Defining the Madison Area

Low-Stress Bicycle Network

and Using it to Build a Better Regional Network

Madison Area

T • P • B

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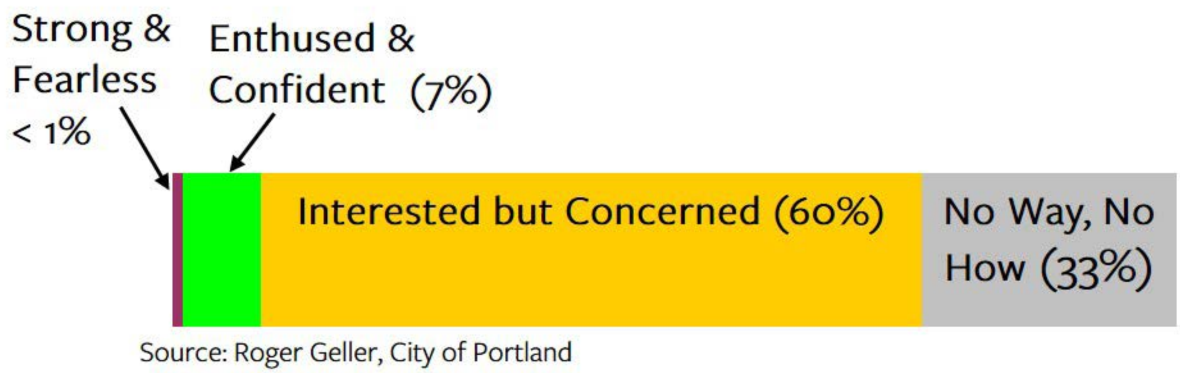
What is the Low-Stress Network?

Level of Traffic Stress (LTS) is an objective, data-driven approach to evaluating traffic-related stress on bicycle routes based on roadway design, traffic volumes, traffic speeds, and other factors. The low-stress bicycle network is all of the routes, including streets and off-street paths, on which an average person would be expected to feel comfortable riding a bicycle. While bicycling confidence varies greatly, a widely cited estimate by Roger Geller, Bicycle Coordinator at the Portland Bureau of Transportation, is that 60% of people are “interested but concerned” about bicycling. They are interested in bicycling but either rarely do so or only do so on a limited amount of their area’s network because they are concerned about their safety in the presence of automobile traffic.

Creating a more comfortable bicycle network by reducing traffic-related stress factors can help to encourage a wider range of people to make more of their trips by bicycle.

Figure 1 Four Stages of Bicycling Comfort



Streets and paths can be divided into four levels of traffic stress (LTS) based on automobile traffic, number of lanes, width of bicycle lanes, and other factors. The stress levels loosely correspond to the different types of bicyclists shown in Figure 1 with the range of LTS 1 to LTS 4 representing the spectrum from lowest to highest stress facilities. Peter Furth, a professor of Civil and Environmental Engineering at Northeastern University one of the developers of the LTS methodology, describes the four levels of traffic stress as follows:

LTS 1: Strong separation from all except low speed, low volume traffic. Simple-to-use crossings. LTS 1 indicates a facility suitable for children.

LTS 2: Except in low speed / low volume traffic situations, cyclists have their own place to ride that keeps them from having to interact with traffic except at formal crossings. Physical separation from higher speed and multilane traffic. Crossings that are easy for an adult to negotiate. Limits traffic stress to what the mainstream adult population can tolerate. The criteria for LTS 2 correspond to design criteria for Dutch bicycle route facilities.

LTS 3: Involves interaction with moderate speed or multilane traffic, or close proximity to higher speed traffic. A level of traffic stress acceptable to the “enthused and confident.”

LTS 4: Involves being forced to mix with moderate speed traffic or close proximity to high-speed traffic. A level of stress acceptable only to the “strong and fearless.”

Routes rated as LTS 1 or 2 comprise the low-stress network.

Benefits of LTS mapping

LTS mapping offers a new way to visualize the existing system of streets and paths that are comfortable for the majority of cyclists, and to identify gaps in the network. It is designed for urban streets rather than rural roadways as higher speeds (above 35 mph) result in a high stress designation regardless of traffic volumes or presence of a bike lane or paved shoulder. Combined with demographic and employment information, and other data, it is particularly powerful.

Potential uses of this information include:

- *Measuring access to jobs and other destinations* – Accessibility to businesses, public services, and other destinations via the low-stress network can be used to inform public sector planning and project design decisions, as well as private housing and business location decisions.
- *Assessing connectivity and identifying gaps in the low-stress network to inform plans, designs, and project prioritization* – Identifying key gaps in the low-stress network enables the prioritization of projects that fill these gaps and can nudge decision makers towards designs that minimize traffic stress for bicyclists.
- *Helping riders identify comfortable routes* – LTS mapping provides a more useful gauge of bicycling comfort than maps and signage that show only designated bicycling facilities or routes, which can vary widely in their level of traffic stress.
    - Wayfinding signage can be improved by prioritizing low-stress routes.
    - Riders can get directions on low-stress routes before their trip using the web-based [Low-Stress Bike Route Finder]() that MATPB staff created.
- *Assessing equity in bicycling accessibility* – Because LTS mapping is based on riders' level of stress rather than designated bicycle infrastructure, it can illuminate disparities in bicycle access that may not be apparent from analyses focused strictly on bicycle-specific infrastructure.
- *Identifying safe routes to school and places for improvement* – LTS mapping can help to identify the best bicycling routes to schools, and the neighborhoods most in need of safe access routes.

Level of Traffic Stress Methodology

Calculating LTS

The methodology used by MATPB in calculating LTS is based on that developed by Maaza C. Mekuria, Peter G. Furth, and Hilary Nixon in their 2012 research report, Low-Stress Bicycling and Network Connectivity and the updated criteria issued in 2017.

LTS scores for each street or path segment are determined by combining the segment score, based on the characteristics of the segment itself, with the intersection score, based on characteristics of the intersecting roadway and the intersection configuration (specifically the presence and design of bike and right turn lanes). Each segment receives the higher (greater stress level) of the two scores as its final LTS. Table 1 and Table 2 summarize the possible range of scores for different types of segments and intersections.

Table 1 Segment LTS Summary

Segment Type	Level of Traffic Stress
Stand-alone paths and segregated lanes (protected lanes, cycletracks, etc.)	LTS = 1
Bike lanes	LTS can vary from 1 to 4
Mixed traffic	LTS can vary from 1 to 4

Table 2 Intersection LTS Summary

Intersection Type	Level of Traffic Stress
Unsignalized Intersections	LTS can vary from 1 to 4
Signalized Intersections	Same as approaching segment unless there is a right turn lane
Right turn lane – pocket bike lane	LTS can vary from 2 to 4
Right turn lane – mixed traffic	LTS can vary from 3 to 4

The scoring criteria for segments and intersections are detailed below.

Segments

LTS scores for each of the different segment types, shown in Table 1, are determined using different scoring systems, with stand-alone paths receiving an LTS score of 1.

Streets with bicycle lanes are scored on several metrics, with their overall score determined by the highest score received on any of the metrics. Because bicycle lanes alongside on-street parking present additional risks to bicyclists compared to bicycle lanes that are not alongside parking, two separate scoring systems are used for bicycle lanes, depending on the presence of on-street parking. Both of these tables are based on those in the original 2012 report, with minor adjustments to make them more consistent with the updated 2017 criteria.

Table 3 details the scoring criteria for bicycle lanes that are not alongside on-street parking. In order to receive an LTS of 1, the street can be no more than one lane in each direction, with a speed limit of 25 mph, and a bicycle lane at least 6 feet wide (including the gutter pan). If any one of these factors moves to a higher LTS score, the segment's overall score increases commensurately. For example, a street with one lane in each direction, with a 6-foot bicycle lane, and a speed limit of 35 mph would receive an LTS score of 3.

Table 3 Criteria for Bicycle Lanes Not Alongside Parking

	LTS ≥ 1	LTS ≥ 2	LTS ≥ 3	LTS = 4
Street width (thru lanes per direction)	1	2, if directions are separated by a raised median	>2 or 2 without a separating median	(no effect)
Bike lane width (including gutter pan)	≥ 6 ft.	< 6 ft.	(no effect)	(no effect)
Speed limit or prevailing speed	≤ 25 mph	30 mph	35 mph	≥ 40 mph

Bicycle lanes that are alongside on-street parking must be wider than those not alongside parking to provide additional space for bicyclists to avoid open car doors and related hazards. Table 4 details the scoring criteria for segments with bicycle lanes alongside on-street parking.

Table 4 Criteria for Bicycle Lanes Alongside Parking

	LTS ≥ 1	LTS ≥ 2	LTS ≥ 3	LTS = 4
Street width (thru lanes per direction)	1	(no effect)	2 or more	(no effect)
Sum of bike lane and parking lane width (including gutter pan)	≥ 15 ft.	> 12 and < 15 ft.	≤ 12 ft.	(no effect)
Speed limit or prevailing speed	≤ 25 mph	30 mph	35 mph	≥ 40 mph

LTS scores for streets without bicycle lanes are based on the number of traffic lanes, speed limits, and average daily traffic (ADT), as shown in Table 5. This is a somewhat simplified version of the criteria proposed by Peter Furth in his 2017 update.

Table 5 Criteria for Mixed-Traffic Streets

# of Through Lanes per Direction	**Effective ADT***	**Speed Limit (mph)**						
		≤ 20	**25**	**30**	**35**	**40**	**45**	**≥ 50**
1	0 – 1500	LTS 1	LTS 1	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4
	1501- 3000	LTS 2	LTS 2	LTS 2	LTS 3	LTS 4	LTS 4	LTS 4
	3000 +	LTS 2	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
2	0- 8000	LTS 3	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
	8000 +	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
3+	Any ADT	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
* Effective ADT = ADT for two-way roads; Effective ADT = 1.5 * ADT for one-way roads.								

Intersections

The LTS criteria used to evaluate intersections, presented in the original 2012 report, varies based on whether the intersection is governed by traffic signals, whether the road is divided, and whether there are right turn lanes. It is important to note that, due to technical limitations, intersection LTS was not used to calculate the LTS scores of off-street paths in this analysis. However, excluding rural areas, where paths may cross high-speed roads at unsignalized intersections, most path intersections are low stress (LTS 1 or 2).

LTS scores for unsignalized crossings are calculated using one of the following two tables, depending on whether the road being crossed has a median at least 6 feet wide that can provide a refuge for bicyclists or is a one-way street.

The rationale for using one set of criteria for two-way streets without medians and another set of criteria for one-way streets and streets with medians is that medians and one-way traffic both make it easier to cross at unsignalized intersections. Medians of at least 6 feet in width provide a refuge for bicyclists, where they can wait for an opening in traffic on the far side of the street. Similarly, there are usually more gaps in traffic on one-way than on two-way streets.

An unsignalized intersection's LTS score is applied to the approaching segment(s) if it exceeds the segment's original LTS score. For example, a road segment with a base LTS of 2 crossing a 30 mph street with one lane in each direction (LTS 1) would maintain its rating of LTS 2. However, the same road segment crossing a 35 mph street with 2 lanes in each direction (LTS 3) would have its rating increased to LTS 3.

Table 6 LTS Criteria for Unsignalized Crossings without a Median Refuge

Speed Limit of Street Being Crossed	Width of Street Being Crossed (travel lanes per direction)		
	1	2	3+
Up to 25 mph	LTS 1	LTS 2	LTS 4
30 mph	LTS 1	LTS 2	LTS 4
35 mph	LTS 2	LTS 3	LTS 4
40+	LTS 3	LTS 4	LTS 4

Table 7 LTS Criteria for Unsignalized Crossings with a Median Refuge and One-way

Speed Limit of Street Being Crossed	Width of Street Being Crossed (travel lanes per direction)		
	1	2	3+
Up to 25 mph	LTS 1	LTS 1	LTS 2
30 mph	LTS 1	LTS 2	LTS 3
35 mph	LTS 2	LTS 3	LTS 4
40+	LTS 3	LTS 4	LTS 4

Signalized intersections do not generally present a barrier to cycling and do not normally affect the LTS scores of approaching segments. However, right-turn lanes can increase traffic stress for bicyclists approaching these intersections. The factors related to right-turn lanes that impact bicyclists include the length of the right-turn lane (which indicates the volume of right-turning traffic) and the speed of right-turning traffic. Two separate scoring tables are used to determine LTS at signalized intersections with right-turn lanes depending on whether there is a pocket bike lane (Table 8) or not (Table 9). Pocket lanes are those that lie between the rightmost through lane (for motor vehicles) and the right-turn lane. For pocket bike lanes, whether the bike lane continues straight or shifts to the left, and whether the turn lane starts abruptly—reducing the overlap between the bike lane and right-turning vehicles—also affects intersection LTS.

Table 8 LTS Criteria for Pocket Bike Lanes

Configuration	**Level of Traffic Stress**
Single right-turn lane up to 150 ft. long, starting abruptly while the bike lane continues straight, and having an intersection angle and curb radius, such that turning speed is ≤ 15 mph.	2
Single right-turn lane longer than 150 ft. starting abruptly while the bike lane continues straight, and having an intersection angle and curb radius such that turning speed is ≤ 20 mph.	3
Single right-turn lane in which the bike lane shifts to the left but the intersection angle and curb radius are such that turning speed is ≤ 15 mph.	3
Single right-turn lane with any other configuration: dual right-turn lanes: or right-turn lane along with an option (through-right) lane.	4

Table 9 LTS Criteria for Mixed Traffic in the Presence of a Right-turn Lane

Configuration	Level of Traffic Stress
Single right-turn lane with length ≤ 75 ft. and intersection angle and curb radius such that turning speed is ≤ 15 mph.	No effect on LTS
Single right-turn lane with length between 75 and 150 ft., and intersection angle and curb radius such that turning speed is ≤ 15 mph.	3
Otherwise.	4

Adjustments to Account for Factors Unaddressed

The LTS scoring system used in Dane County was adjusted to account for several local factors that are unaddressed in the LTS criteria. Specifically, the criteria do not address:

- Streets with peak period parking restrictions
- Streets with bicycle lanes alongside on-street parking in residential areas with very low parking occupancy
- Roundabouts

Streets with peak period parking restrictions, those that are normally a single lane in each direction with parking on both sides where parking is temporarily prohibited in one direction during the morning or afternoon rush hour, were treated as 2-lane streets (one lane in each direction) with a combined width of 12 feet or less for bicycle lanes and parking (LTS 3). Streets with bicycle lanes alongside on-street parking in residential areas with very low parking occupancy, that have a combined width of 11 or 12 feet for bicycle lanes and parking, were treated as having 6-foot bicycle lanes without parking (LTS 2). Roundabouts, which are more complicated to navigate than standard intersection designs, are classified as LTS 2, for one-lane roundabouts, or LTS 3, for roundabouts of more than one lane.

Factors Not Included

It should be noted that the LTS methodology excludes from consideration a number of factors that can affect bicyclist comfort. These would need to be considered at a project level rather than the network level that the LTS methodology is designed for. These include:

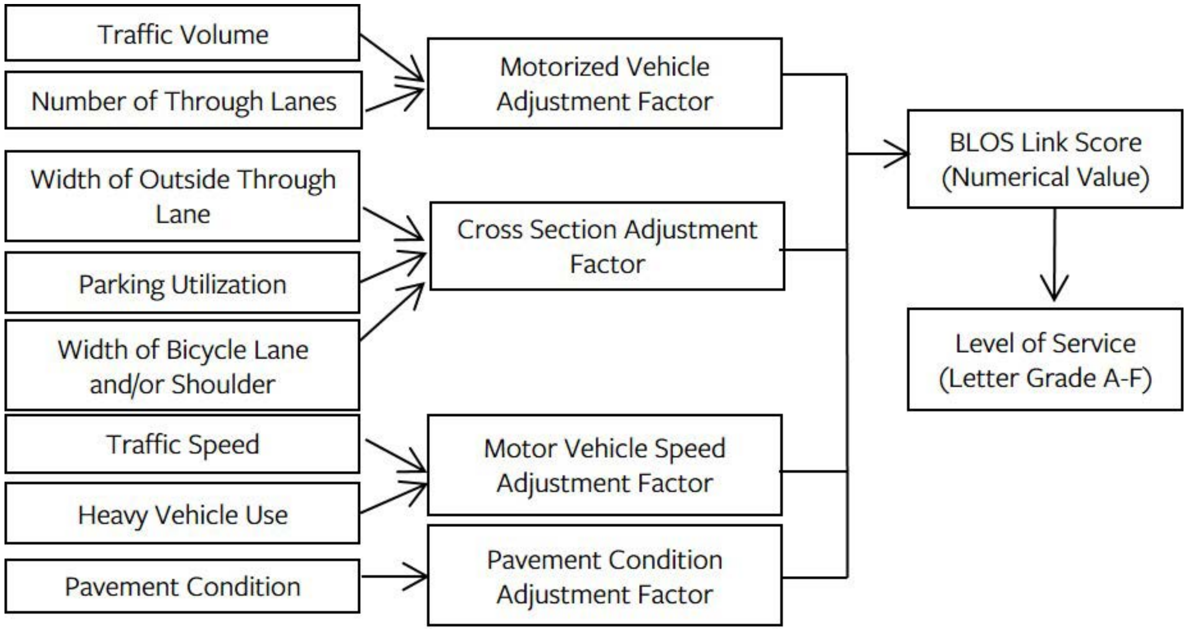
- Left turn lanes
- Topography (steep hills)
- Pavement condition
- High driveway density (e.g., Monona Drive)
- High traffic volumes, particularly truck traffic, on streets with bike lanes
- Rough or skewed railroad crossings
- Neighborhood crime and safety concerns

Advantages

As discussed above, LTS offers many advantages over simply assessing routes based on whether they are equipped with bike lanes or other bicycle-specific infrastructure. However, LTS also has a number of benefits compared to Bicycle Level of Service (BLOS), the other commonly used quantitative system to evaluate bicycle suitability.

BLOS requires much more information to calculate than LTS, does not specifically consider the different types of bicyclists using the system, and is difficult to explain to the public and policymakers. BLOS can be used to calculate level of service for urban streets (Figure 2), rural roads, intersections, and shared-use paths using the methodology provided in the *Highway Capacity Manual*. Higher letter grades (A, B, C) generally correspond to more comfortable riding conditions.

Figure 2 BLOS Methodology for Urban Streets



Due to limited availability of information used to calculate BLOS for intersections, rural routes, and shared-use paths, MATPB only calculated BLOS for urban streets, not including intersections, in the 2015 Bicycle Transportation Plan. However, even this required some assumptions/estimates in the areas of parking utilization and heavy vehicle volumes. The results of the BLOS analysis highlight some of its weaknesses relative to LTS. For example, Campus Drive, a 40 mph high-volume roadway with limited access and shoulders, received a more favorable score (C) than East Gorham Street (F), a 25 mph 2-lane roadway with parking and a bicycle lane, despite the fact that bicyclists are much more likely to avoid Campus Drive than East Gorham Street. The counterintuitive ratings sometimes produced by BLOS result from its sensitivity to on-street parking and heavy vehicles. Similarly, variability in pavement condition (within the acceptable range) is included in BLOS calculations but is unlikely to be a major concern for most bicyclists.

The LTS methodology is much easier to apply, as it is based on commonly available data and does not require the use of complex equations. Because of its simplicity, it has the added benefit of being fairly easy for the general public to understand. For users, the LTS methodology yields more meaningful results than BLOS—allowing cyclists to assess routes based on how much traffic-related stress they are likely to feel. The simplicity of the LTS methodology also makes it much easier to apply on a large scale as a way of evaluating accessibility at the system-wide or neighborhood level. The many factors included in the BLOS intersection criteria (left-turn, right-turn, and through demand flow rates, etc.) make it much more costly to do this type of system-wide analysis. Similarly, paths are easily integrated into the LTS network but require much more data (e.g. volume of path users traveling in each direction by mode and their average speed) and effort to evaluate using BLOS.

While BLOS preceded LTS, both systems have been applied in communities across the US. The state of Oregon is currently updating its Analysis Procedures Manual, which now includes a section (14.4) about LTS methodology, including slightly modified criteria for LTS in urban settings along with criteria to adapt the LTS methodology for use in rural areas.

Weaknesses

The weaknesses associated with the LTS methodology described here stem from its relatively recent growth in popularity, the shortage of research validating its approach, and the fact that it is not directly applicable to rural areas.

The BLOS methodology was based on a qualitative visual preference survey of 120 participants. They were shown video footage of a variety of roadways with bicycle lanes of various widths and without bicycle lanes, which they then rated on an A to F scale. The LTS methodology, which is based on Dutch bikeway design criteria, has not been validated by this type of preference data. While some recent research has indicated that LTS is a valid measure of a household's propensity to cycle, more research is needed to clarify the relationship between LTS and bicyclist comfort and safety.

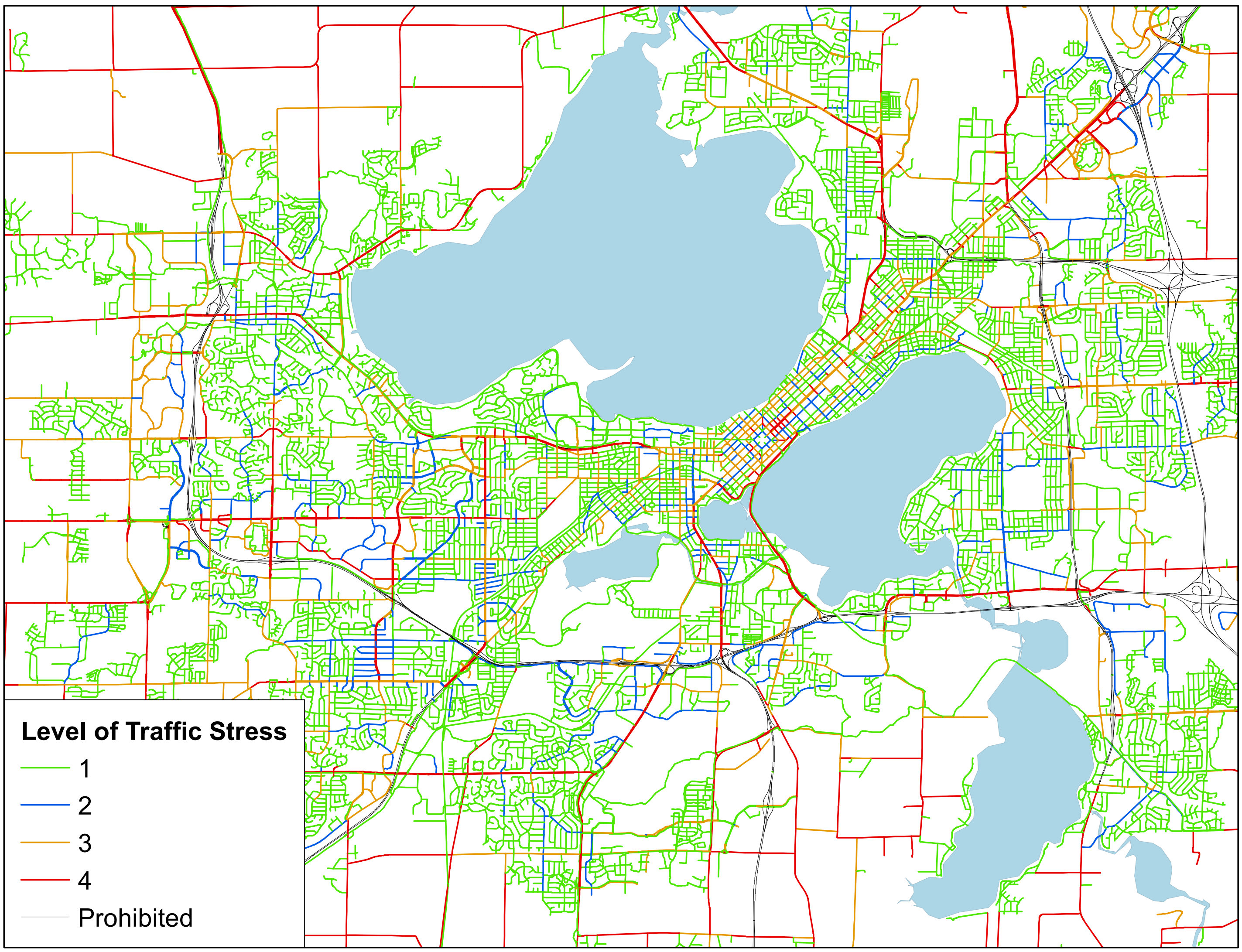
One criticism of the original LTS methodology was that it did not account for other factors, including traffic volumes, which have been shown to affect bicyclist route choice. The updated LTS methodology includes traffic volume among the criteria used to assess mixed traffic streets, but not for streets equipped with bicycle lanes.

The LTS methodology is designed for use on urban streets. Traffic speeds of 35 mph result in LTS ratings of at least 3 and higher speeds generally result in LTS of 4. This sensitivity to speed results in the majority of Dane County's rural routes being rated LTS 4. Oregon DOT's Analysis Procedures Manual includes a separate rural segment LTS criteria for use on rural roads with posted speed limits of at least 45 mph. This methodology excludes speed and rates rural segments between 2 and 4 based on daily traffic volume and paved shoulder width. MATPB will consider incorporating alternate criteria for assessing rural routes in future updates of the LTS analysis and for its Dane County Bicycle Map, which indicates a general suitability level (most suitable, may be suitable depending upon one's skills, least suitable).

Mapping Level of Traffic Stress

Figure 3 shows the level of traffic stress on the bicycle network in the City of Madison and adjacent suburban communities. Overall, 65% of the bicycle network in the Madison metropolitan planning area is low stress (LTS of 1 or 2). However, while low-stress routes make up the majority of route mileage, just 8% of arterial roads (excluding freeways) and 41% of collector roads in the metropolitan planning area qualify as low stress. 57% of arterials and 33% of collectors are rated LTS 4, the highest stress category. Higher stress roads often create low-stress network "islands" between them, limiting low-stress connectivity.

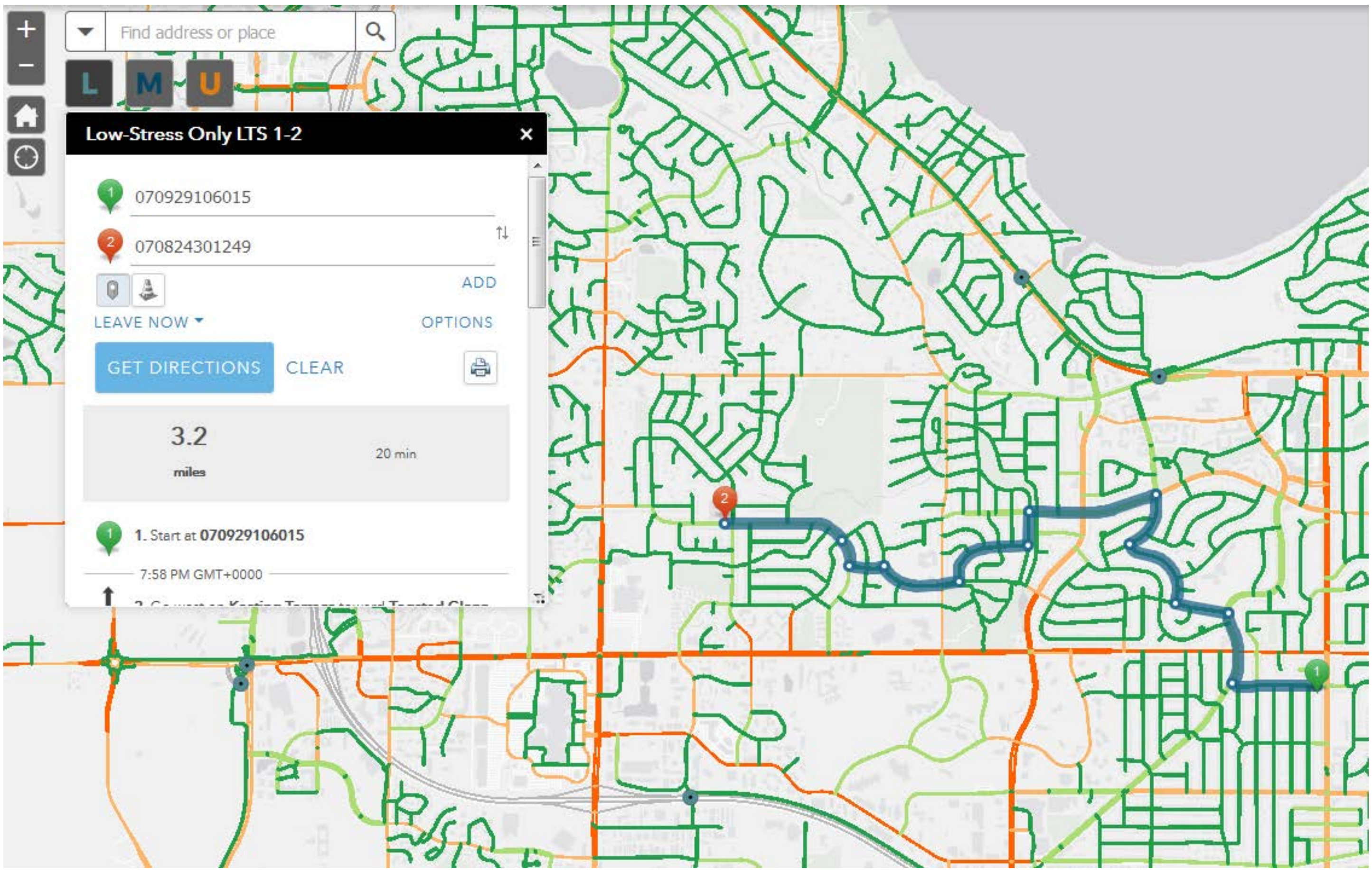
Figure 3 Level of Traffic Stress



Low-Stress Route Finder

The low-stress network is the foundation of the Low-Stress Bike Route Finder, an online GIS application developed by MATPB staff that provides users with directions between points in Dane County tailored to riders' bicycling comfort level—low stress only (LTS 1 or 2), moderate (LTS 1-3), or unrestricted (LTS 1-4). When directions are provided on moderate and unrestricted settings, low-stress routes are preferred. The Route Finder offers additional information on slope and traffic signals, as well as road closures in the City of Madison.   Figure 4 shows a low-stress route between two points in the City of Madison in the Route Finder application.

Figure 4 Low-Stress Bike Route Finder



Accessibility Analysis

Analyzing accessibility to jobs and destinations from different parts of the Madison metropolitan area via the low-stress network is a way to quantify the differences between neighborhoods in how easy it for people to get where they need to go by bike. Mapping accessibility provides insight into the performance of the transportation network by highlighting sharp changes in accessibility. These changes are often due to barriers created by high-stress roadways or gaps in the network that leave riders with overly circuitous routes.

Targeting infrastructure projects to locations where they can affect large improvements in accessibility can maximize efficient use of available resources.

Accessibility Scoring Methodology

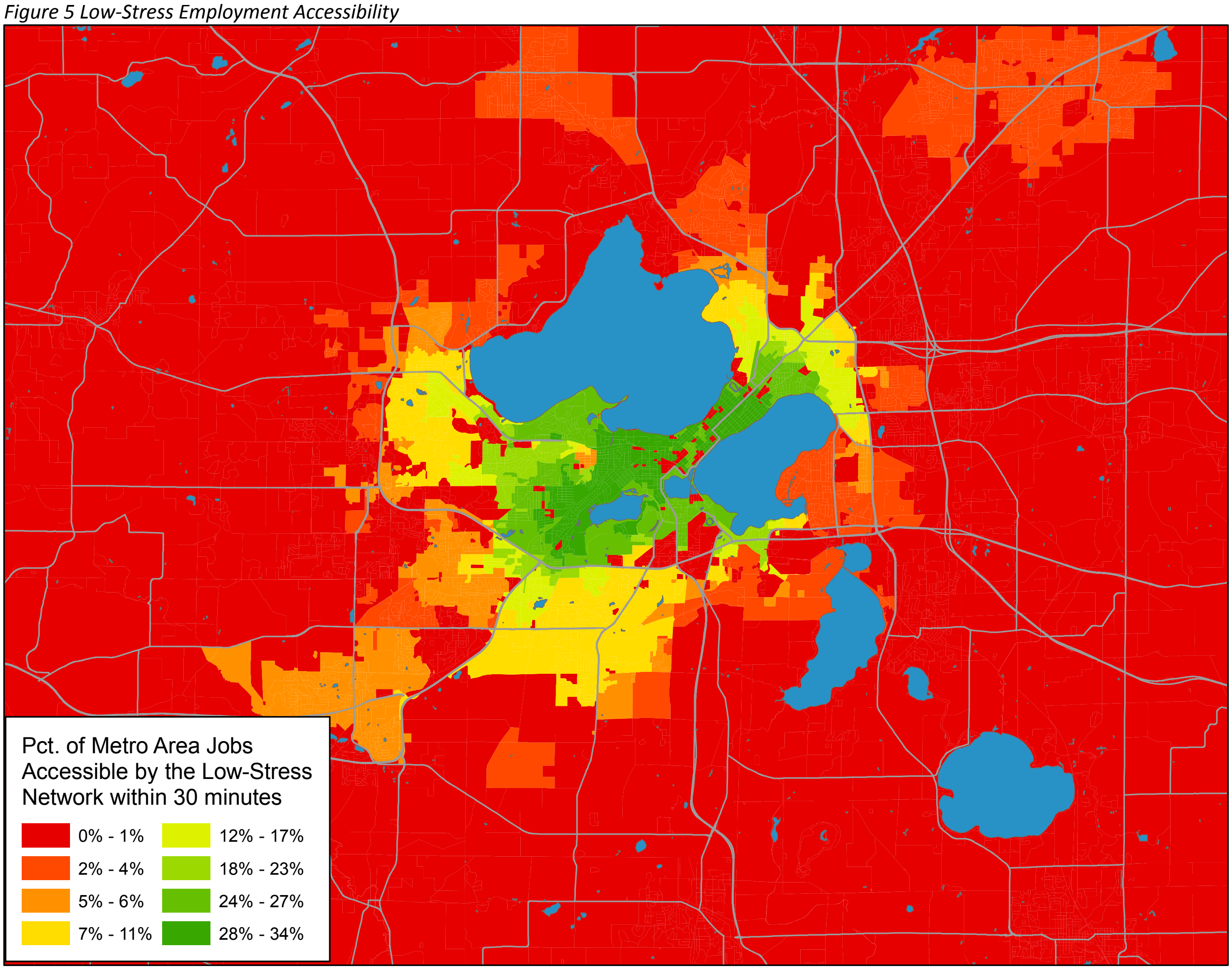
For this analysis, employment accessibility is measured separately from accessibility to other destination types.

Employment Accessibility

Job accessibility is measured as the percentage of jobs in the metropolitan planning area accessible from each census block within 30 minutes (4.8 miles, assuming an average cycling speed of 9.6 miles per hour), via the low-stress network. Access to jobs is measured separately from access to other destination types because workers are expected to be willing to travel farther to employment than to other types of destinations.

Figure 5 shows low-stress job accessibility in the Madison metropolitan planning area. Because so many of the region's jobs are located in downtown Madison and the UW campus area, employment accessibility is highest in central Madison. The quality and density of the bicycle network also contributes to the high levels of accessibility.

Figure 5 Low-Stress Employment Accessibility



Destination Accessibility

Access scores for each census block are based on the absolute and relative bicycle accessibility of 25 different types of destinations within a roughly 10-minute ride (1.67 miles) on the low-stress network. Absolute accessibility scores, based on the number of destinations accessible, accounts for 70% of the total score for each destination type and relative accessibility scores, based on the ratio of accessible to inaccessible destinations, accounts for the remaining 30%. Relative accessibility is used in addition to absolute accessibility to account for the fact that smaller communities and lower density areas may have well-developed low-stress networks but lack a sufficient number of destinations of each type to achieve the maximum absolute accessibility score. Relative accessibility scores are also useful as a way to highlight remaining opportunities for improvement in dense areas that receive maximum absolute accessibility scores but where additional destinations remain inaccessible via the low-stress network. The 70/30 split between absolute and relative accessibility scores is based on the scoring system developed by Toole Design Group for People for Bikes' [Bike Network Analysis (BNA) methodology]. Table 10 details the scoring methodology for absolute accessibility.

Table 10 Destination Accessibility Scoring

Category	Low stress destinations	Marginal points awarded	Maximum Points	Percentage of Blocks Scoring Maximum	Percentage of Blocks Scoring Zero
Grocery	1 2 3	6 3 1	10	11	61
Convenience	1 2	3 1	4	40	50
Restaurant	1 2-6 7-20	1 0.5 0.25	7	15	40
Farmers market	1	2	2	25	75
Coffee shop	1 2 3 4	3 2 0.5 0.5	6	5	72
Community garden	1	1	1	33	67
Child care	1 2-5	2 0.5	4	12	50
Elementary school	1 2	2 2	4	31	54
Middle school	1	4	4	34	66
High school	1	4	4	21	79
University	1	4	4	14	86
Parks	1 2 3 4 5	4 3 1 1 1	10	24	53
Music school	1	2	2	35	65
Theater	1	2	2	21	79

Table 10 Destination Accessibility Scoring Continued

Category	Low stress destinations	Marginal points awarded	Maximum Points	Percentage of Blocks Scoring Maximum	Percentage of Blocks Scoring Zero
Library	1	3	3	30	70
Arts and culture	1	2	2	28	72
Sports	1 2-3 4-5	1 1 0.5	4	16	53
Physical education	1-3	1	3	17	60
Community/Senior Center	1	4	4	28	72
Book stores	1	3	3	19	81
Bank	1-3	1	3	31	51
Shopping	1-28	0.25	7	11	38
Post office	1	1	1	13	87
Worship	1-6	0.5	3	22	44
Medical	1-30	0.1	3	22	37

The maximum possible points for each destination type are based on the Active Living Index methodology developed by MATPB and City of Madison Planning with slight modifications. The number of destinations required to receive maximum points in each category is primarily based on a subjective assessment of the number destinations of each type that would be likely to satisfy the needs of residents. This was largely determined by the likely substitutability of destinations within each type. For example, access to additional schools beyond the ones you or your children attend provides little additional value. Shopping destinations, however, which may sell only one type of product, are less substitutable. Access to a larger number shopping destinations than schools is therefore required to receive full credit.

Beyond these considerations, the scoring system was designed to highlight the range of low-stress accessibility between blocks in Dane County, and to avoid a majority of blocks receiving full credit for any destination type.

Relative scores are calculated as the ratio of accessible low-stress destinations to all destinations in each destination category multiplied by the maximum possible points in each destination category. Example 1 details how to calculate low-stress accessibility for a single destination type; overall accessibility scores are the combined total scores for all destinations.

Example 1
Assume a census block has access to one grocery store on the low-stress network, with two additional grocery stores accessible via higher stress routes.

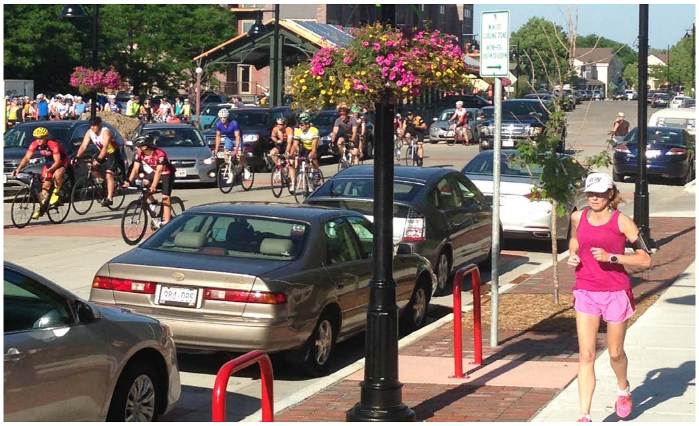
Table 11 Grocery Store Scoring

Category	Low stress destinations	Marginal points awarded	Max. Points
Grocery	1 2 3	6 3 1	10

Part 1 - Absolute Score (70%)
Access to one grocery store = 6 points (see Table 11)

Part 2 – Relative Score (30%)
Ratio of low-stress destinations to all destinations, scaled to maximum point value for destination type =
1 low-stress destination ÷ 3 total destinations × 10 possible points = 3.33 points

Part 3 – Total Score for Destination Type
Combine absolute and relative scores using appropriate weights.
(6 points × 70%) + (3.33 points × 30%) = 4.2 points + 1 =
5.2 points = Grocery Store Accessibility Score



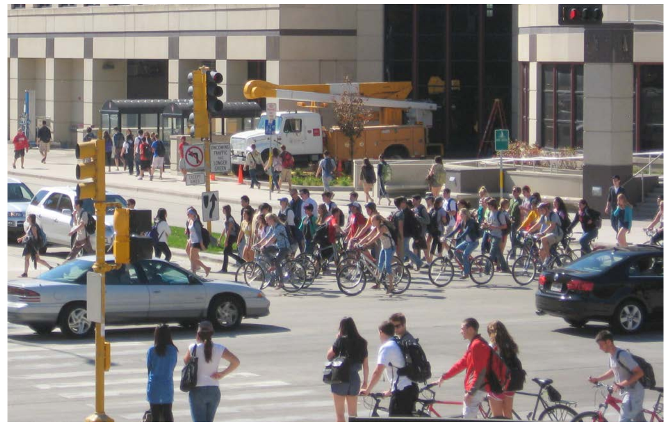


Figure 6 Low-Stress Destination Accessibility

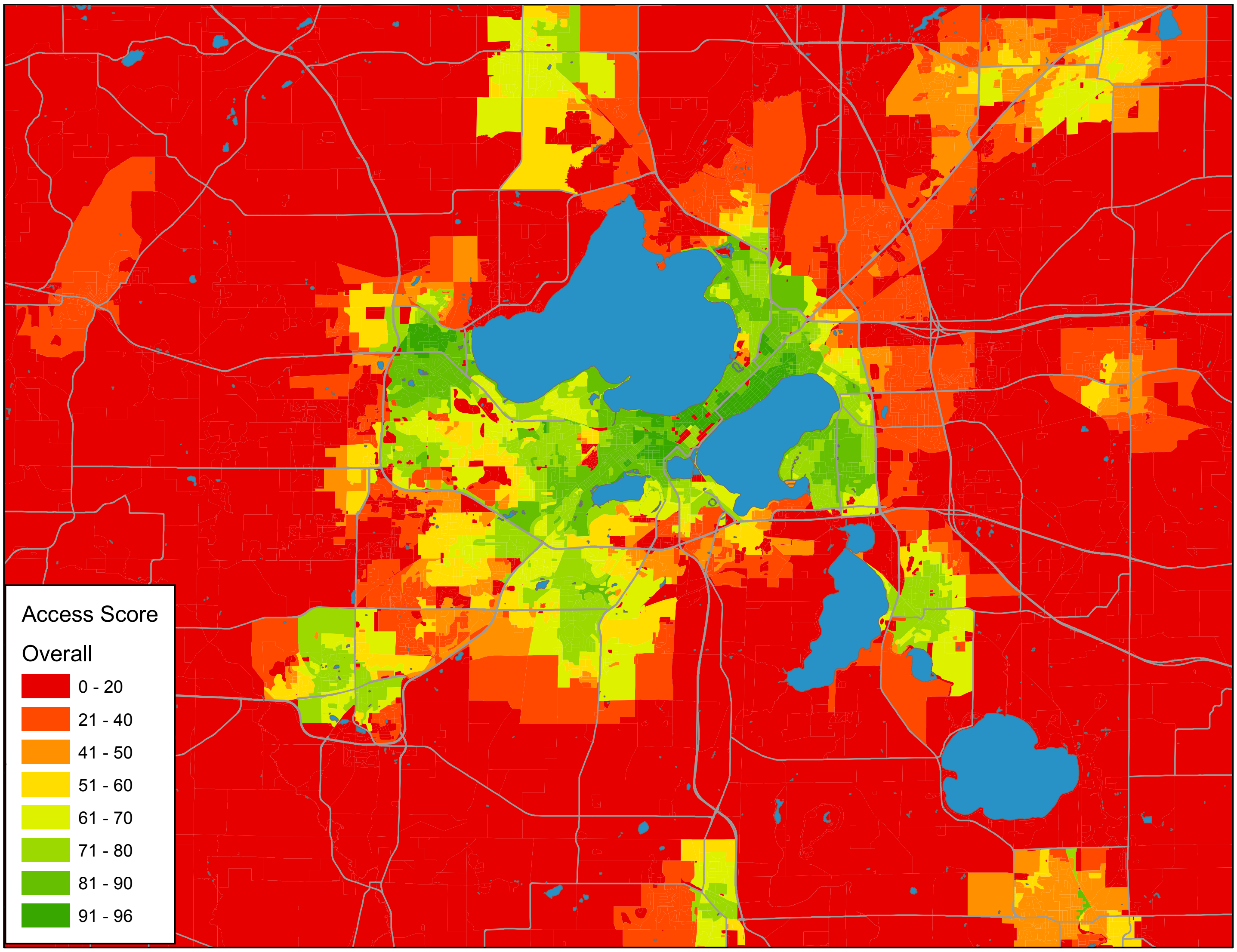


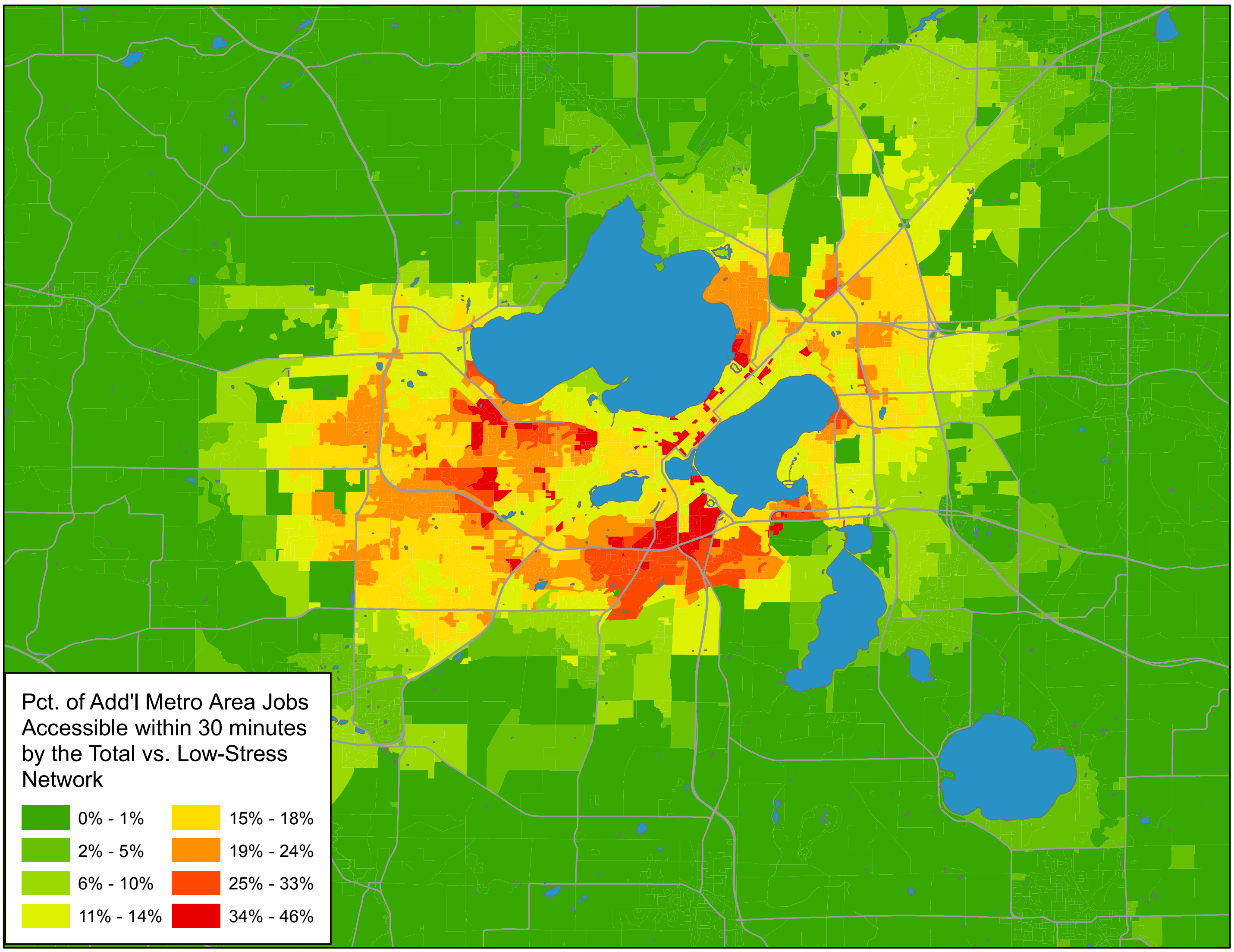
Figure 6 details overall destination accessibility in the Madison metropolitan planning area. Central Madison and several downtown areas of surrounding suburbs stand out as having the highest levels of accessibility. The “islands” of low accessibility in otherwise high accessibility areas are bounded by high-stress routes on all sides.

Relative Accessibility

Relative accessibility of jobs and destinations is an effective way to highlight areas where new low-stress routes would most improve overall accessibility. Relative job accessibility is the difference between the percentage of jobs accessible within 30 minutes using routes of all stress levels compared to those accessible on the low-stress network.

Figure 7 shows relative employment accessibility in the Madison metropolitan planning area. Outlying rural areas have little unmet potential by this measure because even with improvements to the low-stress network, they would have access to few additional jobs. Due to the small number of jobs in these areas, residents would still have to ride more than 30 minutes to reach jobs. By contrast, parts of the south and west sides of Madison, shown in dark orange and red, have the highest unmet potential for job accessibility. In these areas, more than 25% of total jobs in the metropolitan area are currently inaccessible because the network precludes low-stress bicycle travel.

Figure 7 Relative Employment Accessibility



Relative destination accessibility is the ratio of all destinations (across all categories) that are accessible within ten minutes (1.67 miles) on the low-stress network relative to the total number accessible using routes of all stress levels. While this approach yields unpredictable results in rural areas where there are few destinations within a ten-minute ride, it can provide valuable insight in urban locations.

Figure 8 compares overall destination accessibility scores on the west side of Madison (left) with relative destination accessibility scores in the same area (right). While much of the area has high overall access scores, relative access is low. This indicates that, despite the presence of numerous accessible destinations, accessibility could be improved by expanding the reach of the low-stress network.

Figure 8 West Madison- Overall vs. Relative Destination Accessibility

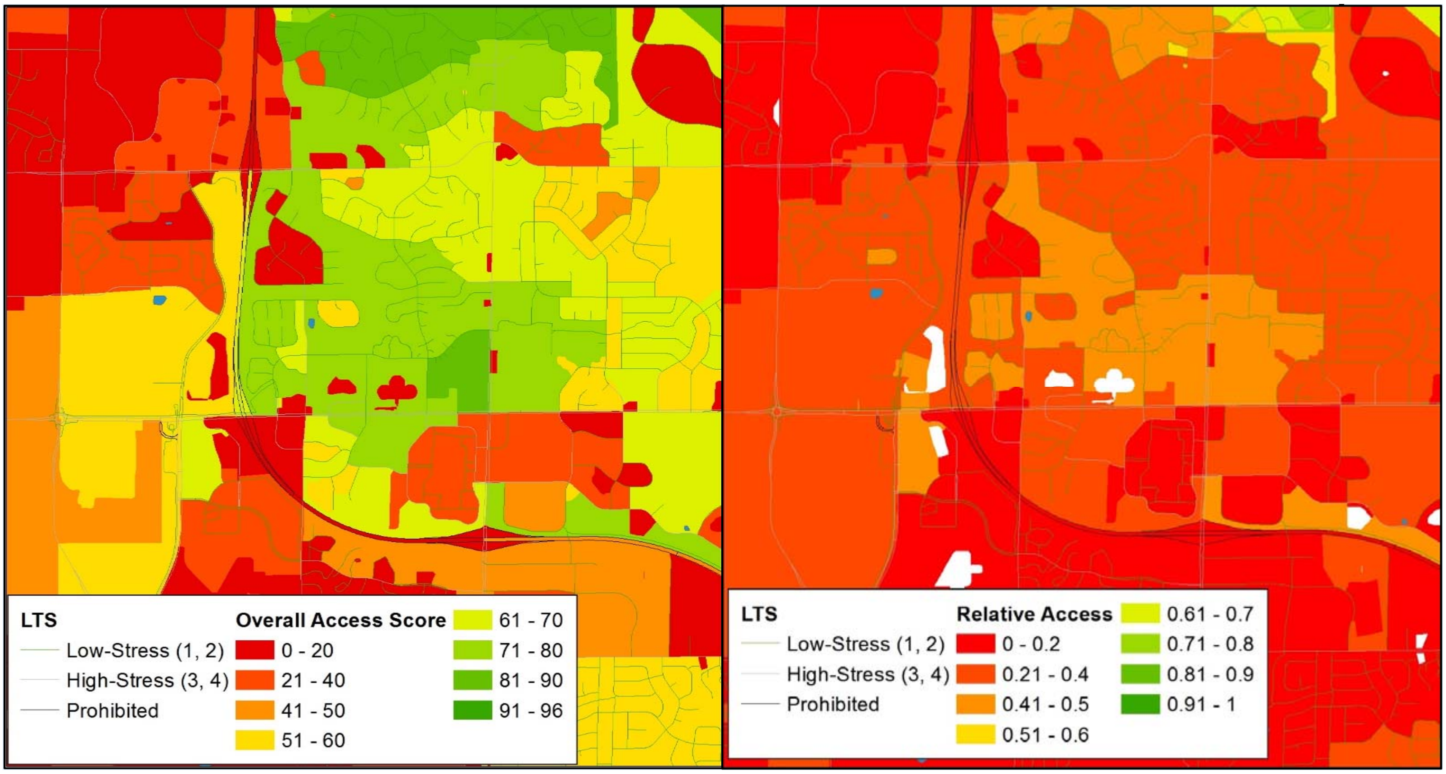
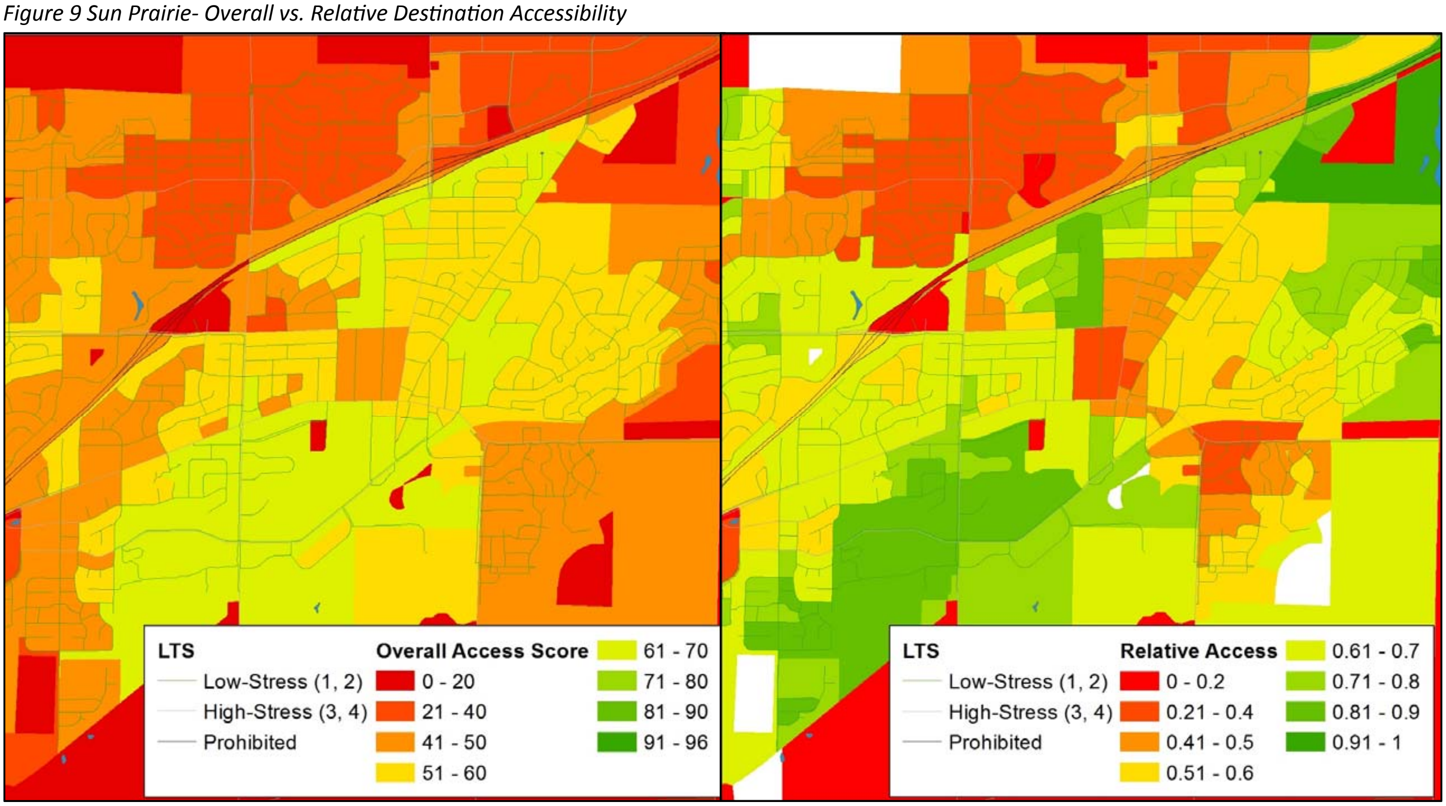


Figure 9 shows overall and relative destination accessibility scores in Sun Prairie. Relative accessibility in Sun Prairie is high, while overall accessibility is lower. This indicates that a large number of the destinations within a ten-minute bike ride are accessible via the low-stress network. Sun Prairie's fairly low overall score is due more to the limited number or diversity of destinations in the area rather than an inability to access the area's destinations on the low-stress network.

Figure 9 Sun Prairie- Overall vs. Relative Destination Accessibility



Identifying Gaps and Barriers in the Low-Stress Network

Mapping low-stress accessibility to jobs and destinations, along with relative accessibility measures, can highlight low-stress network "islands" and key breaks in the low-stress network. Identifying these missing segments is somewhat subjective by nature because it hinges on judgements about how the community is defined, when a route is too circuitous, etc. However, it is a useful starting point in planning and prioritizing bicycle facility improvements.

Figure 10 shows network gaps and barriers identified in west Madison. Gaps are locations where new off-street paths are needed to provide more direct low-stress access. Barriers are high-stress streets that prevent low-stress access along their length and prevent low-stress crossings at unsignalized intersections. The Beltline (US 12/14) as well as several other large high-volume roads in this area prevent residents from accessing West Towne Mall, Woodman's, Walmart and many other nearby destinations by bike. Bolstering low-stress connectivity with the addition of new paths in key locations and improvements to enable low-stress bike access on some of the major roads would significantly improve bicycle accessibility in this area.

Figure 10 Low-Stress Gaps and Barriers in West Madison

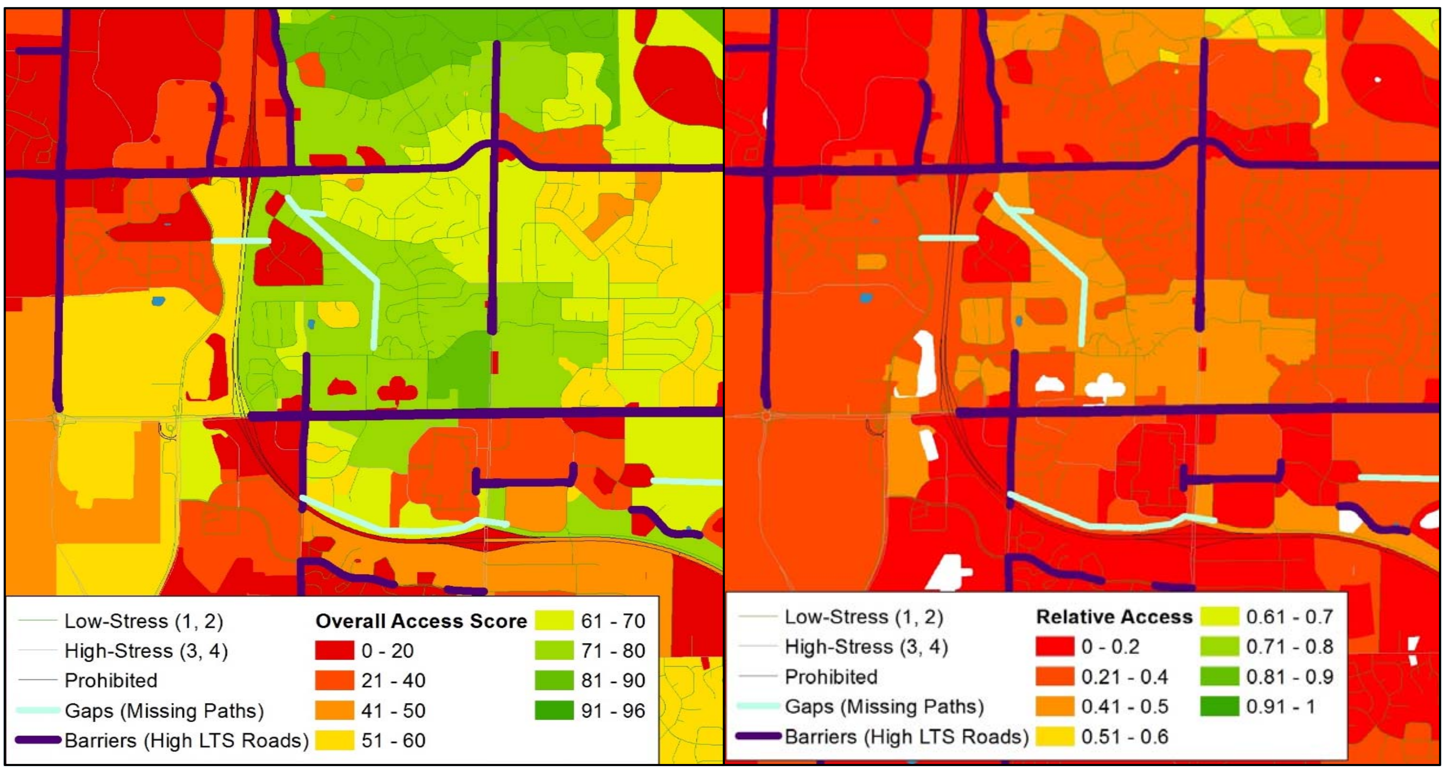


Figure 11 shows the barriers identified in Sun Prairie. Improving Bird Street to allow low-stress travel across US 151, would enable residents living north of the highway to access the destinations along Main Street and in downtown Sun Prairie. Similarly, improvements to Main and Windsor Streets would enable direct low-stress access to many of the area's destinations.

Figure 11 Low-Stress Gaps and Barriers in Sun Prairie

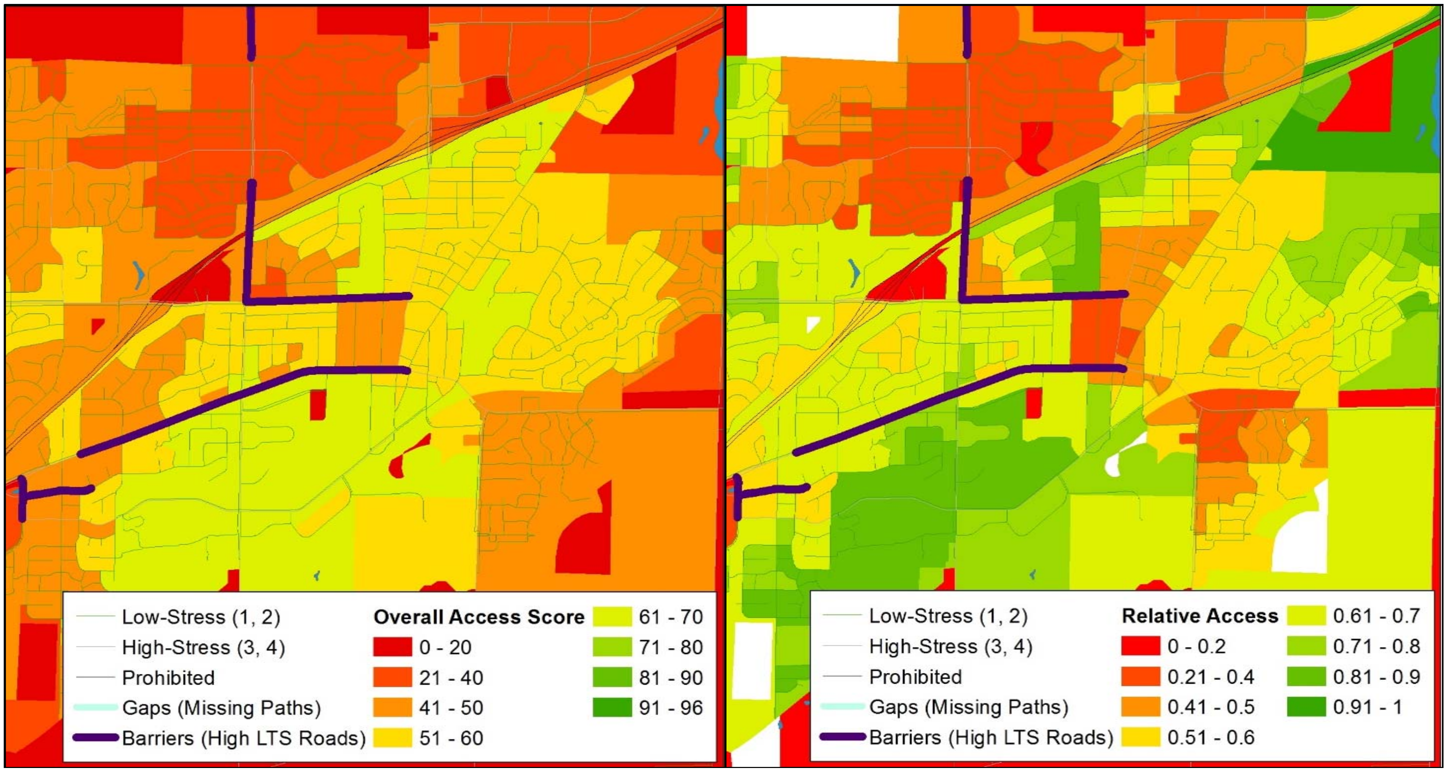


Figure 12 on the next page shows low-stress gaps and barriers identified throughout the Madison metropolitan area. Low-stress network gaps affecting longer distance routes linking Cottage Grove, Cross Plains, DeForest, Oregon, Stoughton, and Waunakee to the larger Madison area low-stress network are not shown. Connections linking the small rural neighborhoods outside of the urban area are also not included.

Next Steps

MATPB staff is sharing the LTS network and low-stress accessibility analysis with the City of Madison and other jurisdictions in the MPO planning area, and will pursue opportunities to provide assistance to local staff. Some communities have already made use of the LTS work. For example, the Village of Windsor used the network and Low Stress Route Finder tool to help develop a wayfinding signage plan for the village. There are plans to incorporate the LTS work into MATPB's regional travel forecast model. Staff will continue to investigate other uses for the LTS work.

MATPB staff maintains a bicycle facility geodatabase and updates it annually. These updates will be used to update the LTS network annually, which in turn will update the Low-Stress Bike route finder.

Figure12 Low-Stress Network Gaps and Barriers