# Bicycle Tourism Trails Study

## Technical Memorandum 3: Recommended Bikeway Design Criteria

Jacobs for TxDOT Public Transportation Division

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**Acknowledgements**

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# Table of Contents

**Introduction** ..... 1
**Review Process** ..... 1
TxDOT Internal Review ..... 1
TxDOT Bicycle Advisory Committee Review ..... 2
**Bikeway Design Criteria** ..... 2
Shared Use Path/Sidepath ..... 2
Buffered Bicycle Lane ..... 6
Bicycle Lane ..... 10
Paved Shoulder ..... 13
**Bikeway Cost Estimates** ..... 16
Bikeway Construction Costs ..... 16
Bikeway Operation and Maintenance Costs ..... 18
**Conclusion** ..... 19
**References** ..... 20

**Tables**

1: Per Mile Bikeway Construction Cost Estimate Ranges ..... 17
2: Bikeway Operation and Maintenance Activities ..... 18

**Figures**

1: Typical Shared Use Path Pavement Structure ..... 4
2: Typical Section, Shared Use Path ..... 4
3: Relevant Texas MUTCD Bicycle Regulatory and Guidance Signage ..... 6
4: Typical On-Road Bikeway Asphalt Pavement Structure ..... 7
5: Typical On-Road Bikeway Concrete Pavement Structure ..... 7
6: Typical Section, Buffered Bicycle Lane ..... 9
7: Typical Section, Bicycle Lane ..... 12
8: Typical Section, Paved Shoulder ..... 14

**Appendix**

A Detailed Bikeway Cost Estimate Tables

## Introduction

The purpose of the Bicycle Tourism Trails Study (BTTS) is to investigate the development of a statewide bicycle tourism trail network. The BTTS was initiated by the Texas Department of Transportation's (TxDOT's) Public Transportation Division (PTN) Bicycle and Pedestrian Program in response to 2005 legislation (Texas Transportation Code § 201.9025 Texas Bicycle Tourism Trails). TxDOT-PTN and its consultant, CH2M (now Jacobs), worked with TxDOT's Bicycle Advisory Committee (BAC) to propose recommendations for the development of bicycle tourism trails in Texas. This study applies BAC and TxDOT-developed quantitative and qualitative routing criteria to provide an example vision of a statewide network of tourism bikeways. The products produced as a result of this study will serve as an initial high-level network analysis for statewide bicycle tourism consideration and future development.

A network of bicycle tourism trails across Texas would highlight the natural, historic, and exceptional landscapes across the unique regions of the state. These tourism trails could draw bicyclists from around the world, showcase communities across the state, and boost economic development. The bicycle tourism trail network could also provide recreational and travel opportunities for local Texans craving a Monday-night ride or perhaps a family weekend adventure.

The purpose of this technical memorandum is to document the recommended bikeway accommodations proposed for inclusion into an Example Network, and provide bikeway design recommendations and estimated costs per mile.

## Review Process

The bikeway types and design elements described in the following section resulted from an iterative refinement process among TxDOT-PTN, Jacobs, the BAC, and other TxDOT Divisions. Bikeway design elements were based on *TxDOT's Roadway Design Manual*[1], the *American Association of State Highway Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities*[2], and the *Texas Manual on Uniform Traffic Control Devices* (MUTCD)[3]. At the time of this report, AASHTO was in the process of updating its *Guide for the Development of Bicycle Facilities* with an unknown completion timeframe.

### *TxDOT Internal Review*

Initially, TxDOT and Jacobs developed seven potential bikeway design types and associated graphics for consideration and discussion. TxDOT-PTN and Jacobs coordinated further refinements to bikeway types and graphics with TxDOT's Design (DES) and Traffic Operations (TRF) Divisions.

### *TxDOT Bicycle Advisory Committee Review*

TxDOT's BAC is comprised of 11 members from across Texas who are approved by the Texas Transportation Commission through a competitive selection process. The members serve 3-year terms, volunteering their time and expenses. In December 2016, a subset of TxDOT's BAC members volunteered to be part of a Working Group to guide the project team.

Beginning in August 2017, TxDOT-PTN and Jacobs met with BAC Working Group members each month to discuss progress and request input on aspects of the bikeway design criteria. Discussion included:

- Anecdotes about bikeway conditions
- Personal experiences from short-and long-distance bicycle trips
- Recommendations to increase bikeway dimensions to accommodate recreational riders 8 to 80 years of age
- Improvements to graphics and cost estimates

The BAC and Working Group advocated for safer, lower-stress accommodations for long-distance bicycling.

As a result of TxDOT/Jacobs/BAC review and refinement processes, the following bikeway designs are recommended for development of Texas bicycle tourism trails:

- Shared use path/Sidepath
- Buffered bicycle lane
- Bicycle lane
- Paved shoulders

## Bikeway Design Criteria

The following bikeway design criteria are recommended for consideration in the development of bicycle tourism trails in Texas. Any design criteria would be subject to currently available guidance and professional engineering judgement. The recommendations, challenges, and design considerations included with each bikeway type provide important details. The content under each bikeway type is intentionally repetitive as future readers may only reference specific bikeway types and not the entire technical memorandum.

### *Shared Use Path/Sidepath*

Shared use paths (SUPs) are two-way accommodations for bicyclists, pedestrians, runners, and other users of all ages and abilities. A SUP offers physical separation from vehicular traffic either by an open space or physical barrier. While sometimes referred to as "trails," this term is frequently associated with recreational hike and/or bike accommodations with

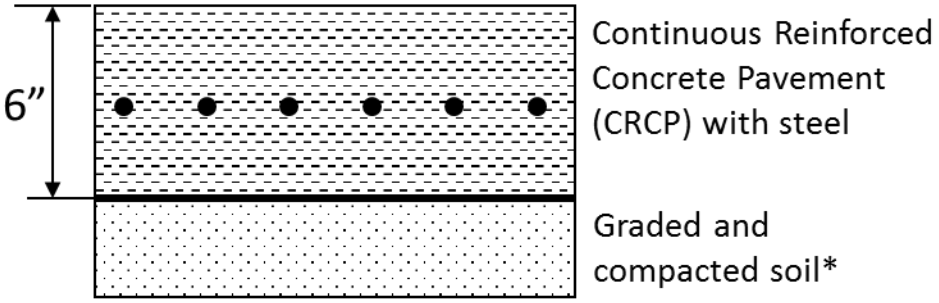
unpaved surfaces. Meanwhile, the term "sidepath" is used to describe an SUP located adjacent to the roadway right-of-way.

Whether located in a park or open space, along a river, seashore, or limited access freeway, SUPs provide a lower-stress experience for bicyclists. In addition, SUPs provide recreational benefits and extend/complement the on-road bikeway network. SUPs may provide safer bicyclist and pedestrian accommodations on high-speed/high-volume roadways.

Recommendations

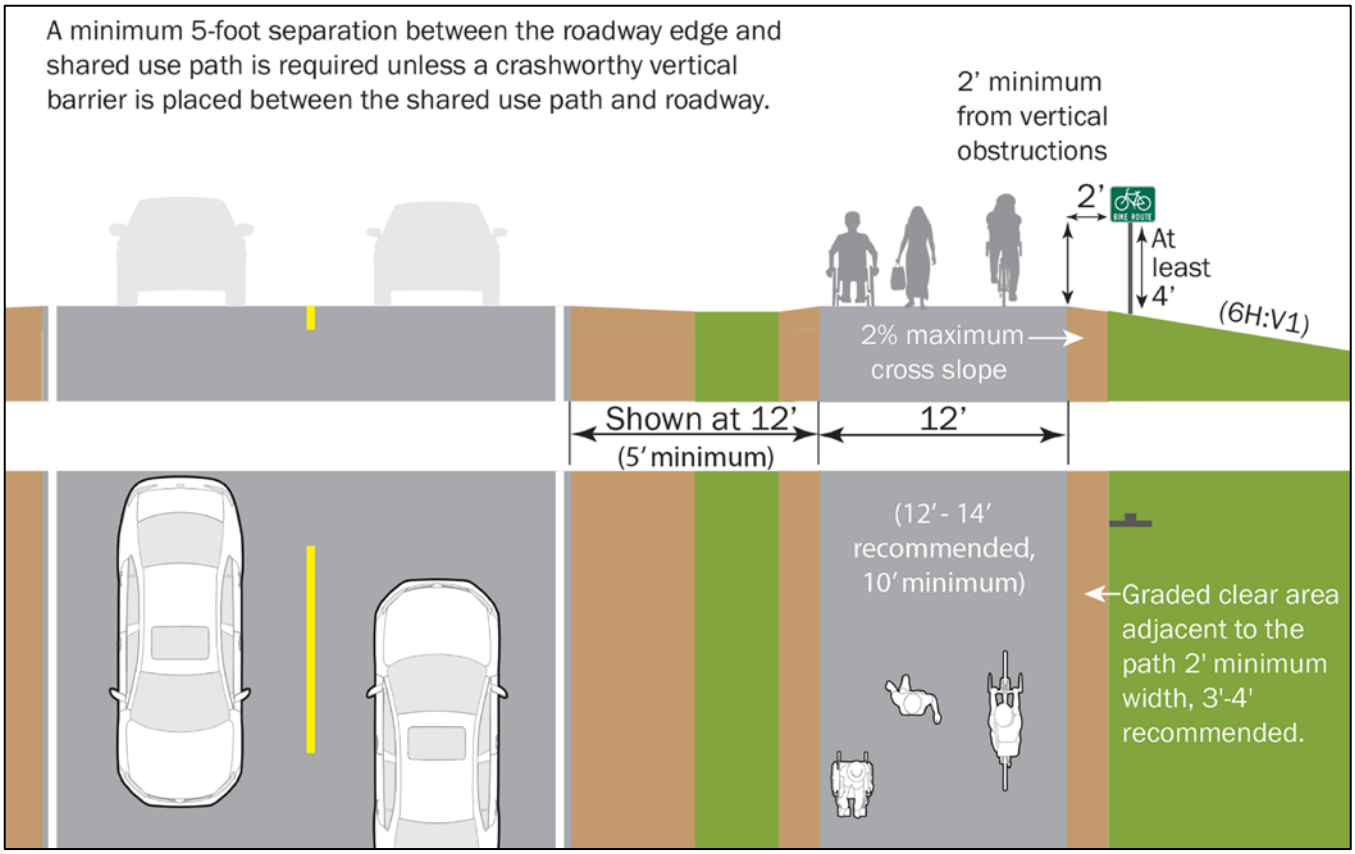
- Based on AASHTO guidance, SUPs should be a minimum of 10 feet wide. For bicycle tourism trail paths, TxDOT recommends SUPs should be 12 to 14 feet wide. See Figure 2 for a graphic representation of SUP/Sidepath design recommendations.
- A 3- to 4-foot-wide graded shoulder area is recommended (minimum 2-foot-wide). A maximum cross-slope of 1V:6H should be maintained on each side of the SUP. If this cross-slope cannot be provided, then additional protection may be needed.
- A minimum 2-foot horizontal clearance should exist between the edge of the pavement to lateral obstructions (pole-mounted signs, bushes, large rocks, and bridge piers).
- A minimum 10-foot vertical clearance from obstructions to pavement is recommended.
- A 1 percent (maximum 2 percent) pathway cross slope is recommended.
- A 6-inch reinforced concrete pavement surface is recommended in most locations. See Figure 1 for typical pavement structure.
- Due to the potential for pavement damage, signage and/or bollards should be installed adjacent to SUPs to deter motorists (including mopeds, motorcycles, and all-terrain vehicles) from driving on SUPs. Signage and/or bollards should be located at entry points along the SUP to limit access for non-motorized users. Additionally, horses are not recommended on paved SUPs.
- Permanent bicycle and pedestrian count equipment should be installed at logical intervals along newly constructed BTTS bikeways to document usage.
- If the distance from the edge of the paved roadway to the edge of the pathway pavement is less than 5 feet, a crashworthy barrier that does not impair sight distance is required.

*Figure 1: Typical Shared Use Path Pavement Structure*




**Additional substructure may be necessary depending on local soil conditions*

*Figure 2: Typical Section, Shared Use Path*




<u>Challenges</u>

- For SUPs independent of roadway right-of-way:
  - Maintenance and emergency vehicle access must be ensured despite distance from roadway. Thicker pavement sections reduce likelihood of pavement damage from these motor vehicles.

  - While SUPs adjacent to roadways may be maintained concurrently with the roadway, non-roadway adjacent SUP maintenance responsibilities must be clearly identified and funded.
- For SUPs adjacent/parallel to roadway right-of-way:
  - At conflict points, motorists entering or crossing the roadway may intersect with SUP users creating safety, operational, and design concerns.
  - Attention to intersection treatments is necessary to allow bicyclists and pedestrians using SUPs to safely cross roadways at intersections.

Design Considerations

- Design Speeds: While recommended design speeds should be determined during project development, for most SUPs in relatively flat areas, a design speed of 18 miles per hour (mph) is generally sufficient. For hilly terrain, design speeds may vary but should not exceed 30 mph. Geometric design and traffic control devices can be used to improve safety.
- Barrier or Railing
  - Barriers or railings should have a lateral offset of a least 1 foot (2 feet recommended) from the edge of the path.
  - If barriers or railings are intended to separate the pathway from traffic lanes they must be crashworthy (that is, proven acceptable for use through crash-testing or in-service performance).
- High volume areas: On SUPs with heavy peak-hour or seasonal volumes or where sight distance constraints exist, a solid yellow centerline stripe may be used to separate directions of travel. In such instances, increases in pathway width are recommended.
- Lighting: Pedestrian-scale lighting is preferred. If a SUP is adjacent or near-adjacent to a roadway, lighting must be sufficient to illuminate both the travel lanes and the pathway.
- Pavement: While vehicle weights anticipated on SUPs will be substantially less than roadways, paths need to sustain emergency, security, and maintenance vehicles. While unpaved surfaces have been included in the Example Network, the completed bicycle tourism trail network is envisioned with hard, all-weather pavement surfaces.
- Signage:
  - Sign placement frequency should be determined on a case-by-case basis. The density of adjacent development and existing signage should be taken into consideration to avoid sign pollution and/or confusion. Signs should be placed for both travel directions and be inclusive of pedestrian and bicycle users.

  - Signs should be placed at least 4 feet above grade and provide a minimum 2-foot horizontal clearance from the pathway edge.
  - If a Texas state agency wishes to advance TxDOT's BTTS and develop a more formal bicycle tourism network, then route numbering and themed signage is recommended in accordance with respective agency guidelines. The Texas MUTCD suggests the use of M1-9, M1-8, or M1-8a. See Figure 3.
- SUP design should address drainage and stormwater management concerns similar to roadway design.
- See the AASHTO Guide for the Development of Bicycle Facilities for additional information on bridges, drainage, and SUP-roadway intersection design.

*Figure 3: Relevant Texas MUTCD Bicycle Regulatory and Guidance Signage*

R3-17 M1-8 M1-8a M1-9

### *Buffered Bicycle Lane*

Buffered bicycle lanes are on-road bikeways designated by pavement markings. As compared to standard bicycle lanes, buffered bicycle lanes provide additional separation from vehicular traffic designated by pavement markings or a vertical barrier (for example, a concrete barrier, a raised median, planters, or bollards). Buffered bicycle lanes with vertical barriers are also known as protected bike lanes or separated bicycle lanes and can be one-way or bi-directional.

While buffered bicycle lanes offer perceived protection from adjacent motorists, for bicycle tourism trails along roadways with higher motor vehicle speeds, physical separation or a crashworthy barrier is recommended. Bicyclists experience lower-stress and enjoy greater levels of comfort with additional physical separation and/or protection from motor vehicle travel lanes. Two valuable resources on separated bike lanes include the Federal Highway Administration's (FHWA's) *Separated Bike Lane Planning and Design Guide*[5] and the National Association of City Transportation Officials' (NACTO's) *Design for All Ages & Abilities*[6]

Where the existing pavement footprint can accommodate two minimum 5-foot-wide bicycle lanes plus buffer space, installation can be accomplished during rehabilitation or resurfacing projects. Installation of bicycle lanes and buffered bicycle lanes during roadway reconfigurations, road diets, and lane diets is detailed in FHWA's *Incorporating On-Road Bicycle Networks into Resurfacing Projects*[7]. See Figures 4 and 5 for typical on-road bikeway pavement structures.

*Figure 4: Typical On-Road Bikeway Asphalt Pavement Structure*

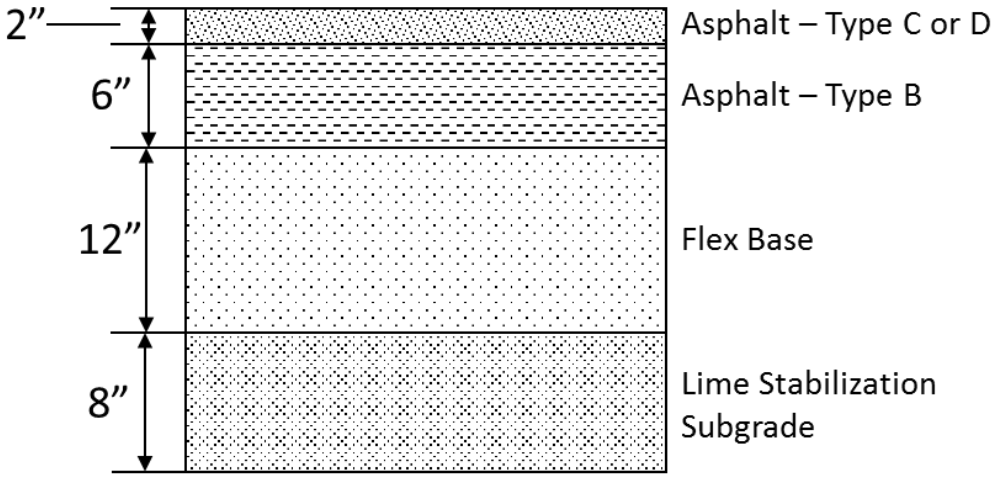
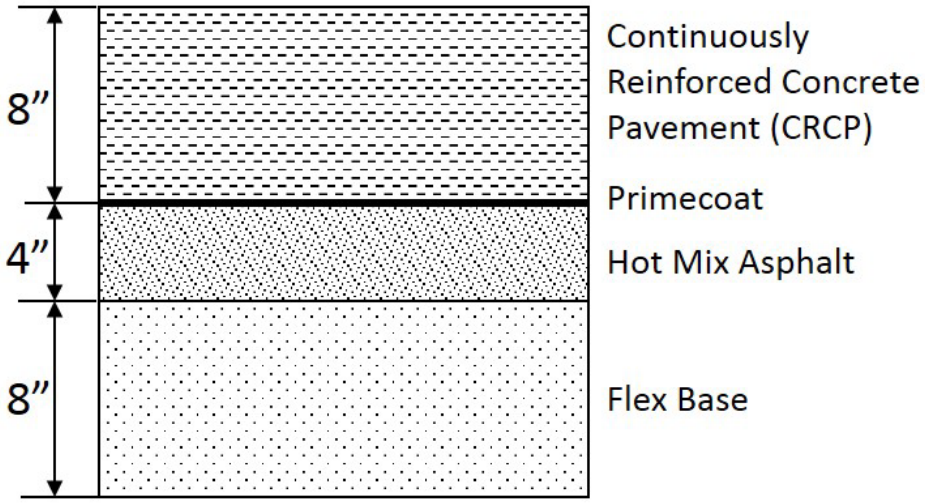



*Figure 5: Typical On-Road Bikeway Concrete Pavement Structure*



Recommendations:

- One-way buffered bicycle lanes should be 5 feet or wider. See Figure 6 for a graphic representation of Buffered Bicycle Lane design recommendations.
- The bicycle lane buffer should be 2 to 3 feet wide. For additional information, see NACTO's Urban Bikeway Design Guide[8].
- The combined width of buffer space and bicycle lane should not exceed 9 feet. This measurement will help deter motorists from using the area as a travel lane.
- Drainage grates and gutter seams should generally not be included in the usable width. AASHTO currently measures bicycle accommodations from face of curb because the width of gutter pans generally falls within the shy distance for bicyclists.
- Bicycle route signage should be used.
- Vertical separation
  - Separation type should be based on the presence of on-street parking, street width, cost, aesthetics, maintenance, and motorized traffic volumes and speeds.
  - Bi-directional buffered bicycle lanes should be a minimum total width of 12 feet wide and include a centerline for separation.
  - The total clear width between the curb face and vertical element should allow room for emergency and maintenance vehicles.
- Bicycle pavement markings/symbols should be placed at regular intervals on the paved surface of the bicycle lane to advise motorists of the on-street bicycle lanes.
- Permanent bicycle count equipment should be installed at logical intervals along newly constructed BTTS bikeways to document usage.

Challenges

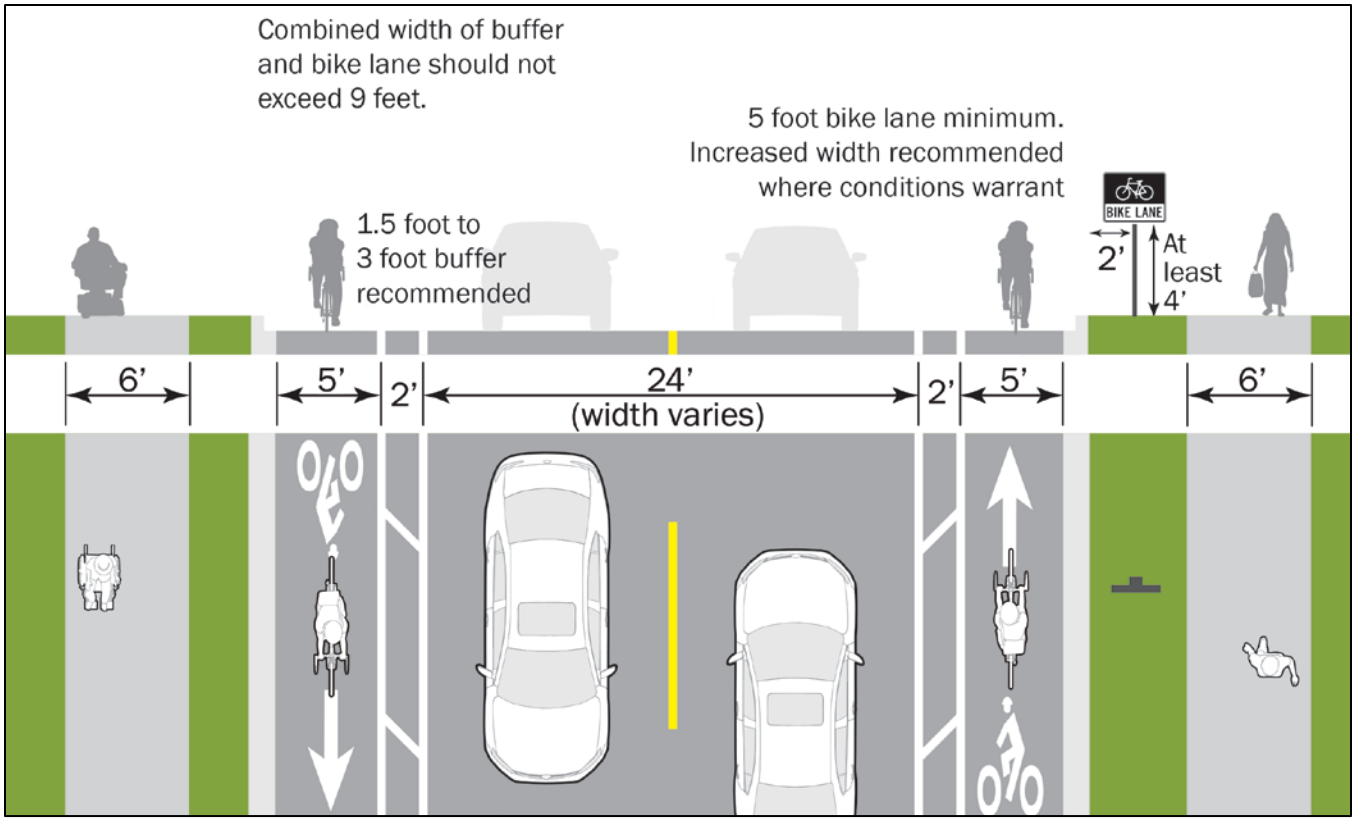
- Relocation and/or adjustments to existing on-street parking may be required to accommodate buffered bicycle lanes.
- Increasing pavement surface area to add bicycle lanes:
  - May be difficult to incorporate into resurfacing projects. Typically, widening can be done effectively during full pavement rehabilitation (that is, complete pavement replacement).
  - May not be possible where right-of-way is constrained
  - May necessitate costly utility relocations, drainage and/or stormwater management
  - May encounter natural environment constraints (wetland, wildlife, or parkland encroachment concerns)
  - May be impractical for bridge sections causing bicyclists to share the outside travel lane with motor vehicles across constrained bridge structures

- May require traffic management control strategies and disruption to motor vehicle travel patterns during construction periods

Design Considerations

- Intersections and other conflict points represent serious safety issues for bicyclists. Special attention should be paid to bikeway design through intersections and other conflict points.
- Signage
  - Sign placement frequency should be determined on a case-by-case basis. The density of adjacent development and existing signage should be taken into consideration to avoid sign pollution and/or confusion. Signs should be placed for both travel directions (Per Texas MUTCD, recommended sign is R3-17 with minimum size of 24 inches high by 18 inches wide). See Figure 3.
  - Signs should be placed at least 4 feet above grade and provide a minimum 2-foot horizontal clearance from the pathway edge.
  - If a Texas state agency wishes to advance TxDOT's BTTS and develop a more formal bicycle tourism network, then route numbering and themed signage is recommended in accordance with respective agency guidelines. The Texas MUTCD suggests the use of M1-9, M1-8, or M1-8a. See Figure 3.

*Figure 6: Typical Section, Buffered Bicycle Lane*



### *Bicycle Lane*

Bicycle lanes are on-street, one-way bikeways that carry bicycle traffic in the same direction as adjacent motor vehicle traffic. Bicycle lanes exist in both urban and suburban areas. They encourage bicyclists to ride on the roadway in a position where they are more likely to be seen by motorists entering or exiting the roadway. Buffered bicycle lanes and bicycle lanes provide a more comfortable experience for less-skilled bicycle users. Additionally, bicycle lanes buffer pedestrians from motor vehicle traffic, improving pedestrian comfort on adjacent sidewalks. While bicycle lanes offer a perceived separation from motorized traffic, for bicycle tourism trails adjacent to roadways with higher motor vehicle speeds, physical separation between the motorized traffic and bicyclists is recommended. For more information on all-ages and all-abilities bikeways, see NACTO's *Design for All Ages & Abilities*[9].

If available rights-of-way can accommodate two minimum 5-foot-wide bicycle lanes (one in each direction), installation can be accomplished during rehabilitation or resurfacing projects. Guidance for installing bicycle lanes and buffered bicycle lanes during roadway rehab or reconstruction, road diets, and lane diets is available in FHWA's *Incorporating On-Road Bicycle Networks into Resurfacing Projects*[10]. Widening the roadway surface to provide bicycle lanes can also be accomplished during complete pavement rehabilitation. See Figures 4 and 5 for typical on-road bikeway pavement structures.

It is generally less expensive to install bicycle lanes as part of a resurfacing project than to install the bicycle lanes separately. Cost savings accumulate for several reasons, including the following:

- Marking eradication: The removal of pavement markings would not be necessary during resurfacing. The process of removing the previous roadway markings can leave visible grooves on the roadway and lead to confusion during low-light and/or when the pavement is wet.
- Traffic control: Maintaining transportation safety during construction is required. (When bicycle lanes are incorporated into a resurfacing project, the overall cost would not increase significantly enough to cause a funding issue.).
- Marking costs: Like traffic control, the cost of adding pavement markings to the budget of a resurfacing project is minor.
- Pavement: To preserve roadway edge and support paved bicycle lanes, additional shoulder preparation work should be completed. When pavement width is added adjacent to an existing pavement section without full-depth pavement replacement, differing pavement sections and uneven wear patterns may result in maintenance issues. A better opportunity to install bicycle lanes occurs during a full-depth replacement of the existing pavement.

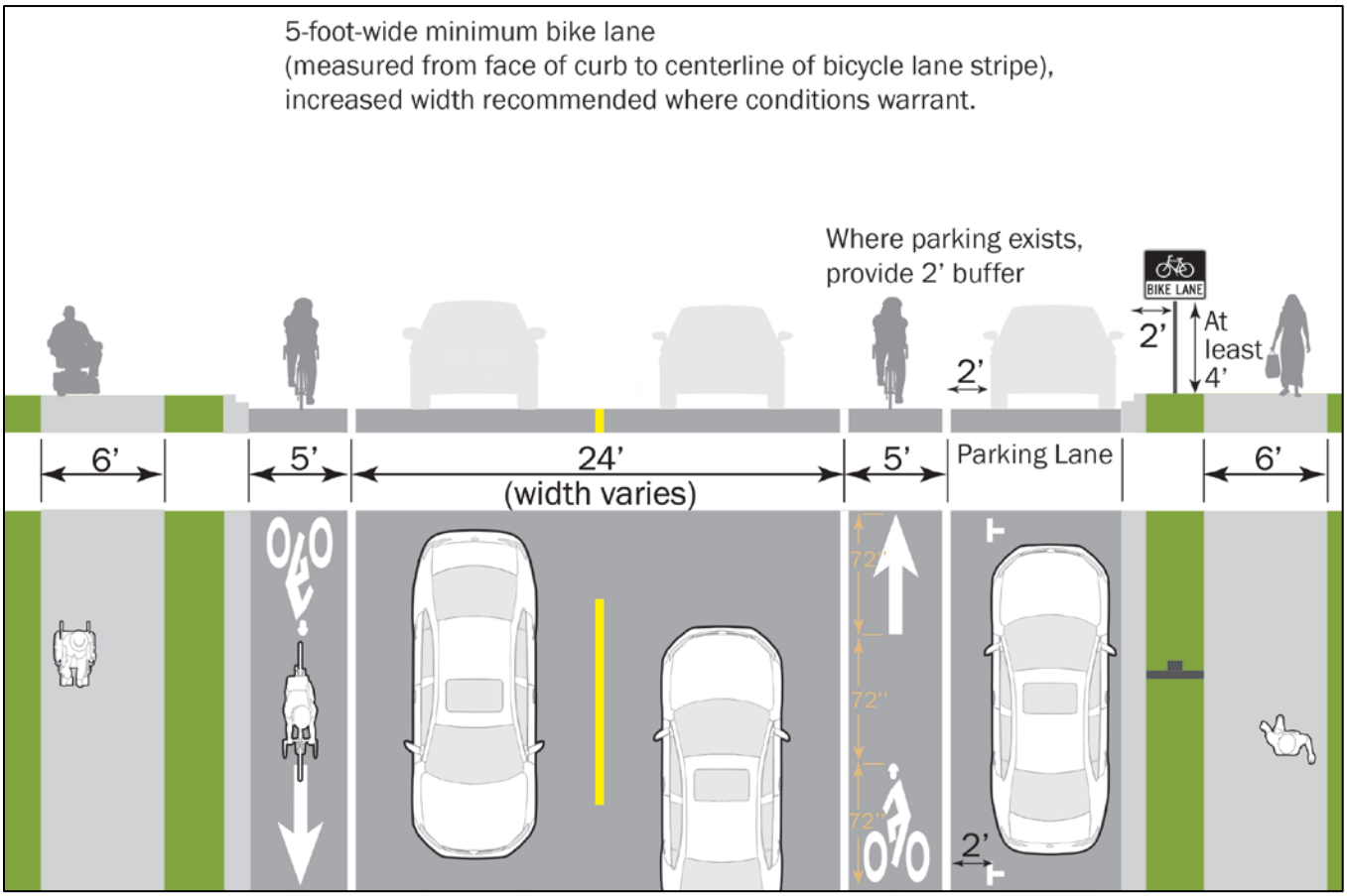
Recommendations

- Bicycle lanes should be a minimum of 5 feet wide when measured from the face of the curb to the centerline of the bicycle lane stripe. Figure 7 provides a graphical representation of bicycle lane design recommendations.
- Drainage grates and gutter seams should not be included in the usable width unless they are bicycle-friendly. AASHTO currently measures bicycle accommodations from face of curb because the width of gutter pans generally falls within with the shy distance for bicyclists.
- Where on-street parking is allowed, a 2-foot wide buffer from the parking stall width should be provided to prevent "dooring."
- One-way bicycle lanes should be provided on both sides of two-way streets.
- Bicycle route signage and bicycle pavement markings/symbols should be placed logically (evaluated on a case-by-case basis) to advise motorists of the bicycle lanes.
- Bicycle pavement markings/symbols should be placed at regular intervals on the paved surface of the bicycle lane to advise motorists of the on-street bicycle lanes.
- Permanent bicycle count equipment should be installed at logical intervals along newly constructed BTTS bikeways to document usage.

Challenges

- Intersections and other conflict points represent serious safety issues for bicyclists. Special attention should be paid to bikeway design through intersections and other conflict points.
- Relocation and/or adjustments to existing on-street parking may be required to accommodate bicycle lanes
- Increasing pavement surface area to designate bicycle lanes:
  - May be difficult to incorporate into resurfacing projects. Typically widening can be done effectively during full pavement rehabilitation (that is, complete pavement replacement).
  - May not be possible where right-of-way is constrained.
  - May necessitate costly utility relocations, drainage and stormwater management
  - May encounter natural environment constraints (wetland, wildlife, or parkland encroachment concerns).
  - May be impractical for bridge sections, causing bicyclists to share the outside travel lane with motor vehicles across constrained bridge structures.
  - May require traffic control strategies to avoid disruption to motor vehicle travel during construction.

*Figure 7: Typical Section, Bicycle Lane*




Design Considerations

- Bikeway design features through intersections and other conflict points should be considered during project development.
- Signage:
  - Sign placement frequency should be determined on a case-by-case basis. The density of adjacent development and existing signage should be taken into consideration to avoid sign pollution and/or confusion. Signs should be placed for both travel directions (Per Texas MUTCD, recommended sign is R3-17 with minimum size of 24 inches high by 18 inches wide). See Figure 3.
  - Signs should be placed at least 4 feet above grade and provide a minimum 2-foot horizontal clearance from the roadway edge.
  - If a Texas state agency wishes to advance TxDOT's BTTS and develop a more formal bicycle tourism network, then route numbering and themed signage is recommended in accordance with respective agency guidelines. The Texas MUTCD suggests the use of M1-9, M1-8, or M1-8a. See Figure 3.

### *Paved Shoulder*

Many Texas roadways have wide paved shoulders and may be compatible for bicycling. Paved shoulders offer a cost-effective way to provide bikeway connectivity between destinations. However, riding a bicycle on a paved shoulder can be intimidating for many bicyclists. The speed and volume of adjacent traffic, the presence of parked cars, rumble strips, and roadway debris can pose significant hazards to bicyclists. Because of these concerns, only roadways with 8-foot-wide (or wider) paved outside shoulders will be considered for inclusion in TxDOT's BTTS.

Adding or widening paved shoulders may be best completed during a pavement replacement project, where all the pavement on a roadway is replaced, but the underlying base is maintained. In this situation, a full-depth shoulder may be added along with the width of the roadway travel lanes. Adding or widening paved shoulders during pavement replacement may have the following advantages:

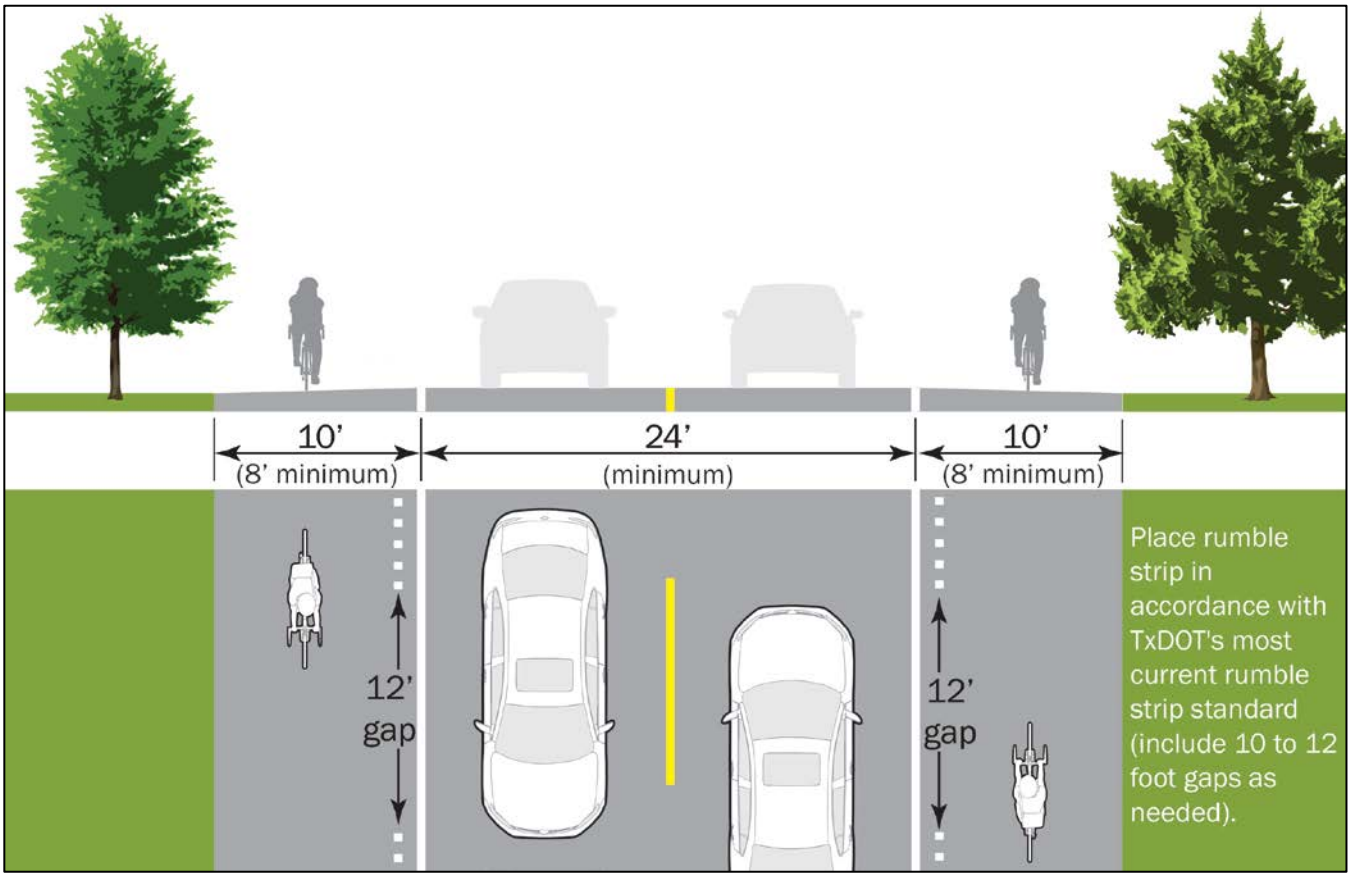
- Cost/efficiencies of scale: In a pavement replacement project, the cost for providing shoulders may be a relatively small portion compared with the cost of the overall project. Having the equipment and materials present would result in a lower material unit cost when compared to a stand-alone shoulder widening project due to the efficiencies of scale.
- Longevity: During a pavement replacement project, there is an opportunity to confirm that the underlying base material beneath the travel lanes and shoulder is uniform. Additionally, if necessary, the pavement depth of shoulders can be increased during a pavement replacement project. Both improvements will lead to longer-lasting shoulders.

Many road segments with existing 8- to 10-foot-wide outside shoulders have been included as part of the initial BTTS Example Network. See Technical Memorandum 2 for additional details about the route development process.

Recommendations

- To be included as a Texas Tourism Trails route, paved shoulders should be at least 8 feet wide and be provided on both sides of a roadway. See Figure 8 for a graphic representation of paved shoulder design recommendations.
- Where rumble strips/shoulder texturing exists, a 10- to 12-foot-wide gap every 40 to 60 feet is recommended to provide bicyclists better access.
- Drainage grates and gutter seams should not be included in the usable width unless they are bicycle friendly.
- Bicycle route signage is recommended.
- Permanent bicycle count equipment should be installed at logical intervals along newly constructed BTTS bikeways to document bicycle and pedestrian usage.

*Figure 8: Typical Section, Paved Shoulder*




Challenges

- Increasing pavement surface area to widen shoulders:
  - May be difficult to incorporate into resurfacing projects (shoulder widening can be done more effectively during full pavement rehabilitation, that is, complete pavement replacement).
  - May not be cost-effective where right-of-way is constrained or in developed areas
  - May necessitate costly utility relocations, drainage and stormwater management
  - May encounter natural environment constraints (wetland, wildlife, or parkland encroachment concerns)
  - May not be possible over bridges, causing bicyclists to share the outside travel lane with motor vehicles on bridges
  - May require traffic control strategies to avoid disruption to motor vehicle travel during construction
- Roadway debris regularly collects on the shoulder. More frequent maintenance and sweeping is recommended to improve the safety of bicyclists.

Design Considerations

- Rumble strips are a type of shoulder texturing effective at reducing the number of single-vehicle, roadway departure crashes.
  - AASHTO guidance[11] requires at least 4 feet of usable paved shoulder between the rumble strip and outside edge of the paved shoulder. Rumble strips should be placed on the shoulder near the outside lane line. A minimum distance of 6 feet of usable paved shoulder is recommended on BTTS routes.
  - See TxDOT's *Roadway Design Manual*[12] and FHWA's guidance[13] on rumble strips and rumble strips for additional information.
- Intersections and other conflict points represent serious safety issues for bicyclists. Special attention should be paid to bikeway design through intersections and other conflict points.
  - Accommodations should be made for bicyclists traveling through intersections when shoulders have been used to provide for right turn or center turn lanes. Such accommodations could include striping a bicycle lane through the intersection to provide connectivity or adding signage that indicates through-bicyclists are permitted to use the right turn lane.
- Signage
  - Sign placement frequency should be determined on a case-by-case basis. The density of adjacent development and existing signage should be taken into consideration to avoid sign pollution and confusion. Signs should be placed for both travel directions (Per Texas MUTCD, recommended sign is R3-17 with minimum size of 24 inches high by 18 inches wide). See Figure 3.
  - Signs should be placed at least 4 feet above grade and provide a minimum 2-foot horizontal clearance from the pathway edge.
  - If a Texas state agency wishes to advance TxDOT's BTTS and develop a more formal bicycle tourism network, then route numbering and themed signage is recommended in accordance with respective agency guidelines. The Texas MUTCD suggests the use of M1-9, M1-8, or M1-8a. See Figure 3.

## Bikeway Cost Estimates

### *Bikeway Construction Costs*

Per mile bikeway cost estimates were developed based on TxDOT's December 2017 Average Low Bid Prices to provide a range of estimated costs for various bikeway improvements. The estimated costs include materials and labor. As the BTTS statewide planning-level cost estimates intend to estimate the construction cost for each of the four bikeway types, devoid of a proposed project location, 20 percent was added to cover anticipated project costs including:

- Plans, specifications, and engineering (PS&E) costs
- Regional soil/environmental conditions
- Regional material and labor cost differences
- Intersection/conflict point design alterations
- Construction mobilization

Conversely, some project development costs are too variable across the state to estimate at the planning level. Right-of-way acquisition in more densely developed urban areas will constitute a much higher portion of the total project cost when compared with rural areas based on real estate prices. Similarly, a roadway widening project requiring the relocation of utility infrastructure (sewage or water supply pipes, or telecommunications or electrical conduit) will cost more than a similar project without these location-specific utility constraints. At this stage, statewide planning-level cost estimates cannot anticipate these highly variable cost differences. The following costs are unaccounted for in BTTS construction cost estimate ranges:

- Right-of-way acquisition necessity and/or cost
- Utility relocation necessity and/or cost

Table 1 summarizes the per mile construction cost estimates by type of bikeway improvement project. Appendix A details costs associated with each type of bikeway improvement project. All bikeway improvement construction costs include the following:

- Pavement
- Pavement markings
- Signage
- Bicycle and pedestrian count equipment (induction loop and infrared beam pair)[14]

Other additional construction costs that vary by bikeway types include the following:

- Rumble strips
- Lighting
- Flexible delineators
- Concrete traffic barriers

*Table 1: Per Mile Bikeway Construction Cost Estimate Ranges*

| Bikeway Improvement Project | Initial Construction Costs[a,b] | |
|---|---|---|
| | Low-end | High-end |
| Construct Shared Use Path | $480,000 | $570,000 |
| *Restripe* roadway for Buffered Bike Lane | $140,000 | $160,000 |
| Widen *concrete* roadway for Buffered Bicycle Lane | $1,190,000 | $1,430,000 |
| Widen *asphalt* roadway for Buffered Bicycle Lane | $1,080,000 | $1,300,000 |
| *Restripe* roadway for Bicycle Lane | $80,000 | $100,000 |
| Widen *concrete* roadway for Bicycle Lane | $1,000,000 | $1,200,000 |
| Widen *asphalt* roadway for Bicycle Lane | $980,000 | $1,180,000 |
| Widen *concrete* Shoulder | $1,040,000 | $1,250,000 |
| Widen *asphalt* Shoulder | $950,000 | $1,130,000 |

Notes:

[a] Construction costs per mile include 20 percent (%) to cover additional project costs including: intersection considerations, mobilization, regional differences, and/or PS&E. Construction costs per mile do not include right-of-way acquisition or utility relocation, as these costs will vary vastly depending on location of bikeway improvements. Base construction costs (materials and labor) were derived using TxDOT's Average Low Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0101.htm] where available.

[b] Low-end cost estimates are calculated as labor and materials costs + 20% allowance for PS&E, regional cost differences, and construction mobilization. High-end cost estimates are calculated 20% higher than the low-end estimates. All costs are provided in 2017 dollars.

### *Bikeway Operation and Maintenance Costs*

To better anticipate the lifecycle costs of bikeway infrastructure, the project team evaluated the Operations and Maintenance (O&M) costs for both on-road bikeways (including buffered bike lanes, bike lanes, and wide shoulders) and off-road SUPs using TxDOT's Average Low Bid prices[15]. Table 2 identifies the O&M activities that the project team included in cost estimates.

*Table 2: Bikeway Operation and Maintenance Activities*

| O&M Category | Maintenance Activities (TxDOT bid item#) | Annualized Per Mile Unit/Activity Cost* |
|---|---|---|
| **Routine Maintenance** *Multiple times each year* | Grass mowing (730 6002) | $216 |
| | Cleaning/brushing (738 2006) | $5,600 |
| | Tree trimming (752 6001) | $1,500 |
| | Vandalism repair | $3,000 |
| | Litter control (751 6005) | $672 |
| **Periodic Maintenance** *Every 1 to 5 years* | Clearance pruning (751 6011) | $1,500 |
| | Major tree trimming (752 6001) | $1,500 |
| | Brush cutback (752 6002) | $1,500 |
| | Roadway edging (751 6007) | $2,112 |
| | Crack sealing (713 6005) | $5,280 |
| | Re-striping (713 6005) | $1,584 |
| | Permanent counter modem, batteries, etc | $92 |

* Periodic maintenance activities do not occur every year. To derive annual maintenance costs for these items, routine maintenance costs were divided by 5 to represent an annualized cost.

Appendix A presents bikeway cost estimates, including O&M costs. While all bikeway facilities will require O&M expenditures to ensure the longevity of the bikeway investment, on-road bikeway O&M activities are assumed to be included in regularly scheduled road maintenance. In other words, a roadway incurs grass cutting, sweeping, and crack sealing costs whether a bike lane exists or not, so these costs are not included in O&M estimates. However, O&M costs are included for shared use paths and sidepaths, as these bikeways are independent of a roadway. Depending on routine maintenance schedules, it may be advisable to allocate funding for increased routine maintenance activities on bicycle tourism trail routes. Roadway debris and litter can severely affect the comfort and safety of a bicyclist.

Long-term maintenance activities will vary based on location-specific attributes such as bikeway usage, soil conditions, and temperature. As previously mentioned, it is assumed on-road bikeways (buffered bike lanes, bike lanes, and wide shoulders) would share the same

typical pavement section as the roadway itself, and are, therefore, assumed to have the same long-term maintenance and repair needs. It is assumed these roadways would need a standard full-depth repair after 15 years. However, off-road SUPs are assumed to need full-depth repair after 30 years, as the majority of traffic loads and wear will result from bicycle and pedestrian users. Long-term maintenance activities anticipated for both on-road bikeways and SUPs include *crack cleaning and sealing* (TxDOT Bid #713 6005, $3 per linear foot) and *full-depth pavement repair* (TxDOT Bid #361 2001, $180 per square yard)[16]. O&M budgets should anticipate these infrequent costs.

## Conclusion

This technical memorandum documents TxDOT's recommended bikeway accommodations and design criteria specific to bicycle tourism trails. The Example Network provided maximizes connectivity to existing and planned bikeway investments around Texas. Ideally, a future Texas Bicycle Tourism Trail network would use the available existing and planned bikeway accommodations. Newly constructed bikeways planned as bicycle tourism trail routes should follow the recommended design criteria described in this technical memorandum. Safety is the top priority at TxDOT. The bikeway design recommendations, challenges, and considerations described under each bikeway type in this technical memorandum are critical to creating a safer bicycle network for users of all ages and all abilities.

# References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11 American Association of State Highway Transportation Officials (AASHTO). 2012. *Guide for the Development of Bicycle Facilities.* 4th Edition. ISBN Number: 978-1-56051-527-2. https://bookstore.transportation.org/item_details.aspx?ID=1943. See Page 4-7.

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13 Federal Highway Administration. 2017. *State of the Practice for Shoulder and Center Line Rumble Strip Implementation on Non-Freeway Facilities*. Publication No. FHWA-HRT-17-026. https://www.fhwa.dot.gov/publications/research/safety/17026/17026.pdf

14 For additional information, read FHWA, 2016. *Traffic Monitoring Guide*. Chapter 4: Traffic Monitoring for Nonmotorized Traffic. https://www.fhwa.dot.gov/policyinformation/tmguide/

15 Texas Department of Transportation (TxDOT). March 2018. Average Bid Prices http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidpricm/s_0702.htm

16 Texas Department of Transportation (TxDOT). March 2018. Average Low Bid Prices http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidpricm/s_0303.htm

# Appendix A:
# Detailed Bikeway Cost Estimate Tables

Jacobs for TxDOT Public Transportation Division (PTN)

May 2018

**Acknowledgements**

Prepared for: TxDOT Public Transportation Division (PTN)

Prepared by: Abe Bekele, Jignesh Shah, and Carl Seifert

Quality Reviewers: Martin Timmerman and Nishant Kukadia

## PER MILE COST RANGES BY BIKEWAY TYPE

### Contruction Cost Estimates[1]

| Bikeway Improvement Project | Ranges[2] | |
|---|---|---|
| | Low-end | High-end |
| Construct Shared Use Path | $480,000 | $570,000 |
| Restripe Roadway for Buffered Bicycle Lane | $140,000 | $160,000 |
| Widen Concrete Roadway for Buffered Bicycle Lane | $1,190,000 | $1,430,000 |
| Widen Asphalt Roadway for Buffered Bicycle Lane | $1,080,000 | $1,300,000 |
| Restripe Roadway for Bicycle Lane | $80,000 | $100,000 |
| Widen Concrete Roadway for Bicycle Lane | $1,000,000 | $1,200,000 |
| Widen Asphalt Roadway for Bicycle Lane | $980,000 | $1,180,000 |
| Widen Concrete Outside Shoulder | $1,040,000 | $1,250,000 |
| Widen Asphalt Outside Shoulder | $950,000 | $1,130,000 |

### Annual Operation and Maintenance Cost Estimates[3]

| Bikeway Type | Routine and Periodic O&M Costs Ranges[2] | |
|---|---|---|
| | Low-end | High-end |
| Shared Use Path | $14,000 | $17,000 |
| Buffered Bicycle Lane | $1,600 | $2,000 |
| Bicycle Lane | $1,600 | $2,000 |
| Wide Outside Shoulder | $1,600 | $2,000 |

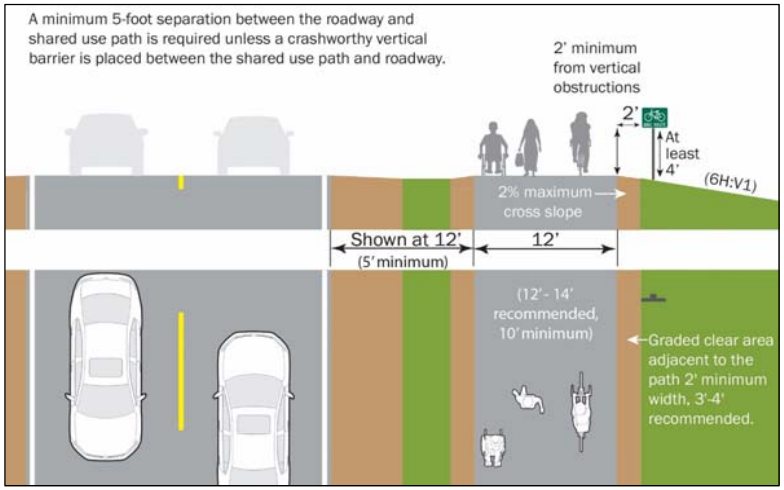
Notes:

[1] Construction costs per mile include 20% to cover additional projects costs including: intersection considerations, mobilization, regional differences, and/or PS&E. Construction costs per mile do not include right-of-way acquisition or utility relocation as these costs will vary prodigiously depending on location of bikeway improvements. Base construction costs (materials and labor) have been derived using TxDOT Average Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0101.htm] where available.

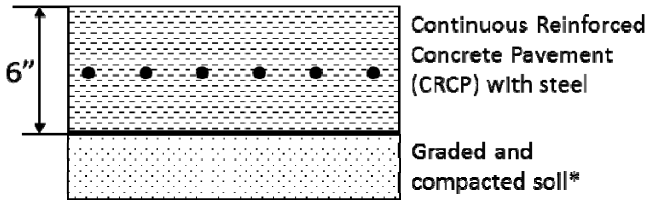
[2] Low-end cost estimates are calculated as labor & materials costs + 20% contingency. High-end cost estimate is 20% higher than the low-end. All costs provided in 2017 dollars.

[3] O&M Costs per year, per mile. While all bikeway facilities will require O&M expenditures to ensure the longevity of the bikeway investment, on-road bikeway (buffered bike lanes, bike lanes, and wide shoulders) O&M activities are assumed to be included in regularly scheduled road maintenance; therefore, these costs are not included in these cost estimates.
Long-Term maintenance includes complete, full-depth pavement replacement. Maintenance costs are listed here as annual portions of necessary total, future investments. For detailed O&M costs, see individual bikeway sheets. All maintenance costs have been derived using TxDOT Average Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidpricm/s_0702.htm] where available.

# SHARED USE PATH/SIDEPATH




**Typical Pavement Structure**




*Additional substructure may be necessary depending on local soil conditions

## ESTIMATED CONSTRUCTION COSTS PER MILE

| SHARED USE PATH CAPITAL COST DESCRIPTIONS<br>Cost Description | Layman's Terms | Unit | Cost | Rounded Costs | Remarks/Assumptions |
|---|---|---|---|---|---|
| 6" REINFORCED CONCRETE SUP | 6" CONCRETE SHARED USE PATH | Per Mile | $387,200 | $387,200 | 12ft wide SUP with 2' clear area |
| BICYCLE ROUTE SIGNS | BICYCLE ROUTE SIGNS | Per Mile | $4,798 | $4,800 | Assumes 10 per mile (case-by-case evaluation) |
| INDUCTION & INFRARED BIKE/PEDESTRIAN | PERMANENT BIKE/PEDESTRIAN COUNTER | Per Unit | $5,820 | $5,800 | Count equipment placement and frequency vary (case-by-case evaluation) |
| | **Cost Per Mile (Subtotal)** | | $397,818 | | |
| | Additional miscellaneous project costs | 20% | $79,564 | | |
| | **Total Cost Per Mile** | | **$477,381** | **$477,400** | |

| POTENTIAL SIDEPATH ITEMS, CAPITAL COST DESCRIPTIONS<br>Cost Description | Layman's Terms | Unit | Cost | Rounded Costs | Remarks/Assumptions |
|---|---|---|---|---|---|
| HIGH PRESSURE SODIUM LIGHT FIXTURE/LED | PEDESTRIAN LIGHTING ASSEMBLIES (100 watt) | Per Mile | $265,000 | $265,000 | Assumes 53 per mile or every 100 ft |

NOTE: Costs have been estimated based upon average installed price (TxDOT Average Bid Prices). See http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0306.htm

## ESTIMATED OPERATION AND MAINTENANCE COST PER MILE

| O&M ACTIVITIES | Annual Rounded Costs | Remarks/Assumptions |
|---|---|---|
| ROUTINE MAINTENANCE - MORE THAN ONCE PER YEAR | $5,000 | Includes sweeping, mowing, litter control, and vandalism repair |
| PERIODIC MAINTENANCE - EVERY FIVE YEARS | $9,000 | Includes tree trimming, edging, seal cracking, and re-striping |
| LONG TERM MAINTENANCE COST- EVERY 30 YEARS | $25,167 | Includes crack sealing and full depth repair after 30 years |
| **ANNUALIZED LIFECYCLE O&M COST PER MILE AFTER 30 YEARS** | **$39,167** | |

NOTES:

1. Shared Use Paths are assumed to be independent of roadway right-of-way. All operation & maintenance activities will be independent of roadway operations and maintenance.
2. Costs have been derived using TxDOT Average Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0101.htm]

# Assumed Pavement Structure

## Continuously Reinforced Concrete Pavement Structure

**NEW 10' SHOULDER (ON BOTH SIDES)**
**COST PER MILE**

| Item | DESCRIPTION | UNIT | QUANTITY | UNIT COST | SUBTOTAL |
|---|---|---|---|---|---|
| 360 | CONC PVMT (CONT REINF-CRCP)(8") | SY | 11,733 | 42 | $492,800.00 |
| 310 | PRIMECOAT AEP | GAL | 3,872 | 3.3 | $12,777.60 |
| 341 | D-GR HMA TY-B PG64-22 (4") | TON | 2,839 | 67.78 | $192,459.05 |
| 247 | FL BS (CMP IN PLC) (TY A GR 4)(8") | SY | 14,080 | 11.68 | $164,454.40 |
| | | | | COST PER MILE | $862,491 |

| | |
|---|---|
| Concrete Pavement Surface Area (CRCP) (SF) | 105,600 |
| Hot Mix Asphalt Surface Area (SF) | 116,160 |
| Flex Base Surface Area (SF) | 126,720 |

**Assumptions:**
3)PRIMECOAT AEP 0.3 gal/square yard

**NEW PAVEMENT FOR 5' BICYCLE LANE (ON BOTH SIDES)**
**COST PER MILE**

| Item | DESCRIPTION | UNIT | QUANTITY | UNIT COST | SUBTOTAL |
|---|---|---|---|---|---|
| 360 | CONC PVMT (CONT REINF-CRCP)(8") | SY | 5,867 | 42 | $246,400.00 |
| 310 | PRIMECOAT AEP | GAL | 2,112 | 3.3 | $6,969.60 |
| 341 | D-GR HMA TY-B PG64-22 (4") | TON | 1,549 | 67.78 | $104,977.66 |
| 247 | FL BS (CMP IN PLC) (TY A GR 4)(8") | SY | 8,213 | 11.68 | $95,931.73 |
| | | | | COST PER MILE | $454,279 |

| | |
|---|---|
| Concrete Pavement Surface Area (CRCP) (SF) | 52,800 |
| Hot Mix Asphalt Surface Area (SF) | 63,360 |
| Flex Base Surface Area (SF) | 73,920 |

**Assumptions:**
3)PRIMECOAT AEP 0.3 gal/square yard

**NEW PAVEMENT FOR 5' BICYCLE LANE AND 2' BUFFER (ON BOTH SIDES)**
**COST PER MILE**

| Item | DESCRIPTION | UNIT | QUANTITY | UNIT COST | SUBTOTAL |
|---|---|---|---|---|---|
| 360 | CONC PVMT (CONT REINF-CRCP)(8") | SY | 8,213 | 42 | $344,960.00 |
| 310 | PRIMECOAT AEP | GAL | 2,464 | 3.3 | $8,131.20 |
| 341 | D-GR HMA TY-B PG64-22 (4") | TON | 1,807 | 67.78 | $122,473.94 |
| 247 | FL BS (CMP IN PLC) (TY A GR 4)(8") | SY | 8,213 | 11.68 | $95,931.73 |
| | | | | | |
| | | | | | |
| | | | | COST PER MILE | $571,497 |

| | |
|---|---|
| Concrete Pavement Surface Area (CRCP) (SF) | 73,920 |
| Hot Mix Asphalt Surface Area (SF) | 73,920 |
| Flex Base Surface Area (SF) | 73,920 |

**Assumptions:**
3)PRIMECOAT AEP 0.3 gal/square yard

## Asphalt Pavement Structure

**NEW 10' SHOULDER (ON BOTH SIDES)**
**COST PER MILE**

| Item | DESCRIPTION | UNIT | QUANTITY | UNIT COST | SUBTOTAL |
|---|---|---|---|---|---|
| 341 | D-GR HMA TY-D PG70-22 (2") | TON | 1,291 | 80 | $103,300.00 |
| 341 | D-GR HMA TY-B PG64-22 (6") | TON | 4,259 | 67.78 | $288,700.00 |
| 310 | PRIMECOAT AEP | GAL | 4,224 | 3.3 | $14,000.00 |
| 247 | FL BS (CMP IN PLC) (TY A GR 4)(12") | SY | 14,080 | 18.9 | $266,200.00 |
| 247 | LIME STAB SUBGR (COMP IN PLC)(8") | SY | 15,253 | 4.5 | $68,640.00 |
| 260 | LIME | TON | 230 | 175 | $40,240.20 |
| | | | | COST PER MILE | $781,080 |

| | |
|---|---|
| Hot Mix Asphalt Surface Area (SF) | 105,600 |
| Hot Mix Asphalt Base Area (SF) | 116,160 |
| Flex Base Surface Area (SF) | 126,720 |
| LSSG Surface Area (SF) | 137,280 |

**Assumptions:**
3)PRIMECOAT AEP 0.3 gal/square yard

**NEW PAVEMENT FOR 5' BICYCLE LANE (ON BOTH SIDES)**
**COST PER MILE**

| Item | DESCRIPTION | UNIT | QUANTITY | UNIT COST | SUBTOTAL |
|---|---|---|---|---|---|
| 341 | D-GR HMA TY-D PG70-22 (2") | TON | 645 | 80 | $51,700.00 |
| 341 | D-GR HMA TY-B PG64-22 (6") | TON | 2,323 | 67.78 | $157,500.00 |
| 310 | PRIMECOAT AEP | GAL | 2,464 | 3.3 | $8,200.00 |
| 247 | FL BS (CMP IN PLC) (TY A GR 4)(12") | SY | 8,213 | 18.9 | $155,300.00 |
| 247 | LIME STAB SUBGR (COMP IN PLC)(8") | SY | 9,387 | 4.5 | $42,300.00 |
| 260 | LIME | TON | 142 | 175 | $24,800.00 |
| | | | | COST PER MILE | $439,800 |

| | |
|---|---|
| Hot Mix Asphalt Surface Area (SF) | 52,800 |
| Hot Mix Asphalt Base Area (SF) | 63,360 |
| Flex Base Surface Area (SF) | 73,920 |
| LSSG Surface Area (SF) | 84,480 |

**Assumptions:**
3)PRIMECOAT AEP 0.3 gal/square yard

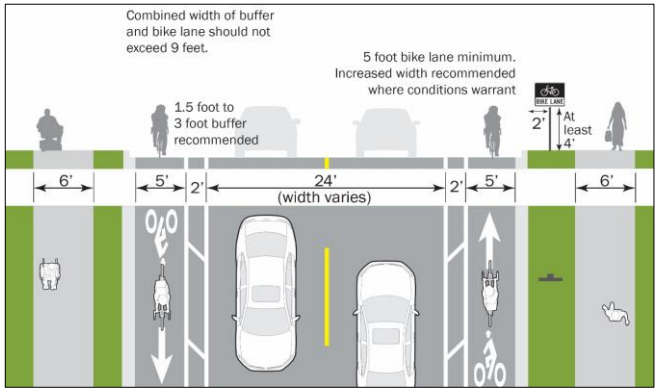
**NEW PAVEMENT FOR 5' BICYCLE LANE AND 2' BUFFER (ON BOTH SIDES)**
**COST PER MILE**

| Item | DESCRIPTION | UNIT | QUANTITY | UNIT COST | SUBTOTAL |
|---|---|---|---|---|---|
| 341 | D-GR HMA TY-D PG70-22 (2") | TON | 903 | 80 | $72,300.00 |
| 341 | D-GR HMA TY-B PG64-22 (6") | TON | 2,710 | 67.78 | $183,800.00 |
| 310 | PRIMECOAT AEP | GAL | 2,464 | 3.3 | $8,200.00 |
| 247 | FL BS (CMP IN PLC) (TY A GR 4)(8") | SY | 8,213 | 18.9 | $155,300.00 |
| 247 | LIME STAB SUBGR (COMP IN PLC)(8") | SY | 8,213 | 4.5 | $37,000.00 |
| 260 | LIME | TON | 124 | 175 | $21,700.00 |
| | | | | COST PER MILE | $478,300 |

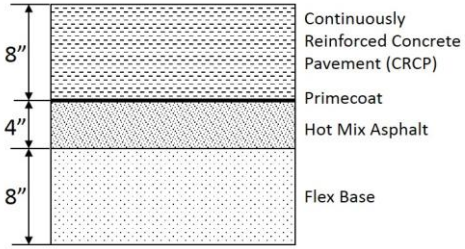
| | |
|---|---|
| Hot Mix Asphalt Surface Area (SF) | 73,920 |
| Hot Mix Asphalt Base Area (SF) | 73,920 |
| Flex Base Surface Area (SF) | 73,920 |
| LSSG Surface Area (SF) | 73,920 |

**Assumptions:**
3)PRIMECOAT AEP 0.3 gal/square yard

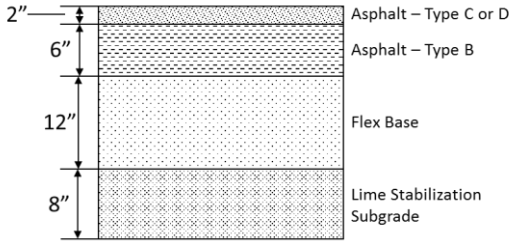
# BUFFERED BICYCLE LANE




**Concrete Section - Typical Pavement Structure**




**Asphalt Section - Typical Pavement Structure**




**ESTIMATED CONSTRUCTION COSTS PER MILE**

| RESTRIPING TWO-LANE ROADWAY FOR BUFFERED BIKE LANES, CAPITAL COSTS DESCRIPTIONS | | Unit | Cost | Rounded Costs | Remarks/Assumptions |
|---|---|---|---|---|---|
| **Cost Description** | **Layman's Terms** | | | | |
| REMOVE LANE MARKINGS | REMOVE LANE MARKINGS | Per Mile | $23,200 | $23,200 | |
| PAV SURF PREP AND PLACEMENT FOR ALL MARKINGS (BIKE ARROW, SYMBOL, AND STRIPES) | SURFACE PREPARATION AND INSTALLATION FOR 6" STRIPES, BIKE ARROW, AND BIKE SYMBOL | Per Mile | $18,964 | $19,000 | Assumes 4, 6" stripes for one mile; diagonal stripes every 15' on each side; and 40 bike arrows and symbols per mile. |
| FLEXIBLE DELINEATORS | FLEXIBLE DELINEATORS | Per Mile | $36,960 | $37,000 | Assumes 530 per mile (1 every 10'). Optional. |
| BICYCLE ROUTE SIGNS | BICYCLE ROUTE SIGNS | Per Mile | $28,403 | $28,400 | Assumes signage at start/end of facility and at 2 intersections/mile |
| INDUCTION & INFRARED BIKE/PEDESTRIAN COUNTER | PERMANENT BIKE/PEDESTRIAN COUNTER | Per Unit | $5,820 | $5,800 | Count equipment placement and frequency vary (case-by-case evaluation) |
| | **Cost Per Mile (Subtotal)** | | $113,347.30 | | |
| | Additional miscellaneous project costs | 20% | $22,669 | | |
| | **Total Cost Per Mile** | | **$136,017** | **$136,000** | |

| WIDENING ROADWAY TO ADD BUFFERED BIKE LANES, CAPITAL COST DESCRIPTIONS | | Unit | Cost | Rounded Costs | Remarks/Assumptions |
|---|---|---|---|---|---|
| **Cost Description** | **Layman's Terms** | | | | |
| ADD **CRCP** PAVEMENT FOR 5FT BICYCLE LANES and 2FT BUFFER | ADD 7' OF **CRCP** PAVEMENT FOR BUFFERED BICYCLE LANES | Per Mile | $571,497 | $571,500 | Refer to Assumed Pavement Structures Table for details |
| **OR** | | | | | |
| ADD **ASPHALT** PAVEMENT FOR 5FT BICYCLE LANES and 2FT BUFFER | ADD 7' OF **ASPHALT** PAVEMENT FOR BUFFERED BICYCLE LANES | Per Mile | $478,300 | $478,300 | Refer to Assumed Pavement Structures Table for details |
| CONC CURB & GUTTER (TY II) | ADD CURB AND GUTTER | Per Mile | $208,032 | $208,000 | |
| IN RD IL AM (TY SP) 48S-10-10 (400W) S | CENTER-MOUNTED STYLE POLE-LIGHTING | Per Mile | $124,546 | $124,500 | Assumes Every 100ft or 27 poles per mile |
| PAV SURF PREP AND PLACEMENT FOR ALL MARKINGS (BIKE ARROW, SYMBOL, AND STRIPES) | SURFACE PREPARATION AND INSTALLATION FOR 6" STRIPES, BIKE ARROW, AND BIKE SYMBOL | Per Mile | $18,964 | $19,000 | Assumes 4, 6" stripes for one mile; diagonal stripes every 15' on each side; and 40 bike arrows and symbols per mile. |
| FLEXIBLE DELINEATORS | FLEXIBLE DELINEATORS | Per Mile | $36,960 | $37,000 | Assumes 530 per mile (1 every 10'). Optional. |
| BICYCLE ROUTE SIGNS | BICYCLE ROUTE SIGNS | Per Mile | $28,403 | $28,400 | Assumes signage at start/end of facility and at 2 intersections/mile |
| INDUCTION & INFRARED BIKE/PEDESTRIAN COUNTER | PERMANENT BIKE/PEDESTRIAN COUNTER | Per Unit | $5,820 | $5,800 | Count equipment placement and frequency vary (case-by-case evaluation) |
| CONCRETE SECTION | **Concrete Section - Cost Per Mile (Subtotal)** | | $994,222 | | |
| | Additional miscellaneous project costs | 20% | $198,844 | | |
| | **Concrete Section - Total Cost Per Mile** | | $1,193,066 | **$1,193,100** | |
| ASPHALT SECTION | **Asphalt Section - Cost Per Mile (Subtotal)** | | $901,025 | | |
| | Additional miscellaneous project costs | 20% | $180,205 | | |
| | **Asphalt Section - Total Cost Per Mile** | | **$1,081,230** | **$1,081,200** | |

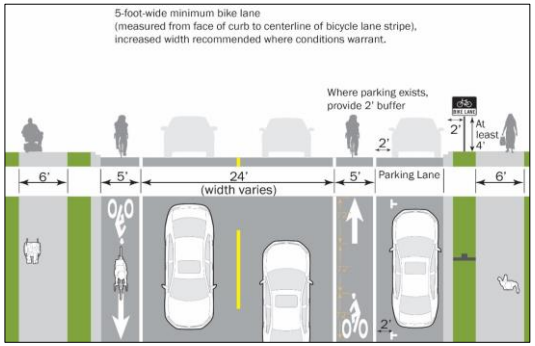
NOTE: Costs have been derived using TxDOT Average Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0101.htm]

**ESTIMATED OPERATION AND MAINTENANCE COST PER MILE**

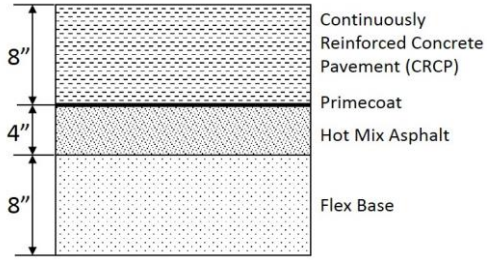
| O&M ACTIVITIES | | Annual Rounded Costs | Remarks/Assumptions |
|---|---|---|---|
| ROUTINE MAINTENANCE - MORE THAN ONCE PER YEAR | | $0 | Assumes part of regular roadway maintenance |
| PERIODIC MAINTENANCE - EVERY FIVE YEARS | | $1,600 | Includes edging, seal cracking, and re-striping for bikeway portion |
| LONG TERM MAINTENANCE COST- EVERY 15 YEARS | | $0 | Includes crack sealing and full depth repair for bikeway portion after 15 years |
| | **ANNUALIZED LIFECYCLE O&M COST PER MILE AFTER 15 YEARS** | **$1,600** | |

NOTE: Costs have been derived using TxDOT Average Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0101.htm]

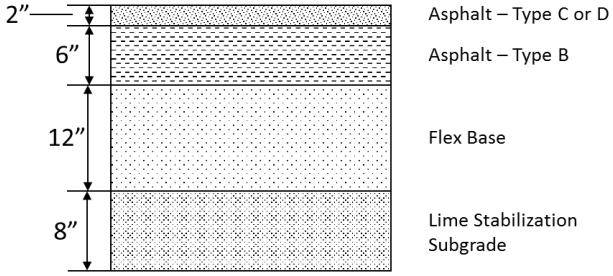
# BICYCLE LANE




**Concrete Section - Typical Pavement Structure**




**Asphalt Section - Typical Pavement Structure**




**ESTIMATED CONSTRUCTION COSTS PER MILE**

| RESTRIPING TWO-LANE ROADWAY FOR BIKE LANE, CAPITAL COSTS DESCRIPTIONS | | UNIT | COST | Rounded Costs | Remarks/Assumptions |
|---|---|---|---|---|---|
| Cost Description | Layman's Terms | | | | |
| REMOVE LANE MARKINGS | REMOVE LANE MARKINGS | Per Mile | $23,200 | $23,200 | |
| PAV SURF PREP AND PLACEMENT FOR ALL MARKINGS (BIKE ARROW, SYMBOL, AND STRIPES) | SURFACE PREPARATION AND INSTALLATION FOR 6" STRIPES, BIKE ARROW, AND BIKE SYMBOL | Per Mile | $11,836 | $11,800 | Assumes 2, 6" stripes for one mile and 40 bike arrows and symbols per mile. |
| BICYCLE ROUTE SIGNS | BICYCLE ROUTE SIGNS | Per Mile | $28,403 | $28,400 | Assumes signage at start/end of facility and at 2 intersections/mile |
| INDUCTION & INFRARED BIKE/PEDESTRIAN COUNTER | PERMANENT BIKE/PEDESTRIAN COUNTER | Per Unit | $5,820 | $5,800 | Count equipment placement and frequency vary (case-by-case evaluation) |
| | **Cost Per Mile (Subtotal)** | | $69,259.30 | **$69,300** | |
| | Additional miscellaneous project costs | 20% | $13,852 | | |
| | **Total Cost Per Mile** | | **$83,111** | **$83,100** | |

| WIDENING ROADWAY TO ADD BIKE LANES, CAPITAL COST DESCRIPTIONS | | UNIT | COST | Rounded Costs | Remarks/Assumptions |
|---|---|---|---|---|---|
| Cost Description | Layman's Terms | | | | |
| ADD **CRCP** PAVEMENT FOR 5FT BICYCLE LANES | WIDEN **CONCRETE** PAVEMENT 5FT ON EACH SIDE | Per Mile | $454,279 | $454,300 | Refer to Assumed Pavement Structures Table for details |
| | | | **OR** | | |
| ADD **ASPHALT** PAVEMENT FOR 5FT BICYCLE LANES | ADD 5' OF **ASPHALT** PAVEMENT FOR BICYCLE LANES | Per Mile | $439,800 | $439,800 | Refer to Assumed Pavement Structures Table for details |
| CONC CURB & GUTTER (TY II) | ADD CURB AND GUTTER | Per Mile | $208,032 | $208,000 | |
| IN RD IL AM (TY SP) 48S-10-10 (400W) S | CENTER-MOUNTED STYLE POLE-LIGHTING | Per Mile | $124,546 | $124,500 | Assumes Every 100 ft or 27 poles per mile |
| PAV SURF PREP AND PLACEMENT FOR ALL MARKINGS (BIKE ARROW, SYMBOL, AND STRIPES) | SURFACE PREPARATION AND INSTALLATION FOR 6" STRIPES, BIKE ARROW, AND BIKE SYMBOL | Per Mile | $11,836 | $11,800 | Assumes 2, 6" stripes for one mile and 40 bike arrows and symbols per mile. |
| BICYCLE ROUTE SIGNS | BICYCLE ROUTE SIGNS | Per Mile | $28,403 | $28,400 | Assumes signage at start/end of facility and at 2 intersections/mile |
| INDUCTION & INFRARED BIKE/PEDESTRIAN COUNTER | PERMANENT BIKE/PEDESTRIAN COUNTER | Per Unit | $5,820 | $5,800 | Count equipment placement and frequency vary (case-by-case evaluation) |
| CONCRETE SECTION | **Concrete Section - Cost Per Mile (Subtotal)** | | $832,916 | | |
| | Additional miscellaneous project costs | 20% | $166,583 | | |
| | **Concrete Section - Total Cost Per Mile** | | $999,499 | **$999,500** | |
| ASPHALT SECTION | **Asphalt Section - Cost Per Mile (Subtotal)** | | $818,437 | | |
| | Additional miscellaneous project costs | 20% | $163,687.38 | | |
| | **Asphalt Section - Total Cost Per Mile** | | **$982,124** | **$982,100** | |

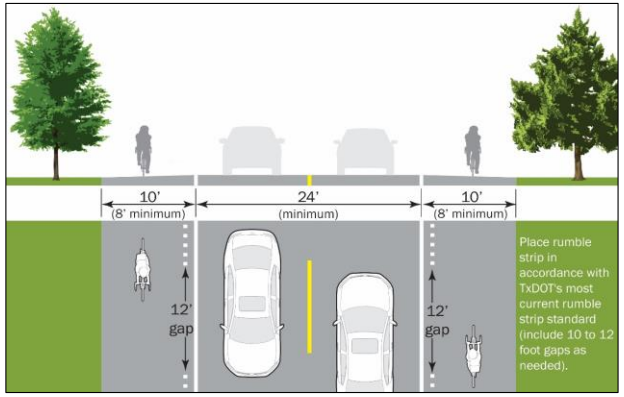
NOTE: Costs have been derived using TxDOT Average Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0101.htm]

**ESTIMATED OPERATION AND MAINTENANCE COST PER MILE**

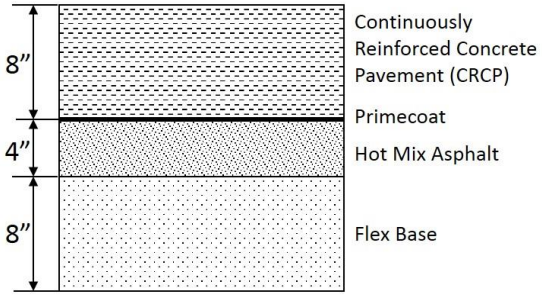
| O&M ACTIVITIES | | Annual Rounded Costs | Remarks/Assumptions |
|---|---|---|---|
| ROUTINE MAINTENANCE - MORE THAN ONCE PER YEAR | | $0 | Assumes part of regular roadway maintenance |
| PERIODIC MAINTENANCE - EVERY FIVE YEARS | | $1,600 | Includes edging, seal cracking, and re-striping for bikeway portion |
| LONG TERM MAINTENANCE COST- EVERY 15 YEARS | | $0 | Includes crack sealing and full depth repair for bikeway portion after 15 years |
| | **ANNUALIZED LIFECYCLE O&M COST PER MILE AFTER 15 YEARS** | **$1,600** | |

NOTE: Costs have been derived using TxDOT Average Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0101.htm]

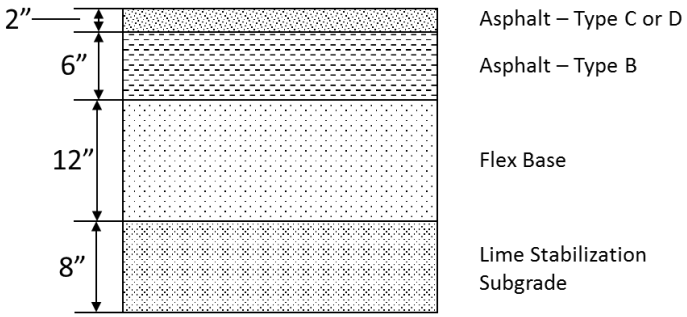
# WIDE SHOULDER




**Concrete Section - Typical Pavement Structure**




**Asphalt Section - Typical Pavement Structure**




**ESTIMATED CONSTRUCTION COSTS PER MILE**

| WIDE OUTSIDE SHOULDERS CAPITAL COST DESCRIPTIONS<br>Cost Description | Layman's Terms | UNIT | COST | Rounded Costs | Remarks/Assumptions |
|---|---|---|---|---|---|
| 10 ft Wide Outside Shoulder (**CRCP**) | WIDEN **CONCRETE** PAVEMENT 10 FT (BOTH SIDES) | Per mile | $862,491 | $862,500 | Refer to Assumed Pavement Structures Table for details |
| | | **OR** | | | |
| 10 ft Wide Outside Shoulder (**Asphalt**) | WIDEN **ASPHALT** PAVEMENT 10 FT (BOTH SIDES) | Per mile | $781,080 | $781,100 | Refer to Assumed Pavement Structures Table for details |
| PAV SURF PREP AND PLACEMENT FOR STRIPES | SURFACE PREPARATION AND INSTALLATION FOR 6" STRIPES | Per Mile | $4,752 | $4,800 | Assumes 2, 6" stripes for one mile and 40 bike arrows and symbols per mile. |
| RUMBLE STRIPS (SHOULDER) | RUMBLE STRIPS (SHOULDER) | Per mile | $1,478 | $1,500 | Rumble strips are required on many TxDOT roadways. See TxDOT Roadway Design Manual for details. |
| INDUCTION & INFRARED BIKE/PEDESTRIAN COUNTER | PERMANENT BIKE/PEDESTRIAN COUNTER | Per mile | $233 | $200 | Cost assumes one counter every 25 miles |
| CONCRETE SECTION | **Concrete Section - Cost Per Mile (Subtotal)** | | $868,954 | | |
| | Additional miscellaneous project costs | 20% | $173,791 | | |
| | **Concrete Section - Total Cost Per Mile** | | $1,042,745 | **$1,042,700** | |
| ASPHALT SECTION | **Asphalt Section - Cost Per Mile (Subtotal)** | | $787,543 | | |
| | Additional miscellaneous project costs | 20% | $157,509 | | |
| | **Asphalt Section - Total Cost Per Mile** | | **$945,052** | **$945,100** | |

| POTENTIAL WIDE SHOULDER ITEMS, CAPITAL COST DESCRIPTIONS<br>Cost Description | Layman's Terms | UNIT | COST | Rounded Costs | Remarks/Assumptions |
|---|---|---|---|---|---|
| IN RD IL AM (TY SP) 48S-10-10 (400W) S | CENTER-MOUNTED STYLE POLE-LIGHTING | Per Mile | $124,546 | $124,500 | Assumes every 100 ft or 27 poles per mile |
| | **Cost Per Mile (Subtotal)** | | $124,546 | **$124,500** | |
| | Miscellaneous | 20% | $24,909 | | |
| | **Total Cost Per Mile** | | **$149,455** | **$149,500** | |

NOTE: Costs have been derived using TxDOT Average Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0101.htm]

*While 8 foot wide shoulders are acceptable as a minimum, when shoulder widing is needed, 10 foot wide shoulders are recommended

**ESTIMATED OPERATION AND MAINTENANCE COST PER MILE**

| O&M ACTIVITIES | Annual Rounded Costs | Remarks/Assumptions |
|---|---|---|
| ROUTINE MAINTENANCE - MORE THAN ONCE PER YEAR | $0 | Assumes part of regular roadway maintenance |
| PERIODIC MAINTENANCE - EVERY FIVE YEARS | $1,600 | Includes edging, seal cracking, and re-striping for bikeway portion |
| LONG TERM MAINTENANCE COST- EVERY 15 YEARS | $0 | Includes crack sealing and full depth repair for bikeway portion after 15 years |
| **ANNUALIZED LIFECYCLE O&M COST PER MILE AFTER 15 YEARS** | **$1,600** | |

NOTE: Costs have been derived using TxDOT Average Bid Prices [http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/bidprice/s_0101.htm]