N.B. This draft has been prepared for the City's review and ease of editing. Once edits have been received, the document will be transferred into a graphically-compelling layout with complete photographs, captions, and tables.

APPENDIX A – DESIGN AND MAINTENANCE RECOMMENDATIONS

INTRODUCTION

The guidance in this appendix is intended to serve as a guide for implementation of the Bicycle Master Plan. Design guidance in this document is based on the *Manual on Uniform Traffic Control Devices* (MUTCD), 2009; the American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities,* 2012; and the National Association of City Transportation Officials (NACTO) *Urban Bikeway Design Guide,* 2012. Guidance in this document is consistent with these manuals. Application of guidance in this document requires the use of professional engineering judgment.

DESIGN

Preference surveys and research studies have found widespread support and interest for bicycling with strong preferences given to the provision of high quality bikeways which provide the following elements:

- Separation from high volumes of fast-moving automobiles
- Maneuverability within the bikeway to operate safely
- Space for cyclists to ride together in a social manner, side-by-side.

> The quality of bicycle facilities has a direct impact on the overall experience of the user, and will therefore have a tremendous influence on the ability of the facility to sustain and attract high levels of ridership.

These qualities are routinely provided on trails, and are increasingly provided on streets through the provision of bicycle lanes, protected bicycle lanes, or bicycle boulevards. Well-maintained, high quality facilities have been demonstrated to attract higher levels of use than poorly maintained or low quality facilities. Likewise, interconnected systems with minimal gaps or interruptions are essential to a functioning bicycle system that supports and attracts high use.

ROADWAY DESIGN STRATEGIES FOR ACCOMODATING BIKE FACILITIES

LANE WIDTHS

Travel lane narrowing is one of the retrofit methods recommended to implement the planned network. Travel lane widths were observed to vary from 10 feet to 17 feet throughout the City on all classifications of roadways. Some streets appeared to have wide lanes where parking lane stripes are not provided and parking demand is low. For bicycle lanes or separated bikeways to be retrofitted onto some Yakima streets, existing travel lanes may need to be narrowed.

Providing wide travel lanes has not proven to provide any safety benefits on low speed urban roadways,[1] whereas wider parking and bike lanes reduce the potential for a hazardous crash between a bicyclist and an opening vehicle door. Wider bike lanes create enough space to allow a bicyclist to pass another bicyclist without having to encroach into the adjacent travel lane. The resulting bicycle lane is more comfortable and is more likely to attract use.

The 2011 AASHTO Green Book states "lane width of 10 feet may be used in more constrained areas where truck and bus volumes are relatively low and speeds are less than 35 mph."[2] This is backed up by recent research[3] focused on the safety of travel lane widths varying between 10 and 12 feet for motorists operating on arterial roadways with posted speeds of 45 mph or less. This research found lane width had no impact on safety or capacity under the majority of urban conditions. The study resulted in a virtual elimination of the capacity reduction formula in the 2010 Highway Capacity Manual related to lane widths as it found little difference between 10, 11 and 12 foot lanes.

The AASHTO Green Book is vague with regard to defining what percentage of truck and bus volume is "low" however there is guidance in research and pavement design guidelines that suggest 10% as a decision point.[4]

FOUR TO THREE LANE CONVERSIONS

Another strategy for adding bicycle facilities to the existing road network is converting a four-lane road to a three-lane road; two travel lanes in each direction and a two-way center turn lane (sometimes called a road diet). In addition to providing space for bicycle lanes, this type of restriping can reduce all

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[1] Potts, Ingrid, Harwood, Douglas and Richard Karen, "Relationship of Lane Width to Safety for Urban and Suburban Arterials, TRB 2007 Annual Meeting

[2] 2011 AASHTO Green Book, Urban Arterial Travel Lane Widths, page 7-29

[3] Potts, Ingrid, Harwood, Douglas and Richard Karen, "Relationship of Lane Width to Safety for Urban and Suburban Arterials, TRB 2007 Annual Meeting

[4] TRB Special Report 214 – Designing Safer Roads, 1987. It is important to note this report documented research proving wider travel lanes increased safety, but this research was only based on rural, 2 lane highways.

types of crashes and lower the amount of speeding on a roadway. Road diets must be carefully considered within the context of the larger transportation system. However, studies have shown that "well-designed road diets do not divert drivers onto other roads. Many roads actually experience an increase in vehicle traffic after a successful diet."[5] Roads with Average Daily Traffic (ADT) volumes of up to 20,000, and in certain cases, higher, are appropriate candidates for a conversion. Yakima has already successfully re-channelized several roads in this manner.

IMAGE: ROAD DIET

FACILITY TRANSITIONS

Corridors that effectively accommodate bicycles often combine multiple facility types due to existing roadway conditions, surrounding land uses, available right-of-way, and other characteristics. While consistency of facility type is desired, when it is not feasible, transitions between facilities should be functional, intuitive, and as infrequent as possible. Properly engineered transitions will invite proper use. For example, a path that transitions to an on-street facility should provide signage, markings, curb cuts, and crossing treatments that direct bicyclists to the correct side of the street to reduce wrong-way riding.

IMAGE: TRAIL TRANSITION

FACILITY TYPES

This section provides design guidance for on-street bicycle facilities, off-street facilities, and crossing (intersection and mid-block) treatments that are recommended for the City of Yakima bicycle network.

PAVED SHOULDERS

Paved shoulders are most often used on rural roadways. Paved shoulders provide space on the outside of travel lanes for bicycle and pedestrian use. Paved shoulders should be a minimum of four feet without the curb; five foot minimum with a curb. Additional space is recommended if motor vehicle speeds exceed 50 mph or if heavy trucks, buses, or recreational vehicles often use the road.

IMAGE: PAVED SHOULDER

SHARED LANES

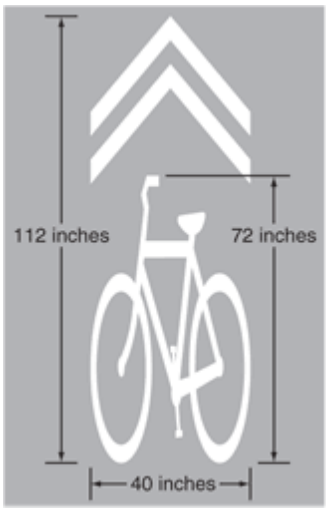
By default, all lanes of all roads where bicycles are not prohibited are shared lanes. When a higher level of guidance and awareness is desired, such as in an urban bikeway network where bikes are likely to be present, a shared-lane marking may be used. A shared-lane marking is a pavement symbol consisting of

[5] Road Diets, a Livability Fact Sheet. AARP, Walkable and Livable Communities Institute.

a bicycle with two chevron markings above it that is placed in the roadway lane indicating that motorists should expect to see and share the lane with bicycles, and indicating the legal and appropriate line of travel for a bicyclist. In general, shared-lane markings are installed on streets where there is not enough space for bicycle lanes or when bicycle lanes are not appropriate due to low speeds or volumes (e.g., on bicycle boulevards). According to the 2012 AASHTO Guide for the Development of Bicycle Facilities and the MUTCD, shared lanes are not appropriate for roads with speed limits over 35mph.

Unlike bicycle lanes, they do not designate a particular part of the roadway for the exclusive use of bicyclists. The purpose of shared-lane markings is to:

- Assist bicyclists with lateral positioning in a shared lane with on-street parallel parking in order to reduce the chance of a bicyclist's impacting the open door of a parked vehicle
- Assist bicyclists with lateral positioning in lanes that are too narrow for a motor vehicle and a bicycle to travel side by side within the same traffic lane
- Alert road users of the lateral location bicyclists are likely to occupy within the traveled way
- Encourage safe passing of bicyclists by motorists
- Reduce the incidence of wrong-way bicycling.



Shared lane markings may be considered in the following situations:

- On arterial streets with a posted speed limit of 35 mph or less, where space constraints and operations make it unfeasible to provide a bike lane.
- On low speed, low volume arterial street sections where gaps exist between two other bicycle facility types to create an on-street bike network connection.
- On bicycle boulevards as a form of on-street wayfinding.
- On low speed, low volume arterial streets with on-street parking, to help position bicyclists to avoid collisions with car doors opening into the travel lane.

SHARED LANE MARKING PLACEMENT

CONSIDERATION FOR SHARED LANE MARKING PLACEMENT WITHIN A TRAVEL LANE

The center of shared lane markings should be located a minimum of 11 feet from the curb or edge of roadway at locations where parking is permitted adjacent to the travel lane. The center of shared lane markings should be located a minimum of 4 feet from the curb or edge of roadway at locations where parking is prohibited.

It may be appropriate to move the shared lane marking towards the center of the travel lane if engineering judgment determines that this placement will enhance the safety of the bicyclist operating within the travel lane. In most cases, it will be a combination of two or more of the following factors

which will indicate that consideration should be given to moving the Shared Lane Marking towards the center of the travel lane:

- Travel lane is less than 12 feet in width
- Number of travel lanes (it may be desirable to place the shared lane marking towards the center of a narrower outside travel lane when a center turn lane is present or when there are multiple travel lanes in the same direction)
- Grade of roadway and expected bicyclist speed (center lane placement often works well when going downhill on streets with grade and higher bicycle speeds).

IMAGE: SHARED LANE MARKING

SITUATIONS WHERE TRAVEL LANES ARE LESS THAN OR EQUAL TO 12 FEET IN WIDTH

Shared lane markings should be placed in the center of the travel lane where travel lanes are less than 12-13 feet to encourage bicyclists to occupy the full lane and not ride too close to parked vehicles or the edge of the roadway. A BIKES MAY USE FULL LANE (R4-11) sign may be used to supplement the marking. Travel lanes of this dimension are too narrow for sharing side by side with vehicles, although 13 foot lanes may appear shareable to road users.

IMAGE: BIKES MAY USE FULL LANE

SITUATIONS WHERE TRAVEL LANES ARE GREATER THAN OR EQUAL TO 13 FEET IN WIDTH

Where travel lanes are 13 feet or wider, motorists will generally be able to pass bicyclists within the same lane or will only need to slightly encroach on adjacent lanes to pass bicyclists. The Shared Lane Marking should generally be located in the right portion of the lane (per the MUTCD minimum requirements) with exceptions for locations adjacent to parking where it is desirable to encourage riding further from parked vehicles. A Share the Road sign (W11-1 AND W16-1P) may be used to supplement the marking.

Research has shown placing the marking in the center of travel lanes wider than 13 feet will likely result in poor compliance by bicyclists who will travel in the right portion of the lane which may undermine the effectiveness of shared lane markings in narrower lanes. Lanes 15 feet or wider generally should not use shared-lane markings, and should instead be marked with a 10 foot travel lane and a 5 foot bike lane.

CONSIDERATIONS FOR SYMBOL PLACEMENT FREQUENCY

Shared Lane Markings should be placed at the far side of an uncontrolled intersection, at both sides of an arterial intersection with traffic control, and at mid-block locations where block faces are more than 250 feet long.

When placing mid-block shared-lane markings, they should be placed in such a manner that the first shared-lane marking a bicyclist or motorist would come upon would in their direction of travel.

Where there are mid-block marked crosswalks, the tip of the chevron should be placed 25 feet beyond the far side of the marked crosswalk.

CLIMBING LANES

Climbing lanes are bike lanes provided only on the uphill side of the street. Bicyclists travel uphill at significantly slower speeds than motor vehicles, and therefore benefit from the presence of a separated lane. Climbing lanes may be used on any street with an uphill grade and insufficient space for bicycle lanes on both sides of the street. Shared-lane markings are provided on the downhill portion of the street. Climbing lanes are not appropriate on streets with rolling hills because lane shifts and transitions would potentially confuse both bicyclists and motorists.

BIKE LANES

Bike lanes designate a portion of the roadway exclusively for bicyclists, and encourage bicyclists to ride with traffic where they are visible to motorists. Bicyclists are not required to ride in bike lanes; a bicyclist may need to leave the bike lane to make a turn, avoid debris or potholes, avoid conflicts with other road users or pass another bicyclist.

In order to maximize bicyclist comfort and reduce potential conflicts associated with opening car doors, bike lanes should be as wide as feasible, with a minimum of 5 feet. Whenever possible, parking lane width should be minimized to increase bicycle lane width. Where there is space for wide bike lanes, buffers may be added to discourage driving or parking in the bicycle lane (see “Buffered Bike Lane”).

The surface of the bike lane should be smooth, stable and slip resistant. Longitudinal or frequent horizontal seams can reduce the quality of the riding surface. Concrete joints should be saw-cut to provide a smooth riding surface, and utility covers should be flush with the bicycle lane surface. Standard bike lane symbols and arrows shall be provided in bike lanes.

HEAVY VEHICLES

On streets with significant heavy vehicle volume and bicycle facilities, consideration should be given to lane widths to prevent heavy vehicles encroaching on the bicyclist’s path. Where possible, buffered or separated bicycle facilities should be used for bicycle facilities on heavy vehicle routes and design should accommodate safe crossings at driveways and to minimize conflict points.

BUFFERED BIKE LANES

image: buffered bike lane

Buffered bike lanes provide distinct advantages over merely providing a wider bike lane. Buffered bike lanes appeal to a wider cross-section of existing and potential bicycle users, provide greater shy distance between motor vehicles and bicyclists, provide space for bicyclists to pass one another without encroaching into the adjacent motor vehicle travel lane, and provide a greater space for bicycling without making the bike lane appear so wide that it might be mistaken for a travel lane or a parking lane.

The preferred location of the buffer is between travel lanes and bike lanes. The buffer may be placed between the bike lane and parking lane where parking turnover is high or on extended downhill segments where bicyclist speeds can be expected to be higher than normal.

Buffer width should be a minimum of 18 inches. On streets with speeds 35 mph or greater, buffer width should be increased and a physical separation element should be used. Buffer zones 4 feet or greater in width should be marked using a chevron pattern as depicted in Chapter 3D of the MUTCD 'Markings for Preferential Lane.' Otherwise a diagonal crosshatch may be used.

PROTECTED BIKE LANES

A protected bike lane, sometimes called a separated bike lane or a cycle track, is a bicycle facility that is physically separated from both the roadway and distinct from the sidewalk. A protected bike lane can be constructed at the roadway level or the sidewalk level.

Roadway Level - Uses roadway space and must be separated from motor vehicle traffic. Separation methods include curbs, raised concrete medians, bollards, on-street parking, large planting pots/boxes, landscaped buffers (trees and lawn) or other methods.

IMAGE: roadway level PBL

Sidewalk Level – Uses space adjacent to the sidewalk and must be separated from pedestrian traffic. Separation methods include different surface treatments, street lighting, plants, etc.

IMAGE: sidewalk level PBL

Intersections where protected bike lanes are present require engineering consideration to ensure appropriate sightlines and yielding behavior. Intersection treatments include restricting turns or using signaling to temporally separate right and left turning vehicles from through bicyclists, and shared turn lanes. The NACTO *Urban Bikeway Design Guide* includes several intersection solutions for protected bike lanes.

By separating bicyclists from motor traffic, protected bike lanes can offer a higher level of safety and comfort than bike lanes and are thus attractive to less confident cyclists. Typical applications for protected bike lanes include:

- Streets with high bicycle volumes

- Streets on which bike lanes would cause all but the most skilled bicyclists to feel stress because of factors such as multiple lanes, high traffic volumes, higher speed traffic, high incidence of illegal parking in the bike lane, and high parking turnover
- Recreational corridors, scenic corridors, or parkways that are part of a regional trail system
- As part of a bicycle boulevard or trail system connection.

Protected bike lanes may be one-way or two-way. In general, one-way cycle tracks are preferred. Two-way cycle tracks may be appropriate for the following situations:

- Streets with few conflicts such as driveways or cross- streets on one side of the street.
- Streets where there is not enough room for a one-way cycle track on both sides of the street.
- One-way streets where contra-flow bicycle travel is desired for connectivity purposes.
- Streets where more destinations are on one side, thereby reducing the need to cross the street.
- As part of a trail or bicycle boulevard facility; for example, where a bicycle boulevard route uses offset residential roads.

BICYCLE BOULEVARDS

Bicycle boulevards will play an important role in Yakima's bicycle network. A primary objective of this Plan is to extend Yakima's trail network by supplementing trails with an on-street bicycling network. The types of riders that are attracted to trails will feel comfortable using bicycle boulevards that are properly designed.

Bicycle boulevards are typically located on non-arterial streets with low motorized traffic volumes and speeds. They include traffic calming measures to reduce vehicle speeds. Safe arterial crossings must be provided. People of all ages and abilities should feel comfortable biking and walking on these streets. Bicycle boulevards may serve as cross-city routes or as a segment of a bike route that includes other protected facility types (e.g., off-street trails or protected bike lanes). A bicycle boulevard may be developed as a parallel alternative to a busier street within the same district, but should generally not be provided in lieu of facilities on the busier street if that street is a more direct route to important destinations. Crosswalks, median islands, Rectangular Rapid Flashing Beacons, stoplights, and half-signals may be used to facilitate crossing major arterials that intersect the bicycle boulevard. The cost of construction will vary depending on the specific traffic calming and intersection treatments implemented.

IMAGE: BBLVD

DESIGN CONSIDERATIONS

There are a number of design considerations that should be made before implementing a bicycle boulevard (discussed below). Streets with existing low volumes (less than 1,000 ADT) are good bicycle boulevard candidates as they typically require minimal or no traffic diversion treatments. These streets

may only require traffic calming measures to get speeds down to 20-25 MPH and increase the comfort and safety of bicyclists. Where traffic volumes exceed 1,000 ADT, traffic reduction measures should be considered in addition to traffic calming measures. One of the most important elements of a bicycle boulevard is creating arterial street crossings that are accessible, safe, and comfortable.

Arterial Crossings

Bicycle boulevards commonly intersect arterial roadways at unsignalized locations. In some cases, they may utilize existing signals or require a new signal, depending on motor vehicle traffic volumes, speed limits, and width of the arterial roadway. Many intersection crossing treatments for bicyclists are based on pedestrian crossing signals, but require special consideration for bicycle operating characteristics such as bicyclist positioning, crossing times, and vehicle length. Crossing treatments including RRFBs, HAWKs, and half signals are included later in this chapter.

Bicycle Priority/Advantage

Design elements that prioritize travel on the bicycle boulevard are intended to raise awareness of the route as a bicycle priority thoroughfare and create conditions that reduce unnecessary delay for cyclists. Design treatments include pavement markings and wayfinding signage, adjustments to stop/yield control, and arterial crossing enhancements.

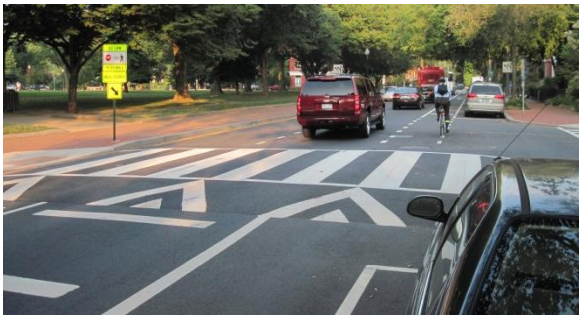
Employing distinctive symbols and/or colors to distinguish the bicycle boulevard from other roadway signs provides visual cues to motorists and cyclists that this is a different type of roadway. Supplementing wayfinding signage with pavement markings helps to further establish bicycle priority, and also encourages proper positioning by bicyclists while sharing the lane with motor vehicles. Yakima has several recommended bicycle boulevards that make frequent turns due to a disconnected street network. Shared-lane markings at intersections can help provide wayfinding and define the bicycle boulevard.

IMAGE: SHARED-LANE MARKING AT BICYCLE BOULEVARD TURN

Stop signs increase cycling time and energy expenditure due to frequent starting and stopping, and therefore tend to result in non-compliance by bicyclists. Bicyclists should be able to travel continuously for the entire length of the bicycle boulevard with a minimum of stops. Assigning stop or yield signs to control cross traffic is one way to minimize stops for bicyclists. Mini traffic circles may be an alternative to stop and yield controlled intersections. Parking may need to be removed near the intersection to improve sight distance of bicyclists and motorists approaching the intersection. After stop or yield signs are reoriented to cross streets to provide bicycle priority, an increase in motor vehicle volume or speed along the route may occur which reduces the comfort and safety of cyclists, negatively impacts the neighborhood, and negatively influences opinions regarding the utility of bicycle boulevards in general. Cut through traffic can be mitigated using traffic calming and diverting treatments.

Traffic Calming

• **Mini traffic circles at 4-way intersections**- Raised circular islands located in the center of intersections of local streets, intended to reduce speed of vehicles approaching the intersection while minimizing delay. Stop and yield signs may be eliminated when mini traffic circles are used. Signage indicating counter-clockwise circulation should be installed in advance and/or on the traffic circle.	
• **Mini traffic circles with Neckdowns at T-Intersection**. T-intersections require the use of smaller circles, limited parking restrictions within the circle, and approach neckdowns to deflect the movement across the top of the tee which otherwise could not be deflected by the circle.	
• **Chicanes** –Raised curb features in the middle of the road or along the edge that create horizontal shifting of travel lanes, which reduces vehicles speeds. Chicanes are typically used on long stretches of straight roadway and are ideal for approaches to signalized intersections where motorists may be inclined to accelerate towards the signal. A "chicaning" effect may also be achieved by alternating the location of on-street parking.	

• **Speed tables or raised crosswalks** - long and broad, flat-topped sections of raised roadway (3-4 inches high and 22 feet wide) that slow traffic by requiring motorists to reduce their speed. Speed tables are more comfortable than speed humps for bicyclists to ride over without reducing their speed. A 22 foot table has a motor vehicle design speed of 25 miles per hour.	
• **Speed cushions** – Similar in design to speed humps, speed cushions are rounded raised areas placed in the center of travel lanes to reduce vehicle speeds. They are generally 10 to 14 feet long (in the direction of travel) with. These are designed to allow free passage of larger chassis vehicles such as fire trucks through the flattened area.	
• **Speed humps** – Speed humps are rounded raised areas placed across the roadway to reduce vehicle speeds. They are generally 10 to 14 feet long (in the direction of travel).	
• **Remove Centerlines**—Studies have shown that motorists speeds are reduced[6] and	**IMAGE: CENTERLINE REMOVAL**

[6] Transport for London. Centreline Removal Trial. August 2014. https://tfl.gov.uk/cdn/static/cms/documents/centre-line-removal-trial.pdf

more room is given when passing cyclists when center lanes are not present.[7] The MUTCD recommends center lines on urban arterials and collectors that have an ADT of over 6,000 vehicles per day. Yakima has several residential streets with centerlines that are likely under this threshold. Where bicycle boulevards are proposed, centerlines are not recommended.	

Traffic Reduction

Traffic reduction design elements are intended to maintain existing low volumes or reduce the overall volume of motor vehicle through trips on the bicycle boulevard, while allowing continuous through travel by bicyclists and other non-motorized users. Impacts on nearby local streets and emergency response should be analyzed before implementing traffic reduction elements.

• **Partial Diverters** - Restrict motor vehicle access while allowing bicycle and pedestrian access, typically restricting through movements or left turns. This type of treatment is typically placed on minor streets at an intersection with an arterial street to manage motor vehicle volumes on the minor street.	
• **Diagonal Diverters** – restrict through motor vehicle access completely at standard 4-way intersections while allowing bicycle and pedestrian access. This type of treatment is typically placed at an intersection of two minor streets to manage motor vehicle	

[7] Shackel, S. C. and Parkin, J. (2014) Influence of road markings, lane widths and driver behavior on proximity and speed of vehicles over taking cyclists. *Accident Analysis & Prevention,* 73. pp 100-108.

volumes on the bicycle boulevard.	
• **Median Closures** – restrict through motor vehicle access to right-in right-out at standard 4-way intersections while allowing bicycle and pedestrian. This type of treatment is typically placed on minor streets at an intersection with an arterial street to manage motor vehicle volumes on the minor street. This treatment can include center medians used to allow bicyclists to cross the arterial.	

The above traffic calming and traffic reduction design elements have been in use in m communities for many years. However, concerns regarding traffic calming and reduction that occur on the bicycle boulevard are likely to be similar to concerns that are raised when these improvements are implemented anywhere else in the community. Most commonly, residents and officials will raise concerns about four potential issues related to traffic reduction and calming:

- Access to property
- Impact on traffic patterns
- Enforcement issues with motorcycles and mopeds
- Emergency response

These are all legitimate concerns that need to be considered, and can be addressed through a combination of good design and, if needed, enforcement.

To deal with each of these concerns it is important to involve stakeholders early. For residents living along a planned bicycle boulevard street and concerned about accessing their property, presenting the design so that they can see how their access is affected is an important first step. Trial installations of design elements can alleviate resident concerns regarding access by allowing them to “try out” design features and allow any necessary modifications to be made before the city commits to a permanent installation. It is also very important during the initiation and conceptual planning phases to highlight the positive attributes of bicycle boulevards and the benefits residents can expect, including fewer cars on their street, fewer speeders, and less noise.

When motor vehicle traffic is restricted on the bicycle boulevard it may induce an increase in motor vehicle traffic on adjacent streets. It is important to examine the impacts of diversion elements both on the proposed bicycle boulevard and nearby streets, and include mitigation (e.g., additional traffic calming on adjacent streets) for any impact in their designs.

Traffic-calming elements can be a concern to first responders if the design substantially increases response times to properties along the bicycle boulevard. Having the support of the fire and police department is critical--without it development of a bicycle boulevard may be delayed or permanently deferred. Emergency services need to be engaged early in the planning process in order to identify acceptable design elements. Traffic reduction and calming design elements may be designed in such a way that allows a wide-chassis vehicle, such as a fire truck, to pass over, while preventing a similar movement of most passenger vehicles.

TRAILS

Trails or shared use paths accommodate both pedestrians and bicyclists and may be located in independent rights-of-way or adjacent to a roadway. The AASHTO Guide for the Development of Bicycle Facilities provides additional guidance on shared use path design.

Width of shared use path should be evaluated based on user volumes and established level of service measures. Wider paths are also necessary when there is significant use by inline skaters, adult tricycles, children, or other users that need more operating width, larger maintenance vehicles, steep grades, and/or curves. Recommended widths are as follows:

Minimum width is 10 feet, desirable is 12 feet or wider in areas with high pedestrian volumes.

- A minimum of 11 feet width is needed to enable bicyclists to pass another user going in the same direction while a user approaches from the opposing direction.

Trail/Shared Use Path Crossings

- Right-of-way priority should not automatically be assigned to motor vehicles. Trail user volumes and behavior must be considered, observed and adjusted as volumes shift over time.
- Curb bulbs may be used to enhance visibility of trail users at crossing.
- Bollards should be used only if drivers may mistake the trail for a road.
- Rectangular rapid flashing beacons or a signal should be considered where traffic volumes and speeds on the intersecting roadway make it difficult for trail users to find a gap in traffic that allows them to cross comfortably, where motorist yielding compliance is low, or where there are high volumes of path users.
- Raised crosswalks may be considered on lower volume roadways.

Trails adjacent to the roadway are called sidepaths, and have some unique operational challenges. Sidepaths are useful on roadways with high volume and high speed motor vehicle traffic that might discourage bicyclists from riding on the roadway.

- The sidepath should terminate in a bicycle facility at both ends to discourage wrong-way riding on the roadway.
- Sidepaths are best for areas where there are few roadway crossings, as motorists may not expect a bicyclist at driveways.
- Driveway and intersection design approaches that reduce driver speeds and heighten awareness or path users should be employed. Strategies include:
    - Tight corner radii
    - Maintenance of path elevation through driveway (raised crosswalk)
    - Reduce the density of driveways through access management.

Image: trail crossing

INTERSECTION TREATMENTS

Intersections are where most conflicts between bicyclists and motorists occur. Complicated or busy intersections can act as barriers to less confident bicyclists, especially if they are not designed in a way that makes it clear how and where bicyclists and motorists are intended to travel. Design innovations such as green bike lanes, bike boxes, and bicycle signals can make traveling through an intersection more comfortable for all modes.

Bicycle boulevards must have proper intersection treatments to function well as a bicycle facility. The Yakima recommended network includes marking crosswalks, installing Rectangular Rapid Flashing Beacons (RRFBs), Half-signals, and full signalized intersections. Median islands, curb ramps, and bicycle markings and signage can enhance these crossings. Crossing treatments recommended in the network maps (Appendices B and C) require further engineering review to ensure proper installation.

BIKE LANES AT INTERSECTIONS

BIKE LANES THROUGH INTERSECTIONS

For bike lanes on arterials, the bike lane should remain solid at minor driveways and alleys, and may be striped with a dotted line through minor intersections or major driveway crossings. Bike lanes are not normally striped through major intersections, but a dotted extension line may be appropriate to guide the bicyclist through the intersection. At high conflict areas, some cities have had success with green pavement markings through intersections.

IMAGE: BIKE LANE AT MINOR INTERSECTION

THROUGH BIKE LANES ADJACENT TO TURN ONLY LANES

Where intersections include right-turn only lanes for motor vehicles, the bike lane should not be continued on the right side of the right-turn only lane. The bicycle lane should transition to the left of the right-turn lane with a merging area. A "Begin Right Turn Lane/Yield to Bikes" sign (R4-4) is recommended at the beginning of the merge area. A "Right (or Left) Lane Must Turn Right (or Left)" sign (R3-7R) should be located adjacent to the turn lane per the MUTCD. Green markings within the merge area and the bicycle lane may increase visibility and awareness.

IMAGE: Through bike lane

SHARED BICYCLE TURN LANE

Another option for providing guidance for road users where bike lanes and right-turn only lanes exist is a shared bicycle turn lane. Shared-lane markings are placed within the inside portion of a turn-only lane to guide bicyclists to the intersection and improve positioning of motorists within the turn lane. For right turn lanes which are less than 13 feet, shared lane markings should be placed within the center or left hand portion of the turn lane. An "EXCEPT BIKES" plaque should be posted beneath any mandatory turn lane signs to permit through travel by bicycles. A sign indicating combined lane and/or vehicles must yield to bicyclists may be desirable. Shared lane markings may be placed on green pavement markings to further raise motorist awareness of the shared lane.

IMAGE: right turn mixing zone

ROUNDABOUTS

Roundabouts provide non-signalized traffic control at intersections. They typically include a one- or two-lane roadway that encircles a central island around which vehicles travel counterclockwise. Continuing bicycle lanes through roundabouts has not been shown to improve safety. Rather, bicycle lanes should terminate in advance of crosswalks at roundabouts, providing sufficient space for bicyclists to merge with motor vehicles. The installation of shared lane markings at the entrance to roundabouts informs bicyclists of proper lane positioning while riding through the roundabout and alerts motorists to expect merging bicyclists. Providing ramps up to the sidewalk allows bicyclists the option of navigating the roundabout as a pedestrian.

Image- bike ramps at roundabout

INTERSECTION MEDIAN BARRIERS

Intersection median barriers are raised curbs or islands that extend along a street, preventing vehicles from making U-turns or left turns from cross streets. The median barrier is typically placed on the street with higher traffic volumes. Median barriers can improve safety and convenience for bicyclists and

pedestrians when crossing refuges are installed, and are often used in conjunction with bicycle boulevards.

Intersection median barriers are a type of traffic diversion and should be used only after a complete traffic analysis. This treatment may be considered in the following locations:

- Where cut-through traffic on a neighborhood street has been observed to be a problem
- Where analysis of traffic patterns in the area shows that cut-through traffic would not be diverted to a nearby street
- Where local residents would not have to drive excessive distances to access their homes. Excessive distance may be defined during the planning process, but generally residents should not have to drive more than a quarter mile (total distance) beyond the direct route
- Where there are bicycle/pedestrian priority routes (i.e. Bicycle Boulevards). Intersection median barriers not only reduce motor vehicle volumes on residential streets, making these streets safer and more comfortable for biking and walking, but also provide an opportunity to enhance crossings of higher volume and speed roadways
- Where emergency response times are not negatively impacted.

IMAGE: MEDIAN BARRIER

BICYCLE BOX

A bicycle box provides a head start at the onset of the green signal, reduces the potential for "right hook" collisions, and facilitates bicyclists' left turns by enabling a "J" or "Copenhagen" left. A bicycle box should be 10 feet minimum depth, and the full width of bicycle lane (if present) and adjacent general purpose travel lane together. Green pavement markings and a lead-in approach/ingress lane can be used to enhance visibility. Stop lines for motor vehicles are placed behind the bike box. Include "Stop Here on Red," sign (R10-6A) "Wait Here," or "Let's Get Behind It!" sign, pavement markings within the box are advisable, as are "No Turn on Red" restrictions (R10-11). The bicycle box should be located to minimize the likelihood of motor vehicle encroachment from turning vehicles. This may require the stop line be recessed further from the crosswalk in some locations.

Image: bike box

Image: 17_two stage left turn

SIGNAL TIMING

Where bicycle facilities intersect with arterials or other roadways where signals require actuation, signal detection systems need to be calibrated to explicitly detect bicyclists (see RCW 47.36.025). Section 9D.02 of the 2009 MUTCD states: "On bikeways, signal timing and actuation shall be reviewed and adjusted to consider the needs of bicyclists." Accommodating bicyclists at actuated intersections is one relatively cost-effective way in which a city can make significant strides to improve the safety and level

of service provided to bicyclists. It is recommended the City review its signal timing policy and revise as necessary to accommodate bicyclists at all intersections located on the bicycle network as it is implemented, and develop a protocol for assessing concerns from bicyclists regarding detection or additional time to cross at other locations.

BICYCLE SIGNAL HEAD

Bicycle signal heads provide clear direction to bicyclists crossing signalized intersections. Instructing bicyclists to use the pedestrian signal is less costly, but pedestrian signals are not timed for bicycle movements. The result is that bicyclists may have unclear information about when it is safe to enter the intersection. Bicycle signal heads can be designed to call a green signal phase through the use of loop detectors (or other passive detection such as video or radar) or push button. Bicycle signal heads and separate bicycle signal phase should be considered at intersections and trail crossings with very high volumes of cyclists or locations where it is desirable to provide separate phasing for the bicyclists. Presently the MUTCD has no provision for bicycle signals; however bicycle signals are under experimentation in many jurisdictions, and detailed in the NACTO Urban Bikeway Design Guide. It is expected that bicycle signals will be incorporated in the next edition of the MUTCD.

Image: bike signal

PAVEMENT DETECTION MARKING

Bicycle detection is used at actuated signals (signals that are user-activated by pavement sensor/loops, video, or push buttons) to alert the signal controller of bicycle crossing demand on a particular approach. Bicycle pavement markings may be used to show where a bicyclist should stop to trigger a demand-actuated signal.

For installation of signal detection markings, signal equipment should be investigated first to ensure that it can detect bicycles. When installing roadway markings, consider the following priorities:

- Place detector markings at all new and upgraded signals with loop detectors
- Systematically adjust sensitivity and add pavement markings at all signals along existing and new bicycle routes
- Investigate and adjust (if possible) signal sensitivity and add markings at locations requested by the public.

Placement of bicycle detector markings should consider the following:

- The bicycle detector symbol should be placed in the optimum location for the bicycle to actuate the signal
- The detection zones and markings should be placed within the pathway of bicycles so that they do not have to maneuver into a different position within the lane in order to be detected

- If bicyclists are expected to use multiple lanes of a roadway (e.g. right and left turn lanes) provide detection and markings in multiple lanes.

IMAGE: loop detector

BIKE ACTIVATED PUSH BUTTON

Signals specifically intended for pedestrian and bicycle street crossings such as midblock crossings, HAWK signals, or RRFBs (see below for RRFB and HAWK details) may require special activation. Bicycle-activated push buttons are a separate push buttons located along the curb or location easily accessed by bicyclists. Bicycle activated push buttons allow bicyclists to activate the signal without having to change their course of travel, dismount or detour onto the sidewalk to use a pedestrian push button. This improves convenience, compliance and efficacy of the signal. The disadvantage of push buttons is that they are challenging for bicyclists wanting to make a left turn. The following design considerations should be taken into account:

- Place push button within reach of the curb but with appropriate setbacks to avoid being hit by passing motor vehicles
- Push buttons work well on streets without parking or where there are parking restrictions at the approach to the intersection
- Use a large button for easy actuation by bicyclists
- Placement of the push button assembly and bicycle queuing should take right-turning motor vehicles into consideration.

Image: push button bike signal

RRFB

A Rectangular Rapid Flashing Beacon is a pedestrian warning signal consisting of yellow LED lights in two rectangular clusters, or beacons, that employ a stutter-flash pattern similar to that used on emergency vehicles. The beacons are often mounted below a standard pedestrian crossing warning sign and above the arrow plaque used to indicate the crossing location. RRFBs are actuated either by a push-button or passive detection.

Image: RRFB

- RRFBs should be considered at uncontrolled intersections or at mid-block crossings where additional measures are needed due to high volumes and speeds
- They should be considered where there are high volumes of pedestrians or bicyclists, a high number of vulnerable pedestrians (e.g. near schools, senior centers), or at off-street path crossings or as part of a bicycle boulevard network.

HAWK/PEDESTRIAN HYBRID BEACON

"HAWK" stands for High-intensity Activated crossWalK and is also referred to as a pedestrian hybrid beacon. A HAWK signal is a push button-activated pedestrian and bicycle signal that increases pedestrian and bicycle safety at crossings while stopping vehicle traffic only as needed.

HAWK signals may be used at mid-block crossings (including off-street path crossings) and should be considered at crossings where high traffic volumes and speeds make it difficult for pedestrians and bicyclists to cross the street, and where warrants for a conventional signal are not met. HAWK signals provide a protected crossing while allowing vehicles to proceed through a pedestrian/bicycle crossing as soon as it is clear, thus minimizing vehicle delay. HAWK signals may also provide audible information for visually impaired pedestrians.

Image: HAWK

HALF SIGNAL

Half signals are located at the intersection of an arterial and non-arterial. The traditional signal heads face the arterial, while the local street is stop-controlled. The signal heads on the major street rest in green until activated by a pedestrian or bicyclist, and they then turn yellow and red, allowing a pedestrian or bicyclist to cross the arterial. Half signals may be confusing for motorists using the side street, and are best paired with right-in, right-out restrictions such as on a neighborhood greenway.

IMAGE: HALF SIGNAL

BIKE PARKING

Conveniently located bicycle parking is an important element of a multimodal transportation system because it allows bicyclists to secure their bicycles at their intended destination. Bicycle parking may be provided in a variety of forms depending on whether it is for short-term or long-term use (e.g. a brief shopping stop, an all-day event, or workplace and residential parking). Short-term parking may include individual or multiple bike racks placed within the furniture or building frontage zones on a sidewalk or in high-capacity corrals placed within the street (where there is a defined motor vehicle parking lane). Long- term parking racks may be sheltered and placed in off-street locations such as parking garages/lots or transit station entrances. Long-term parking may have limited access depending on the operational hours of the parking area. When installing bicycle parking, the following considerations should be kept in mind:

- Well-designed and placed bicycle parking promotes a more orderly streetscape, preserves the pedestrian right-of-way and prevents damage to trees and street furniture
- Bike racks should support the bike at two points and provide a sturdy frame to secure a U-lock around the rack, bike frame, and one wheel

- Bicycle parking should be conveniently placed within close proximity to destinations such as businesses, parks, schools and other community facilities, and major transit stops and stations
- In general, placing one or two racks at multiple locations along a block face is preferred to grouping all the racks at one location. In order to ensure that there is adequate parking to meet demand, parking utilization should be periodically assessed, and additional parking should be provided where demand is high
- In areas with high bicycle parking demand and limited sidewalk space, in-street corrals or other high capacity bike rack designs may be considered. In-street corrals have an added benefit of improving sightlines for motor vehicles when placed at the near side of an intersection.

IMAGE: BIKE RACK (STANDARD)
IMAGE: BIKE CORRAL

BIKES AND TRAIN TRACKS

Train tracks that cross roadways or shared use paths can create safety issues for bicyclists. Bike tires are easily caught in the flangeway and may slip on the rails when wet. As described in the 2012 AASHTO Guide for the Development of Bicycle Facilities, design considerations for bikes and railroad tracks include:

- Crossing angle: Bicycle facilities should be designed to cross railroad tracks at an angle of 60 to 90 degrees, such that bicyclists can avoid getting wheels caught in the flangeway
- Crossing surfaces: Concrete or rubber crossing surfaces are recommended (concrete performs best). Timber and asphalt surfaces are not recommended
- Flangeway width should be minimized when practical. This is a greater issue with heavy rail track.

Image: Railroad xing

DRAIN GRATES

Utility covers and drainage structures should be located outside of the surface of on-street bicycle facilities where feasible. Where they are unavoidable, utility covers in the bike lane should be smooth and flush with the roadway surface. Drain grates must be designed such that narrow tires cannot get caught. When new drain grates are installed or existing drain grates replaced, they must conform to bicycle friendly grate design standards specified by WSDOT (WSDOT vaned grate, herringbone grate, or other grate with an opening perpendicular to the direction of travel, 4 inches or less center to center, see WSDOT Design Manual).

Deck grating can be extremely slippery, particularly in wet conditions. Bicycle tires, with their small contact area, are extremely vulnerable to loss of traction. If deck grating must be installed, it must be

treated to increase traction and the seam width between the decking and the adjacent pavement should be no wider than 3/8 inch.

IMAGE: DRAIN GRATES

ADDITIONAL STREET DESIGN RESOURCES

The following list provides information on where to find additional bicycle facility and street design guidance.

- AASHTO Guide for the Development of Bicycle Facilities (https://bookstore.transportation.org/item_details.aspx?ID=1943)
- MUTCD (http://mutcd.fhwa.dot.gov/)
- WSDOT Design Manual (http://www.wsdot.wa.gov/Publications/Manuals/M22-01.htm)_
- NACTO Bikeway Design Guide (http://nacto.org/publication/urban-bikeway-design-guide/)
- FHWA Separated Bike Lane Planning and Design Guide (http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm)
- BIKESAFE (http://pedbikesafe.org/BIKESAFE/index.cfm)
- APBP Bicycle Parking Guide (http://www.apbp.org/?page=publications)
- PEDSAFE (http://pedbikesafe.org/PEDSAFE/index.cfm)

MAINTENANCE

RECOMMENDED APPROACH TO SCHEDULES, COSTS CONSIDERATIONS

Roadway surfaces are subject to deterioration and debris accumulation. If unmitigated, a facility that was in perfect condition may become unusable for bicyclists or pedestrians. It is important to consider that surface conditions that are satisfactory for motorists may cause complications for bicyclists who utilize narrower tires. Bicyclists face a variety of impediments that can be easily managed through an effective maintenance program. While safety of all roadway users is a top priority, a good maintenance program should also aim to protect public funds invested in bicycle and pedestrian infrastructure.

This section outlines responsibilities relative to the maintenance of Yakima right-of-ways owned assets in the public right-of-way. The Public Works Department (PWD) is the primary owner of and manages the reconstruction of city streets, sidewalks and bridges. The PWD is also responsible for installing and operating traffic and parking management devices and managing access for pedestrians, motor vehicles and bicyclists. Yakima Transit is responsible for maintenance of transit property such as bus shelters and

signage. PWD owns the City's right-of-ways in coordination the Parks Department and Yakima Water Services (SPWS).

MAINTENANCE SCHEDULE

The City of Yakima aims to improve the life and sustainability of roadways and sidewalks in the most cost-effective and efficient way possible. Below is a breakdown of the typical life cycle of city roadways and sidewalks with respect to operations and maintenance. During the design of a project, an operations and maintenance plan should be developed to address all aspects of the life of a street, from daily, weekly, and seasonal requirements to routine maintenance. Note that maintenance practices are opportunities to incorporate Complete Streets principles.

The list below is a general guide for when maintenance practices typically occur; however, improvements may be needed at any time to address safety and access concerns.

STREET SWEEPING

Streets may feature high-quality bicycle facilities; however, if these facilities are strewn with gravel, sand, or other debris, they become far less safe and attractive to users. As a part of routine maintenance, roadways should be swept to remove any litter. When sweeping vehicle lanes, bicycle lanes or sidewalks, debris should not be swept from one facility to the other. Debris can be removed from roadways with curbs through the use of vehicles that vacuum the debris, while uncurbed roads can be swept. The following recommendations apply to street sweeping:

- All bicycle facilities should be swept routinely. Identifying routes of particular importance will help ensure greater rider comfort. Facilities that may require more frequent sweeping include popular commuter or recreational corridors and roadways that regularly build up debris.
- Establish a sweeping schedule for facilities that anticipates both routine and irregular sweeping needs. Routine sweeping schedules may occur at regular intervals, with greater frequency seasonally. Strategies for inspection and sweeping after unanticipated events should also be established. These events may include flooding, storm events, or vandalism.
- Sweep project area after roadway repairs.
- Continue to update priority routes for street sweeping as new facilities are constructed.
- Reduce the volume of debris on roadways through ordinances that require parties responsible for debris to contain it. Possible requirements include paving gravel and dirt driveway approaches, enforcing coverage on tarps on trucks loaded with gravel or sand, or clean up after construction operations that leave gravel and dirt on the roadway.

SNOW REMOVAL AND STORAGE

Cold winter weather with snow is common in Yakima. Snow, slush, and ice impact all modes of transportation and timely clearance is essential to maintaining safe and accessible streets. Street design should proactively incorporate provisions to facilitate snow clearance and storage for all modes, with pedestrians, bicyclists, and transit users given the same attention as motorists. Street crossings and sidewalks should be accessible for the elderly, young children, the disabled, and people pushing carts and strollers.

Prior to a major snow or freezing rain event, the City aims to spread de-icing material on all major arterial streets. Other priority locations include streets near schools, hospitals, stop signs and hills. When snow accumulations reach three inches, the City of Yakima plows the major arterial streets, and the streets near schools, hospitals, stop signs and hills.

Sidewalks must have a clear unobstructed accessible pathway. Particular attention should be given to clearing curb ramp at crosswalks. Hydrants, catch basins, crossing islands, medians, and building entrances must also be accessible. Sidewalks should be cleared within three hours of snowfall ending (or three hours from sunrise if snow falls overnight).

CONSIDERATIONS

- Bike lanes and center turn lanes do not get the heavy traffic to break up snow and ice. Special maintenance such as extra salt is needed to reduce snow and ice accumulation.

Some in-street elements such as raised medians, traffic circles, pork chop islands, etc. may be obstacles to plowing and may need additional maintenance such hand shoveling to fully clear snow from pedestrian pathways.

RESTRIPING

All markings should be maintained in a legible condition so they can be easily interpreted by all roadway users, including motorists. While newly installed markings are highly visible, they may fade over time, greatly reducing their perceptibility, especially at night. The following strategies apply to pavement marking maintenance:

- Establish routine marking inspections, including assessing visibility at night.
- Markings should be replaced on an as needed basis, with substandard markings being replaced as soon as possible. Markings in high-use areas may need restriping more than once a year.
- Roadways where markings don't follow current City design guidelines should be updated to standards as part of regular maintenance.
- Transitions to county roadways should be evaluated, especially at frequently traveled routes in and out of the city. Coordination with the County may be necessary.

- Consider the cost of using more durable materials such as thermoplastic versus more frequent maintenance of less durable materials such as paint.

RESURFACING

Resurfacing of streets is an excellent opportunity to add bicycle lanes, curb ramps and new or realigned crosswalks. The bike plan should be considered before every resurfacing project.

SURFACE REPAIR

Pavement surface condition significantly affects the quality of a bicycle facility, and poor surfaces can deter riders. Defects such as longitudinal cracks or joints, potholes, and root heaves can degrade riding conditions considerably. The following recommendations apply to maintaining the surfaces of bicycle facilities:

- Perform routine assessments of roadway surfaces for abnormalities. Make the necessary repairs in a timely manner after observing or receiving comment of any abnormality.
- Correct any pavement edges, seams, or potholes. Keep in mind that bicyclists have a higher level of sensitivity to surface irregularities during the overlay process.
- In order to avoid leaving an edge or seam on the surface of a bicycle facility, the overlay should encompass the whole roadway surface when possible.
- As funding allows, replace parallel-slatted drain grates with bicycle-safe grates. Prioritize replacements on routes with bicycle facilities. Install bicycle-safe grates on all new projects.
- Use overlays as an opportunity to complete multiple projects at once. Projects that might be completed in conjunction with an overlay include road widening or paving approaches to unimproved road and driveway connections.
- Ensure that surface repairs do not result in seams running longitudinally through bicycle facilities or areas which are anticipated to have high ridership.
- In order to lessen inconvenience to bicyclists and extend the lifecycle of bicycle facilities, carry out preventative maintenance on a consistent basis. Preventative maintenance may include eliminating intrusive tree roots, placing root barriers, selecting paving materials with longer lifecycles, and removing debris from storm drains.