MONTGOMERY COUNTY BICYCLE PLANNING GUIDANCE

JULY 2014

Montgomery County
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PURPOSE OF THIS GUIDANCE

The purpose of this document is to assist Montgomery County as it updates its bicycle plans to accommodate a diverse group of bicyclists, differing travel purposes, and a variety of contexts beyond what has traditionally been considered. This approach can be used by planners and designers to update the Countywide Bikeways Functional Master Plan, area-specific master plans, and as part of the facility planning of capital projects. This document will use emerging research on bicyclists' attitudes and desires, coupled with successes from other jurisdictions, to provide the types of bicycle facilities and degree of network connectivity that can appeal to potential bicyclists who may currently be dissuaded by safety and convenience concerns. It will enable planners and designers to:

1. predict the success of a facility in attracting different types of bicyclists; and
2. allow planners to be strategic in their placement of facilities to take advantage of existing low stress connections to achieve maximum network connectivity for bicyclists.

WHAT YOU SHOULD GET OUT OF THIS GUIDANCE

- A spectrum of bicycle facility types ranging from the least to highest separation from traffic
- How various user groups respond to different bicycle facility types
- A decision-making process to the feasibility of accommodating the target user group, based on the context
- Tools for identifying when an alternate bicycling route is needed
- The importance of connectivity
- Potential barriers reducing the effectiveness of existing and proposed bicycle routes

DOCUMENT ORGANIZATION

This document is broken into three basic sections:

1.) **Background Research**
This section includes the latest research on how different "types" of bicyclists perceive safety and comfort on different facility types. It also includes planning considerations, such as the importance of connectivity, and a spectrum of bicycle infrastructure from least to highest separation from traffic.

2.) **Bikeway Selection Guidance**
This section includes a flow chart that guides users through a series of questions and actions to determine which bicycle facility type is most appropriate and feasible, and whether an alternate location for bicycle facilities should be considered. To do this it uses speed and volume charts (also known as nomographs) as a screening tool to identify an initial facility type for two target audiences: "enthused and confident" and the "interested but concerned" population. The "strong and fearless" segment of the population does not typically demand dedicated bicycle facilities. The identified bicycle facility type is then evaluated using the Level of Traffic Stress to assess its effectiveness.

3.) **Bethesda Case Study**
The Bethesda case study uses this bicycle facility planning guidance to help planners create a network of low-stress bicycle facilities.

BACKGROUND RESEARCH

TYPES OF BICYCLISTS

Research conducted at Portland State University has identified four general groups of attitudes towards bicycling.[1] Very confident bicyclists who are comfortable operating in the roadway as a vehicle are classified as the "strong and fearless," and are estimated to make up only 4% of the population. Bicyclists who are comfortable riding on some roadways, but prefer bicycle facilities separate from vehicular traffic (bike lanes or shared use path) are classified as "enthused and confident" and are estimated to make up approximately 9% of the population. Bicyclists who would like to ride more, but have safety concerns that are dissuading them are classified as "interested but concerned" and make up most of the population (56%). The remaining people are classified as "no way no how," and have no interest in riding a bike for transportation.

Figure 1 below shows the comfort level of each of these groups with different facility types on a four-lane street with on-street parking and 30-35mph vehicle speeds.[2] The responses of the "interested but concerned" group are circled in yellow, because they are the largest segment of the population and represent the greatest opportunity for increasing bicycling. ***It is important to note that less than half of this group feels comfortable in a standard bike lane, but most feel comfortable in a separated bike lane (such as a cycle track).*** This highlights the importance of physically separated facilities in creating bicycle facility networks that appeal to this very large subset of the population, and thus have the potential to attract many more riders than standard bicycle facilities.

1 Dill, Jennifer, and Nathan McNeil. "Four Types of Cyclists?." Transportation Research Record: Journal of the Transportation Research Board 2387.1 (2013): 129-138.

2 The survey sampled 902 adults in urban and suburban areas to understand characteristics and preferences.

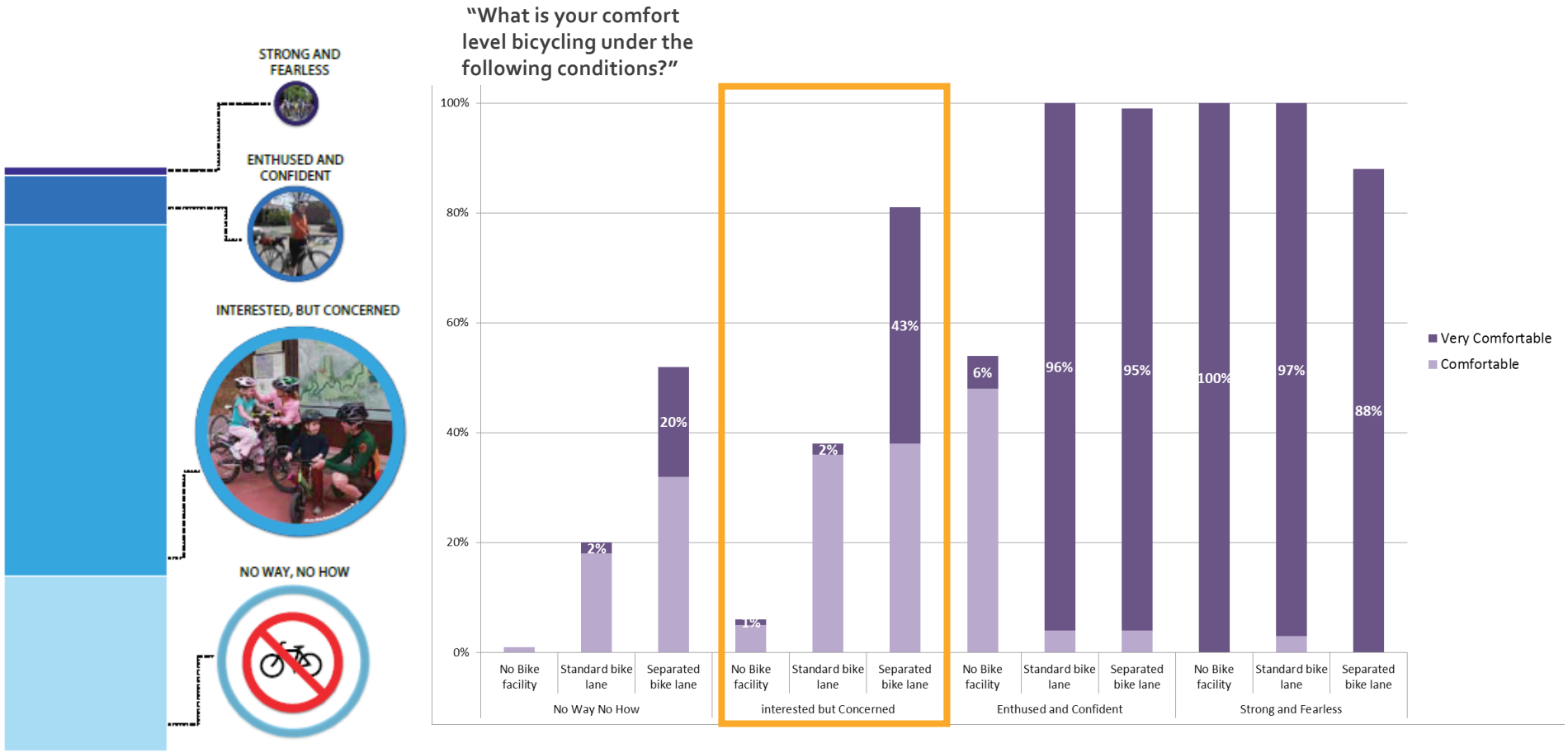


FIGURE 1 | TYPES OF BICYCLISTS AND THEIR FACILITY COMFORT LEVELS

TYPES OF FACILITIES

Most current bike lanes in the United States tend to be on collector or minor arterial roadways, with the intent of paralleling major corridors. While the standard bike lane may be a safe treatment for these locations, the figure on the previous page highlights that it may not feel safe to all bicyclists or potential bicyclists depending on the context of a given street or road. While the standard bike lane was the primary on-street bicycle facility used in the United States for many years, there are other facility types that have proven to be successful internationally for many years and are gaining acceptance.

Figure 2 illustrates various types of bicycle facilities along a spectrum from least to most separation from traffic:

- **Shared Lane Markings (Sharrows)** - Pavement markings that provide wayfinding guidance to bicyclists and alert drivers that bicyclists are likely to be operating on the road in mixed traffic. They are often coupled with traffic calming or traffic diversion treatments to form "bicycle boulevards," where through movement of bicycles is prioritized. (2A)
- **Bike Lanes** - An on-road bicycle facility designated by striping, sighing, and pavement markings. Standard Bike Lanes are 5 to 6 feet wide. Wide Bike Lanes are 6 to 7 feet wide (2B)
- **Buffered bike lane** - Bike Lanes enhanced with a painted buffer providing separation from traffic lanes. Buffered Bike Lanes are typically 8 to 9 feet wide. (2C)
- **Cycle tracks** - A bicycle facility that is physically separated from traffic and pedestrians. Separation may be vertical (curb) or horizontal (landscaped panel, parking lane), or a combination. Cycle tracks can be provided in one-way (5 to 7 feet wide) or two-way (8 to 12 feet wide) configurations. (2D)
- **Shared use paths** - A bicycle facility that is physically separated from traffic, but that is intended for "shared" use by a variety of groups, including pedestrians, bicyclists, and joggers. Shared Use Paths are asphalt or concrete and typically 10 to 14 feet wide, but can be 8 feet wide in limited situations.

Least Separation → **Most Separation**

SHARROW (2A) | **STANDARD BIKE LANE (2B)** | **BUFFERED BIKE LANE (2C)** | **TWO-WAY CYCLE TRACK (2D)** | **SHARED USE PATH (2E)**

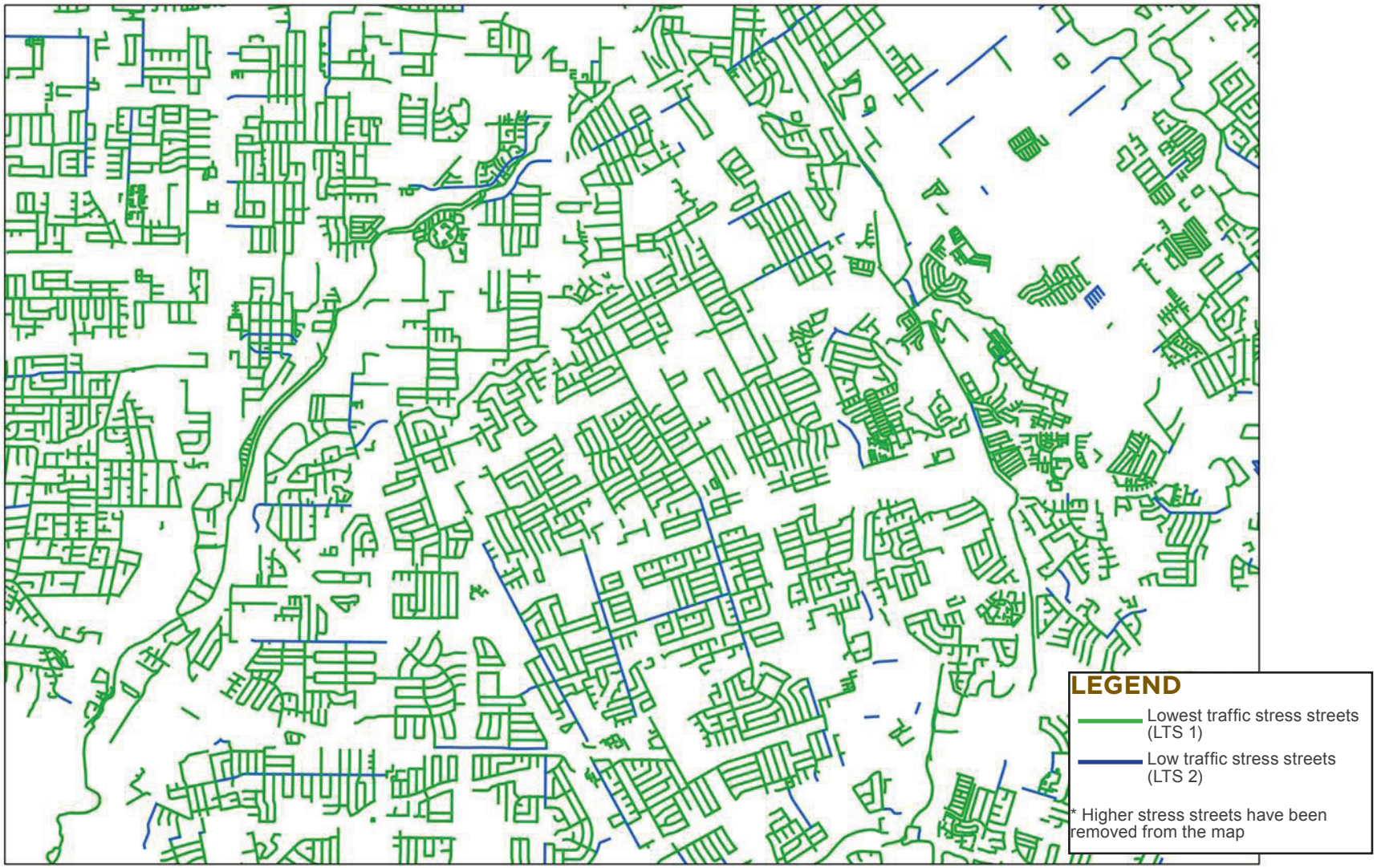
FIGURE 2 | TYPES OF BICYCLE FACILITIES

THE IMPORTANCE OF CONNECTIVITY

Bicycle facilities must be integrated into the larger bicycle network if they are to attract a wide array of bicyclists. For this reason, it is crucial that bicycle facility investments be considered from the point of view of the connectivity of the bicycle network as a whole. Two high quality bike facilities cannot be considered part of a network if they are separated from one another by even a few blocks of roadway that is perceived to be unsafe.

While bicyclists are shown to tolerate some level of detour to remain on facilities that feel comfortable, if a comfortable route is not available, the "interested but concerned" bicyclist is likely to perceive barriers and impediments where gaps in the bicycle network exist. An analysis of an area's network from this "perception of safety" perspective is a very powerful tool for planners because it can allow them to identify barrier areas and address them in a way that can "unlock" more of the existing network to "interested but concerned" bicyclists.

Figure 3 illustrates a network-based analysis of bicycle comfort in San Jose, including only the low-stress routes that would be comfortable for "interested but concerned" bicyclists. The result is a disconnected network with pockets of comfortable streets.



Mekuria, Maaza, Peter Furth, and Hilary Nixon. "Low-stress bicycling and network connectivity." Mineta Transportation Institute Report 11-19 (2012).

FIGURE 3 | LOW STRESS BICYCLE NETWORK IN SAN JOSE, CALIFORNIA

BIKEWAY SELECTION GUIDANCE

Selecting the appropriate bicycle facility requires an understanding of the roadway characteristics and the types of cyclists expected to use it, in conjunction with applicable engineering standards and guidance. The following flow chart outlines a bicycle planning approach for Montgomery County. This tool includes a multi-step process for planners and engineers to determine the best bikeway solution for an existing or proposed roadway to accommodate bicyclists of varying skills and comfort levels. In the event that there is insufficient space to accommodate the desired bikeway facility on a primary route, the process may lead to implementation of both a facility on the primary route designed for confident cyclists and one on a parallel route designed for mainstream adults.

Notes:

1. Use the "Designing for Interested but Concerned" chart to pre-select bikeway facility type (page 8).
2. Use the "Level of Traffic Stress" methodology to refine the facility type (page 11).
3. Determine engineering and cost feasibility.
4. If the facility is not feasible, determine a secondary option for the "interested but concerned" population while continuing to evaluate the necessary facility for the "enthused and confident" population (page 9).
5. The "interested but concerned" population is unlikely to be served if their trip length increases by more than 30 percent

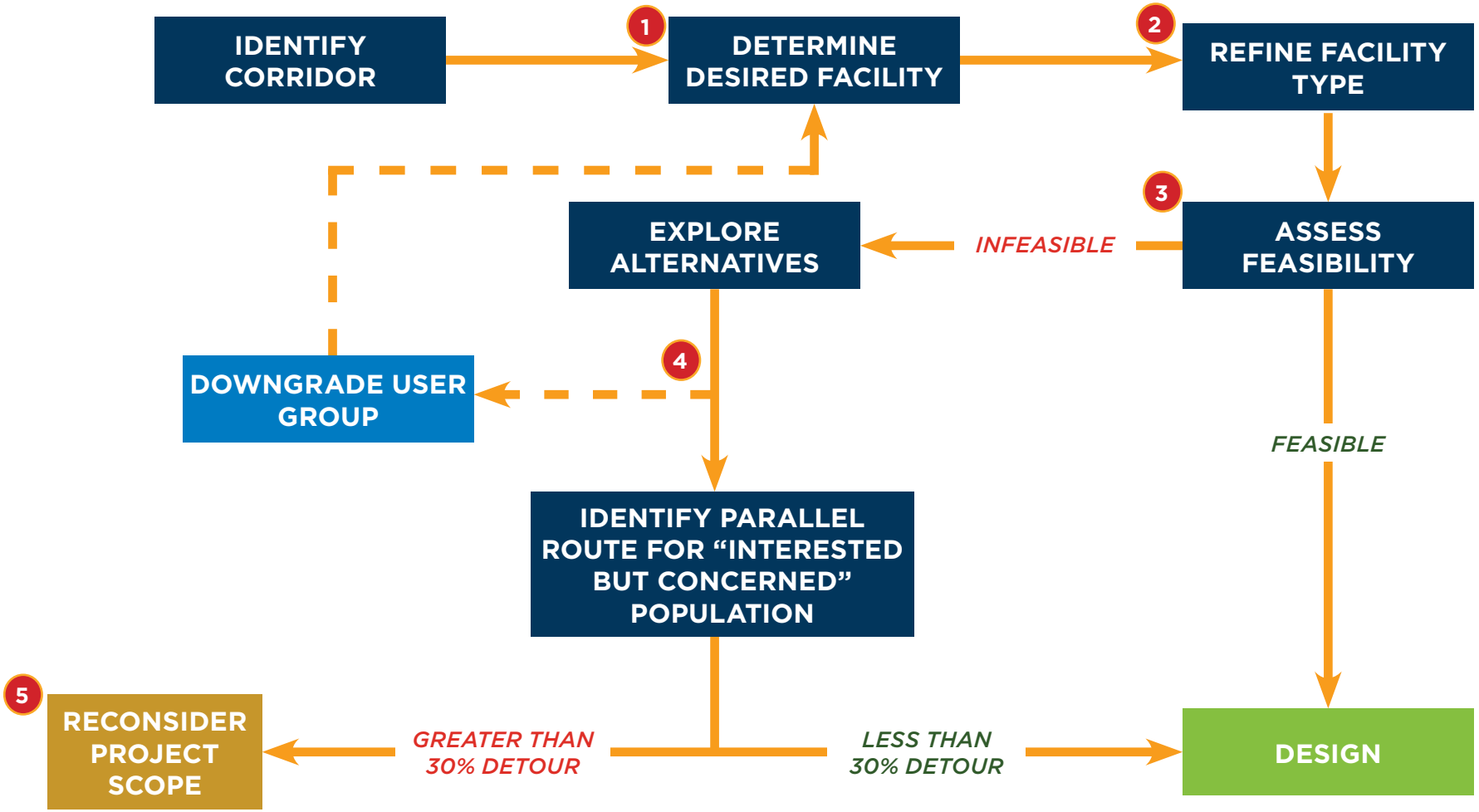


FIGURE 4 | DECISION-MAKING PROCESS

DESIGNING FOR THE INTERESTED BUT CONCERNED

The "interested but concerned" population requires additional levels of separation at lower traffic volumes and speeds than have traditionally been provided. The chart at the right helps the planner identify what types of facilities are appropriate in different speeds and traffic volumes.

Traffic volumes (on the y-axis) are daily volumes, and traffic speed (on the x-axis) is actual (e.g. 85th percentile). In the absence of observed speed data, design or posted speeds may be used.

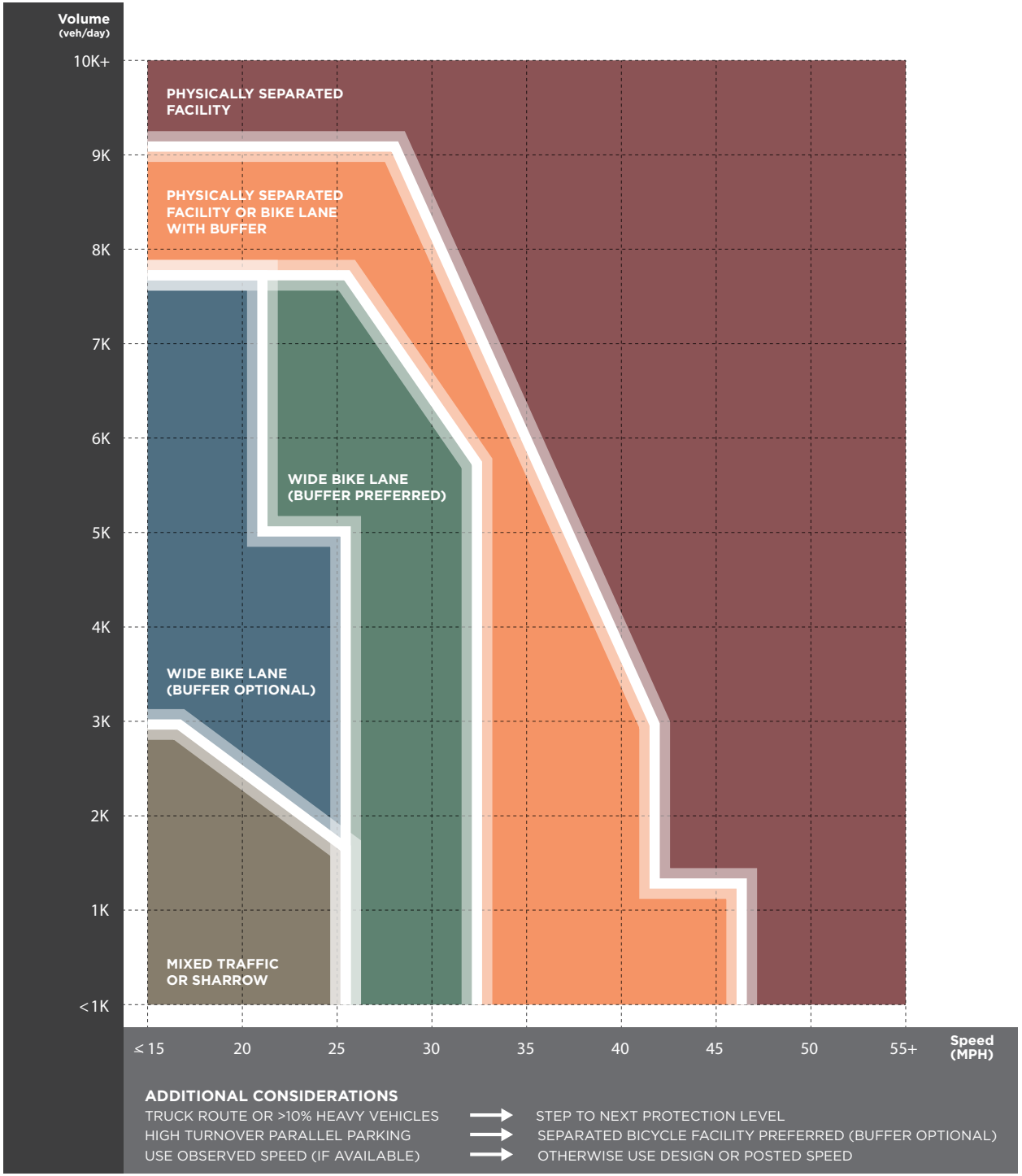


FIGURE 5 | PRE-SELECTION FOR INTERESTED BUT CONCERNED

Note: a physically separated facility is a cycle track or a shared use path

DESIGNING FOR CONFIDENT CYCLISTS

Confident cyclists generally require less physical separation from traffic than the general population. They are comfortable riding in roads where the traffic operates at higher volumes and speeds, so planning for confident cyclists usually requires less dedicated space within the roadway.

As with the "Interested but Concerned" chart, the Confident Cyclists facility selection tool (at right) is based on daily vehicle volume (y-axis) and observed vehicle speed (x-axis).

Note: a physically separated facility is a cycle track or a shared use path

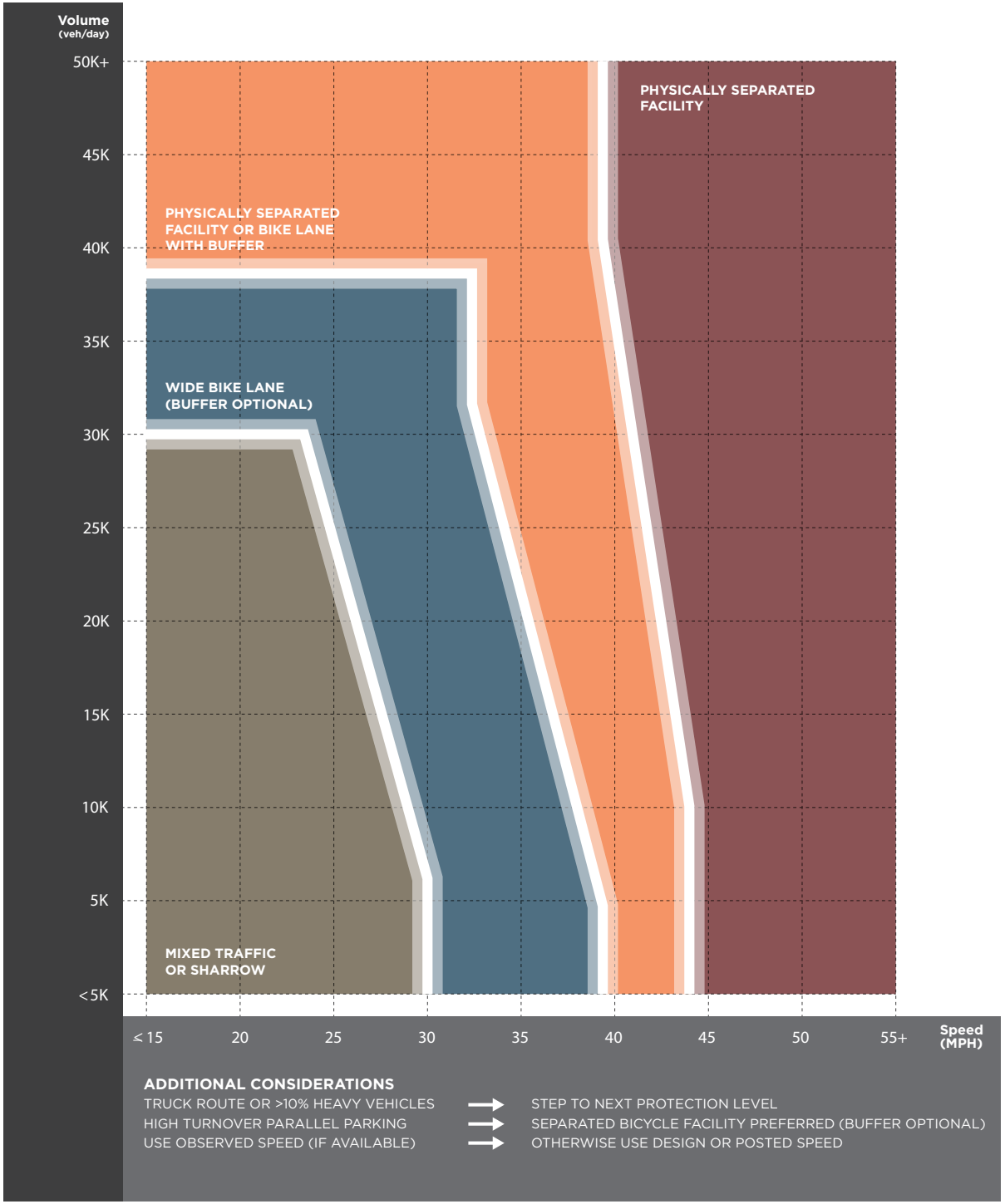


FIGURE 6 | PRE-SELECTION FOR CONFIDENT CYCLISTS

DESIGN CONSIDERATIONS

Additional considerations and mitigations for design are listed in the table below

CONSIDERATION	MITIGATION
Bus stops along bike route	Bike lanes: Minimize and clearly mark conflict areas to alert bicyclists and buses Physically separated facilities: Provide pedestrian queuing, landing, and shelter (if present) between bike facility and roadway, if feasible.
Bikeway adjacent to on-street parking with low occupancy	Consider removal or consolidation of parking
Bikeway adjacent to on-street parking with high turnover	Wide or buffered bike lanes preferred to reduce risk from opening car doors
Front-in perpendicular or angled parking	The use of back-in angled parking preferred
Bikeways along streets with numerous commercial driveways and/or unsignalized intersections	Clearly sign and mark conflict areas with colored pavement to warn motorists and bicyclists. Design high-volume driveways as intersections
Bikeways crossing a major signalized intersection	Consider bike boxes, turn-queue boxes, warning signs and markings, bicycle signals (especially at separated bicycle facility)
New bicycle route connecting existing facilities	Provide continuity with adjacent facilities, where possible. Provide bicycle facility at same or higher level of protection compared to adjacent facilities.
Bikeway on a truck route or road with greater than 10% heavy vehicles	Step up to next level of protection recommended by the chart (i.e. from mixed traffic to bike lanes, from buffered bike lanes to separated bicycle facility). Generally, separated bicycle facilities preferred, bike lane with buffer optional, depending on speed & volume characteristics of the roadway.

When an alternative route is needed, the following considerations are appropriate:

- The "interested but concerned" population may be willing to divert to a lower stress facility if the increase in trip length is less than 30%.[1] Even with the designation of a lower stress parallel route, "enthused and confident" cyclists will likely still prefer the primary route; thus, the primary route should still be designed for confident cyclists.
- Provide a high-quality, functional design for parallel route. For example, if mixed traffic is appropriate for the "interested but concerned" population on a parallel route, consider providing a bicycle boulevard to minimize bicycle delay, reduce traffic speeds, and brand the route to increase awareness and visibility.
- Include wayfinding to direct bicyclists to the alternative parallel route. Wayfinding should provide information about the facility on the parallel route, such as the destination and distance to the destination (e.g., "Downtown Silver Spring via Fenton Cycle Track" or "Glenmont Metro via Grandview Bike Blvd").

1 Dill, Jennifer, and John Gliebe. "Understanding and measuring bicycling behavior: A focus on travel time and route choice." (2008).

LEVEL OF TRAFFIC STRESS (LTS) METHODOLOGY

Building off the Portland State University research identifying "four types of cyclists," research led by the Mineta Transportation Institute[1] developed a methodology for evaluating the level of traffic stress that bicyclists experience on road segments, intersection approaches, and unsignalized crossings. Using this approach, a street network can be classified into four stress levels, ranging from low stress to high stress. For a bicycle network to attract the broadest segment of the population, it must provide low-stress connectivity, defined as:

> "providing routes between people's origins and destinations that do not require cyclists to use links that exceed their tolerance for traffic stress, and that do not involve an undue level of detour."

The LTS methodology focuses on the following criteria for evaluating traffic stress on bicyclists:

Segments

- Presence or absence of parking
- Presence or absence of bike lane
- Street width (number of lanes)
- Width of bike lane and parking lane
- Speed limit or prevailing speed
- Frequency of vehicles parked in bike lanes

Intersection Approaches

- Presence of right turn lane(s)
- Length of right turn lane
- Turn lane configuration (bike lane shifts vs. bike lane continues straight)

Unsignalized Crossings

- Width of cross street
- Speed limit of cross street
- Presence or absence of median refuge

The analysis applies a "weakest link" logic, wherein the stress level is assigned based on the lowest-performing attribute. For example, even if a segment has mostly low stress characteristics, the occurrence of one high-stress attribute (e.g. a narrow outside lane) dictates the stress level for the link.

LTS values are highly predictive of the comfort level that bicyclists will experience on a given facility. Generally, "interested but concerned" bicyclists will be comfortable on facilities with an LTS of 1 or 2. More confident and experienced bicyclist types may be comfortable on higher LTS facilities. Mapping an area's network using LTS shows what portion of the network is suitable for different rider groups.

The Level of Traffic Stress methodology identifies four stress levels based on key facility and traffic factors

Stress level 4 – High stress, only suitable for experienced bicyclists

Stress level 3 – Moderate traffic stress for all bicyclists

Stress level 2 – Low traffic stress, and suitable for most adults

Stress level 1 – Requires little attention to surroundings; suitable for most children

1 Mekuria, Maaza, Peter Furth, and Hilary Nixon. "Low-stress bicycling and network connectivity." Mineta Transportation Institute Report 11-19 (2012).

CRITERIA FOR BIKE LANES ALONGSIDE A PARKING LANE

	LTS ≥ 1	LTS ≥ 2	LTS ≥ 3	LTS ≥ 4
Street width (thru lanes per direction)	1	NA	2 or more	NA
Sum of bike lane and parking lane width	15 ft or more	14 or 14.5 ft	13.5 ft or less	NA
Speed limit or prevailing speed	25 mph or less	30 mph	35 mph	40 mph or more
Bike lane blockage	rare	NA	frequent	NA

WEAKEST LINK LOGIC

The example at the left shows the evaluation of a bike lane on a street with a parking lane. While it scores LTS 1 or 2 for number of lanes, speed, and frequency of vehicles parked in the bike lane, the sum of the bike lane and parking lane are too narrow for "interested but concerned" cyclists, so the link gets an overall score of LTS 3.

DOWNTOWN BETHESDA CASE STUDY

To demonstrate the principles of this guidance, the Bikeway Guidance Tool was applied as a case study in Downtown Bethesda, where the Montgomery County Planning Department is updating the 1994 Bethesda CBD Sector Plan.

EXISTING CONDITIONS

The maps below show the bicycle network in downtown Bethesda that is available to different types of bicyclists. Figure 7A shows the entire street network within the planning area. The network for the "enthused and confident" group, identified in Figure 7B, is relatively complete and can be further improved if a few key barriers (outlined in pink) are addressed. However, the bicycle network for the "interested but concerned" population, shown in Figure 7C, is highly disconnected. A critical gap in the bicycle network for this group is on the Capital Crescent Trail at the intersection of Woodmont Avenue and Bethesda Avenue (circled in pink).

In the maps on this and the following pages, the lowest stress routes are colored blue and green (LTS 1 and 2), and are suitable for attracting "interested but concerned" cyclists. Yellow streets correspond to LTS 3 and may be used by the "enthused and confident."

BETHESDA STREET NETWORK (7A) **ENTHUSED AND CONFIDENT (7B)** **INTERESTED BUT CONCERNED (7C)**

FIGURE 7 | EXISTING LEVELS OF TRAFFIC STRESS AND NETWORK AVAILABLE TO DIFFERENT USER GROUPS

CONDITIONS WITH PLANNED FACILITIES

The maps below show the bicycle network in downtown Bethesda that will be available to the "interested but concerned" and "enthused and confident," groups, once the bikeways in the County's master plans are fully implemented. With completion of the bike lane on Woodmont Avenue, "enthused and confident" bicyclists will have near-complete access to destinations within the study area on a comfortable route (this facility is outlined in pink in Figure 8B). Bicycle improvements at strategic intersections for crossing Wisconsin Avenue could address most of the remaining barriers.

The major changes to the network for the "interested but concerned" group, shown in Figure 8C, are the shared use path along Bradley Boulevard and the completed Capital Crescent Trail (these facilities are highlighted). These connections "unlock" the network for the "interested but concerned" population, for most of the southern and eastern portions of the study area. However, there is still a lack of low stress connectivity north of the Bethesda Metro Station.

BETHESDA STREET NETWORK (8A) **ENTHUSED AND CONFIDENT (8B)** **INTERESTED BUT CONCERNED (8C)**

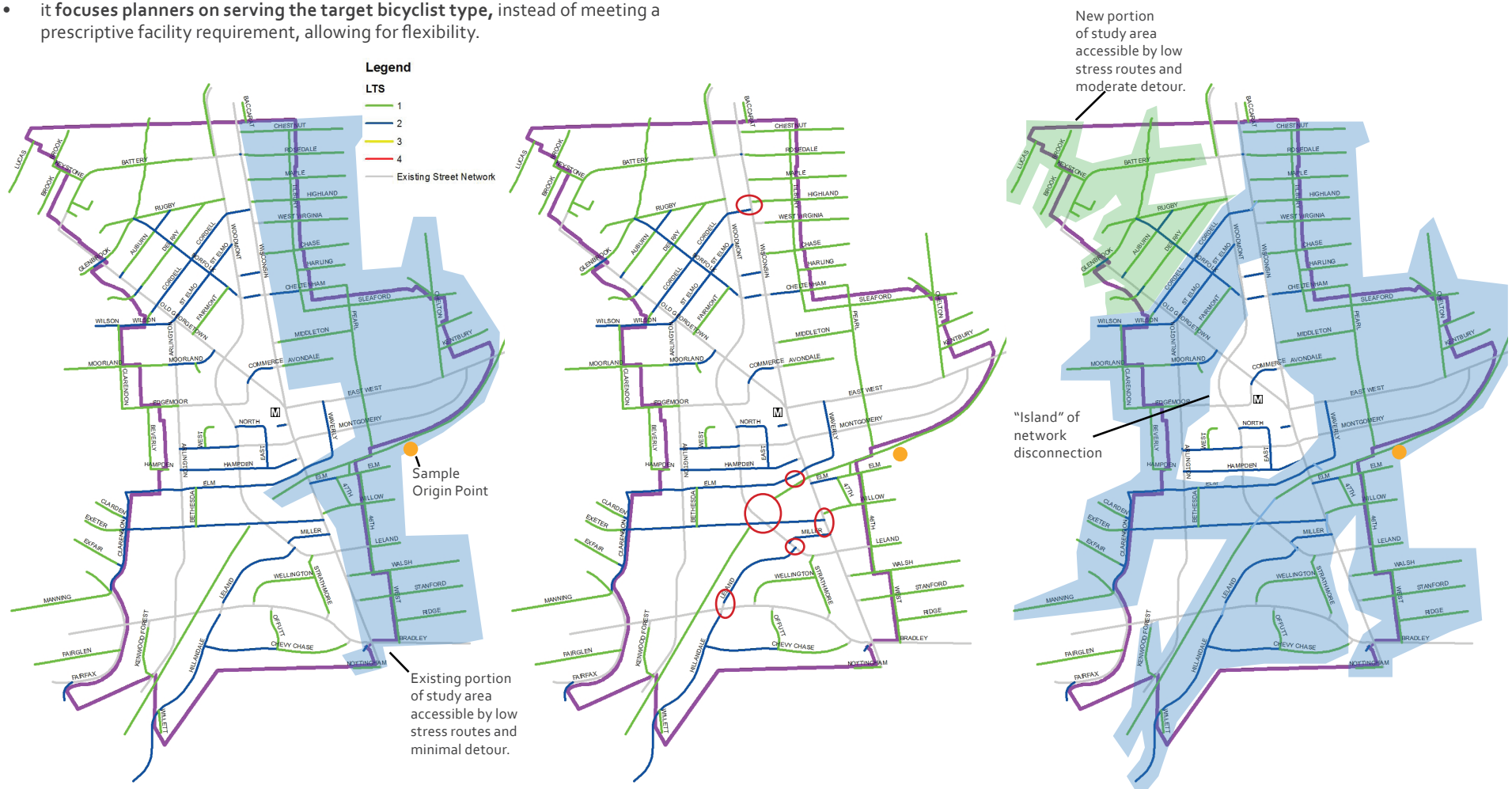
FIGURE 8 | PLANNED FUTURE CONDITIONS AND NETWORK AVAILABLE TO DIFFERENT USER GROUPS

APPLICATION OF GUIDANCE

This section demonstrates how the Bikeway Guidance Tool can aid planners in building a complete bicycle network for a specific user group. The network mapping confers the following advantages:

- it **recognizes the value of local streets** as part of a low stress bicycle network, especially when coupled with wayfinding;
- it allows planners to **unlock more of the network** for their desired user group with **smaller, strategic interventions; and**
- it **focuses planners on serving the target bicyclist type,** instead of meeting a prescriptive facility requirement, allowing for flexibility.

To demonstrate this process, a sample origin point (on the Capital Crescent Trail) was chosen, and the portion of the study area that an "interested but concerned" bicyclist could reach using existing low stress routes is highlighted in blue in Figure 9A. Planners can then use the LTS methodology to identify key obstacles to unlocking more of the network from that location by implementing specific intervention measures (spot improvements). Figure 9B highlights key missing intersection connections, and Figure 9C shows the resulting unlocked network when these obstacles are addressed.



EXISTING CONDITIONS (9A)

MISSING INTERSECTION CONNECTIONS (9B)

BICYCLE NETWORK AFTER INTERSECTION IMPROVEMENTS (9C)

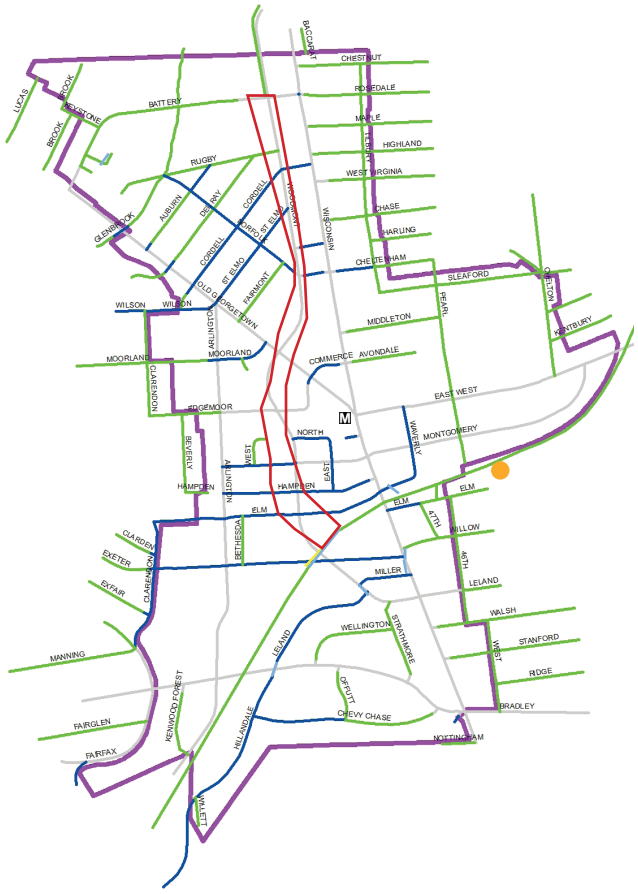
FIGURE 9 | NETWORK CONNECTIVITY FOR INTERESTED BUT CONCERNED - BEFORE AND AFTER INTERSECTION TREATMENTS

APPLICATION OF GUIDANCE

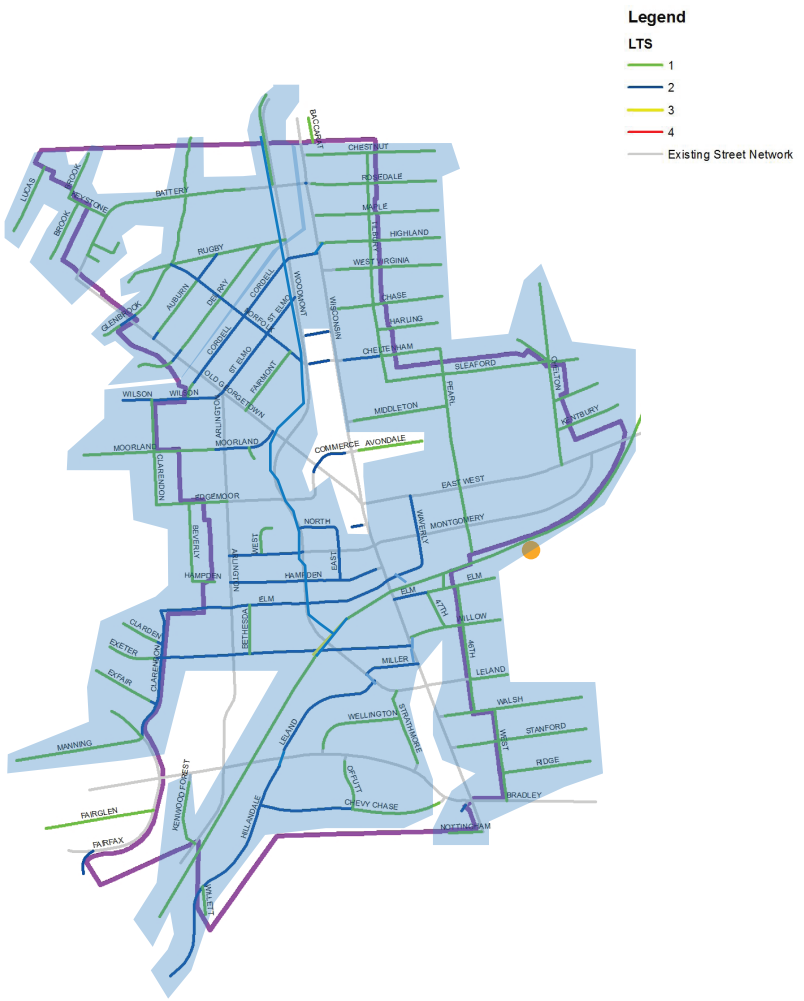
While the application of intersection interventions creates low stress routes to the vast majority of the study area, the addition of select high quality bicycle facilities on roadways can further reduce the necessity for detours.

Wisconsin Avenue and Woodmont Avenue are two of the most direct routes for north-south travel within downtown Bethesda but remain substantial barriers to bicycle travel even after intersection treatments are applied. Both roadways intersect the Capital Crescent Trail.

Woodmont Avenue is promising for intervention because it experiences lower traffic volumes than Wisconsin Avenue and is recommended to have bicycle lanes under current plans. However, application of the Bikeway Guidance shows that the appropriate facility for "interested but concerned" bicyclists on Woodmont Avenue is a separated bike lane or cycle track. If a cycle track facility on Woodmont Avenue and the suggested intersection interventions are built, the bicycle network for the "interested but concerned" population would cover most of downtown Bethesda (see Figure 10B).



REMAINING KEY OBSTACLE (10A)



BICYCLE NETWORK AFTER INTERSECTION IMPROVEMENTS AND WOODMONT AVE CYCLE TRACK (10B)

FIGURE 10 | NETWORK CONNECTIVITY WITH ADDITION OF SEPARATED BIKE LANE COMPARED TO PLANNED CONDITIONS