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## Appendices

- Appendix A – Crash Analysis Summary
- Appendix B – Worksheet
- Appendix C – Case Study
Introduction

Designing a transportation corridor to meet the needs of all of the anticipated users is a choice. As interest in bicycling increases, more people are demanding greater physical separation between the bikeway and vehicle lanes. Bikeway design should reflect this desire for separation, while considering the safety and comfort of the facility at and between intersections.

Bicycle safety research completed for this study, based on facilities in Oakland and Kent Counties, informs general trends of sidepath/sidewalk safety performance. This safety analysis provides contextual information to establish a basis for which corridor and intersection designs should be encouraged or avoided.

This Sidepath Intersection & Crossing Treatment Guide lays out a straightforward process for integrating high-quality bikeways into a proposed roadway project or as a stand-alone project. Efforts should be made to construct the “optimal” design. If this design cannot be achieved, then barriers to that design should be documented. Working through this design process can help the designer identify techniques to improve bikeway comfort and safety for the “interested but concerned” bicyclist. This guide has been created to reflect the latest state of the practice principles for designing optimal bicycle facilities.

Purpose and outline

Sidepaths are used throughout the state of Michigan to provide separated pedestrian and bicycle facilities for non-motorized roadway users. These facilities are often constructed adjacent to state or county roads and are generally implemented concurrently with roadway modifications. In an effort to improve the selection of the most appropriate bikeway in conjunction with proposed roadway projects, Michigan Department of Transportation (MDOT) has examined the safety performance and interactions of motor vehicles and bicyclists at intersections with sidepaths. This analysis sought to determine if construction of the sidepath improved conditions for non-motorized roadway users. The Sidepath Intersection & Crossing Treatment Guide is organized into the following major components:

- Safety implications of sidepaths
- Bikeway selection
- Intersection treatment selection

As noted in Exhibit 1, the first step involved fundamental safety research conducted by Toole Design Group (TDG) and Wayne State University to create a baseline for sidepath safety performance. This research informed selection of intersection treatments that should be implemented, depending on roadway characteristics.

Sidepath research highlights

TDG and Wayne State University conducted a safety analysis using data for six years of bicycle-related crashes occurring in Kent and Oakland counties on roadway facilities under several jurisdictions. Due to constraints in crash data report descriptions, sidepath crashes and sidewalk crashes were combined into one crash category. The five statistically-significant trends found in the data were:

- Bicyclists riding against traffic are at higher risk than in other corridor forms

1 The crash analysis and research focused on bicyclists, not pedestrians. However, most of the treatments suggested here would also improve safety for pedestrians using sidepaths.
• Bicyclists riding against traffic have a higher risk of crash with right-turning vehicles
• Bicyclists riding against traffic have a higher crash risk at commercial driveways and signalized intersections
• Bicyclists riding through signalized intersections have a higher risk than at intersections with other types of traffic control
• At signalized and unsignalized intersections, sidepath/sidewalk bicycle crashes tend to occur with left- or right-turning vehicles.

Appendix A contains details about each of these trends.

Reducing crash risk for bicyclists
Bicyclists riding against traffic and riding through intersections are at the greatest risk for crashes. Several overarching principles can be applied to reduce bicyclist crash risk in both situations.

Crash risk reduction for bicyclists riding against traffic
Bicyclists riding against traffic is a challenging behavior to curtail. Providing facilities on both sides of the street as well as a combination of “Wrong Way” and informational signage to encourage bicyclists to ride with traffic may create positive reinforcement to minimize their crash risk. Also, providing clear signage and pavement markings to warn motorists of a bicycle contraflow conflict may increase the likelihood that motorists will be attentive to bicyclists. The intersection treatments described in the next section are designed to increase motorist awareness at sidepaths.

In addition to installing cost-effective signage and markings, constructing safer and lower-stress bicycle crossings of the main roadway can enable more bicyclists to ride with the direction of motor vehicle traffic. On some roadways, signalized and unsignalized crossings are infrequent. In the absence of controlled crossing locations, midblock crossings may be attempted. However, crossing midblock can be challenging and may be illegal in some circumstances. This configuration results in limited opportunities to facilitate safe roadway crossings to allow bicyclists to ride with traffic rather than against it.

A sample shared use path treatment that can encourage bicyclists to ride with traffic is shown in Exhibit 2. The difference in pavement texture helps demarcate where bicyclists and pedestrians are anticipated and the minimalistic bicycle path is narrow enough to encourage bicyclists to ride in a single direction; ideally, with traffic. Signage could be added to this type of design to further advise bicyclists to ride with traffic.

Crash risk reduction for driveways, unsignalized intersections, and signalized intersections
There are several external resources available to identify treatments to minimize and bicyclist crash risk at intersections, such as the Highway Safety Manual clearinghouse and the BIKESAFE online guide. Consulting these resources can be useful for reducing bicyclist crash risk through design. Specific sidepath/sidewalk crash data as part of this project have revealed techniques to tailor crash reduction measures for existing infrastructure. Three primary risk-reduction strategies have been identified which are described here in further detail.
Establish priority

Roadway users yield to each other based on the roadway environment, rules of the road, and signage that reinforces these regulations. For the sidepaths/sidewalks that were evaluated and studied in this project, there are seldom situations where signage is provided to both the motorist and sidepath user at the intersection of conflict. Since bicyclists are among the most vulnerable road users, their movements could be prioritized by posting signage instructing motorists to yield or stop. At signalized intersections, prioritizing bicycle movements could be achieved by adjusting signal timing to provide an exclusive sidepath signal phase.

Another method to encourage priority for bicyclists is to construct a raised sidepath crossing which requires the motor vehicle to “ramp up” to the sidepath. The raised crossing can be constructed so that motor vehicle speeds are naturally reduced at the point of conflict. **Lower motor vehicle speeds increase the likelihood that a motorist will yield to a bicyclist in the crossing.**

**Speed reduction**

Intersection speed management is possible using a range of treatments from right-of-way clarification to vertical deflection. The 2016 FHWA document *Achieving Multimodal Networks: Applying Design Flexibility & Reducing Conflicts* provides important guidance toward applying speed management principles. The guide indicates that raised intersections and raised crosswalks can be used on arterial streets. Using this guidance and associated design principles, treatments that minimize crash risk for bicyclists may also improve safety for motorists.

Implementing vertical deflection with a raised bicycle crossing is one method to manage vehicle speeds. Exhibit 3 illustrates a raised crossing of a bikeway at a side street. **The vertical rise of the crossing can be constructed to attain a desired vehicle speed.** At driveways, 5 mph may be appropriate speed management target. At unsignalized intersections, 10-15 mph may be more appropriate to balance traffic flow while maintaining sidepath user safety.

Horizontal treatments can also be used to manage motor vehicle speeds. In the safety analysis of sidepaths/sidewalks, many of the recorded crashes occurred between bicyclists and turning motor
vehicles. One approach to mitigating these conflicts is to decrease curb radii, which are often designed to accommodate heavy vehicles. In some situations, heavy vehicle traffic volumes may be low enough that the need for large curb radii is reduced. In lieu of reconstructing intersection corners, smaller radii may be created using cost-effective plastic delineators, or retrofitted truck aprons. Exhibit 4 illustrates a truck apron that discourages high-speed turns for passenger cars but still allows truck movements.

Exhibit 4: Truck apron example design treatment

Increase bicyclist visibility

Increasing motorist awareness and the visibility of bicyclists at sidepath crossings are two concepts that can decrease bicycle crash risk. While bicyclists share responsibility in being aware of and visible to drivers, targeted signing, striping, and geometric techniques can increase the conspicuity of vulnerable users.

A simple method to increase motorist awareness of the presence of bicyclists is to deploy appropriate signage and pavement markings. Applicable signage is shown in Exhibits 5 through 7. Pedestrian and bicycle regulatory and warning signs, including R10-15, W11-1, and W11-2, among others, can heighten a motorist’s attentiveness to a sidepath user.

Exhibit 5: Applicable regulatory signage related to sidepaths
Exhibit 6: Applicable regulatory and signal signage related to sidepaths

Exhibit 7: Applicable warning signage for sidepaths
Yield pavement markings (shark’s teeth), dashed white lines designating the bicycle crossing (elephant’s feet), and other markings can be used in conjunction to provide multiple visual cues and decrease the crash risk to a vulnerable user.iii

Providing sufficient approach clear space for motorists to see bicyclists at intersections is also an appropriate method to increase visibility. Obstructions should be removed from this clear space such as trees, large poles, etc. Also, the length of the clear space should increase with higher roadway and turning movement speeds. As noted earlier, raised crossings are not only effective speed management tools, but they also elevate the presence of sidepath users, which increases their visibility.

Modifying roadway geometry is another way to increase bicyclist visibility at various intersection forms. In particular, protected intersection geometry modifies the timing and positioning at which a turning motorist will see or encounter a bicyclist, as shown in Exhibit 8.

In a protected intersection, the offset geometry and decreased turning radius better orients a motorist to face bicyclists in the crossing, rather than conventional designs that position a bicyclist closer to the travel lanes and in the motorist’s blind spot. One key design consideration is to offset the sidepath 6 to 16.5 feet² from the curbline of the parallel roadway. This offset distance also creates space for a right-turning motorist to queue for a through-moving bicyclist.iii, iv, vi Coupled with signage and pavement markings, protected intersections can be effective in reducing crash risk for pedestrians and bicyclists.

Exhibit 8: Protected intersection geometry

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² An offset of up to 24 feet may be appropriate for roadways with traffic speeds of 55 mph or greater.
Bikeway selection

Highways and roadways across Michigan vary in width, capacity, and land use context, among other characteristics. Selecting an appropriate bikeway for these corridors should be based on bicycle user comfort thresholds, national best practices, safety research from this sidepath research project, and crash risk reduction measures.

Bicycle design user

Bicycle design users can be classified into four categories (Exhibit 9):

- Experienced and Confident
- Casual and Somewhat Confident
- Interested but Concerned
- Not Interested

These categories are determined by the user’s tolerance of traffic stress when riding a bicycle. The experienced and confident design user is comfortable riding in mixed traffic and sharing lanes with motorists. The casual and somewhat confident bicyclists are comfortable riding on streets with automobiles, but prefer dedicated bicycle facilities, particularly when those facilities are separated from motor vehicle traffic. The interested but concerned design user would like to ride a bicycle but has reservations about mixing with motorists, preferring to ride in a bikeway completely separated from motor vehicle traffic.

The interested but concerned design user represents the majority of potential bicyclists in any community. Growth in bicycle ridership will come primarily from this group, and bicycle facilities should be planned and designed with the interested but concerned user in mind. Accordingly, low-stress bikeways that separate bicyclists from motorists, as achieved by sidepaths, should be the default design. Intersection crossing treatments and other design details should be geared towards increasing safety while enhancing the comfort perceived by this design user.

Selecting an appropriate bicycle facility for the interested but concerned design user can be performed using a chart indicating prevailing traffic volumes or vehicle speeds, as shown in Exhibit 10. For the purposes of this guide, the separated bike lane or shared use path component of the chart is analogous to selecting a sidepath, which provides physical protection from motor vehicle traffic.

Exhibit 9: Bicycle users by percent of population

For the purposes of the Sidepath Intersection & Crossing Treatment Guide, the interested but concerned rider is the assumed design user for selecting bicycle facilities in a corridor and applying the intersection design treatments. Furthermore, the highways and roadways identified for bikeway improvements will likely exceed 6,000 ADT and 30 MPH. Therefore, selecting a sidepath should be appropriate for designers using this Sidepath Intersection & Crossing Treatment Guide.
Bikeway width and intersection treatment selection process

Identifying design parameters and constraints and incorporating supporting design elements for a sidepath along roadways in Michigan has been outlined in a step-by-step process, which is illustrated in Exhibit 6.

Exhibit 11: Sidepath design process
Step 1: Identify corridor

The first step in the sidepath design process is to identify the corridor and project limits. Typically, roadway projects are undertaken to address vehicle capacity or pavement condition needs and a sidepath is considered as an additional feature. The type of construction undertaken influences the extent to which the corridor design can accommodate optimal sidepath design parameters.

Three primary types of projects allow for incorporation of sidepaths:

A) New Construction
B) Reconstruction / Expansion Projects
C) Construction Projects within existing right-of-way

These project types provide different opportunities for creating a sidepath or enhancing existing sidepath conditions on a given corridor. New construction and reconstruction projects may provide the greatest opportunity for incorporating sidepaths designed according to best practices. In an unconstrained corridor, right-of-way acquisition can include the area needed for an optimal sidepath design. In constrained corridors or in construction projects that maintain the existing right-of-way, the ability to implement an optimal facility may be compromised, or require adjustments to other roadway design elements to accommodate the optimal sidepath design.

Step 2: Collect data

Following identification of the corridor, limits, and project type, the existing conditions can be inventoried and evaluated for design opportunities. Collecting these data will help in understanding the modifications that can be implemented on a corridor-wide basis.

The following data need to be collected on a corridor-wide basis to establish existing conditions:

- Crash data – identify contextual crash risk issues
- Right-of-way (ROW) – widths and location of limits
- Vehicle lanes – quantity and widths
- Center turn lane – presence and width
- Landscape strip or street buffer – presence and width
- Sidepath/sidewalk – presence and width
- Bicycle lane – presence and width
- On-street parking – presence and width

These corridor dimensions and data must be known and understood so that potential improvements can be assessed in subsequent facility selection steps. The following data can be used to evaluate intersections and/or driveways as available:

- Traffic signal timing
- Geometric data
  - Presence of a turn lane
  - Turning radii of corners intersecting the potential sidepath
- Traffic information
  - Vehicle counts (and heavy vehicle percentage)
  - Pedestrian counts
  - Bicycle counts

The availability of pedestrian and bicycle count data may be limited. In locations where this data is not available, consider the use of an online tracking system, such as the Strava Global Heatmap\(^3\) for additional information on bicycle and pedestrian activity in the area.

Step 3: Review crash history

Performing a basic safety analysis may identify potential high crash risk areas. These locations can then be addressed in the subsequent corridor and intersection treatment design phase.

It should be noted that a lack of crashes along a corridor does not mean that a crash risk is not present. Corridors that exhibit some of the crash risk factors described in this guide may not attract many bicyclists in their current configuration, leading to low exposure for crashes.

In addition, not all crashes involving bicyclists are reported. It may be necessary to engage other stakeholders, such as bicycle advocacy groups or local agencies to identify any under-reported crashes or near-misses for bicyclists along the corridor.

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\(^3\) [https://labs.strava.com/heatmap/](https://labs.strava.com/heatmap/)
Step 4: Assess existing bicycle network
Connecting to the existing bikeways in the immediate vicinity of the selected corridor will improve the effectiveness of the overall bicycling network in the area. The proposed project extents may not necessarily complete an entire connection, but due to the infrequency of roadway projects, filling the gaps present in each project area will result in an overall enhanced bicycle network. Inventorying the surrounding bicycle network is important to determining whether network-wide bicycle improvements can be made. Consult any available local bicycle plans to see if other jurisdictions have plans to connect to the project corridor in the future. If sidepaths cannot be added to both sides of the roadway, this assessment will help to determine the most convenient side for improvements, so that network connectivity is maximized.

Step 5: Assess existing bikeways along the corridor
The roadway may already include a wide shoulder or on-street bikeway. To determine if these on-street bikeways should be replaced by or supplemented with a sidepath, consult Exhibit 10 or the most recent AASHTO Bikeway Design Guide for guidance on facility selection.

The proposed project corridor may also already include a sidepath on one side of the roadway. However, due to the increased crash risk when bicyclists ride against traffic, the proposed project may be an opportunity to encourage bicyclists to ride with traffic by adding a sidepath on the opposite side of the roadway. Installing bicycle facilities on both sides of the roadway is recommended, even if the facilities are two-way. For roadways that are more than one lane in each direction, installing sidepaths on both sides of the roadway is strongly recommended.

Step 6: Determine achievable sidepath width
The optimal sidepath design includes wide paths on both sides of the roadway with a comfortable buffer between the path and the road. Given an unlimited amount of right-of-way, this optimal facility could easily be incorporated into any new construction or reconstruction project. However, implementing a sidepath can be more challenging in situations where adjusting other roadway design elements is required.

Below are some considerations for the incorporation of sidepaths into roadway corridors.

Table 1 depicts the optimal sidepath dimensions. If the optimal facility cannot be constructed, the factors inhibiting the corridor’s optimal sidepath design should be documented. Documenting the issues that compromise the optimal design will help planners and engineers identify ways to implement bikeways of a comfortable width.

The optimal sidepath dimensions shown in Table 1 follow AASHTO guidelines for shared use paths, which will provide a comfortable facility for most bicycle design users. If heavy use of the sidepath is expected, consider increasing the bikeway width to allow for more comfortable movements of pedestrians and bicyclists.

Table 1: Optimal sidepath dimensions

<table>
<thead>
<tr>
<th>Two-Way Facility</th>
<th>One-Way Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>12’ Shared use path</td>
<td>7’ Bikeway</td>
</tr>
<tr>
<td></td>
<td>5’ Sidewalk</td>
</tr>
<tr>
<td>≥6’ Street buffer</td>
<td>≥6’ Street buffer</td>
</tr>
</tbody>
</table>

Accommodating the optimal sidepath dimensions may be achieved by narrowing other roadway facilities such as vehicle lanes, parking stalls, raised center medians or striped median spaces, or by expanding the right-of-way of the corridor. Prioritization of these competing design features depends on the context of the roadway and the needs of the community. If the optimal sidepath cannot be accommodated, documenting the reasons that the optimal sidepath dimensions cannot be implemented may simultaneously help the designer overcome design barriers.
Table 2 provides the AASHTO minimum guidelines for sidepath width and a recommended minimum width for the buffer area. Designs that deviate from the optimal dimensions should not fall below these minimum values.

**Table 2: Minimum sidepath dimensions**

<table>
<thead>
<tr>
<th>Two-Way Facility</th>
<th>One-Way Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>8’ Shared use path</td>
<td>4’ Bikeway</td>
</tr>
<tr>
<td>5’ Street buffer*</td>
<td>5’ Street buffer*</td>
</tr>
</tbody>
</table>

\*The street buffer should be reduced first if there is not enough width to provide a minimum shared use path or bikeway facility.

Evaluating and installing the highest-grade facility possible is critical to providing bikeways that all bicyclists can safely and comfortably use. As a progressively narrower facility and buffer are designed, decreased bicyclist use of the facility should be anticipated. It is important for the designer to use a variety of techniques to achieve the highest-grade bikeway possible.

**Step 7: Select intersection treatments**

Sidepath intersection designs should seek the optimal treatment. If the optimal treatments are not included, documentation should be prepared describing why lower-grade facilities need to be implemented. The following guiding concepts lay the foundation for the highest-grade facilities.

**Intersection treatment selection process**

The process to select appropriate intersection treatments for the proposed project corridor begins with trying to accommodate the Grade A facility within the proposed right-of-way at the intersection itself. Exhibit 11 illustrates this process.

Achieving a Grade A facility (and subsequent Grade B-F facilities) may be done by modifying the approach geometry and/or control to the intersection. Expanding the right-of-way may be needed in certain circumstances to provide sufficient offset distance or sidepath setbacks. If the Grade A or B facility cannot fit easily, the barriers to implementation should be documented. Describing why the optimal intersection facility cannot be installed will provide a process for trying to overcome design barriers.

**Crossing priority (traffic control)**

Even with signage to reinforce or dictate the rules of the road, roadway users may need redundant visual cues in some locations to establish consistent yielding behavior between modes, especially at intersections and driveways.

While motor vehicles must legally yield to pedestrians and bicyclists at sidepath crossings, automobiles generally have de facto priority at driveways, unsignalized intersections, and signalized intersections because of their larger size, possible free-flow movements, and large corner radii. Modifying the de facto priority of vehicle movements can be achieved through geometric changes that create additional visual cues reminding motorists to yield to bicyclists and pedestrians. Advanced bicycle and pedestrian warning and regulatory signs, such as those shown in Exhibits 5-7 should be employed. However, these warning signs and markings should be installed in conjunction with other speed reduction methods to reinforce their validity.

**Signal Phasing**

Volume thresholds for signalized intersection treatments should be employed in conjunction with the intersection treatment selection process. These thresholds, provided in Table 2, are based on the Massachusetts Department of Transportation Separated Bike Lane Planning and Design Guide.

**Table 3: Protected signalization thresholds for sidepaths**

<table>
<thead>
<tr>
<th>Sidepath Protected Signalization Thresholds</th>
<th>Motor Vehicles per Hour Crossing Two-way Sidepath</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right-turn</td>
<td>100</td>
</tr>
<tr>
<td>Left-turn across one lane</td>
<td>50</td>
</tr>
<tr>
<td>Left-turn across two lanes</td>
<td>0</td>
</tr>
</tbody>
</table>

These volume-based signalization thresholds are intended to mitigate the safety risks identified with vehicles turning across the sidepath, while reducing the cost of high-quality facilities in locations where conflicts are
infrequent. Bicycle exposure to automobile traffic is a well-documented indicator of risk, so the design outcomes created by these volume thresholds may reduce risk for a sidepath user at an intersection.

**Vertical deflection**
As described the speed reduction section on page 3, using vertical deflection (e.g., raised crossings), at intersections and driveways can slow motor vehicles because they would need to “ramp up” to the bicycle crossing. Combining physical and visual cues can help remind motorists that they are crossing an area where bicyclists may be present.

**Horizontal deflection**
As described in the speed reduction section on page 4, roadway geometry influences vehicle speeds around curves at intersections and driveways. Geometry can be employed to offset the bikeway to a location that further increases the visibility of crossing bicyclists to a turning motorist. Safety research has indicated that a larger offset distance (6'-16.5') results in crash risk mitigation for bicyclists.

**Description of intersection treatment grades**
Based on the previous intersection treatment concepts, intersection treatment grades can be defined. Signalized, unsignalized, and driveway intersection variants of the Grade A facility are provided in Tables 5 through 8.

**Driveway treatment thresholds**
Three types of driveways have been defined which are usage dependent. Some of the design elements have been omitted from low-usage and medium-usage driveway types because lower motor vehicle volume and therefore lower risk to sidepath users is anticipated. The vehicular volume thresholds for low-, medium-, and high-usage driveways are presented in Table 8.

Thresholds have been established which represent varying degrees of risk to bicyclists proceeding through the driveway “undisrupted” (i.e., their speed can be maintained without potential). For example, low-usage driveways may represent one or several single-family homes. In this scenario, constructing a raised crossing, modifying curbs, and offsetting the sidepath from the primary roadway may not be appropriate or cost-effective. Medium-usage driveways could represent a subdivision or a small strip mall development. Similarly, curbwork and changes to offset the path from the primary roadway may not be cost-effective. However, due to higher motor vehicle usage compared to lower-usage driveways, a raised crossing could provide a good balance between cost and potential safety benefit for sidepath users. High-usage driveways should be treated as full unsignalized intersections.

<table>
<thead>
<tr>
<th>Driveway Usage Classification</th>
<th>Motor Vehicles per Hour Crossing Two-way Sidepath</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Medium</td>
<td>10-50</td>
</tr>
<tr>
<td>High</td>
<td>&gt;50</td>
</tr>
</tbody>
</table>

Differentiating these driveway types allows the designer to achieve a Grade A driveway crossing without proposing cost-prohibitive designs, which may result from horizontal or vertical construction. Also, the driveway types provide the designer with greater flexibility when proposing design elements. Importantly, engineering judgment should be used if additional design elements need to be provided for the low- and medium-usage driveway classifications.
### Table 5: Grade A facility – signalized intersection

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Intersection Treatment Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated bicycle signal phase or leading interval</td>
<td>Crossing Priority</td>
</tr>
<tr>
<td>- based on vehicle volume thresholds</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Raised crossing - motorists ramp up to sidepath by at least 6 inches and crossing hump is designed for 10 mph</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Curb radii - exiting and entering intersection curb radius is 0-15’</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Offset distance - exiting and entering the edge of the sidepath is 6’-16.5’ offset from the travel lane</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Signage - sidepath user warning signage is provided for motorists</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Striping - white pavement markings are provided for the intersection crossing</td>
<td>![Icon]</td>
</tr>
</tbody>
</table>

**Exhibit 12: Grade A signalized intersection treatment**

### Table 6: Grade A facility – unsignalized intersection

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Intersection Treatment Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorist Stop/Yield signs - bicyclists have priority through intersection</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Raised crossing - motorists ramp up to sidepath by at least 6 inches and crossing hump is designed for 10 mph</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Curb radii - exiting and entering intersection curb radius is 0-15’</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Offset distance - exiting and entering the edge of the sidepath is 6’-16.5’ offset from the travel lane</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Signage - sidepath user warning signage is provided for motorists</td>
<td>![Icon]</td>
</tr>
<tr>
<td>Striping - white pavement markings are provided for the intersection crossing</td>
<td>![Icon]</td>
</tr>
</tbody>
</table>

**Exhibit 13: Grade A unsignalized intersection treatment**
Table 7: Grade A facility – driveway intersection (High Usage)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Intersection Treatment Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorist Stop/Yield signs</td>
<td>Crossing Priority</td>
</tr>
<tr>
<td>have priority through intersection</td>
<td></td>
</tr>
<tr>
<td>Raised crossing</td>
<td></td>
</tr>
<tr>
<td>motorists ramp up to sidepath by at least 6 inches and crossing hump is designed for 10 mph</td>
<td></td>
</tr>
<tr>
<td>Curb radii</td>
<td></td>
</tr>
<tr>
<td>exiting and entering intersection curb radius is 0-15’</td>
<td></td>
</tr>
<tr>
<td>Offset distance</td>
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</tr>
<tr>
<td>exiting and entering the edge of the sidepath is 6’-16.5’ offset from the travel lane</td>
<td></td>
</tr>
<tr>
<td>Signage</td>
<td></td>
</tr>
<tr>
<td>sidepath user warning signage is provided for motorists</td>
<td></td>
</tr>
<tr>
<td>Striping</td>
<td></td>
</tr>
<tr>
<td>white pavement markings are provided for the intersection crossing</td>
<td></td>
</tr>
</tbody>
</table>

Exhibit 14: Grade A driveway intersection treatment – high usage

Table 8: Grade A facility – driveway intersection (Medium Usage)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Intersection Treatment Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorist Stop/Yield signs</td>
<td>Crossing Priority</td>
</tr>
<tr>
<td>have priority through intersection</td>
<td></td>
</tr>
<tr>
<td>Raised crossing</td>
<td></td>
</tr>
<tr>
<td>motorists ramp up to sidepath by at least 6 inches and crossing hump is designed for 10 mph</td>
<td></td>
</tr>
<tr>
<td>Signage</td>
<td></td>
</tr>
<tr>
<td>sidepath user warning signage is provided for motorists</td>
<td></td>
</tr>
<tr>
<td>Striping</td>
<td></td>
</tr>
<tr>
<td>white pavement markings are provided for the intersection crossing</td>
<td></td>
</tr>
</tbody>
</table>

Exhibit 15: Grade A driveway intersection treatment – medium usage
Table 9: Grade A facility – driveway intersection (Low Usage)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Intersection Treatment Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crossing Priority</td>
</tr>
<tr>
<td><strong>Motorist Stop/Yield signs</strong> - bicyclists have priority through intersection</td>
<td><img src="image" alt="Motorist Stop/Yield signs" /></td>
</tr>
<tr>
<td><strong>Signage</strong> - sidepath user warning signage is provided for motorists</td>
<td><img src="image" alt="Signage" /></td>
</tr>
<tr>
<td><strong>Striping</strong> - white pavement markings are provided for the intersection crossing</td>
<td><img src="image" alt="Striping" /></td>
</tr>
</tbody>
</table>

Motorist Stop/Yield signs - bicyclists have priority through intersection

Signage - sidepath user warning signage is provided for motorists

Striping - white pavement markings are provided for the intersection crossing

The Grade A treatments are intended to mitigate the risk associated with a sidepath crossing. **An intersection receives a lower grade when one design element is removed from the overall design.** For example, if sidepath users do not have a dedicated signal phase, but the intersection design includes all other design elements, including signage, offset distance, etc., then the intersection treatment will be rated as Grade B. **Each subsequent removal of a design element will result in a whole letter grade drop of the overall facility.** Also, each removal of a design element needs to be addressed when documenting why the facility rating drops to Grade C and below.

**Overall corridor rating**

The overall grade of the corridor is only as strong as the grade of the “worst” intersection treatment. This “weakest link” method represents the “interested but concerned” bicyclist’s decision making processes. If one part of the trip is uncomfortable, most of these users will default to another mode of travel for the trip. This corridor rating system is intended to encourage designers to be as consistent as possible in terms of including crash risk-minimizing treatments.

As treatments are eliminated from a crossing design, the grade of the corridor progressively falls. Exhibit 10 illustrates an example Grade D driveway intersection treatment with a minimal set of treatments.
Step 8: Design & engineering

After the corridor and intersection sidepath treatments are chosen based on the highest grade possible, the bicycle facilities can be fully designed. With a rigorous design process, crash risk can be reduced for bicyclists in a sidepath. Creation of a safer, low-stress facility can maximize bicyclist use in the corridor.

Conclusion

This Sidepath Intersection & Crossing Treatment Guide has illustrated techniques to mediate general crash trends discovered during the safety analysis. Strong safety performance of sidepaths/sidewalks can guide the recommended design of sidepaths and associated intersection treatments. The described design process is intended to provide the designer with sufficient information to create an optimal sidepath design. However, no guide can anticipate every context or design situation, and engineering judgment should always be used when considering non-motorized facilities.

7 Massachusetts Department of Transportation. Separated Bike Lane Planning & Design Guide. 2015.
Appendix A: Sidepath research highlights

As part of this project, Tool Design Group and Wayne State University conducted a safety analysis with six years of bicycle-related crashes occurring in Kent and Oakland counties on MDOT roadway facilities. First, a high-level summary of crashes was produced to establish the context of existing safety conditions. Table 1 presents the crashes occurring in the roadway and in sidepath/sidewalk facilities. Due to constraints in crash data report descriptions, sidepath crashes and sidewalk crashes were combined into one crash category.

Table A-1: Crash Location and Severity (Kent and Oakland County Data)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Count</th>
<th>%</th>
<th>Location</th>
<th>Count</th>
<th>%</th>
<th>Severity</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway-Intersection</td>
<td>379</td>
<td>47.0%</td>
<td>Intersection</td>
<td></td>
<td></td>
<td>Fatal</td>
<td>7</td>
<td>1.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A - incapacitating injury</td>
<td>43</td>
<td>11.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B - nonincapacitating injury</td>
<td>153</td>
<td>40.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C - possible injury</td>
<td>116</td>
<td>30.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No Injury</td>
<td>60</td>
<td>15.8%</td>
</tr>
<tr>
<td>Roadway-Non-Intersection</td>
<td>331</td>
<td>41.1%</td>
<td>Non-Intersection</td>
<td></td>
<td></td>
<td>Fatal</td>
<td>9</td>
<td>2.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A - incapacitating injury</td>
<td>37</td>
<td>11.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B - nonincapacitating injury</td>
<td>111</td>
<td>33.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C - possible injury</td>
<td>118</td>
<td>35.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No Injury</td>
<td>56</td>
<td>16.9%</td>
</tr>
<tr>
<td>Drive</td>
<td>95</td>
<td>11.8%</td>
<td>Drive</td>
<td></td>
<td></td>
<td>Fatal</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>A - incapacitating injury</td>
<td>9</td>
<td>9.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B - nonincapacitating injury</td>
<td>29</td>
<td>30.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C - possible injury</td>
<td>43</td>
<td>45.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No Injury</td>
<td>14</td>
<td>14.7%</td>
</tr>
<tr>
<td>Sidestpath/ Sidewalk- Intersection</td>
<td>1128</td>
<td>82.6%</td>
<td>Intersection</td>
<td></td>
<td></td>
<td>Fatal</td>
<td>4</td>
<td>0.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A - incapacitating injury</td>
<td>52</td>
<td>4.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B - nonincapacitating injury</td>
<td>403</td>
<td>35.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C - possible injury</td>
<td>459</td>
<td>40.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No Injury</td>
<td>210</td>
<td>18.6%</td>
</tr>
<tr>
<td>Sidestpath/ Sidewalk-Non-Intersection</td>
<td>31</td>
<td>2.3%</td>
<td>Non-Intersection</td>
<td></td>
<td></td>
<td>Fatal</td>
<td>1</td>
<td>3.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A - incapacitating injury</td>
<td>2</td>
<td>6.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B - nonincapacitating injury</td>
<td>10</td>
<td>32.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C - possible injury</td>
<td>13</td>
<td>41.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No Injury</td>
<td>5</td>
<td>16.1%</td>
</tr>
<tr>
<td>Sidestpath/ Sidewalk-Drive</td>
<td>207</td>
<td>15.2%</td>
<td>Drive</td>
<td></td>
<td></td>
<td>Fatal</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A - incapacitating injury</td>
<td>10</td>
<td>4.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B - nonincapacitating injury</td>
<td>70</td>
<td>33.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C - possible injury</td>
<td>95</td>
<td>45.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No Injury</td>
<td>32</td>
<td>15.5%</td>
</tr>
</tbody>
</table>

While Table 1 indicates that there are more crashes classified as occurring on a sidepath/sidewalk, crashes occurring on the roadway tend to be more severe. More crash trends have been identified in the detailed crash analysis report titled “Sidepath Application Criteria Development for Bicycle Use.” (i)

The crash data were further parsed to examine several key characteristics important to the design and operation of sidepaths. Findings from the analysis of crash trends as they relate to design and operations are as follows:

**Crash Trend #1: Bicyclists riding against traffic are at higher risk than those riding with traffic**

Crash Trend 1 illustrates that bicyclists traveling against traffic comprise a greater proportion of sidepath/sidewalk crashes (64.8 percent).
There are several roadway characteristics which may contribute to a bicyclist’s decision to ride in the opposite direction to traffic on the sidepath. Because many intersecting roadways have multiple vehicular travel lanes, crossings are challenging. Also, with low pedestrian activity and sidepaths that are typically 8 feet wide, bicycling in the opposite direction to traffic is not geometrically discouraged.

One explanation for the increased crash rate is that drivers may not expect bicyclists traveling in the opposite direction.

**Crash Trend #2: Bicyclists riding against traffic have a higher risk of crash with right-turning vehicles**

Of sidepath/sidewalk bicyclist crashes, 34 percent involved right-turning vehicles and bicyclists traveling against traffic. The next largest bicycle/vehicle crash types by direction are: right-turning vehicles and bicyclists traveling with traffic (10 percent), and vehicles traveling straight and bicyclists traveling against traffic (angle crash – 8 percent).
**Crash Trend #3:** Bicyclists riding against traffic have a higher crash risk at commercial driveways and signalized intersections

72 percent of sidepath/sidewalk crashes at commercial driveways involved bicyclists traveling against traffic. 64 percent of sidepath/sidewalk crashes at signalized intersections involved bicyclists traveling against traffic.

**Crash Trend #4:** Bicyclists riding through signalized intersections have a higher risk than at intersections with other types of traffic control

Intersection crash statistics illustrate that 51 percent of sidepath/sidewalk bicycle crashes occur at signalized intersections. Of the 51 percent of crashes, 61 percent involve right-turning vehicles and 15 percent involve left-turning vehicles.

By comparison, 31 percent and 10 percent of all intersection-related sidepath/sidewalk bicycle crashes occur at unsignalized intersections and driveways, respectively.

In most cases, signalized intersections can be assumed to have greater traffic volumes for all modes than unsignalized intersections, based on the necessity of the traffic signal. Higher traffic volumes at signalized intersections – the greater exposure inherent in these contexts – can increase the crash risk between a bicycle and motor vehicle.
**Crash Trend #5:** At signalized and unsignalized intersections, sidepath/sidewalk bicycle crashes tend to occur with left- or right-turning vehicles. At signalized intersections, 59 percent of sidepath/sidewalk crashes occur with right- or left-turning vehicles. Other crash types based on motor vehicle movement at signalized and unsignalized intersections comprise less than 10 percent (e.g., vehicles going straight, stopped, etc.).

The majority, or 68 percent, of sidepath/sidewalk crashes at signalized intersections occur with right- or left-turning vehicles. At unsignalized intersections, 59 percent of sidepath/sidewalk crashes occur with right- or left-turning vehicles.

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1 Sidepath Application Criteria Development for Bicycle Use. Wayne State University. 08/11/2017.
SIDEPATH INTERSECTION AND CROSSING DESIGN WORKSHEET

This worksheet is intended to guide designers in the application of the Sidpath Intersection and Crossing Treatment Guide. Complete this worksheet as early in the design process as possible to ensure the incorporation of the highest quality sidepath design.

Step 1 : Identify Corridor
Define the project type:
☐ New construction
☐ Reconstruction / expansion
☐ Construction within the existing right-of-way
☐ Other, describe:

Briefly describe the project that includes the sidepath being evaluated (e.g. project limits, construction timeline, planning process):

Step 2 : Collect Data
Recommended corridor and intersection data are listed below, check all that were reviewed:
☐ 10 years of data for crashes involving bicyclists & pedestrians
☐ Right-of-way width & limits
☐ Corridor AADT
☐ Number and width of through lanes, turn lanes
☐ Presence/width of existing sidewalk/sidewalk
☐ Presence/width of existing on-street bicycle lane
☐ Presence/width of on-street parking
☐ Intersection turning radii
☐ Signal timing information
☐ Intersection TMCs
☐ Pedestrian volumes
☐ Bicycle volumes
☐ Other, describe:
If any of the above were not reviewed, please explain:
Step 3: Review Crash History
Date range of crash data reviewed:

Are there any patterns to non-motorized crashes along the corridor or at a given intersection (e.g. multiple crashes at the same location, crashes involving the same direction of travel or turning movement)?

Were there any fatalities? □ Yes □ No
If yes, describe any crash factors that this design project could address:

Step 4: Assess Existing Bicycle Network
Describe the local or regional bicycle plans that were reviewed:

Is the corridor included explicitly in any of these plans? □ Yes □ No □ N/A
If a local or regional bicycle plan was not available are there any nearby land uses or destinations that may attract bicycle users to the corridor (e.g. schools, parks, or retail districts)?

Step 5: Assess Existing Bikeways Along The Corridor
How would a bicyclist use the corridor under current conditions? Check all that apply.
□ Existing sidewalk at least 8 feet wide
□ Existing sidewalk less than 8 feet wide*
  (Unless bicycle use on sidewalks is specifically prohibited by local ordinance.)
□ Marked on-street bikeway (with or without buffer / protection)
□ Wide shoulder at least 4 feet wide
□ Shared lane with marking (e.g. sharrow)
□ Shared lane with no marking
□ Other, describe:

If an existing sidewalk or sidepath is present, is it present on both sides? □ Yes □ No
Step 6 : Determine Achievable Sidepath Width
What type of sidepath is included in the design?  [ ] one-way  [ ] two-way
Does the sidepath design meet the optimal width dimensions described in the sidepath intersection and crossing safety guide?  [ ] yes  [ ] no
If not, describe the barriers to meeting the optimal design:

Step 7 : Select Intersection Treatments
A Grade A facility includes each of the following treatments. Check the boxes for each treatment included at corridor intersections.
[ ] Crossing priority, describe:

[ ] Vertical deflection of at least 6 inches
[ ] Horizontal deflection of at least 6 feet
[ ] Curb radii no larger than 15 feet
[ ] Signage, describe: Click or tap here to enter text.
Based on the treatments incorporated in the design, assign a letter grade to the facility
[ ] 5 = A  [ ] 4 = B  [ ] 3 = C  [ ] 2 = D  [ ] 0-1 = F
If any treatments were not included, describe the barriers to meeting the optimal design:

Step 8 : Design & Engineering
Include this worksheet in the project documentation.
Appendix C: Case study

The following case study applies the Sidepath Intersection & Crossing Treatment Guide methodology to a hypothetical corridor in Michigan. The following information is available for the corridor:

- Funding is for construction within the existing right-of-way.
- The existing right-of-way width is 90 feet, with two through lanes and a continuous center left-turn lane. All lanes are 12 feet wide. There is no shoulder or on-street bike lane.
- The corridor has a mix of commercial and residential land uses.
- There is one signalized intersection and one unsignalized intersection along the corridor.
- Grades along the corridor are generally flat. The southbound approach to the signalized intersection is slightly downhill.
- Corridor AADT is 45,000 vehicles per day.
- Corridor posted speed limit is 50 mph.
- Heavy vehicle percentages are around 2%, and some businesses receive deliveries by semi-truck.
- There are two commercial driveways serving multiple businesses, one subdivision entrance, and several individual residential driveways on the corridor. The commercial driveways serve, among other destinations, a grocery store and multiple restaurants/coffee shops with drive-through windows.
- An 8-foot sidepath already exists along some segments of the corridor and its pavement is in good condition, but it is not continuous.
- The buffer between the 8-foot sidepath and the street varies from 3 feet to 7 feet in width.
- The corridor is not currently shown on any local bicycle plans; however, it is the only bicycle-accessible route across a river for 2 miles in either direction.
- Pedestrian and bicycle volume data are not available, but the designer saw a handful of pedestrians and at least one bicyclist on a recent field visit. Strava data showed light usage.
- There have been 4 bicycle-involved crashes on the corridor in the last 10 years, including one fatality at the unsignalized intersection. The bicyclist was riding against traffic on the existing 8-foot sidepath on the south side of the roadway and was struck by a right-turning driver.

Exhibit 1 illustrates the extents of the corridor and other characteristics.

Exhibit 1. Case study corridor existing conditions with proposed sidepath location shown
Steps 1 – 5: Data collection and background information
Using the Sidepath Intersection & Crossing Treatment Guide, the available data is reviewed and observations are documented on the provided worksheet. Because there are already sidepaths on either side for portions of the high-traffic corridor and the corridor provides a necessary connection for bicyclists, providing a continuous sidepath on both sides should be considered. The right-of-way is sufficient to incorporate at least the minimum width sidepath and buffer on both sides of the roadway.

Because there is no bicycle volume information, a crash rate cannot be calculated. However, the occurrence of a bicycle-involved fatality suggests that safety treatments at the unsignalized intersection should be as robust as possible.

Step 6: Determine achievable sidepath width
The existing right-of-way width is divided into 60 feet of curb-to-curb roadway width and 15 feet behind the curb on both sides. The existing sidepath meets the minimum requirements, but not the optimal requirements. However, because the pavement is in good condition, and the budget for this project is limited, the existing segments are to remain as-is.

In the areas where a new sidepath will be added, providing the optimal sidepath width of 12 feet would leave only 3 feet for the buffer - less than the recommended 6 feet. Roadway lane widths were reviewed, but given the motor vehicle volumes and speeds, no additional space is available. A compromise between width and buffer space is sought, and a 10-foot path with 5-foot buffer is designed.

Step 7: Select intersection treatments
Driveway intersection treatments
Although driveway volumes are not available, land uses can be used to estimate traffic volumes. The driveways along the corridor can be divided into low-, medium-, and high-volume crossings based on the land uses served. The single-family residential driveways are assumed to have fewer than 20 crossings per day. The subdivision entrance serves a neighborhood of 30 homes, and is assumed to have fewer than 200 crossings per day. The commercial driveways are assumed to fall into the “high” volume category, based on the number of businesses and the presence of the drive-through operations.

Low-volume driveway treatments
Grade A driveway treatments are feasible for these low-volume locations without complications. Public engagement with the homeowners to ensure bicyclist priority at the crossings may be needed.

Medium-volume driveway treatments
Constructability of vertical deflection at the subdivision entrance will not be an issue. However, it is a new concept for drivers in the area. Public engagement during project development to fully explain and get buy-in on the concept may be needed.

High-volume driveway treatments
At the two commercial driveways, constructability of vertical deflection and the sidepath offset are not problematic. However, the grocery store owner is concerned about trucks accessing their store. The store receives deliveries from 53-foot trucks once or twice a day. In this case, a truck apron is used to achieve a 15-foot curb radius for passenger cars, and provide a larger, 40-foot radius for trucks when needed.

All driveways receive a Grade A rating.

Unsignalized intersection treatment
Due to the recent fatality at the unsignalized intersection, every effort is made to incorporate Grade A treatments.

The intersection currently has relatively large curb radii which can be reduced to 15 feet to minimize turning speeds. Traffic volume data indicate that there are not many trucks making this movement, so moving the curb to reduce the radius is feasible, and a truck apron is not deemed necessary.

In this case, achieving the desired offset distance happens to include the purchase of right-of-way from businesses on the corners of the intersection. The agency developing the plans engages these stakeholders early and often, and is able to reach an agreement to make
the purchase and achieve an 8-foot offset. The project timeline is delayed by a few months as a result. The intersection receives a Grade A rating.

**Signalized intersection treatment**

At the signalized intersection, traffic volumes are high enough to apply intersection design treatments adhering to the motor vehicle thresholds shown in Table 2. The eastbound and westbound right-turn volumes exceed the 100-vehicle threshold for a protected signal phase. However, capacity at the intersection is limited, and a traffic operations study found that a fully-protected phase for the sidepath in every cycle is not feasible. A 7-second leading interval is included in the design, with the option to add detection and a fully-protected phase if field results after installation suggest that the leading interval is not sufficient.

Plastic delineators are selected to decrease the effective turning radius of passenger vehicles, while still allowing for turning movements of large trucks. The agency developing the plans happens to own both roadways at this intersection, as well as the necessary right-of-way to achieve a 6-foot sidepath offset.

A review of the approach grades and drainage on the southbound approach determined that integrating vertical deflection was not feasible without significant reconstruction of the drainage system. Omitting the vertical deflection on this approach, but incorporating all other treatments, results in a Grade B rating for this intersection.

**Overall project score**

Because bicyclist comfort is based on the weakest link in their trip, the overall Grade for the corridor is a Grade B, based on the signalized intersection treatments.