sign along the pathway can instruct bicyclists to yield to pedestrians per City code. The approach is based on the assumption that the fastest bicyclists will remain in the roadway and share the lane with the motor vehicles rather than leave the roadway and have their travel impeded by pedestrians and driveway crossings.



A ramp that eases the transition from a Bike Lane to a Shared-use Path is provided where the Bike Lane ends.

Fig. 9.5A. Bicycle Entrance Ramp from Sidewalk Bikeway to Bike Lane Design Guideline



Applications

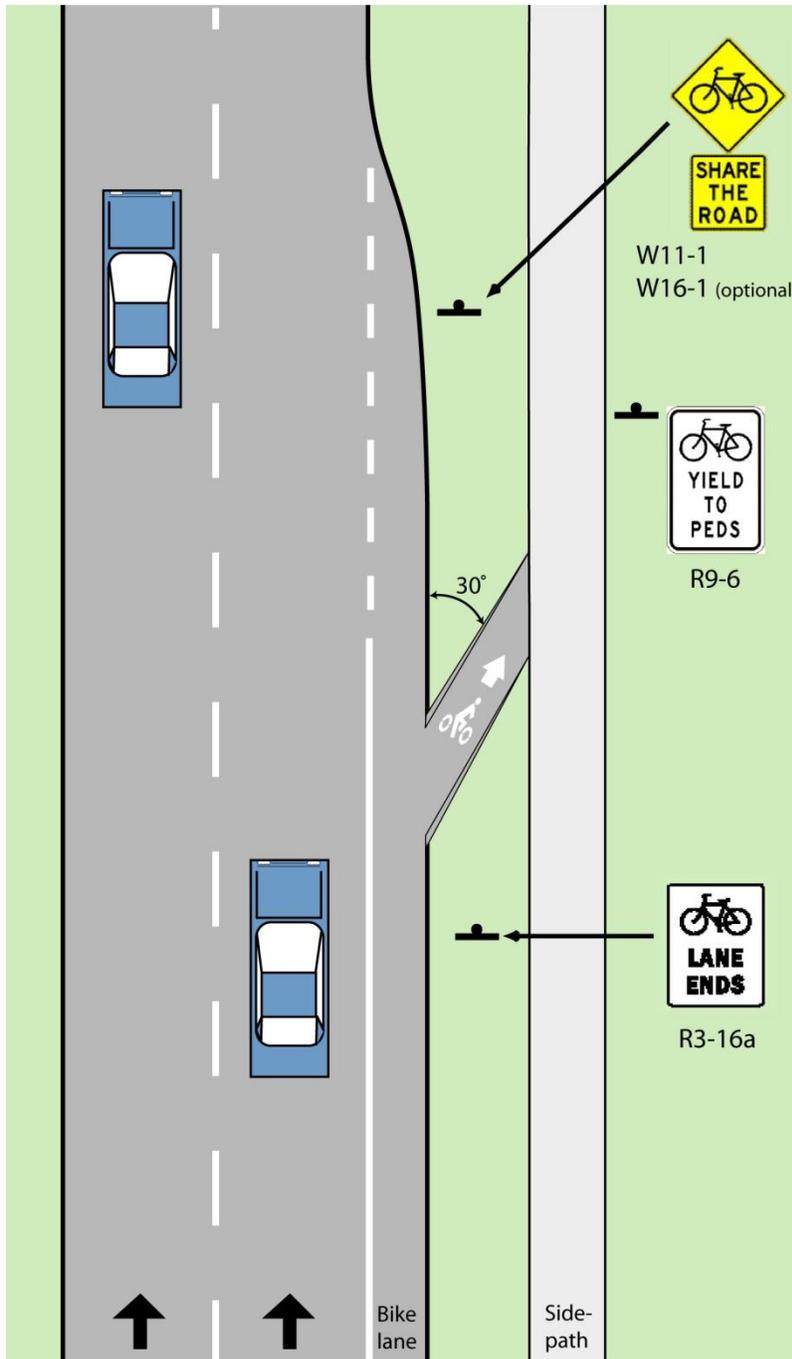
The bike entrance ramp is used to provide easy transition from a sidewalk bikeway to a bike lane or to allow a bicyclist to enter the roadway to make a turn as a vehicle.

The ramp may be used where a bike lane begins or periodically along a sidewalk bikeway that parallels a bike lane.

Key Elements:

1. Bicyclists have an option to bike either in the bike lane or along the sidewalk bikeway.
2. The ramp should resemble a curb ramp with flared sides and a flush edge with the road grade.
3. The mouth of the ramp (not including the flared sides) should be 5’ wide or sized to fit maintenance vehicles designed for sweeping and snow removal.
4. When used at the beginning of a bike lane, the road should be widened to accommodate the bike lane and protect bikers entering the roadway from the sidewalk bikeway given the sharp angle of entry. As the road is flared, dashed pavement markings should be used to indicate the beginning of the bike lane and an area where bikers in the roadway can merge into the bike lane.

Fig. 9.5B. Bicycle Exit Ramp from Bike Lane to Sidewalk Bikeway Design Guideline



Applications

The bike exit ramp is used to provide easy transition from a bike lane to a sidewalk bikeway.

The ramp may be used where a bike lane ends or periodically along a sidewalk bikeway that parallels a bike lane.

Key Elements:

1. Bicyclists have the option of bicycling in the roadway or on a sidewalk bikeway.
2. The exit ramp should resemble a curb ramp with flared sides and a flush edge with the road grade.
3. The mouth of the ramp (not including the flared sides) should be 5’ wide or sized to fit maintenance vehicles designed for sweeping and snow removal.
4. Where a bike lane ends, dashed pavement markings indicate the end of the bike lane and an area where bikers are merging back into the roadway. Dashed lines should begin well in advance of the end of the bike lane to ensure adequate warning and a large transition zone.
5. A bike symbol and arrow on the ramp to discourage bicyclists on the sidewalk bikeway to enter the roadway going the wrong way.

9.6 Modifying Existing Facilities

The existing road infrastructure must be considered when looking at how bicycle lanes may be added. Waiting for a complete road reconstruction at which time the “ideal” scenario may be applied would result in unnecessary delay in implementing a bicycle lane system. Also, in many cases, existing development, historic structures and natural features dictate that the roadway width will change little if at all even in the long run. Hence, approaches to modifying facilities that work within existing curb lines and with existing storm sewer systems need to be employed.

In some cases, existing travel lanes may need to be narrowed to accommodate bicycle lanes. In other cases there may be excess road capacity that permits eliminating a lane in order to accommodate bicycle lanes. There may be cases where an alternative road configuration that includes bicycle lanes will work equally as well if not better than the existing conditions for motorists, such as a four to three lane conversion. In most cases though, incorporating bicycle lanes is a compromise between the ideal motorized transportation facility and the ideal bicycle facility in order to establish a true multi-modal facility within existing infrastructure limitations. The following guidelines illustrate various techniques for modifying existing facilities in order to incorporate bicycle lanes.

Adding Bike Lanes to High Speed Four and Five-Lane Roads

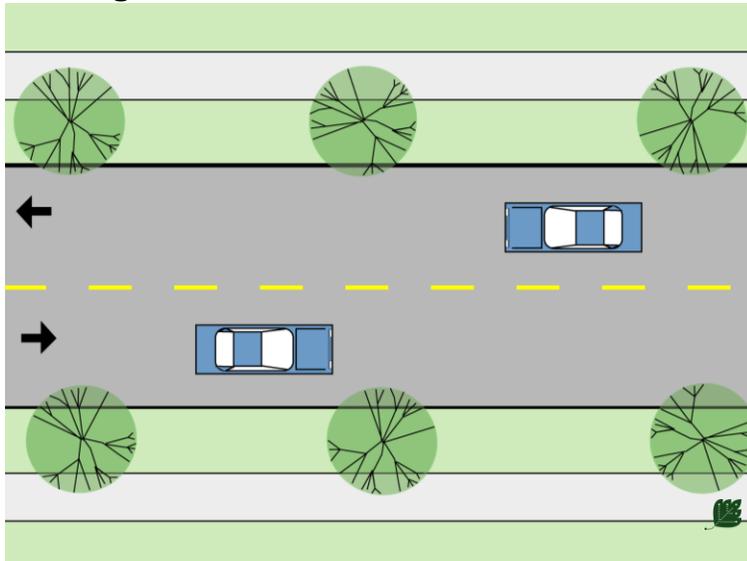
The narrowing of high speed four and five-lane roads to accommodate bike lanes has some specific conversion issues. Given the higher volumes of traffic, higher speeds and higher number of heavy vehicles on some of these roadways, it is desirable to keep the motor vehicle lane widths as close to an 11' minimum as possible or put in place measures to slow the traffic speeds.

As an interim measure for roads less than 60' wide, a bike lane on one side may be considered in conjunction with a shared lane/side path option on the other side. The bike lane should be located on the side with the most driveways and intersecting roads. The other option to consider if there are numerous intersecting roads and driveways on both sides to lower the speed of the roadway so that sub-11' lanes are more appropriate. This is best accomplished with changes to the physical roadway with such things as planted medians and/or crossing islands. These in combination with the narrow lanes will naturally slow traffic.

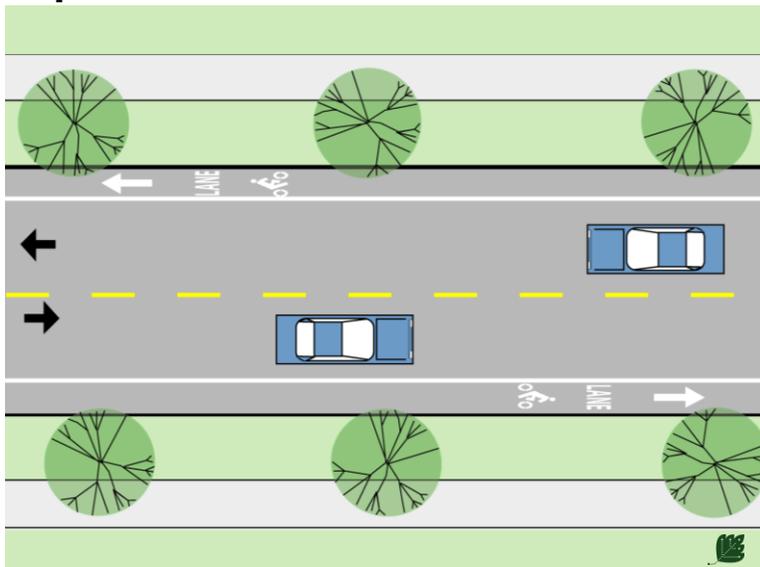
When there is not a bike lane in the road, the bicyclist should be provided the option to use a sidewalk or to bike in the road. Exit and entrance ramps should be used to ease the transition between on-road and off-road facilities.

Fig. 9.6A. Providing Bicycle Lanes Through Lane Narrowing Design Guidelines

Existing Conditions



Proposed Condition



Description

The travel lanes are narrowed allowing room for the inclusion of a bike lane. The bicycle lane has the additional advantage of providing a buffer between the travel lane and the curb.

AASHTO guidelines specifically discuss narrowing travel lanes in order to accommodate bicycle travel, although there are some situations where narrowing lanes may not be appropriate.

Application

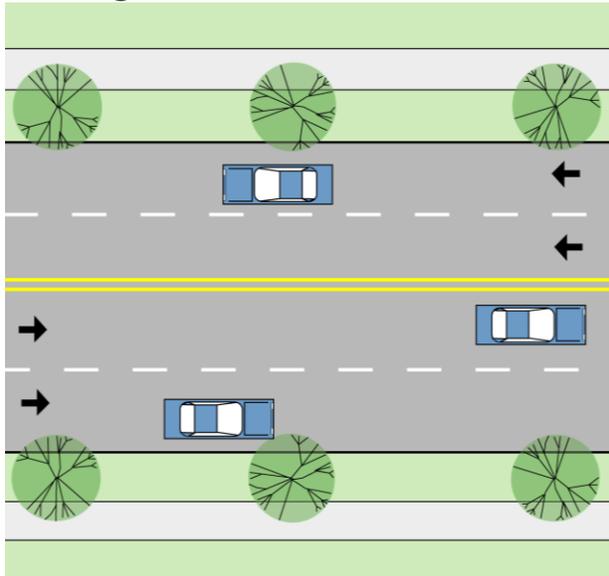
In general, lane narrowing to provide for bicycle lanes may be considered in the following situations (as measured from back of curb):

- 31' or wider, 2 lane road
- 41' or wider, 3 lane road (2 lane road with a center turn lane)
- 45' or wider, 2 lane road with parking on both sides
- 51' or wider, 4 lane road
- 55' or wider, 3 lane road with parking on both sides
- 61' or wider, 5 lane road

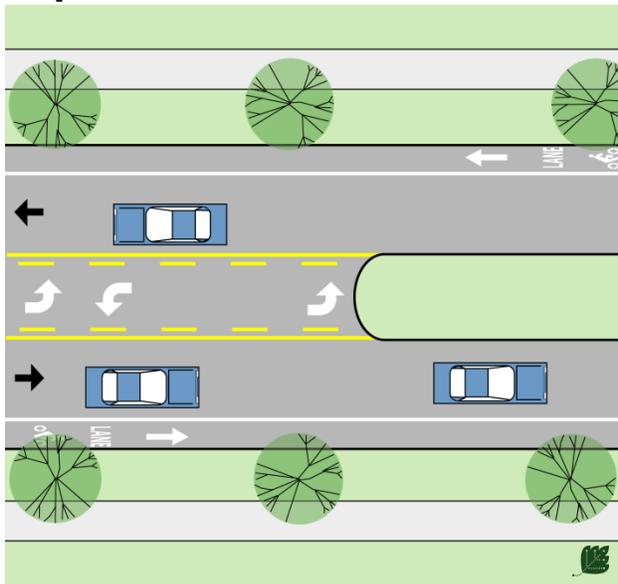
Higher speed roads may require additional width; see notes on multi-modal roadway design guidelines.

Fig. 9.6B. Four-Lane to Three-Lane Road Conversions Design Guidelines

Existing Conditions



Proposed Conditions



Description

Four-lane roads present several operational difficulties to motorists. Traffic is often weaving from lane to lane to avoid vehicles that are stopped in the left lane while waiting for a gap in oncoming traffic to make a left turn, or those slowing down in the right lane to make a right turn. The presence of a bicycle in the curb lane also adds to the weaving of traffic if there is not sufficient lane width to pass the bicycle while staying within the lane.

This constant weaving of traffic also makes judging when to enter the road from a driveway or side street difficult as lane positions are changing frequently. This is especially the case for left turns. To address the operational difficulties of 4-lane roadway, the roadway is reconfigured to two through lanes; a center shared left turn lane and/or median and two bike lanes.

Application

This type of conversion has been used on roadways with up to 24,000 vehicles per day (VPD). Modeling research has shown that there is no loss in Vehicular Level of Service until about 1,750 vehicles per hour (approximately 17,500 VPD) compared to a four-lane configuration. In addition to a significant improvement in the Bicycle Level of Service, these conversions have been also shown to provide a:

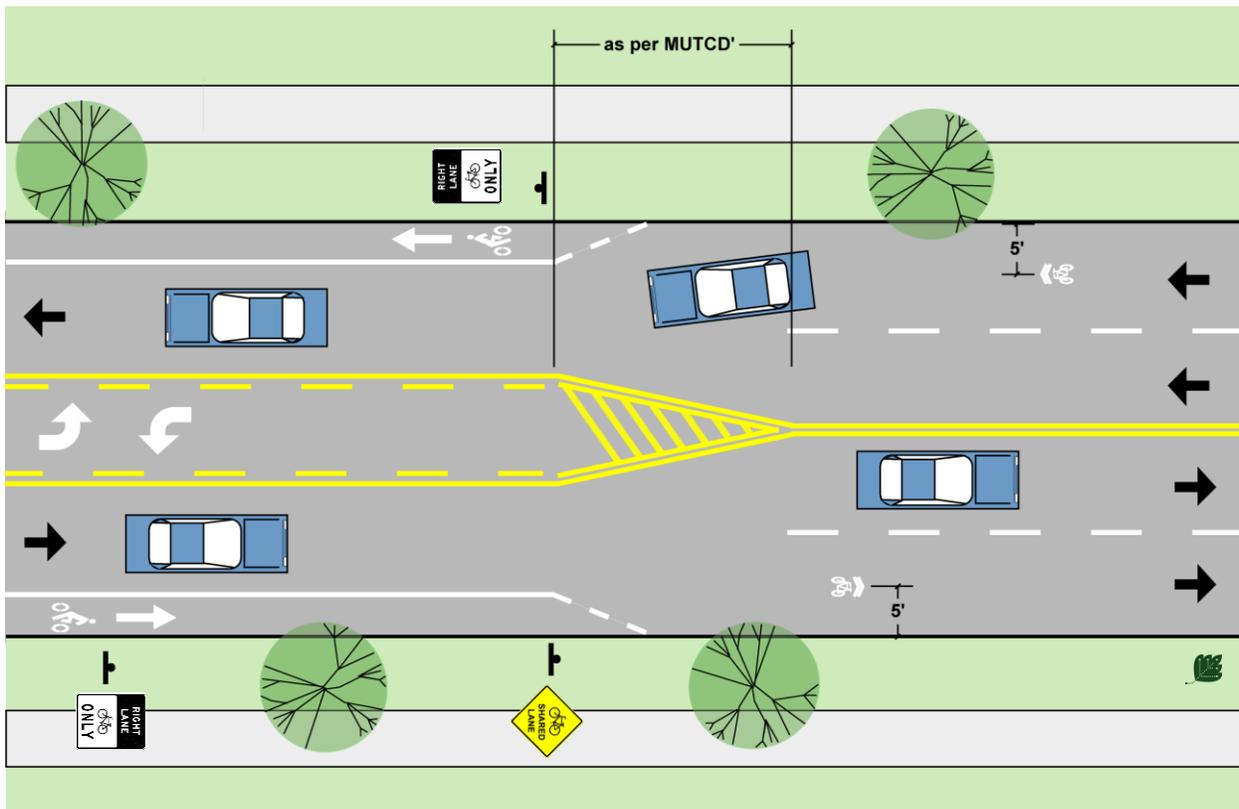
- Reduction of the 85% speed by about 5 MPH
- Dramatic reduction in excessive speeding (60-70%) of vehicles going greater than 5 MPH over the posted speed limit.
- Dramatic reduction in the total number of crashes (17-62%).

Application statistics are referenced from:

Guidelines for the Conversion of Urban Four-lane Undivided Roadways to Three-lane Two-way Left-turn Lane Facilities, April 2001, Sponsored by the Office of Traffic and Safety of the Iowa Department of Transportation, CTRE Management Project 99-54

Conversions though must be evaluated on a case-by-case basis as numerous factors influence the appropriateness of 4 to 3 lane conversion.

Fig. 9.6C. Near-term Opportunities – Transition From Three Lanes to Four Lanes at Signals



Description

Where two motor vehicle lanes are needed to accommodate motor vehicle stacking at signalized intersections the bicycle lane may be dropped and replaced with the Shared-Use Arrow.

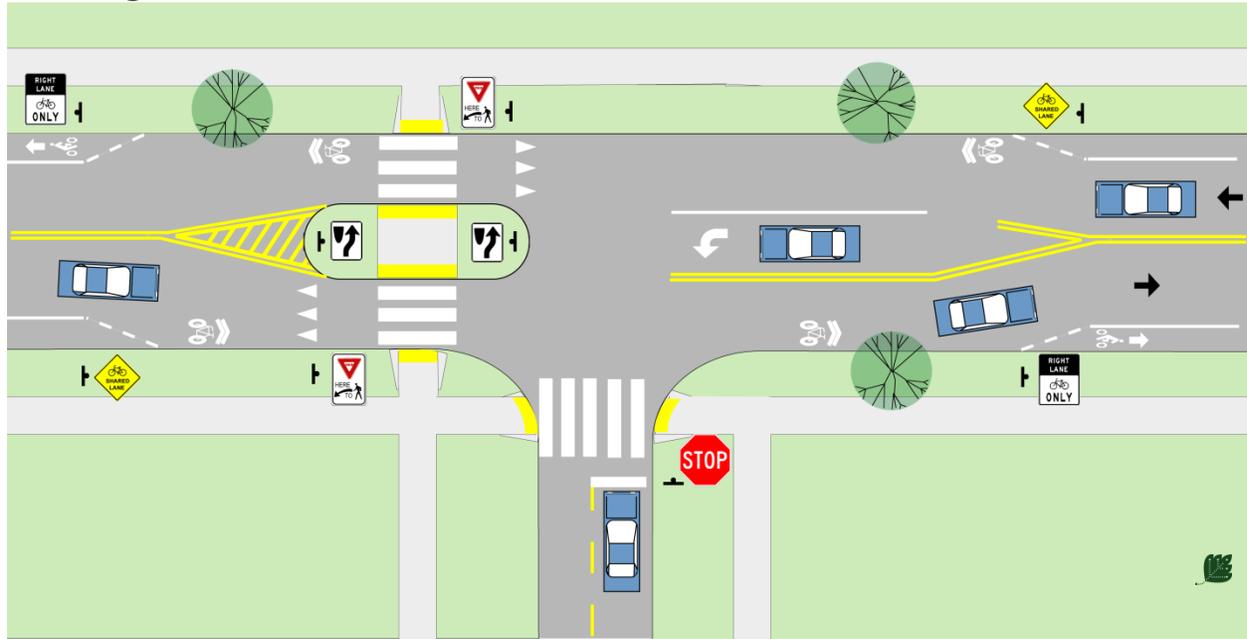
Application

This is an interim approach to accommodating vehicle stacking needs to be used where a bike lane is interrupted in the vicinity of a signal. The long-term solution would expand the intersection to accommodate bicycle lanes. The length of the four-lane segment should be minimized.

Three to Two-Lane Road Conversions

There are cases where a three-lane cross section is used consistently when the need for turn lanes is only intermittent. In these cases a bike lane may be added in places where the turn lane is not warranted. The bike lane then may be dropped when the turn lane is introduced.

Fig. 9.6D. Near-term Opportunities – Accommodation of Turn Lanes and Crossing islands



Description

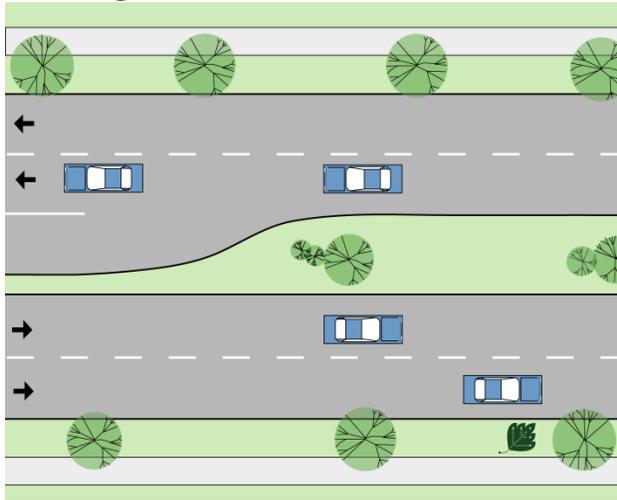
Where a designated left-turn lane is warranted and/or a pedestrian crossing island is appropriate, the bicycle lane may be dropped and replaced with the Shared-Use Arrow.

Application

This is an interim approach to accommodating the turn lane and the crossing island. The long-term solution would expand the intersection to accommodate bicycle lanes. The length of the left-turn lane should only be as long as it needs to be to accommodate the conditions of each specific site.

Fig. 9.6E. Four to Two-Lane Boulevard Conversions Design Guidelines

Existing Conditions



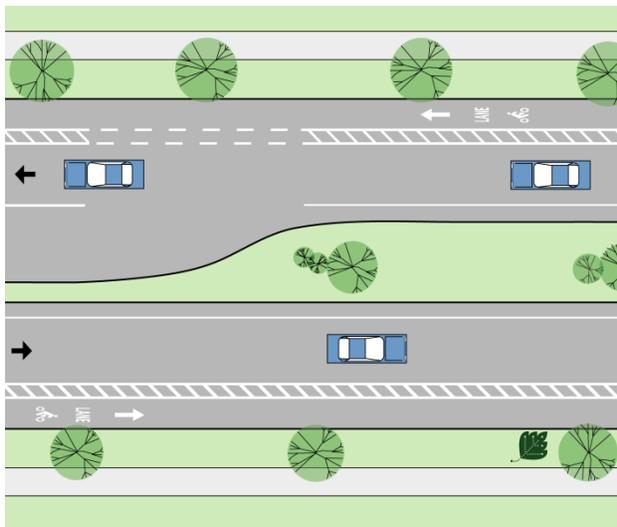
Description

The existing condition is a four-lane boulevard with designated turn lanes. These roads have tremendous traffic volume capacity. There are some situations where this road design exceeds the needs of the roadway.

In the proposed condition, two lanes of through traffic are eliminated and bicycle lanes are added. As bicycle lanes are considerably more narrow than travel lanes, a striped buffer is added between the vehicular travel lane and the bike lane and an edge line is placed a few feet from the inside curb. This allows emergency vehicles to pass.

This striped buffer is replaced with a dashed line where bicycle-merging movements are expected.

Proposed Conditions

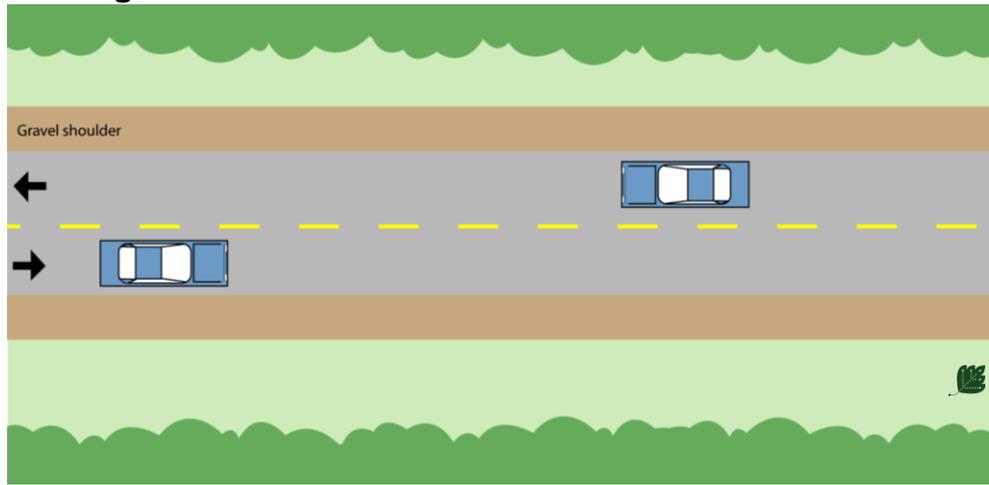


Application

Where the existing and expected traffic volumes do not warrant four lanes of traffic with extended designated turn lanes.

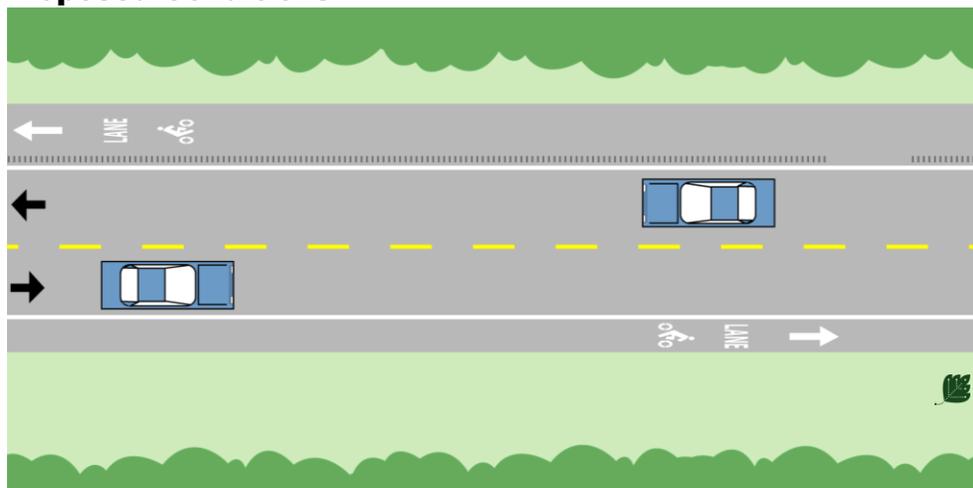
Fig. 9.6F. Paving Shoulders

Existing Conditions



A rural cross-section (no curbs) with gravel or grass shoulder. The existing roadway travel lanes are not of a sufficient width to accommodate bicycle lanes by lane narrowing.

Proposed Conditions



Description

Paving the shoulder provides a separate bicycle facility and improves roadway conditions from a motor vehicle and maintenance standpoint. The use of rumble strips is discouraged as they may cause a bicyclist to lose control when they leave the bicycle lane to make a turn or to avoid an obstacle. If extenuating circumstances call for the use of rumble strips, breaks should be provided where appropriate to allow for a bicycle to safely leave the bike lane.

Application

Paved shoulders should be provided on all rural cross section roadways within the City. Where appropriate, bicycle lane pavement markings may be applied.

9.7 Travel Across The Road Corridor

Despite the dangers or inconveniences that exist, at some point in a pedestrian's or bicyclist's journey they will be required to cross a road. Crossing roadways pose challenges to safe navigation for pedestrians and bicyclists on their journeys. Ways to get across a road (including railroads) include intersections, mid-block crosswalks, bridges and tunnels. All pose unique challenges to pedestrians and bicyclists.

Bicyclists and pedestrians in many cases, cross the road in very different fashions. Bicyclists in the roadway most likely will make left turns just like a vehicle, merging across lanes as necessary. Their restrictions to crossing the road are primarily based on their comfort level of riding with traffic and the volumes, speed and gaps that exist. Some bicyclists, depending on the traffic conditions, choose to make left turns as pedestrians. They leave the roadway and cross the road at a crosswalk.

For pedestrians and bicyclists who choose to cross the road as a pedestrian, crossing a road can be an intimidating experience. There are often limited safe and legal crossing options. Pedestrians are directed to cross roads at either intersections or at mid-block crosswalks. Each of those options has their own set of issues.

Intersection Issues

While generally, intersections are the safest place for pedestrians and bicyclists to cross the road, there are a number of issues to consider. Intersections are the most common places of conflict for automobiles, bikes and pedestrians. Even at a simple four way stop, there can be up to twelve different possible movements from the cars alone. Add in more lanes of traffic, and it can quickly get overwhelming. In 2009, 52% of non-motorized crashes in Southeast Michigan were intersection related¹. However, if designed correctly, intersections can facilitate convenient and safe interactions for all users.

Signalized intersections are the hubs of activity on the roadway. It is a place with conflicting demands from many different users. For the most part, a roadway's vehicular capacity is determined at signalized intersections. From a pedestrian's standpoint, they often face a sea of left turning vehicles, right turning vehicles, and through traffic from four directions. When crosswalk signals require activation by a push button, pedestrians often ignore them because of their inconvenience. Even when pedestrians push the button, in most cases there is no feedback to the pedestrian that they have indeed activated the signal. Often when the signal phases are long, they will assume that the button is broken and cross the road at an inappropriate time.

Vehicles turning right-on-red also pose dangers to pedestrians. The driver of a vehicle is focused on the traffic to the left, looking for a gap. Frequently drivers do not look right for pedestrians beginning to cross the street before beginning their turn. Another problem occurs in situations where the view of the oncoming traffic is obstructed if the vehicle is behind the stop bar. Often times the driver of the vehicle will advance over the crosswalk to improve their sightline. If they are unable to proceed they completely block the crosswalk with their vehicle. This is a common occurrence especially in the downtown area where right-on-red is permitted even when clear sight lines do not exist from behind the stop bar.

Vehicles turning left at busy intersections with few gaps in traffic can also be problematic to pedestrians. The driver of a left turning vehicle in such cases is often focused primarily on finding a suitable gap in oncoming traffic and may commit to turning left before noticing a pedestrian in the crosswalk.

¹ Michigan Traffic Crash Facts, 2009.

Unsignalized intersections are also key points where pedestrians and bicyclists want to cross the road corridor. When the crosswalks are left unmarked, pedestrian travel is often discouraged.

The aforementioned issues are addressed throughout the following guidelines and in *Section 4 – Proposed Policies and Programs*. In addition, special attention has been paid to addressing crossings at points other than signalized intersections.

General Crosswalk Design

Marking a crosswalk serves two purposes: (1) it clarifies that a legal crosswalk exists at that location and (2) it tells the pedestrian the best place to cross.¹ Several issues should be considered when designing safe crosswalks, including visibility, communicating the pedestrian's intent, minimizing crossing distance, snow obscuring the road surface, and accommodating persons with special needs.

Visibility

Increasing the visibility of all users crossing the road is a key issue for pedestrian safety. The ability of pedestrians to see motorists is equally as important as their own visibility in the roadway. Marked crosswalks should be included only where sight distance is adequate for both pedestrians and motorists. Obstructions in sight lines should be minimized. Visibility can also be improved with the following design treatments:

- Wide white ladder crosswalks.
- Stop lines or yield lines that are set back from the crosswalk a sufficient distance to increase visibility from all lanes of traffic.
- Signage directing motorists to yield to the pedestrians.
- Placement of signage that does not obstruct the visibility of the pedestrians.
- Curb extensions (bulb outs), extending the curb out at intersections, also minimizes the pedestrian crossing distance.
- Removal of low hanging branches and minimal planting between the oncoming vehicles and the sidewalk approaches to the crosswalk such that sight distances are in accordance with AASHTO guidelines.
- Lighting of the crosswalk and the sidewalk approaches.

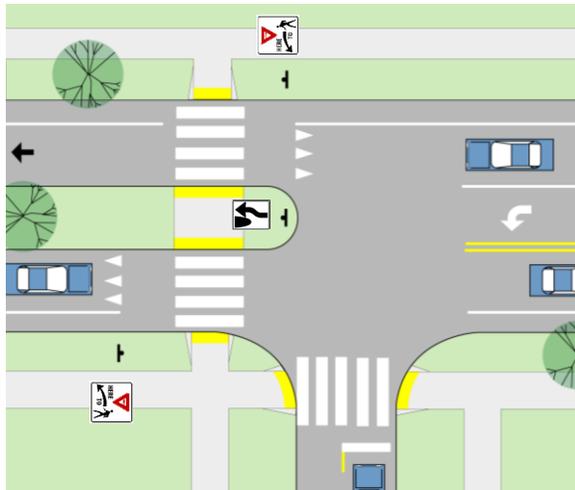
¹ AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities (Draft)*. August 2001.

Understanding the Pedestrian's Intent

Road users should be able to discern if a pedestrian is planning to cross the road so that they may take appropriate measures. If a crosswalk is located where a sidewalk directly abuts the roadway, the road users cannot tell if someone is simply going to walk by the crosswalk or abruptly turn and attempt to cross the street. Also, places where pedestrians may typically congregate, such as bus stops, may cause road users to needlessly stop. To help clarify the pedestrian's intent to cross the road, intersections should incorporate the following features:

- A short stretch of sidewalk perpendicular to the roadway where only pedestrians planning to cross the street would typically stand.
- Placing bus stops past the crosswalk to avoid blocking the crosswalk.
- Distancing the crosswalk from places where pedestrians may congregate adjacent to the roadway without the intent to cross the road.
- Installing curb extensions to reduce the crossing distance for pedestrians and to slow traffic, (see Fig. 9.7B)

Figure 9.7A. Pedestrian Crossing Island



Crossing islands

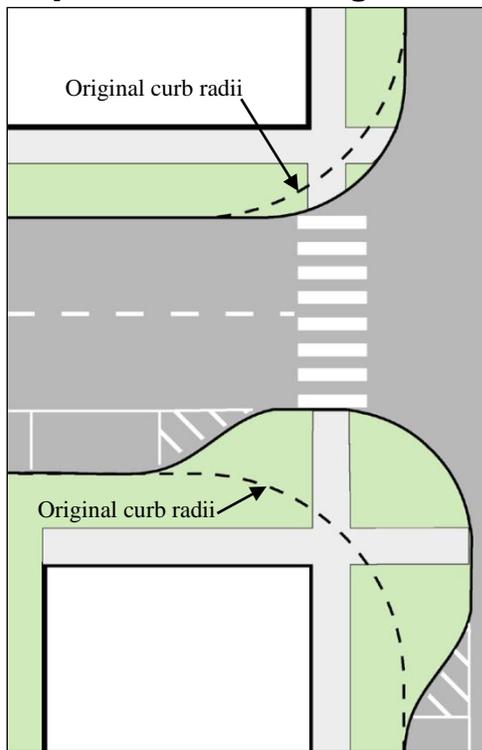
Crossing islands are raised areas that separate lanes of opposing traffic and eliminate the need for pedestrians to cross more than one direction of traffic at a time (see Figure 8.7A to the left).

Crossing islands allow the pedestrian to undertake the crossing in two separate stages. This increases their comfort level and opens up many more opportunities to safely cross the road.

Crossing islands increase the visibility of the crosswalk to motorists and reduce pedestrian crossing distances.

Crossing islands should be considered for all unsignalized marked crosswalks that traverse three or more lanes.

Fig. 9.7B. Effect of curb extensions and smaller curb radii on pedestrian crossing distances



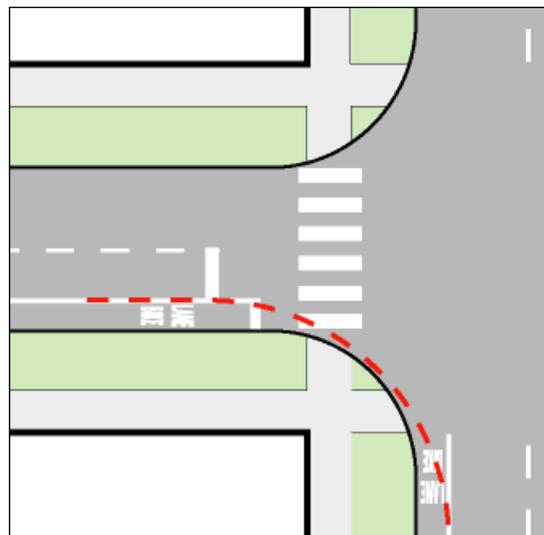
Minimizing Crossing Distances

Minimizing the distance that pedestrians need to cross the street is another critical safety solution. As crossing distances increase, the comfort and safety of a pedestrian decreases. Simple design solutions such as reducing curb radii, and adding curb extensions, shorten crosswalk distances. As well, they reduce the potential for pedestrian-vehicle conflict. Larger corner radii promote higher turning speeds and increase pedestrian crossing distances. See the figure to the left.

In addition to increasing visibility and shortening crossing distances for pedestrians, curb extensions increase the space available for directional curb ramps and prevent parked cars from encroaching on the crosswalk. Curb extensions also serve to make a pedestrian’s intent to cross the road known to motorists before they have to step into the roadway.

For signalized intersections, shorter crosswalks mean more time for the pedestrian “Walk” phase and a shorter clearance interval “Flashing Don’t Walk” phase.

Fig 9.7C. Effect of Bike Lanes on Turning Radius



Minimizing Turning Radius When Bike Lanes are Present

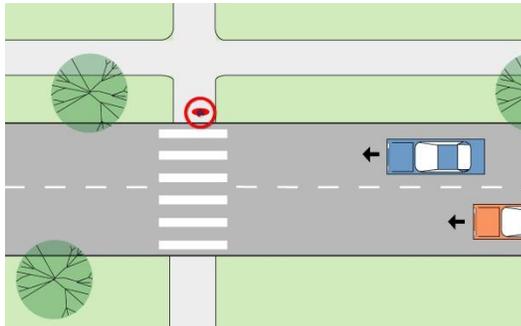
Bicycle lanes provide an added advantage of effectively increasing the turning radius for motor vehicles. This is especially the case where both intersecting roads have bike lanes as shown in the figure to the left.

This also applies to driveways. When a sidewalk is close to the road, the curb radius of an intersecting driveway is typically quite small. In these cases, a bicycle lane can significantly improve the ease of entering and exiting the driveway. For example a 5’ curb radius adjacent to a 3.5’ bike lane has an effective turning radius of 10’ (including the gutter).

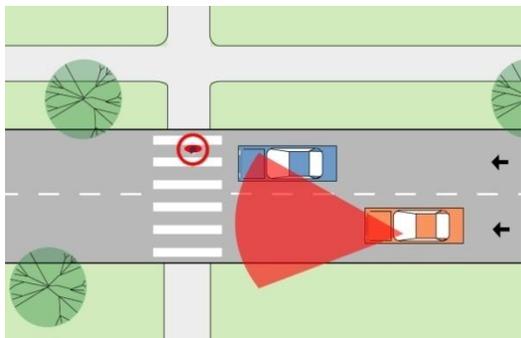
The increased effective turning radius means that motorists are less likely to encroach on adjacent motor vehicle lanes during the turning movements.

Fig. 9.7D. Multiple Threat Crashes Issues

Whenever a crosswalk traverses multiple lanes of traffic traveling in the same direction, there is a potential for what is known as a multiple-threat crash. The crash unfolds as follows:



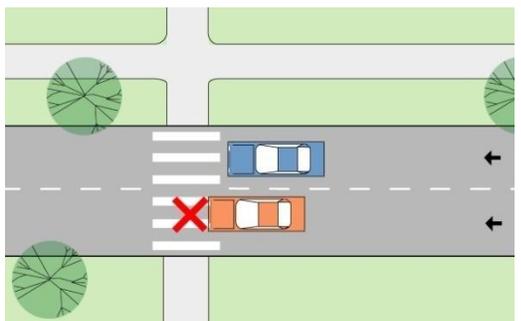
1. The driver in the lane closest to the pedestrian sees the pedestrian approaching the ramp or just entering the roadway and begins to slow down



2. The driver closest to the pedestrian lane stops, yielding the right-of-way to the pedestrian. The car is stopped immediately adjacent to the crosswalk, therefore blocking the sightlines between the pedestrian and the driver of the other car.



3. The driver of the other car fails to see the pedestrian and continues towards the crosswalks without slowing down.



4. The driver of the second car does not see the pedestrian until it is too late to come to a complete stop and hits the pedestrian.

A combination of high visibility crosswalks, yield lines set back from the crosswalk, and crosswalk signage on both sides of the street can help provide better visibility of pedestrians in the crosswalk. See Fig. 9.7Q for recommended countermeasures.

Fig. 9.7E. Countdown Signals



“Walk” Phase



Clearance Interval



“Don’t Walk” Phase

Description

These operate in the same manner as typical pedestrian signals, with one addition. At the onset of the Clearance Interval (flashing “Don’t walk” or red hand), the signal counts down the remaining time until the “Don’t Walk” phase (solid “Don’t Walk” or red hand).

Pedestrians find these very intuitive to use and they can help clear up many misunderstandings as to the purpose of the Clearance Interval. Studies have shown that fewer pedestrians remain in the street at the end of the Clearance Interval with countdown signals than with standard pedestrian signals. These signals have been very well received by pedestrians and have reduced complaints in some communities regarding pedestrian signal timing.

Application

The City should consider using the pedestrian signals with an integrated countdown clock for all new and replacement pedestrian signals. The City should consider adding countdown clocks to existing signals at high pedestrian volume signalized crosswalks and locations where the crosswalk is longer than 50’.

Fig. 9.7F. Portable Speed and Traffic Detectors**Description**

These portable detectors have the ability to perform traffic counts, speed studies and indicate a driver's speed on a LED display. Some models have a strobe light that may be activated when the speed limit is exceeded. They have been shown to reduce speed in before and after studies.

Application

These may be moved into an area where speeding is of concern to residents. The device may be used without displaying the speed to get a baseline speed study and traffic count in an unobtrusive manner. It may then be set to display the speed. Numerous inexpensive mounting plates may be put in place around the City and the detector can be easily and economically moved from place to place. These would be ideal for school zones where speed is a concern.

Fig. 9.7G. Active Crosswalk Warning Systems**Description**

A flashing beacon and/or in-pavement flashing LEDs are activated when a pedestrian is present. The signals may be passively activated through a number of methods or activated via a standard push button. The pedestrian approach can also be set to flash a red light with a sign indicating to cross after traffic clears. Various manufacturers have solar powered models with radio controls to activate flashers on advance warning signs and on signs on the opposite side of the street. This significantly reduces the cost of installation and operation.

Application

These systems are best located at pathway and major road intersections, or mid-block crosswalks on major roadways where pedestrian traffic is sporadic. Passive activation works best when there is a long pedestrian approach such as a pathway.

Fig. 9.7H. Rectangular Rapid Flash Beacon



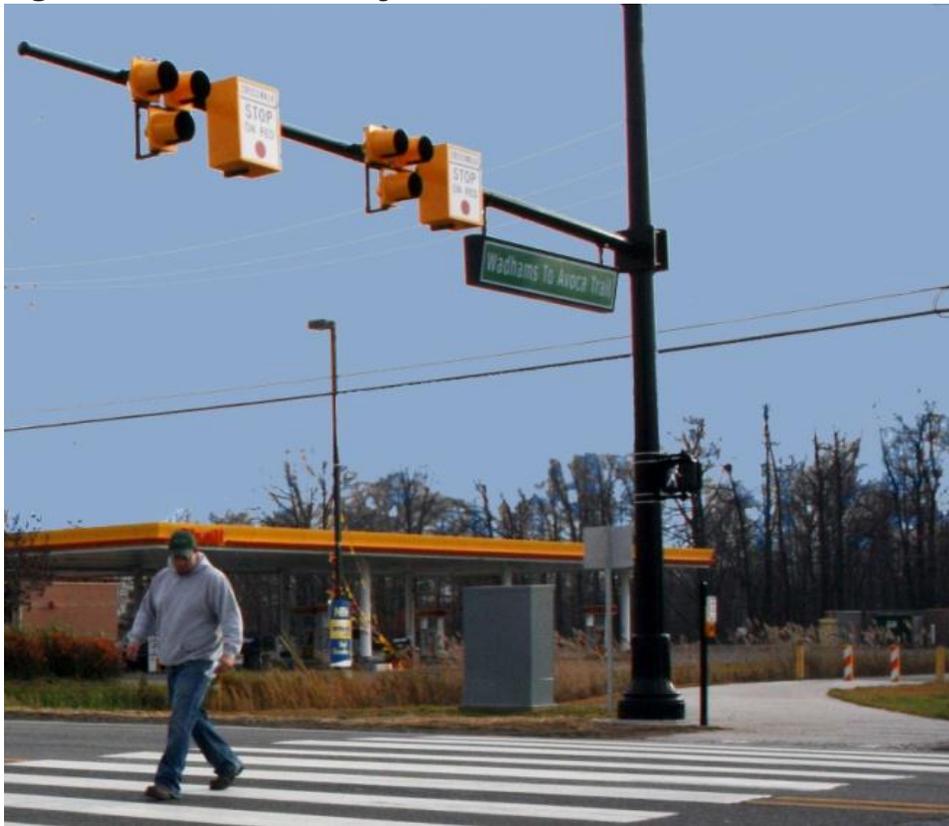
Description

Actuated Rectangular Rapid Flash Beacons are high intensity LED flashers that are paired with crosswalk signs. The LED flashers alternate and get motorists attention when activated. They can be passively or push-button activated and are sometimes linked to advanced warning signs. Various manufacturers have solar powered models that significantly reduce the cost of installation and operation.

Application

These systems are best located at pathway and major road intersections, or mid-block crosswalks on major roadways where pedestrian traffic is sporadic. Passive activation works best when there is a long pedestrian approach such as pathway.

Fig. 9.71. Pedestrian Hybrid Beacon



Description

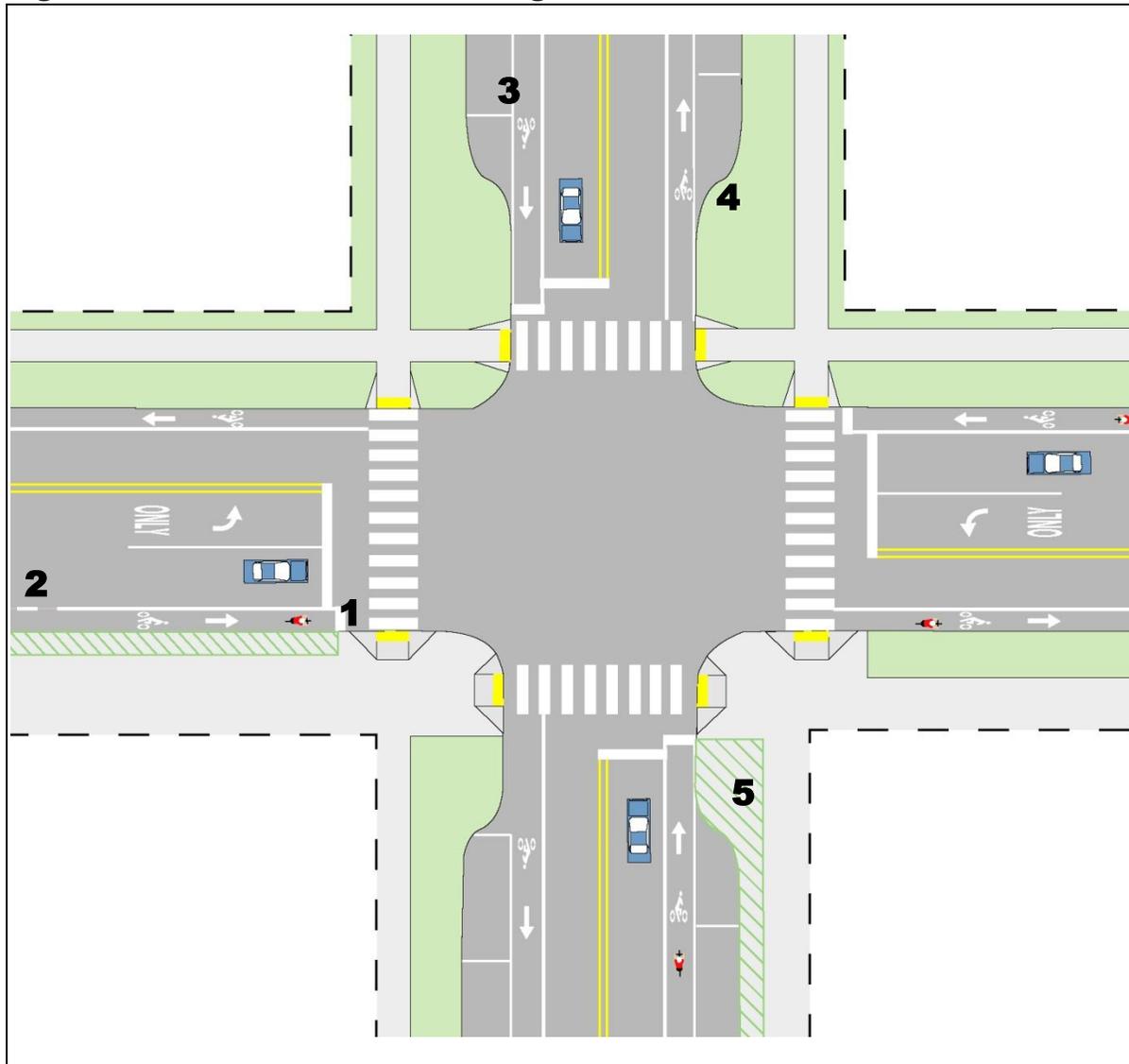
The Pedestrian Hybrid Beacon, also known as a HAWK signal, is a beacon used to help pedestrians cross mid-block where a traditional pedestrian crosswalk signal would be inappropriate. The pedestrian hybrid beacon is similar to an emergency beacon in that the signal’s purpose is clearly signed adjacent to the signal.



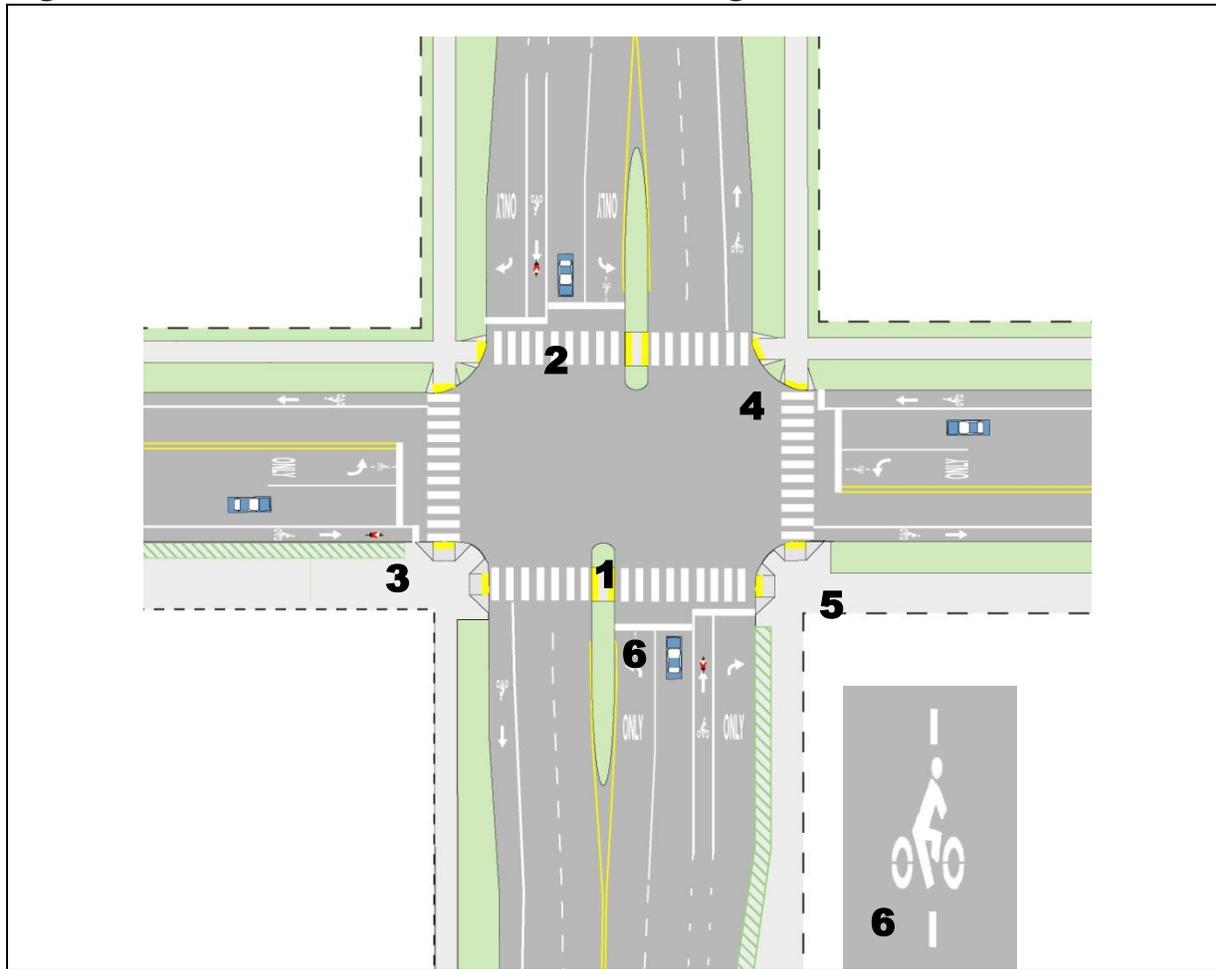
The signal is kept dark at its resting state. When a pedestrian activates the crossing button, a flashing yellow signal is displayed to motorists. This is followed by a steady yellow then a solid red at which time the pedestrian is displayed a walk signal. During the clearance interval, the motorists are displayed an alternating flashing red signal. Motorists may then move forward if the pedestrian or bicyclist has already crossed the road.

Application

These system work best at mid-block crosswalk locations where poor sight lines, infrequent usable gaps and/or inability to install a crossing island make an unsignalized crossing unsafe. They should not be installed at or within 100 feet of an intersection.

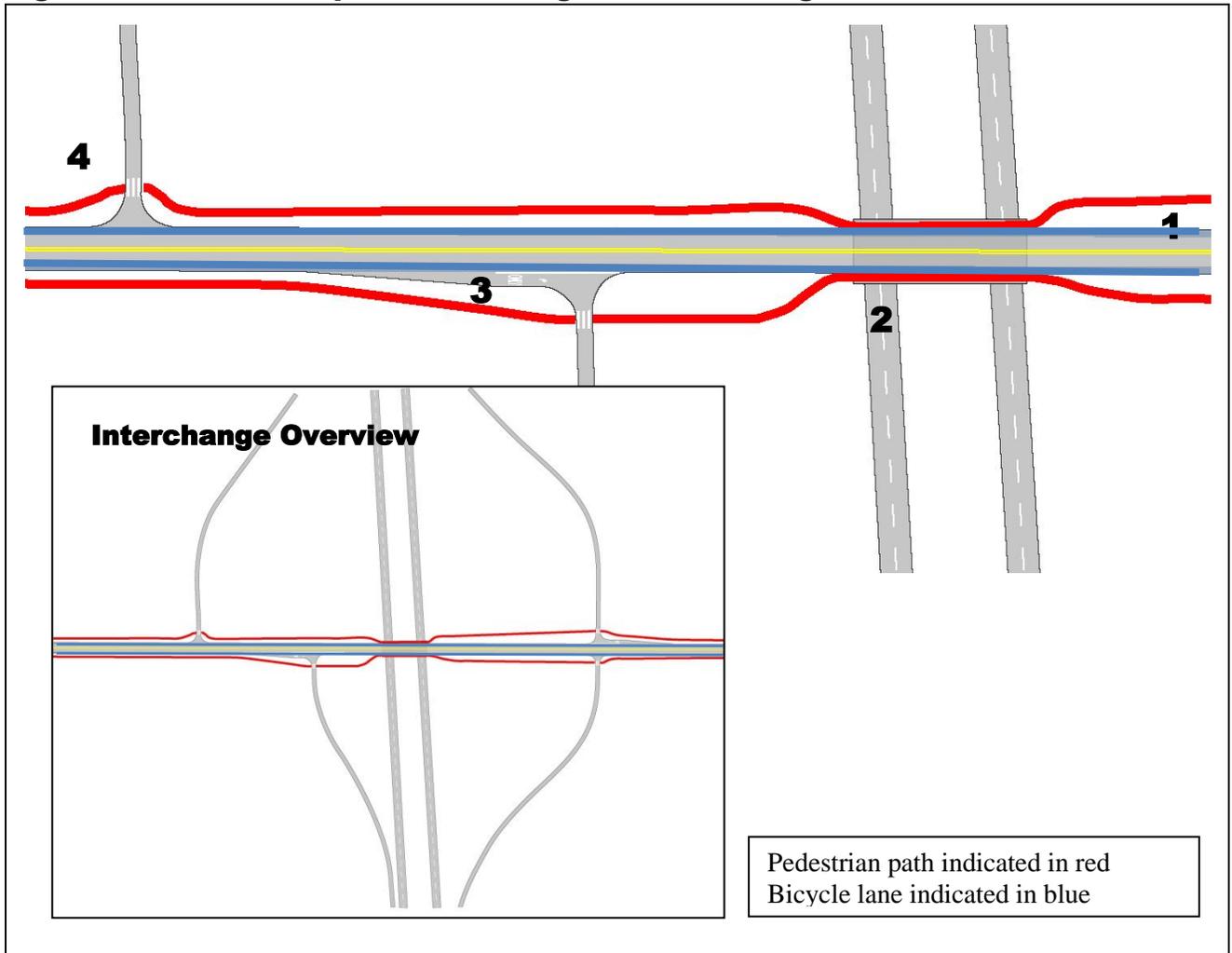
Fig. 9.7J Urban Intersection Design Guidelines**Key Elements**

1. Bike lane striping should stop at the pedestrian crosswalks and resume on the far side of the intersection. Unusual alignments may be aided by extending dashed guidelines through the intersection.
2. Bike lane striping is dashed at the intersection approach to indicate that bikers may be merging with traffic to make a turn.
3. Striping between the parking lane and bike lane encourages motorists to park closer to the curb and discourages motorists from using the bike lane in combination with an unused parking bay as a travel lane.
4. Curb extensions reduce the crossing distance of pedestrians and improve sight distance for both motorists and pedestrians. Curb extensions should be used wherever there is on-street parking.
5. In urban areas, a furniture and street tree zone provides a buffer from the street and improves the pedestrian level of service rating. A sufficiently wide travel way should be clear of any obstructions.

Fig. 9.7K. Multi-lane Urban Intersection Design Guidelines**Key Elements**

1. Pedestrian crossing islands should be installed at wide, multi-lane streets with high traffic volumes. Curbs, signs, and street hazard markings should delineate the islands.
 2. Crosswalks should be a minimum of 10' wide and clearly marked with a white ladder design to increase visibility and resist tire wear.
 3. Bike stop bar is advanced several feet ahead of vehicle stop bar to minimize conflicts of right turning cars with through bike traffic.
 4. A small curb radius shortens the pedestrian's crossing distance and controls traffic speed around corners. Bike lanes provide a significantly larger effective turning radius than the actual curb radius and should be considered in turning radius calculations.
 5. Perpendicular ramps should be built 90 degrees to the curb face and should include a detectable warning strip for visually impaired people.
 6. Traffic detectors in left turn lanes should be designed to detect bicycles. Detectors should include pavement markings that indicate where bikes can best be detected.
 7. Timing of the traffic signal should allow adequate all red phases to provide sufficient clearance time for bikes to clear an intersection.
- Other intersection features may include Right-On-Red turning restrictions, leading pedestrian interval signal phases, and audible signals for visually impaired users where appropriate.

Fig. 9.7L. Urban Overpass Interchange Retro-fit Design Guidelines



Key Elements

1. Bike lanes must be on both sides of the road to allow cyclists to ride with traffic.
2. Sidewalks with barriers between the sidewalk and the roadway should be provided at the bridge. If retrofitting an existing bridge, consider cantilevering a sidewalk.
3. The through bike lane should be to the left of the right turn lane onto the approach ramp.
4. Curb radii of ramps are tightened to narrow pedestrian crossing distances and crosswalks are clearly marked.

Signal Timing and Turn Restrictions

The length of a pedestrian signal is generally determined primarily by the motor vehicle flow with the exception of a few cases where the motor vehicle phase is lengthened to accommodate a long pedestrian clearance interval. Where there is heavy pedestrian flow, such as in the campus area, the flow of pedestrians should be given the same consideration as motor vehicles in setting signal timing.

Where intersection geometry is such that the intersection is wider than typical, motor vehicle clearances should be evaluated to make sure that the pedestrian Walk phase is not started when motor vehicles would be moving through the crosswalk. Also, the motor vehicle clearance time should be set to account for bicycle traffic.

Motorists are prohibited from blocking crosswalks by law. The City should evaluate restricting right turns where a vehicle cannot see cross street traffic without entering a crosswalk. Where there is significant pedestrian traffic in a crosswalk that conflicts with motor vehicles making right turns, the City should evaluate the feasibility of using a leading pedestrian interval of approximately 5 seconds. A leading pedestrian interval providing pedestrians with the "Walk" phase prior to motor vehicles given the green light has been shown to help prevent right turning vehicles from cutting off pedestrians trying to leave the curb.

Unsignalized Mid-block Crosswalks

The majority of pedestrian trips are ¼ mile or less, or a five to ten minute walk at a comfortable pace²³. Any small forced detour in a pedestrian's path has the potential to cause significant time delays if not shift the trip to another mode (most likely motorized). Pedestrians will seek the most direct route possible and are not willing to go far out of their way. Thus, they will often cross the road whether there are crosswalks or not. This results in the increased likelihood of pedestrians unexpectedly dashing out mid-block. This is the second most common type of pedestrian/vehicle collision after intersection related crashes.²⁴

A concern with any mid-block crosswalk is providing the pedestrian with a false sense of security. This concern must be weighed against accommodating and encouraging pedestrian travel. If we are to encourage safe and legal pedestrian travel, well designed, high visibility mid-block crosswalks should be provided at appropriate locations. The use of a sign oriented toward pedestrians that states "Cross Road When Traffic Clears" has been used in other communities to underscore the pedestrian's responsibilities at unsignalized crosswalks.

Understanding pedestrian routes and common pedestrian destinations will guide the placement of mid-block crosswalks at needed locations. According to AASHTO's *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, there are numerous attributes to consider when determining whether placement of a mid-block crosswalk is appropriate. These include:

- The location is already a source of a substantial number of mid-block crossings.
- A new development is anticipated to generate mid-block crossings.
- The land use is such that pedestrians are highly unlikely to cross the street at the next intersection.
- The safety and capacity of adjacent intersections or large turning volumes create a situation where it is difficult to cross the street at the intersection.
- Spacing between adjacent intersections exceeds 200 m (660 ft or an 1/8 of a mile).
- The vehicular capacity of the roadway may not be substantially reduced by the midblock crossing.
- Adequate sight distance is available for both pedestrians and motorists.

The 2009 MUTCD revised guidance for provision of marked crosswalks states:

New marked crosswalks alone, without other measures designed to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence, should not be installed across uncontrolled roadways where the speed limit exceeds 40 mph and either:

- A. *The roadway has four or more lanes of travel without a raised median or pedestrian refuge island and an ADT of 12,000 vehicles per day or greater; or*
- B. *The roadway has four or more lanes of travel with a raised median or pedestrian refuge island and an ADT of 15,000 vehicles per day or greater*

²³ AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. July 2004.

²⁴ FHWA, *Pedestrian and Bicycle Crash Types of the Early 1990's*, Publication No. FHWA-RD-95-163, June 1996

Unsignalized Marked Mid-block Crosswalk Signage

Fig. 9.7M. Crosswalk Signage



Pedestrian Warning Sign

**W11-2
and
W16-Ahead**



**Preferred
Crossing Sign**

R1-5

The current version of the Michigan Manual of Uniform Traffic Control Devices illustrates numerous ways to sign a crosswalk. When an advanced warning sign is desired, the W11-2 and W16-Ahead should be used. At the crosswalk itself there are a number of options. One option is to use a W11-2 (pedestrian warning sign) with a W16-7P (arrow pointing at the crosswalk). Another option uses one of the new Yield Here to Pedestrian Signs either the R1-5 (shown) or the R1-5a (where the word pedestrian is used rather than the icon). It is recommended in most cases to use the R1-5 in conjunction with a yield line consisting of a row of isosceles triangle pavement markings across approach lanes and pointed towards approaching vehicles. This helps to get vehicles to yield to pedestrians at a safe distance back from the crosswalk.

Fig. 9.7N. In-Road Signs



R1-6

Many communities use Yield to Pedestrian signs placed within the crosswalk that alert motorists of pedestrian crossings and calm traffic in the vicinity of the crosswalk. These in-street crossing signs cannot be used at signalized locations. If the In-Street Pedestrian Crossing sign is placed in the roadway, the sign should comply with the breakaway requirements of AASHTO’s guidelines. The in-street sign may be used seasonally to prevent damage in winter from plowing operations.



In-Road Removable Yield to Pedestrian signs may be used temporarily as part of an education and/or enforcement program in a targeted area or on a semi-permanent basis for critical crosswalks.

Fig. 9.7O. Yellow vs. Fluorescent Green Signs



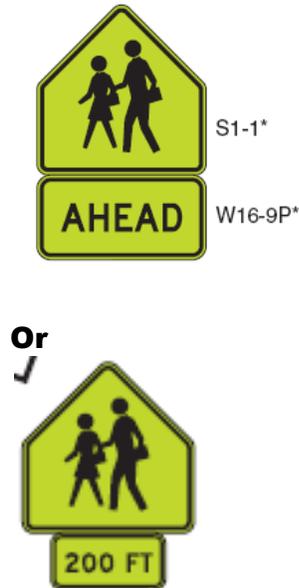
W11-2



The 2009 MUTCD requires fluorescent yellow-green colored signs be used for school and school bus signs. MDOT has until the end of 2011 to adopt these changes. Fluorescent yellow-green colored signs are optional for pedestrian, bike and playground signs, however, if they should be used consistently throughout the city.

Fig. 9.7P. School Crossing Sign Options

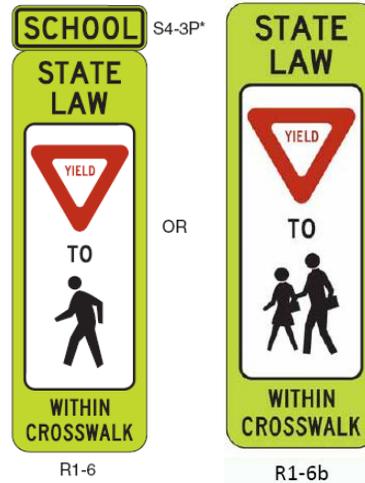
Advanced Warning



Crosswalk Warning



In-Street Pedestrian Crossing Sign Alternative to Crosswalk Warning Sign



The use of the STATE LAW legend is optional on the R1-6 series signs

Overhead Pedestrian Crossing Signs



The Overhead Pedestrian Crossing (R1-9 or R1-9a) may be modified to replace the standard pedestrian with schoolchildren symbols and may be used at unsignalized school crossings. The STATE LAW legend may be omitted on the R1-9 signs.

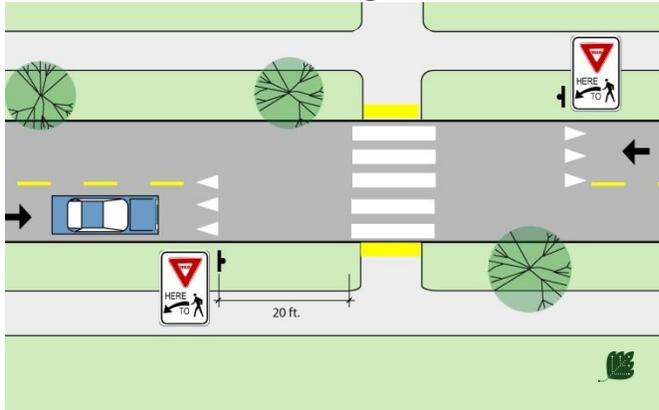
The School Crossing signs are intended to be placed at established crossings that are used by students going to and from school. However, if the crossing is controlled by stop signs, S1-1 should be omitted at the crosswalk location. Only crossings adjacent to schools or on designated routes to school should be signed with S1-1.

The In-street Pedestrian Crossing (R1-b or R1-6a) sign may be used at unsignalized school crossings. If used at a school crossing a SCHOOL (S4-3P) sign may be mounted above the sign.

The signs in Fig. 9.4P are required in the 2009 MUTCD. MDOT has until the end of 2011 to adopt these changes.

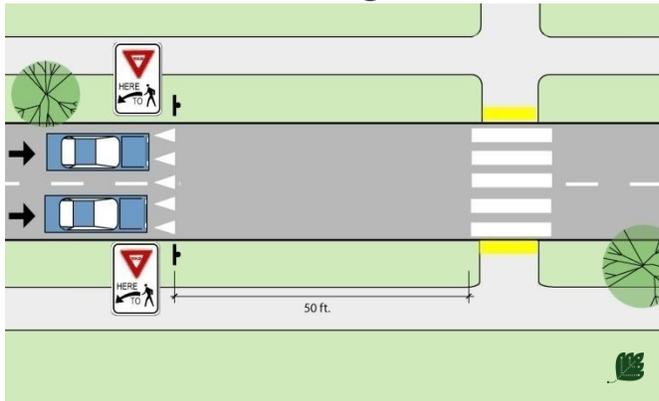
.Fig.9.7Q. Crosswalk Sign and Yield Line Placement

“Yield to Pedestrian Sign” on a One or Two-Lane Road



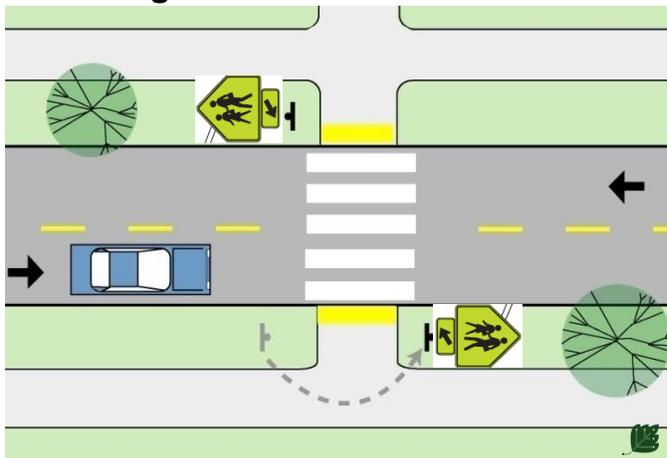
“Yield Here to Pedestrians” signs and yield line pavement markings should be placed a minimum of 20 ft. in advance of a crosswalk to encourage drivers to stop a greater distance from the crosswalk.

“Yield to Pedestrian Sign” on a Multi-Lane Road



“Yield Here to Pedestrians” signs and yield line pavement markings should be placed further in advance of a crosswalk on multi-lane roads to minimize the risk of a multiple-threat crash (see illustration in this section) and provide improved visibility for motorists in adjacent lanes.

School Sign Placement



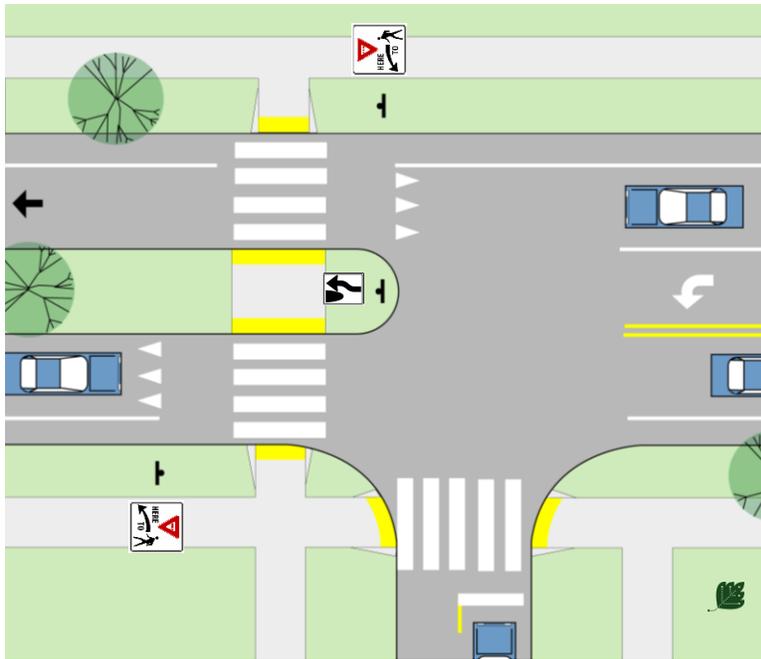
“Yield Here to Pedestrians” signs should be placed on either side of the road to ensure visibility for motorists in both lanes.

School Crossing Signs should be placed behind the crosswalk to improve visibility of crossing pedestrians rather than in front of the crosswalk where the large signs may obstruct motorists’ views.

**Selected Placement of Crosswalks at Tee Intersections
Design Guidelines**

On some roads it may be desirable to mark only one of the crosswalks at a Tee intersection in order to channel pedestrians to a safer crossing point and to maximize the effectiveness of the crosswalk by not overusing high visibility crosswalks.

Fig. 9.7R. Unsignalized Tee Intersection with Turn Lane Guidelines



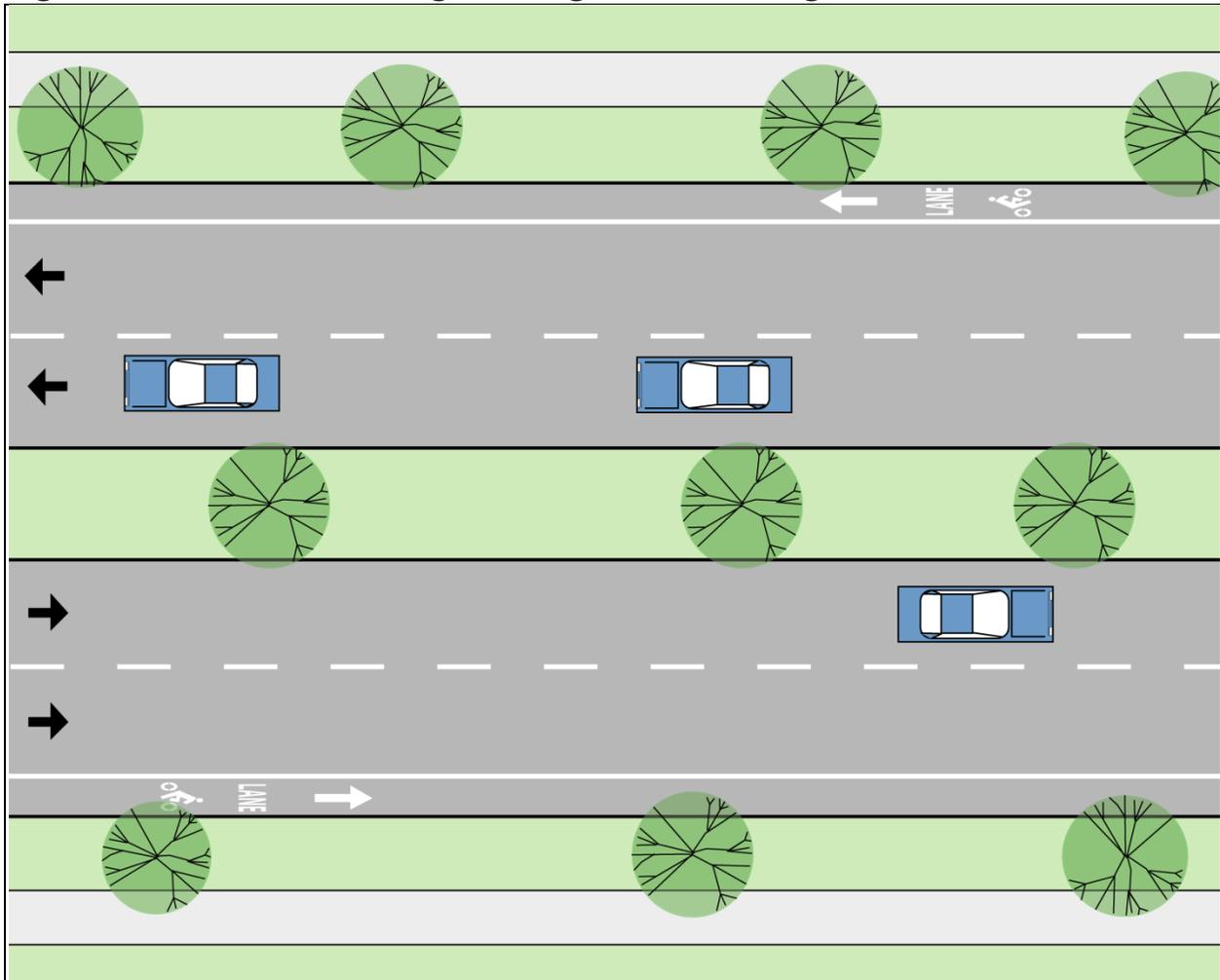
Description

At unsignalized Tee intersections with center turn lanes, the marked crosswalk is located to the left of the intersecting street and the turn lane is converted to a pedestrian crossing island. The crossing island should be located such that it requires left turns from the intersecting street to have a fairly tight turning radius, therefore reducing their travel speed.

Curb ramps should be provided at all legal crosswalks, regardless of whether the crosswalk is marked. Driveways should be prohibited in the vicinity of the intersection.

The treatment shown should be used in conjunction with advance warning signs (not shown).

Fig. 9.7S. Informal Crossing Utilizing Medians Design Guidelines



Description

Raised medians may somewhat accommodate dispersed informal crossings by able-bodied adults during periods of no or low snowfall.

Key Elements

A median with plantings that permits traversing by foot and allows good visibility between the driver and the pedestrian.

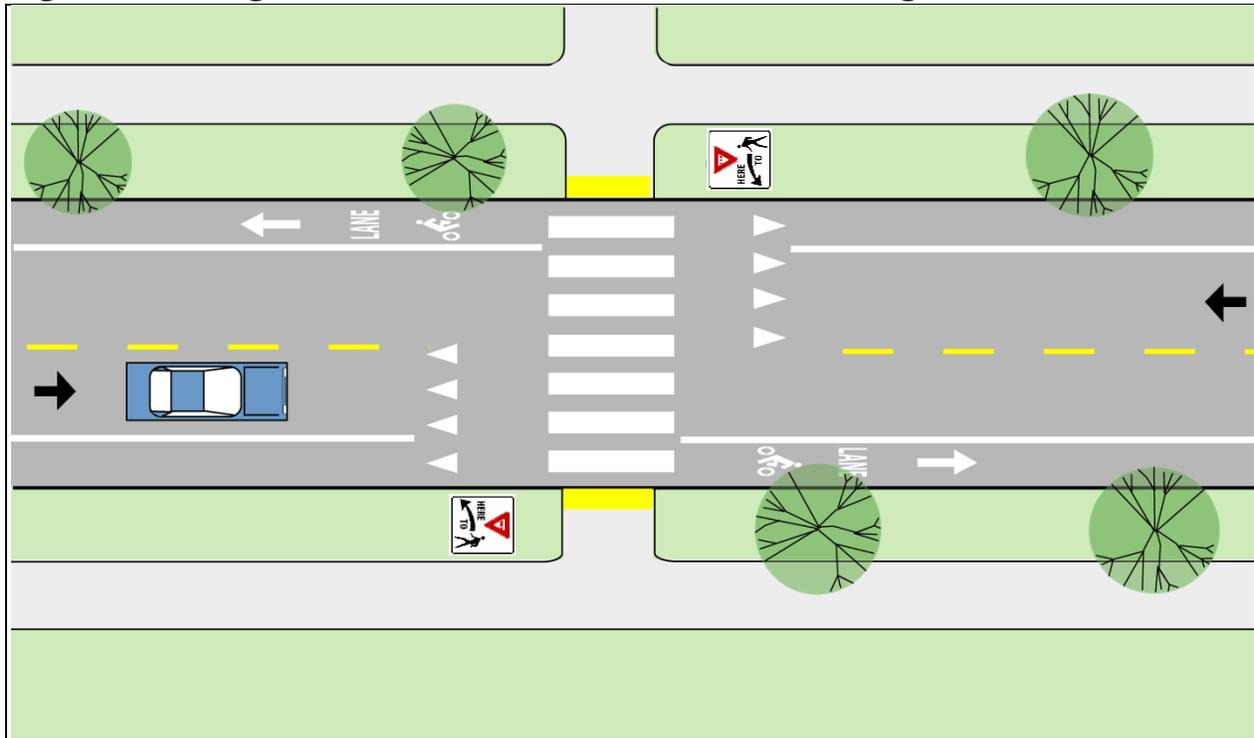
Applications

On roads of four or more lanes where dispersed crossings are anticipated, where center left-turn lanes are unused, where minimum pavement is desired, and where traffic calming is desired. They may be used where a marked crosswalk is being considered as a Near-term Opportunities measure.

Example



Fig. 9.7T. Unsignalized Basic Mid-block Crosswalk Design Guidelines



Description

A mid-block crosswalk for a two-lane road at an unsignalized location without parking. The treatments shown should be used in conjunction with advance warning signs (not shown).

Key Elements:

- The yield markings are set back from the ladder crosswalk to minimize the potential for a multiple threat crash.
- Where crossing signs other than the R1-5/ R1-5a “Yield Here to Pedestrians” are used, yield lines should be omitted.
- Sightlines are kept clear of vegetation.
- A 2’ wide detectable warning strip is used at the base of the ramps.

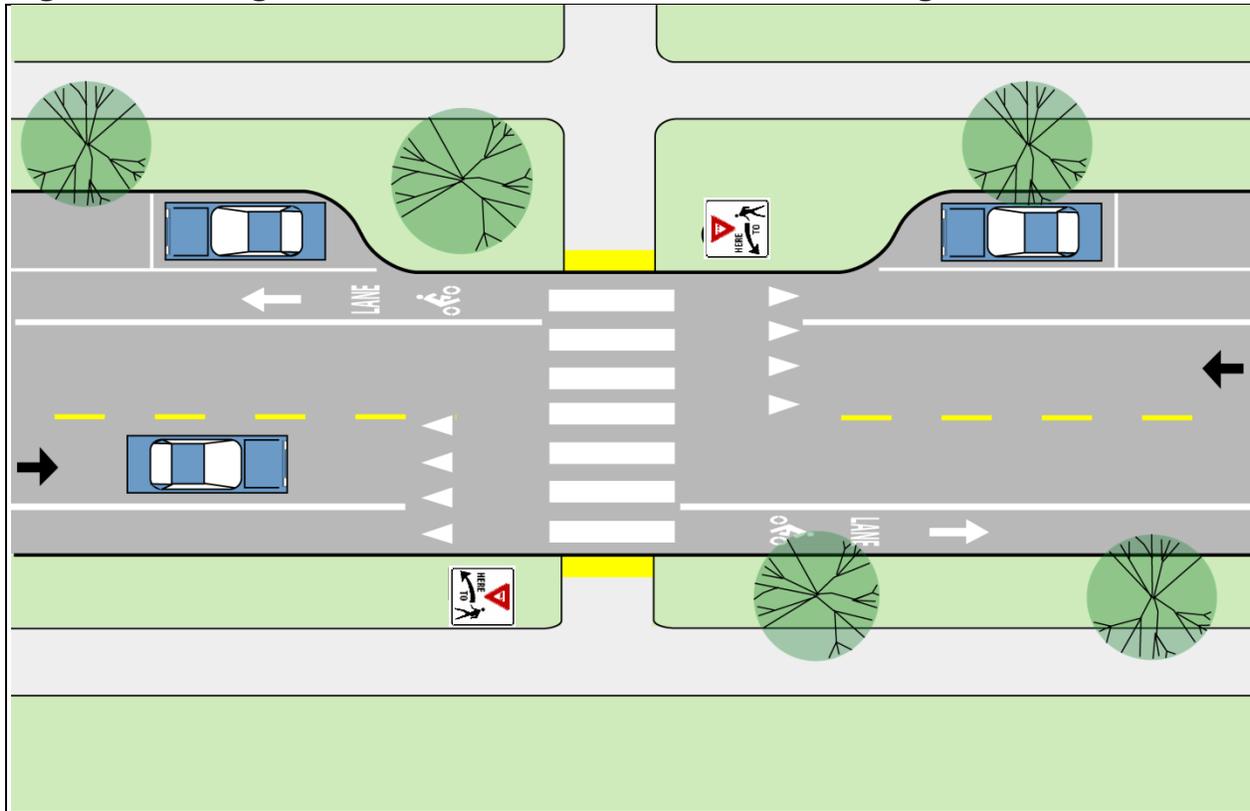
Applications

Generally used on relatively low volume, low speed roads where sufficient gaps in the motorized traffic exist. This crosswalk design should not be used in any situations where there are greater than two travel lanes or when there is on street parking.

Example



Fig. 9.7U. Unsignalized Mid-block Crosswalk With Parking Guidelines



Description

A mid-block crosswalk for a two-lane road at an unsignalized location with parking. The treatments shown should be used in conjunction with advance warning signs (not shown).

Key Elements:

- See elements listed under Unsignalized Basic Mid-block Crosswalk.
- A bulb-out extends the pedestrian ramp into the sightlines of oncoming vehicles, reducing the potential for a “dart-out” type crash.

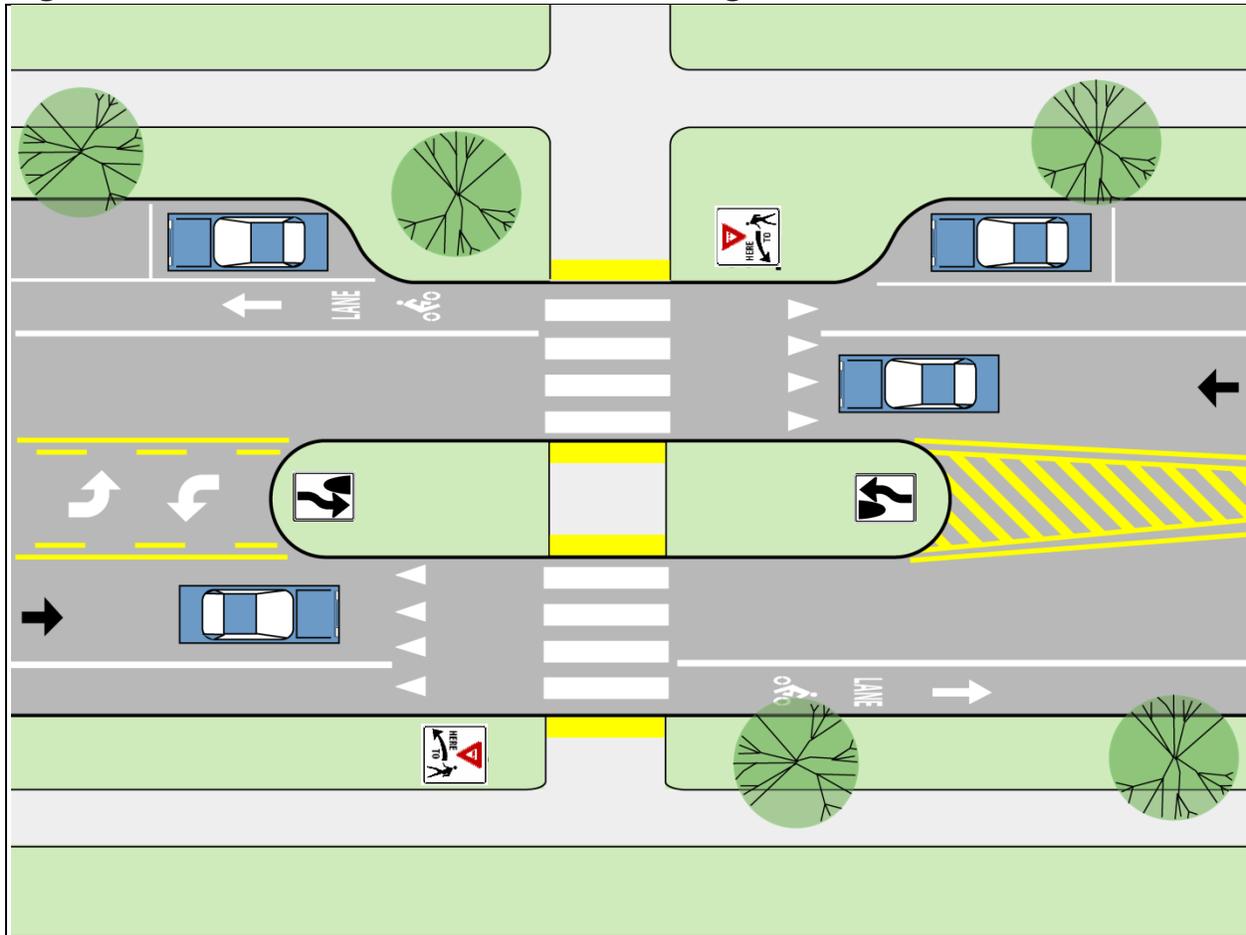
Applications

Generally used on relatively low volume, low speed roads where sufficient gaps in the motorized traffic exist. This crosswalk design should not be used in any situations where there are greater than two travel lanes.

Example



Fig. 9.7W. Mid-block Crosswalk with Crossing island Guidelines



Description

A mid-block crosswalk for a two-lane or three-lane road at an unsignalized location with or without parking. The treatments shown should be used in conjunction with advance warning signs (not shown).

Key Elements:

- See elements listed under Unsignalized Basic Mid-block Crosswalk and Unsignalized Mid-block Crosswalk with Parking.
- A crossing island is provided to break the crossing into two separate legs. The island has a minimum width of 6’ with 11’ or wider preferred.
- Planting on crossing islands should be kept low so as not to obstruct visibility.

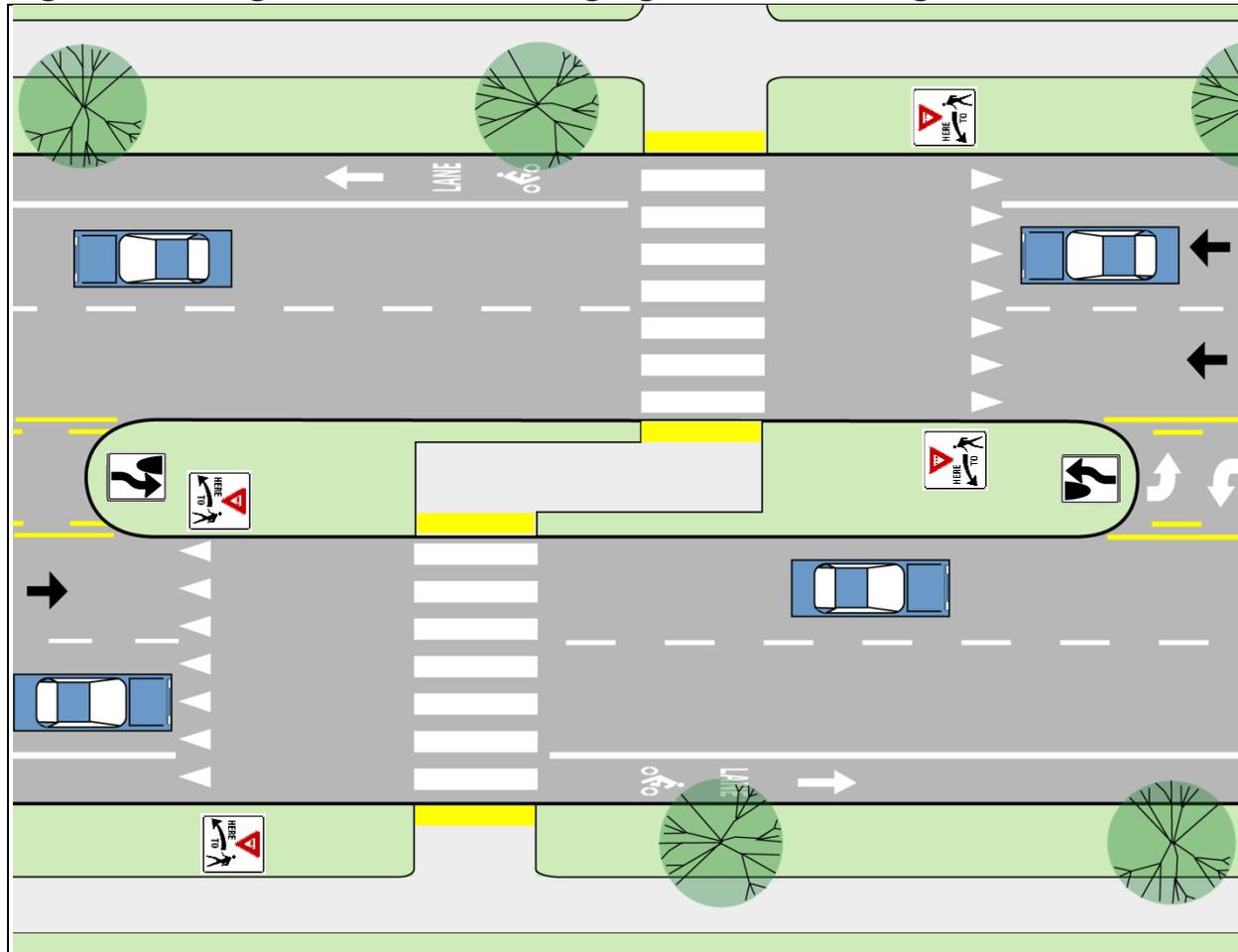
Applications

Generally used on a higher volume and higher speed road where suitable gaps to cross both directions of traffic in one movement are infrequent.

Example



Fig. 9.7X. Unsignalized Mid-block Zigzag Crosswalk Design Guidelines



Description

A mid-block crosswalk for a four or more lane road at an unsignalized location without parking.

Key Elements:

- See elements listed under Unsignalized Basic Mid-block Crosswalk and Unsignalized Mid-block Crosswalk with Crossing Island.
- The crosswalks are staggered to direct the pedestrian view towards oncoming traffic.
- Yield markings are set further back to improve pedestrian visibility from both lanes and minimize multiple-threat crashes.
- Median signs are placed higher than typical so as not to impede sightlines.

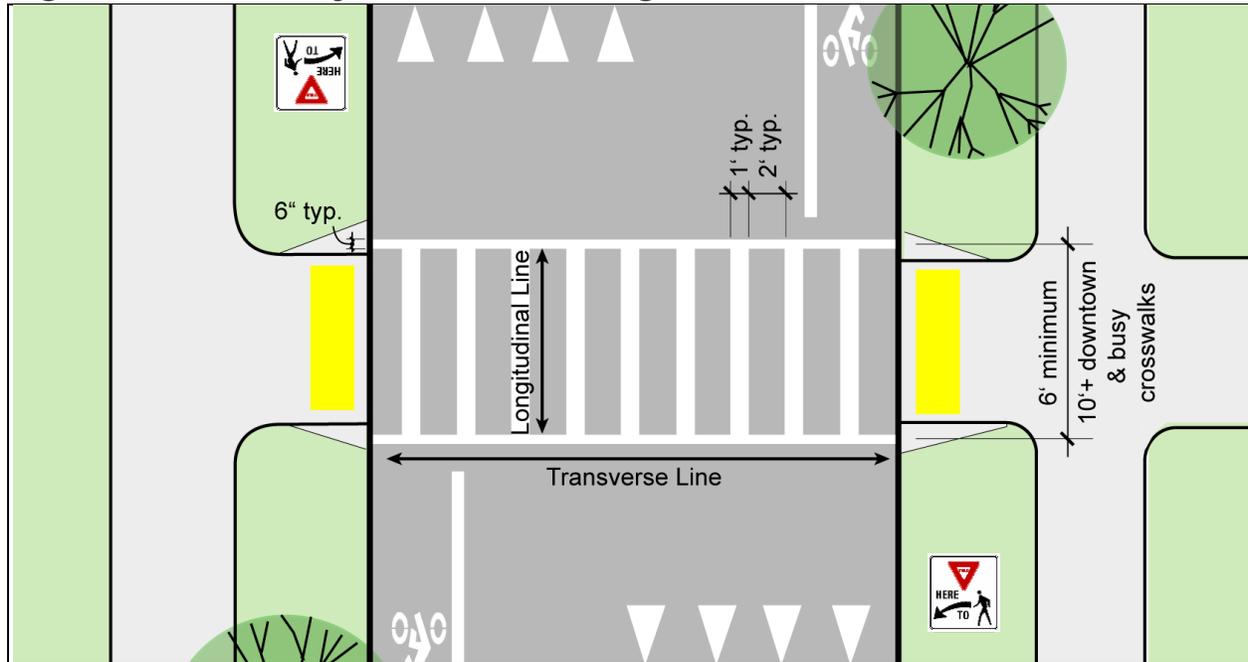
Application

Generally used on high volume / high-speed multi-lane roads.

Example



Fig. 9.7Y. Ladder Style Crosswalk Design Guidelines



Description

A combination of Transverse and Longitudinal style crosswalks to improve visibility for motorists and usability for pedestrians with sight impairments.

Key Elements:

- All crosswalk markings are highly skid-resistant and strongly contrast pavement.
- Longitudinal lines are no more than 1’ wide to minimize areas of thermoplastic markings.
- The clear spacing between the longitudinal lines is no more than 2’ to improve the visibility of the crosswalk to motorists.
- Transverse lines are used to aid pedestrians with sight impairments in finding the edge of the crosswalks (this can be difficult with longitudinal lines alone, especially when spaced far apart).
- The width of the crosswalk is set such that it can easily accommodate all pedestrians crossing the road.

Application

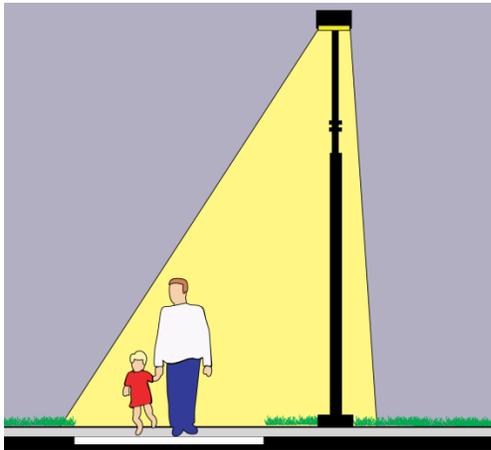
For all marked mid-block crosswalks across Arterial and Collector streets and signalized crosswalks downtown. Also, on local streets where there is a high potential for conflict between motorists and pedestrians such as crosswalks that serve schools. Locations where pedestrian crossing is sporadic require high visibility as the motorist’s expectation for the presence of pedestrians is low.

Example



Lighting of Crosswalks

Lighting is a key element for a pedestrian's safety and comfort. It is most important to provide lighting where a pedestrian crosses a roadway to make the pedestrian visible to motorists. All marked crosswalks, including intersections and midblock crossings, should be well lit with overhead lighting. The lighting should be such that it illuminates the side of the pedestrian facing traffic. Lighting along sidewalks and roadside pathways increases the comfort level for pedestrians at night and in the early morning, especially for school age children. However, the cost of lighting an entire pathway could be prohibitive; therefore lighting should be administered where there are safety issues first and foremost.



Marking of Crossing Islands

Crossing islands can present an obstruction in the roadway for motorists. The presence of this obstacle is key to the visibility of the crosswalk even more so than the signage or pavement markings and flush crossing islands have not been shown to have the same safety benefits as raised crossing islands. When the crosswalk is located in a left-turn lane it is located outside of the typically traveled roadway and is a minimum obstruction. When the road flairs around a crossing island it is more of an obstruction for a motorist. To draw attention to the obstruction, typical pavement markings as called for in MUTCD should be utilized. In addition, reflective material may be added to the sign posts, and reflective flexible bollards may be placed on the ends of the islands to increase the island's visibility at night and during inclement weather.

Roundabouts

In many situations, roundabouts have several advantages over typical intersection design: vehicles move at slower speeds, traffic flows more smoothly, and reduced pavement enhances aesthetics and offers the opportunity for landscaping in the central and splitter islands. There are however, serious drawbacks to roundabouts for those with vision impairments, and two-lane roundabouts are problematic for bicycles in particular. Roundabouts, especially larger ones, can present significant out-of-direction travel for pedestrians. Depending on the nature of the surrounding land uses and the design of the roundabouts, pedestrians may attempt to walk directly across the center of the roundabout.

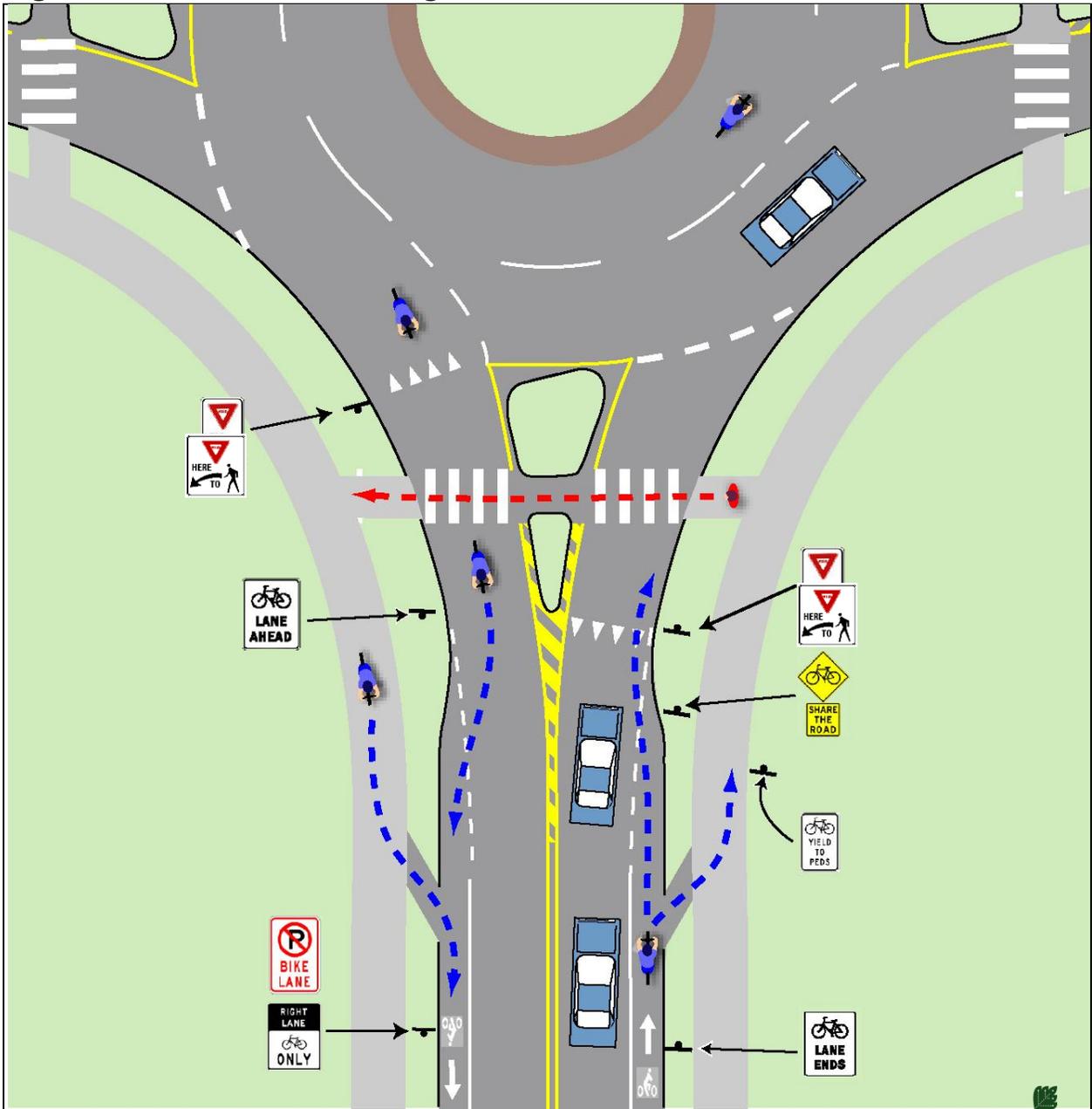
Because there are no traffic control signals to provide a pedestrian “walk” signal, pedestrians wait for an appropriate gap in traffic and cross. The splitter or diversion islands provide a crossing island for the pedestrian, breaking the road crossing into two stages so that they are only dealing with one direction of traffic at a time. This system works quite well for pedestrians without vision difficulties. Studies have shown a reduction in pedestrian crashes for single lane roundabouts and about the same number for multiple lane roundabouts as compared to a traditional signalized intersection. Pedestrians with vision impairments often find roundabouts very intimidating as the audible queues are sometimes insufficient to judge a suitable gap in traffic. Research is currently underway to determine the most appropriate way to accommodate blind and vision impaired pedestrians in roundabouts.

Multi-lane roundabouts are especially problematic for bicyclists. Studies have shown that while single lane roundabouts have about the same number of bicycle crashes when compared to traditional signalized intersections, multi-lane roundabouts have significantly more. AASHTO warns that the overbuilding of roundabouts should be avoided. Design guidelines recommend allowing bicyclists who are traveling in the roadway approaching the roundabout to exit the roadway prior to the roundabout and navigate the roundabout as a pedestrian would. More confident bicyclists may remain in the roadway and merge with the motor vehicles. Bike lanes should not be placed within the roundabout itself because a bicyclist close to the edge of the roadway is not the usual position where an entering motorist expects to look for circulating traffic.

Design Guidelines:

- Roundabout approaches should include bicycle entrance and exit ramps to give bicyclists the option of biking on a sidewalk bikeway as well as the roadway.
- Roundabouts should include pedestrian crossing islands on all entering roadways.
- The use of roundabouts should be accompanied by an education campaign regarding the issues with blind pedestrians and a motorist responsibly when they see a pedestrian using a white cane.
- The bicycle and pedestrian safety issues should be carefully evaluated for any multiple lane roundabouts.
- The latest research on accommodating blind and vision impaired pedestrians in roundabouts should be consulted before designing and constructing a roundabout.
- Bicycle and pedestrian pavement markings and signs should be regularly evaluated for every roundabout.

Fig. 9.7Z. Non-motorized Design Considerations for Roundabouts



9.8 Local Roadways

The local roadways that serve residential and mixed use areas are critical to the success of a City's non-motorized system. Local roads that serve neighborhoods are typically attractive non-motorized links due to the lower vehicle volumes and speeds.

Bicycle Travel in Neighborhoods

Bicycles typically do not need any special accommodations on local residential streets as they can comfortably share the road with the limited motor vehicle traffic. Some local residential streets, by themselves or in combination with off-road paths, provide excellent and attractive alternatives to the primary road system. In some cases, it may be desirable to sign bicycle routes that provide access to destinations such as schools and parks where the route may not be obvious to a cyclist unfamiliar with the area.

Public vs. Private Roads

It is just as important to provide safe and comfortable pedestrian facilities on private streets as on public streets. Regardless of ownership, neighborhood roads should include concrete sidewalks a minimum of 5' wide and compliant with ADA standards, on both sides of the street with a landscaped buffer between the sidewalk and the road.

An issue with private roads is the perception that they may not be open for use by the general public. For this reason public roads should always be the preference for new developments. In crafting development agreements that incorporate private roads it should be clear that the roads are open to all pedestrians and bicyclists and that there should be no signage or physical structures that imply that non-motorized access is limited to the residents of that neighborhood.

Both public and private neighborhood streets should be designed to incorporate the same pedestrian safety enhancing measures as those previously noted for primary public roadways. These include reduced curb radii, narrower street widths, curb extensions, and traffic calming measures such as speed tables.

Connectivity Between Neighborhoods and to the Primary Road System

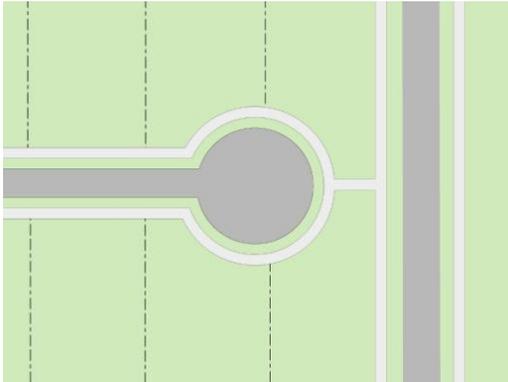
If a new development has limited road access to surrounding arterial streets, special access points for pedestrians and bikes should be incorporated between property lines or along utility rights-of-way. Non-motorized connectivity between adjacent residential, commercial and institutional developments should be provided. The City can regulate the form and shape of new neighborhoods to support and promote pedestrian and bike mobility by modifying master plans and development standards. Careful site design encourages walking by making non-motorized travel more direct than motorized transportation modes.

Neighborhood Roadways Design

Public and private street standards should clearly require sidewalks on both sides of the street, subject to City review. Neighborhood streets should have the following amenities to encourage pedestrian and bicycle access in neighborhoods:

- Design the road to slow vehicular speeds.
- Small block sizes.
- Interconnected streets.
- Sidewalks on both sides of the streets.
- Landscaped buffer between the street and the sidewalk with street trees that will provide shade.
- Connections to adjoining neighborhoods.
- Direct walkway connections between residential areas and commercial and institutional areas when not afforded by the street system

Fig. 9.8A. Cul-de-sac connector



Grid patterned streets with sidewalks and small block sizes are preferred for pedestrian use. They allow pedestrians to have multiple options in route choices and follow the most direct route possible. It is desirable for street networks and pedestrian facilities to correspond wherever possible. However, even if grid streets are not desired or feasible, pedestrian and bike links should still be provided even where the road does not connect. If cul-de-sacs and dead end streets are used, pedestrian and bike cut-throughs meeting AASHTO guidelines should be created to link to adjacent streets (Figure 8.8A).

9.9 Neighborhood Connector Routes

Neighborhood connector routes are designated routes that are primarily located on low speed, low traffic volume local roads and connecting pathways. They link neighborhoods to parks, schools and downtowns. Signs provide wayfinding by noting direction and distance to key destinations. Generally, neighborhood connector routes begin as guided routes and as their popularity grows and opportunities arise they can be developed to incorporate additional amenities, such as traffic calming measures, rain gardens and public art. The following sections describe the different types of elements that can be applied to a neighborhood connector route.

Bike Route Signs and Wayfinding

Bike route signs and wayfinding techniques can be used to established guided and named routes along a neighborhood connector route.

Route Characteristics

Routes signed as a Bike Route should be roads that have a relatively high Quality/Level of Service for bicyclists. The route should not have any known hazards to bicyclists and should be maintained in a manner that is appropriate for bicycle use. While many local roads may meet these criteria, the key is that the road is part of a specific route to a particular place. Obvious routes need not be marked. Bike Routes should be used judiciously to identify obscure routes to key destinations that avoid travel along major roadways.

Where a bicycle route on a local road intersects a busy multi-lane primary road and continues on the other side of the road, a traffic signal or appropriately designed mid-block crossing should be provided.

Bike Routes generally do not include specific bicycle improvements such as Bike Lanes. Bike Lane pavement markings and signs already indicate that a road segment is designed to specifically accommodate bicycles. Bike Route signs are to be used where no obvious bicycle facility exists yet the route is advantageous to bicyclists. Thus road segments with Bike Lanes should generally not be marked as a Bike Route, except where the bike route uses these facilities as short connectors to continue the route.

Bike Route Guide Signs

The most basic bike route signs are Bike Route Guide Signs (shown to the right). These are used on designated bike routes to inform bicyclist of changes in direction and the distance to the next destination. Bike Route Guide Signs are placed at changes in direction of designated bike routes. Not every bicycle facility will necessarily be designated a bike route. Bike routes should be used where the signage would help direct a bicyclist to a key destination that may not be obvious.



D1-1c
MUTCD 2009

Bike Route Identification Signs

Some bike routes are significant enough to warrant a name or numerical designation. Typically these are key connectors between off-road trails or used to help delineate a trail that incorporates many different facility types. Bike Route Identification Signs (shown to the right) establish a unique identification for a bike route. These signs are typically used with auxiliary plaques that indicate the direction of travel and any changes in direction of the route.



M1-8a
MUTCD 2009

Bicycle and Pedestrian Boulevards and Neighborhood Greenways

Bicycle and Pedestrian Boulevards and Neighborhood Greenways are Neighborhood Connectors that function as premium bicycle and pedestrian routes. They create an attractive, convenient and comfortable environment that is welcoming to all cyclists and pedestrians. Bicycle and Pedestrian Boulevards and Neighborhood Greenways are a great way to navigate through a city, where arterial and collector roads may be undesirable to bicyclist and pedestrians. They can also function as an extension of an off-road trail, creating a smooth transition between two trail systems.

Bicycle and Pedestrian Boulevard Design Elements

Bicycle and Pedestrian Boulevards are located on low-volume and low-speed streets that have been optimized for bicycle and pedestrian travel through special treatments that allow through movement for bicyclist and pedestrians while discouraging similar through trips by non-local motorized traffic. Bicycle and Pedestrian Boulevards can take many forms. Special treatments such as traffic calming and traffic reduction, signage and pavement markings and intersection crossing treatments all help to optimize these routes for cyclists.

The following are some example of treatments that can be used to develop a Bicycle and Pedestrian Boulevard:



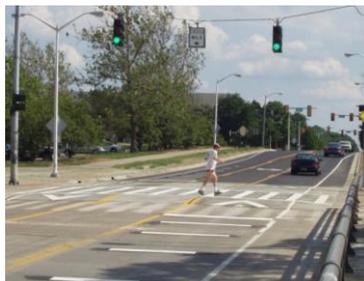
Pavement Markings
Identifies this route as a Bicycle Boulevard



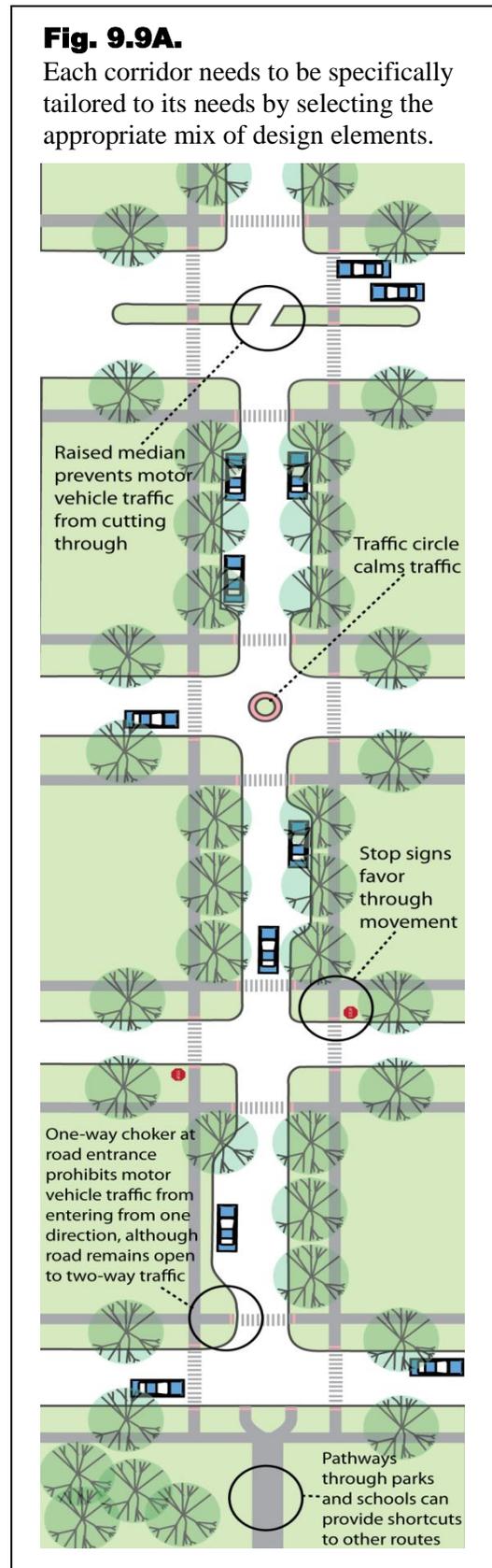
Traffic Reduction
Restricts motorized vehicles while allowing bicycle traffic



Traffic Calming
Mini Traffic Circles help reduce speed at intersection without stopping



Traffic Calming
Speed Tables help to reduce speed and enhance the crosswalk



Neighborhood Greenway Design Elements

Neighborhood Greenways incorporate all the elements of bicycle boulevards but take the concept to the next level.

They typically incorporate sustainable design elements such as:

- rain gardens
- bio-swales
- native plantings

They should incorporate pedestrian amenities such as:

- art installations
- benches
- interpretive sign
- community vegetable gardens
- ornamental gardens

They may take on many different looks from avant-garde to traditional.



Lansing, MI



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Neighborhood Connector Routes Implementation

Neighborhood connector routes, for the most part, utilize existing roadways and pathways in a community. When it comes to implementation, many of these routes can be accomplished in the first phase by simply adding some signage and wayfinding to designate them as a route. As the route grows in popularity, or when funding becomes available, other elements such as traffic calming, rain gardens and street art can be incorporated. However, before any routes are established always make sure there are safe road crossing in place where a neighborhood connector route intersects a major roadway. The following is an example of how a neighborhood connector route could be implemented over time.

Existing Conditions	
	<p>Local Roadway in a Residential Neighborhood</p> <ul style="list-style-type: none"> • Low speed • Low traffic volumes • Majority of bicyclists feel comfortable riding their bicycle in the street. <p>This could essentially be any road in a residential neighborhood.</p>

First Phase	
	<p>Designate as a Neighborhood Connector Route</p> <ul style="list-style-type: none"> • Map out Neighborhood Connector Routes • Add wayfinding signage to route • Provide safe road crossings especially where a neighborhood connector route meets a major road <p>Providing safe crossing at major roads and signage that directs bicyclists and pedestrians to major destinations is essential to this phase.</p>

Implementation of Connector Pathways

Due the existing road network, many times neighborhood connector routes require off-road pathways to continue a route where a roadway ends. These pathways are critical to the success of the network because they generally link up isolated neighborhoods and provide key connections to get to major destinations such as schools and parks. Many times these types of pathways are funding and opportunity based. When available, it is recommended that these pathways be implemented along existing right-of-way or semi or quazi-public areas first because they tend to provide the least resistance.

Second Phase



Add Traffic Calming Elements to Create a Bicycle and Pedestrian Boulevard

- Mini Traffic Circles
- Orient Stop Signs for bicycle movement
- Medians
- Curb Extensions and bump outs
- Chicanes

When restricting vehicle access down the street it is important to maintain bicycle access to continue through.

Third Phase



Establish the route as a Neighborhood Greenway

- Rain gardens/Bio-swales
- Permeable pavement
- Unique bike route identification sign with name and optional custom logo
- Art Installations

9.10 Off-Road Trails

There are many types of Off-road Trails, each with unique issues. One type of Off-road Trail is the independent pathway that is separate from the road system. Independent pathways include rail-to-trail corridors, paths through parks and other trail systems. Independent pathways can be important and beneficial links to the non-motorized transportation system provided they have direct connections to the existing network of bike lanes and sidewalks. If designed and maintained properly, they can be the “jewels” of a City’s non-motorized transportation system.

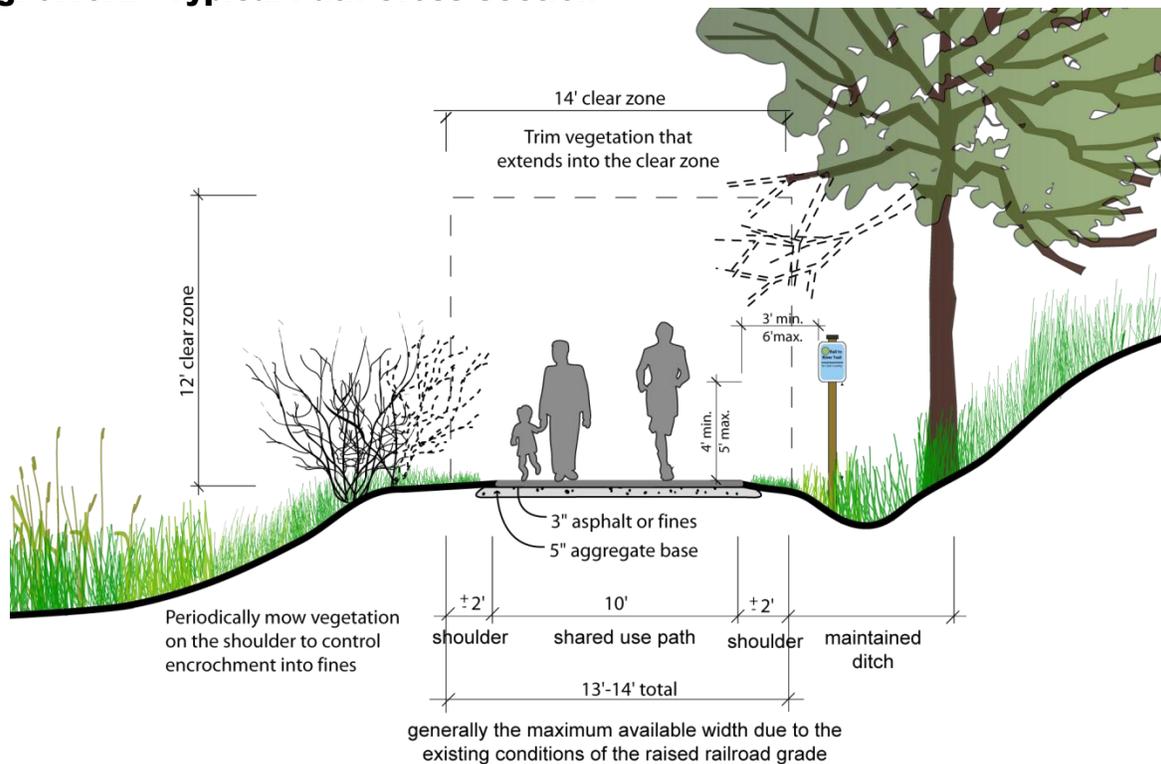
Independent pathways should be designed to accommodate shared uses including cyclists, walkers, strollers, in-line skaters, and people in wheelchairs. For the safety of all users, the pathway should be built wide enough to accommodate these shared uses. AASHTO guidelines indicate that a 10’ wide path is the minimum width for a Shared-Use path. The preferred minimum width is 12’ in most cases in urban areas with 14’ to 16’ being common widths.

Studies done by the Rails-to-Trails Conservancy have shown that off-road pathways in general are quite safe from a personal safety standpoint. But in urban areas it is important that pathways follow the principles of Crime Prevention Through Environmental Design (CPTED).

Trail Cross Section Design Guidelines

Figure 9.11A below illustrates several key points about the design and maintenance of Shared-Use paths. Whether the surface of the path is asphalt, fines or other material, it should have a solid base and positive drainage as the path may have maintenance vehicles on it at all times of the year. The vegetation along the trail should be regularly trimmed and mowed to maintain a clear zone around the trail.

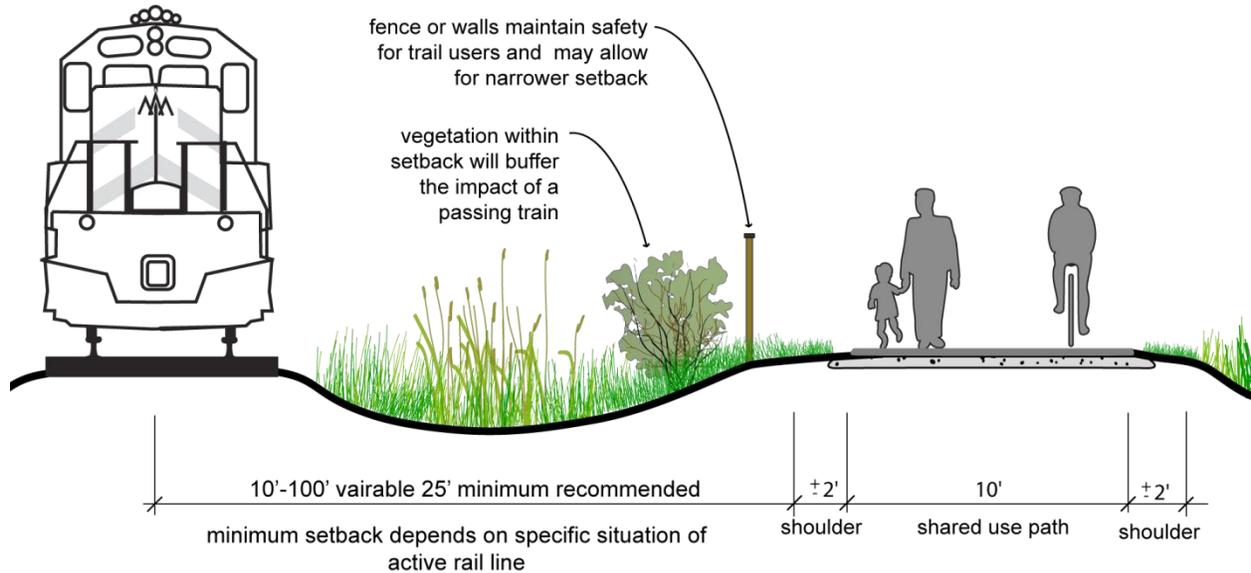
Fig. 9.10A. Typical Path Cross Section



Rail with Trail Design Guidelines

Figure 9.11B below illustrates how a trail can be incorporated alongside an active railroad. These may be built on an easement within the railroad right-of-way or on property immediately adjacent to the railroad. The trail may be separated from the railroad by a fence where the trail is in close proximity to the railroad.

Fig. 9.10B. Rail with Trail Cross Section



Key Recommendations:

- The 10' to 100' potential setback distance from an active rail line responds to the specific situation of the rail line (i.e. type, speed and frequency of trains, right-of-way width, level of separation, sight lines and topography)
- A minimum of 25' setback with a fence is recommended.
- Vegetation planted within the setback zone provides an additional level of security and buffers the impact of a passing train

For further information please refer to the following resources:

- U.S. DOT federal Highway Administration 2002 “Rails-with-Trails: Lessons Learned, Literature Review, Current Practices, Conclusions” at, www.fhwa.dot.gov/environment/rectrails/rwt
- Rails to Trails/National Park Service 2000 “Rails with Trails, Design, Management, and Operating Characteristics of 61 Trails Along Active Rail Lines at, www.railstotrails.org
- California 2009 “Rails-with-Trails: A Survey of Trails Along Active Rail Lines” at www.railstotrails.org



Allegheny Highlands Trail, Maryland
www.railstotrails.org

Independent Pathway / Road Intersection Design Guidelines

Independent pathways often intersect roadways at unsignalized mid-block crossings. Many of the design guidelines for a typical mid-block crosswalk apply but because of the unique nature of independent pathways, several additional safety points must be considered. The following plan illustrates the key points needed for a safe design of the intersection of an independent pathway with a roadway:

- Clear signage that identifies user rights-of-way and notifies both the users of the pathway and the motorists that an intersection is approaching.
- Pavement markings at the beginning of the trail intersection notify users of direction of travel and rights-of-way. Pavement markings further along the trail should be minimized to avoid visual clutter.
- The pathway should meet the roadway at as close to a 90-degree angle as possible for maximum visibility of users.
- Supplemental trail signage is often set back outside the road right-of-way.
- Regardless of the surfacing material of the trail, asphalt or concrete should be used for the portion of the trail that intersects the road. The hard surface increases traction for bicycle users and cuts down on debris from the shoulder of the road accumulating in the pathway. The change in materials can also help to notify users of the upcoming intersection. At rural intersections, gravel shoulders should also be paved adjacent to the trail to minimize debris in the stopping zone.

Fig. 9.10C. Typical Pathway/Roadway Intersection

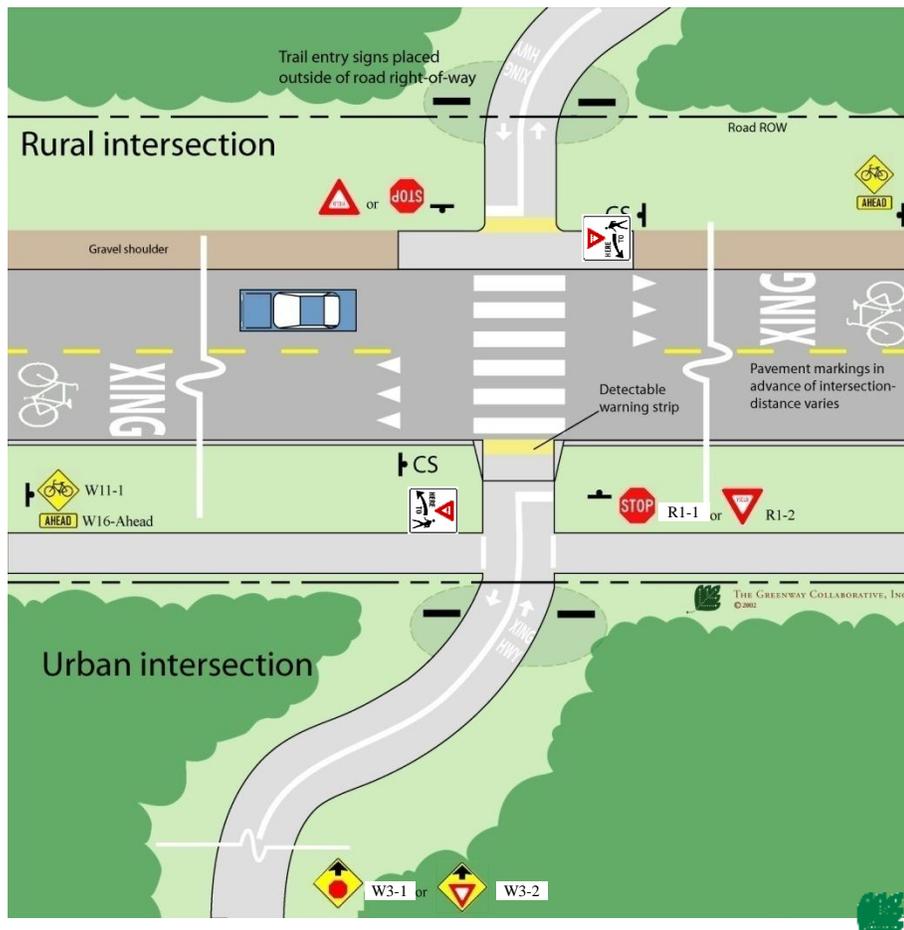


Fig. 9.10D. Trail Signs at Road Intersections
Trail View



Key Recommendations:

- Two sign posts form a gateway to the trail at road intersections.
- On the right above a Stop or Yield sign, a standard street name sign is used to identify the cross street.
- All parts of the signs should be set back 3' from the trail.
- On the left side, an optional plaque identifies the local agency in charge of the trail, trail rules, and emergency and maintenance contact numbers.

Road View



Key Recommendations:

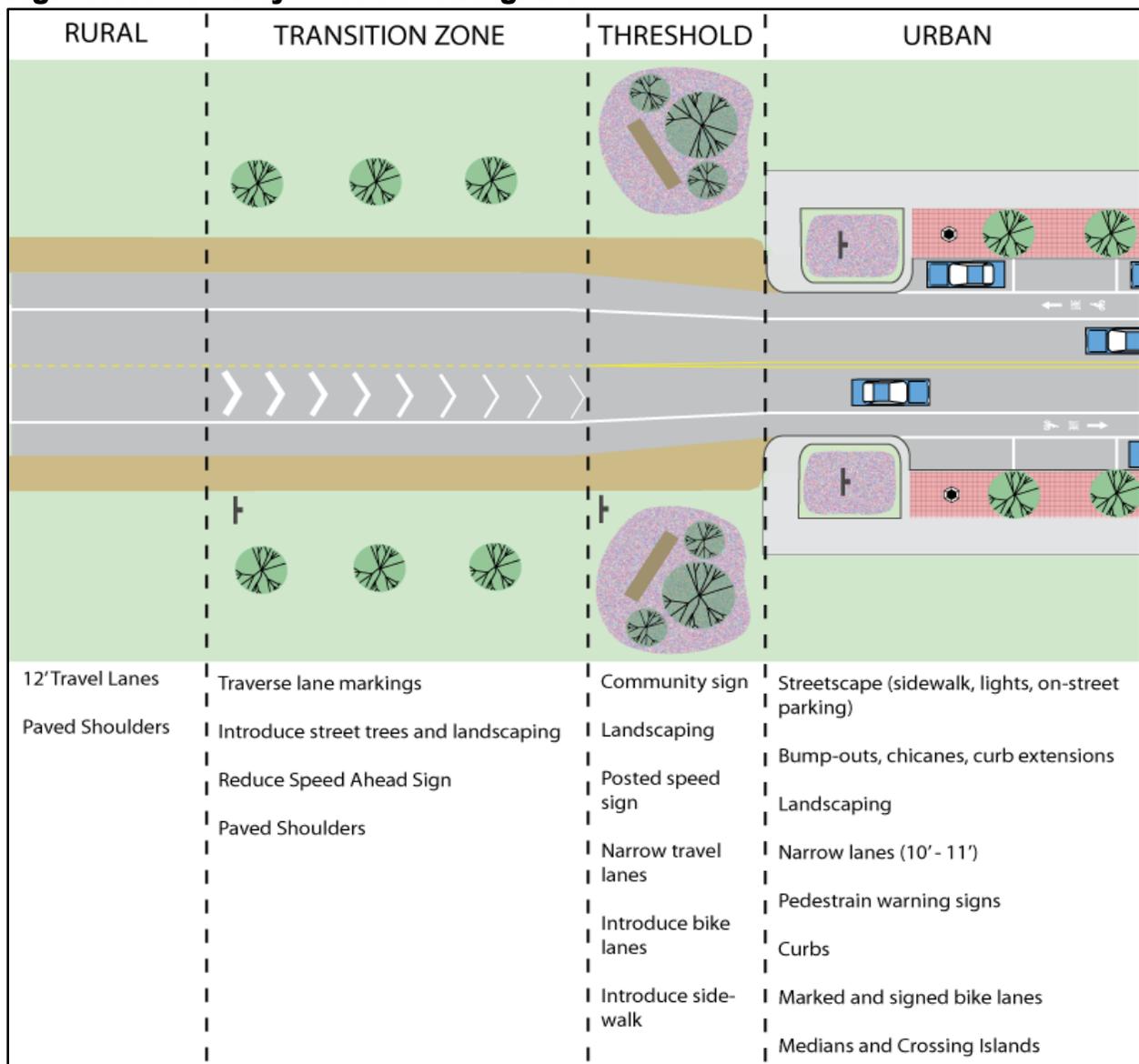
- On the right side, a No-Motor-Vehicle Sign and a Bicycle Yield-to-Pedestrian Sign should be posted to address the key rules of the trail.
- On the left side, a Bike Route Destination sign listing the direction and distance to the next major destination may be placed.
- On the left side, the Bike Route Identification Sign with a custom logo, direction of travel and route name may be used to identify the route.
- A detectable warning strip should be placed across the entire trail.
- Pavement markings should be used for the first 100' to 150' of trail.

9.11 Gateway Transition

Many times the main roadway that cuts through a small community is also a major roadway. In these situations it is difficult for motorists to transition from 55 mph to 30 or 25 mph. When this situation occurs it is important to visually and physically establish a gateway to the community so motorists know they are entering an urban environment and should slow down their speeds. Elements such as traverse lane markings, street trees, landscaping, signage, and narrow travel lanes help to establish the gateway.

Gateway treatments should be used when a roadway changes from a rural to an urban setting and needs to provide a slower environment for non-motorized users. Many of the small villages and communities in Isabella County could benefit from these types of improvements. Figure 3.2E displays the types of elements that may be applied in each zone to encourage the appropriate motor vehicle speeds.

Fig. 9.11A Gateway Transition Diagram



9.12 Commercial Centers

Many new commercial, office, institutional and mixed use developments being built today are designed for easy access by motor vehicles and do not take into adequate consideration the patrons arriving by other means of travel. Aspects of site design can discourage non-motorized traffic when designed solely for automobile use. New developments today often have poorly placed bike-parking facilities, large setbacks with parking lots that lack direct access for pedestrians or bicyclists and face large arterial roadways with little or no direct access to neighborhoods and residential areas that may be surrounding them. These problems can be remedied by improving site design and enhancing connections to the external transportation system.



Most commercial developments are oriented to motor vehicles, resulting in an often oppressive environment for pedestrians and bicyclists.

Circulation within the Site

Buildings with frontages located near the street create a streetscape that is comfortable and accommodating to pedestrians, and help keep traffic moving at slower speeds. Parking to the side or the rear of the building keeps the streetscape intact, allows easy access for pedestrians from adjacent sidewalks and minimizes automobile and pedestrian conflicts. As the building frontages are moved back from the streetscape to accommodate parking, the pedestrian's sense of exposure to traffic, the distance they must walk to access the store, and their resulting discomfort substantially increases.

Setback of the building frontages from adjacent intersections also complicates pedestrian travel across the roadways. Typical development patterns are "L" shaped with the majority of buildings set back from the intersection and one or two isolated buildings near the intersection. This pattern places the majority of the buildings away from the primary pedestrian crossing point and puts a large expanse of parking between the isolated buildings on the corner and the majority of the buildings. Depending on the development across the street, "L" shaped developments can set up strong pedestrian desired lines across mid-block locations. Because of the large scale of most of these developments, the distance between the desired lines and the signal is significant.

If orienting proposed development projects to improve non-motorized uses is not a feasible option in designing the layout of the buildings, then providing clear, direct and safe pedestrian access at mid-block locations is necessary to minimize out of direction travel through or around the parking lot by pedestrians. Parking lots can be dangerous areas for pedestrians and present many challenges for safe navigation. Older adult pedestrians have a high incidence of accidents involving vehicles backing up, a common maneuver in parking lots.²⁵ Site plans should be required to include the following design measures:

- Reduce building setbacks as much as possible and provide walkways to the entrances that are clearly marked, accessible and buffered from the surrounding parking lot.
- Use raised crosswalks and striping to clearly differentiate the walkways from driveways. Speed tables and raised crosswalks can calm traffic and increase visibility.

²⁵ National Highway Traffic Safety Administration. *Pedestrian Safety for the Older Adult*.

Fig. 9.12A. Typical Commercial Center at Intersection of Main Roads

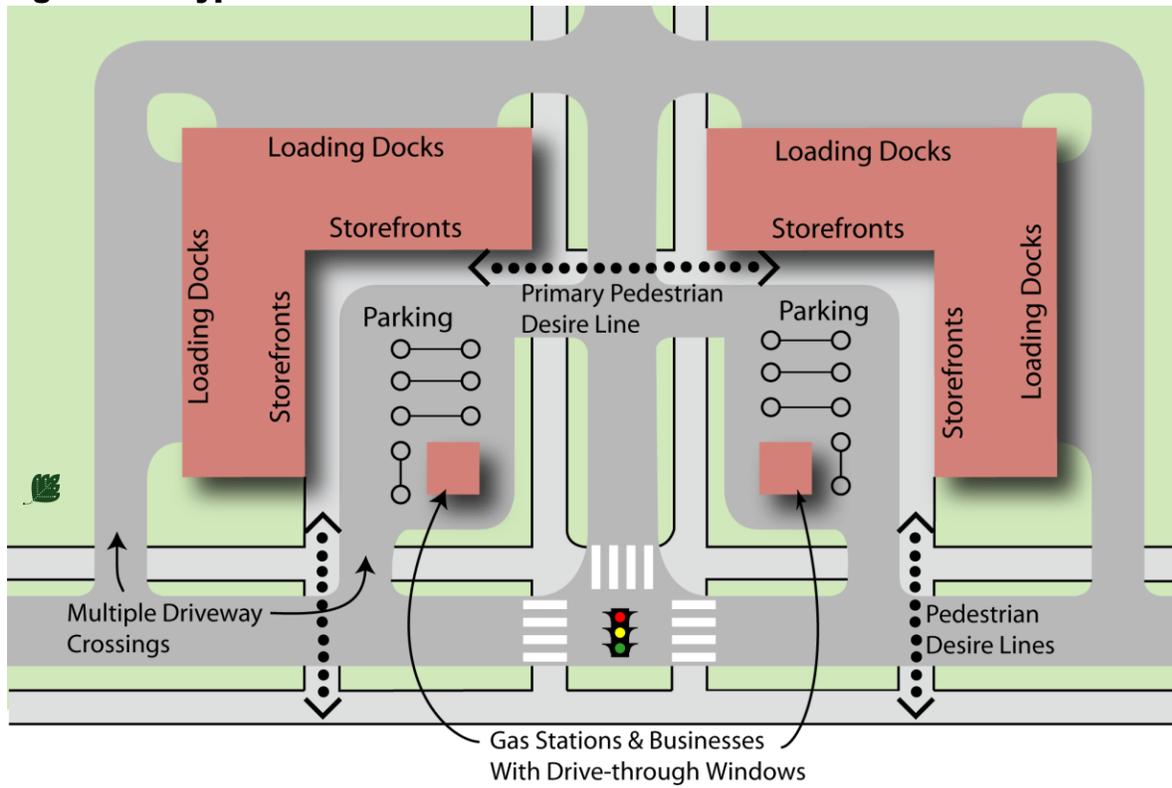
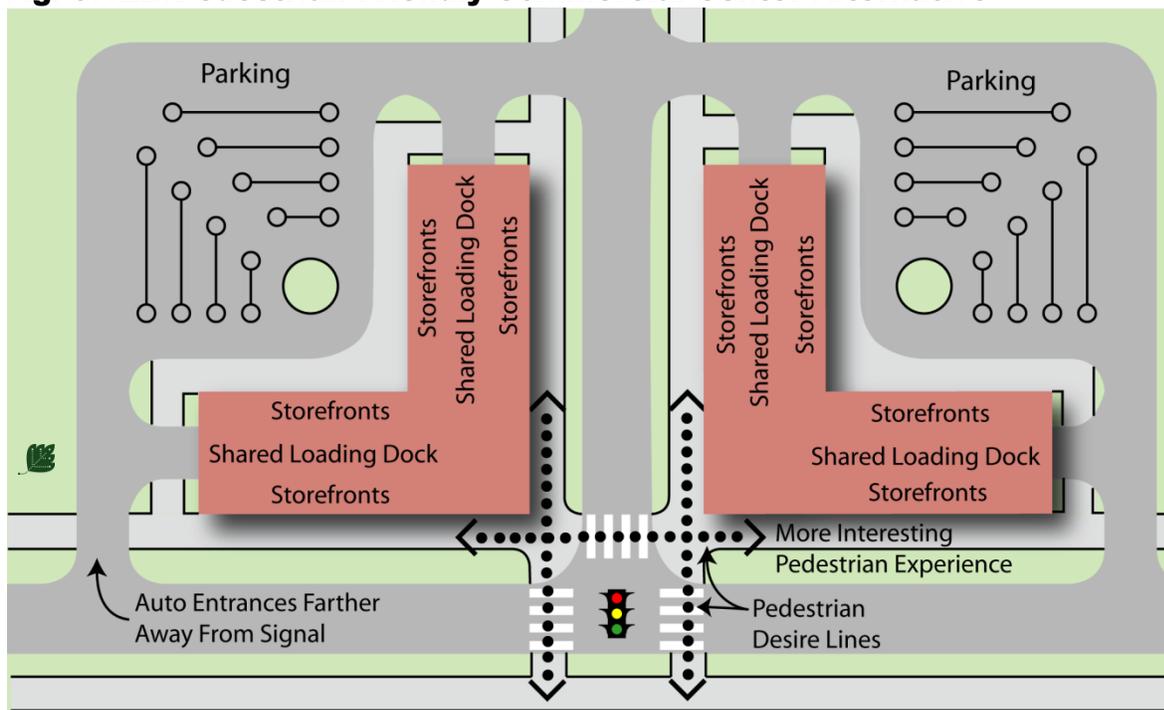


Fig. 9.12B. Pedestrian Friendly Commercial Center Alternative



- Provide trees and other plantings to buffer pedestrians from parking areas, enhance parking lot aesthetics, and minimize the pedestrian's exposure to the elements while crossing the vast expanse of pavement.
- Walkways should have direct and clear access to building entrances and be designed to safely go through the parking lot, or circumnavigate it if necessary.
- Walkways along the buildings should be wide enough to accommodate several people abreast and have frequent curb cuts and ramps for accessibility, as well as tactile and audible pedestrian information.

Just as pedestrians need direct and clear access through the parking lots to the buildings, bikes should also be safely directed through the parking lot. Bike parking should be provided in a visible and convenient location. Many cyclists are reluctant to lock their bikes in an area that is out of the way and unfrequented because of the greater likelihood of theft. This leads to situations where bikes are locked to anything available such as signposts or railings. These bikes can cause hazards for pedestrians and obstacles to accessibility. Providing bike parking facilities in convenient and well-lit locations will minimize these problems.

The site plan review process will allow the City to ensure that these design measures are followed. The City should require that developers include these specific pedestrian and bike accommodations early in the site planning.

Connections to the External System

The site must have convenient and safe access to pedestrian, bicycle and transit facilities outside the development. Frequently, large new developments are located on the edge of town along major arterials with limited non-motorized facilities. New developments should always connect to an existing non-motorized transportation network. Commercial developments should include specific plans for connecting to existing facilities and neighborhoods in surrounding areas.

Motor vehicle access to commercial development should be constructed as a conventional driveway with small turning radii and a ramp up to the sidewalk level, rather than a typical public intersection where the roadbed continues at the same level and there are curbs on either side. Use of driveway entrances rather than typical intersections enhance pedestrian safety and comfort because motorists must drive slowly when entering and exiting the development. When a typical intersection-style entrance is used, the sidewalk should continue across the entrance, preferably at sidewalk height, so the right-of-way is clearly established and motorists understand they are entering a pedestrian area. Supplemental signage and crosswalk pavement markings should be used to indicate a crosswalk and the pedestrian right-of-way.

Plantings should be pulled back away from the entrance crossings to allow maximum visibility for both pedestrians crossing the entrance and the cars entering the commercial development. The radius of the intersection curb should be kept as small as possible, and the width of the driveway should be the minimum needed. Just as roads are updated to accommodate vehicular access at new developments with turning lanes or signals, so should non-motorized facilities be updated with new crosswalks, signage and pedestrian signals.

New roadway designs often favor access control for businesses along the road. In this scenario, several businesses share access through one driveway instead of each business having its own entrance and exit onto the main street. In addition to the advantages for vehicles, this is an advantage for the lateral movement of pedestrians along the street because they do not have to cross as many driveways.

However, more direct pedestrian access points from the sidewalk to the individual building entrances should be incorporated. The spacing of crosswalks along the primary road to developments across the road should also be considered.

The design and placement of the buildings should allow direct and clear access from surrounding neighborhoods and residential areas. Too often, what could be a short walk to a nearby store from a residential street becomes dangerous and un-navigable because the store does not have public access on the side facing the residential streets. Both pedestrian and bicycle access should be unimpeded from these areas. During site plan evaluation, development access and travel distances from surrounding residential areas should be a prime consideration.

Encouraging Mixed Use

While tying commercial developments to surrounding residential areas is a good practice, a better practice is to eliminate the segregation of commercial and housing areas. Incorporating higher density housing into commercial developments can dramatically alter the character of commercial development making the project more similar in feel to a small downtown rather than a strip development. For more information see the Land Use Considerations in the next section. Mixed land uses can significantly increase the number of non-motorized trips.

Site Design Checklist

A site design checklist or similar tool should be provided to developers and used by the City in their review of site plans to make sure that bicycle and pedestrian issues are being adequately addressed. The following checklist was adapted with minor modifications from *The Canadian Guide to Promoting Sustainable Transportation through Site Design* by the Canadian Institute of Traffic Engineers. It is a part of a larger publication that looks at site design issues more fully.

Land Use & Urban Form Checklist:

- Densities are sufficient to support transit (3 to 7 households an acre / 4 to 7 jobs an acre)
- Highest density land uses are located close to activity nodes such as transit corridors and intersections.
- Proposed use provides or adds to a diversity of land uses in the surrounding area and does not result in large tracts of similar uses.
- Proposed use is compatible with adjacent land uses and with long term land use plans for the area.
- Adjacent street network provides for connectivity of transit, cycling and pedestrian routes.
- Mixed uses help support non-motorized transportation.

Safety & Security Checklist:

- Overall site design attempts to minimize conflict points between vehicles, pedestrians and cyclists.
- Sight distances have been considered in overall site design and in the placement of entry signs and landscaping.
- Consideration has been given to personal security for pedestrians, cyclists and transit users.
- Buildings are located close to the street, but provide adequate clearance for pedestrian activities along street frontage.
- Where appropriate, retail, restaurants and other pedestrian oriented uses animate the street frontage.

Building Entrances Checklist:

- Building entrances are located close to the street, with direct pedestrian access.
- Potential conflict points between users arriving by different modes are minimized.

Internal Transportation Network Checklist:

- Roads and paths match up with surrounding networks and ensure direct connections through the site for cyclists and pedestrians.
- Block lengths are limited and mid-block crosswalks are provided where appropriate.
- Traffic-calming principles are applied, where appropriate (proper site design should avoid the need to apply extensive traffic calming).
- Appropriate measures have been taken to ensure easy progress of transit through the site.

Desired Pedestrian & Cyclist Routes Checklist:

- Safe, continuous and clearly defined routes for pedestrians and cyclists are provided along desire lines including links to surrounding residential areas.
- Weather protection and amenities such as trees are provided.
- Intersections are designated to facilitate pedestrian and cyclist crossings.

Transit Stops Checklist:

- Walking distances to stops do not exceed 1300 feet, and pathways to stops are safe and direct.
- Waiting areas are well lit and attractive.

Site Grading Checklist:

- Terrain along pathways is kept reasonably level, and ramps are also provided wherever stairs are necessary.
- Slopes along pathways are designed to avoid the ponding of slush and water.

Motor Vehicle Parking Configuration & Treatment Checklist:

- Off-street parking is located away from the street, preferably behind buildings or underground.
- Vehicle access is separate from pedestrian access, and access and egress controls are designed so vehicles do not block pedestrian ways.
- Parking lots are kept small and designed to prevent speeding.
- Pedestrians have protected walkways through the lots.

Motor Vehicle Parking Supply & Management Checklist:

- Off-street parking should be provided, where necessary, at the sides and rear of buildings.

Bicycle Parking Checklist:

- Bicycle parking is located near entrance for short term users in a high visibility location.
- Weather protected bicycle parking for longer term users is provided in a secure area. Storage possibilities for gear are considered.
- Showers, changing rooms and lockers are provided within employment centers.

Passenger Pick-up & Drop-off Areas Checklist:

- Passenger pick-up and drop-off areas are located to the side or rear of buildings, downstream from the entrance, but no more than 100 feet away from it.

Loading Areas Checklist:

- Loading areas are located off the street, and are screened from public view.
- Loading area access is designed so that pedestrian, cyclist, and transit routes are never severed.

Internal Road Design Checklist:

- Appropriate traffic signals and compact geometry of intersections control speeds and allow for safe passage of cyclists. Roads are designed to cross at right angles. Sight lines are respected.
- Lanes are designed to accommodate motor vehicles and cyclists, and remind users of the other networks on the site.
- Facilities for cyclists and sustainable modes are provided and continued across the site.

Pedestrian Facilities Checklist:

- Sidewalks are provided along all roads, and follow pedestrian desire lines where possible.
- Properly signed crossings are provided wherever a path or sidewalk crosses a road.
- Pathways are clearly defined, delineated, and are of a sufficient unobstructed width. Appropriate amenities such as lighting and weather protection are provided and safety along path is addressed.

Transit Facilities Checklist:

- Stops are located close to the main entrances of activity generators. Crosswalks are provided at all stops.
- Stops and waiting areas are properly illuminated, visible from a distance, and have warranted amenities such as shelters and benches.
- Spacing between stops is minimized.
- Shelters and rest areas are provided at transit stops and locations where there is a high number of users, the elderly or the disabled.
- Shelters and rest areas are identifiable, accessible, placed appropriately, and are comfortable.

Wayfinding Checklist:

- Appropriate signage and physical features are provided for users of all networks to determine their location, identify their destination, and progress towards it.

Street Furniture & Amenities Checklist:

- Amenities are provided to create a comfortable and appealing environment, pre-empting litter and responding to user needs.

Landscaping Checklist:

- Landscaping does not compromise user security and safety.