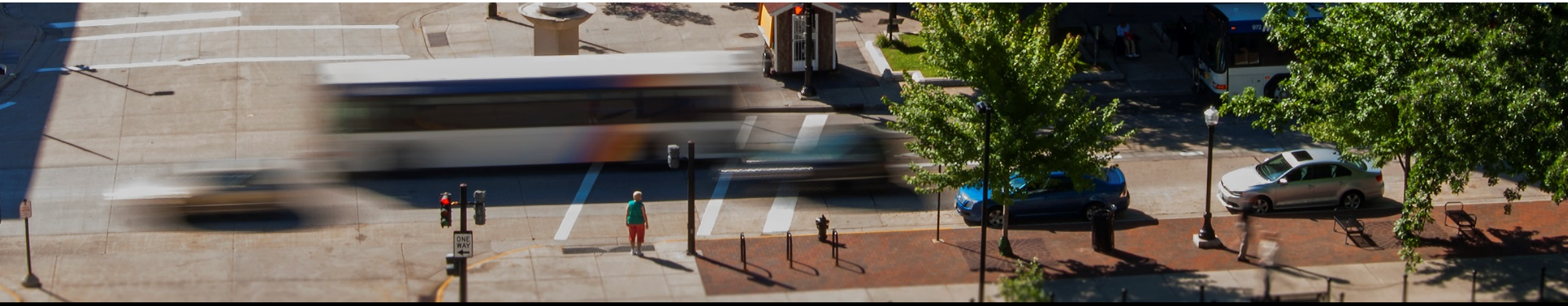
Using Level of Stress Analysis for Bicycle Facility and Route Planning



MATPB
Madison Area Transportation Planning Board

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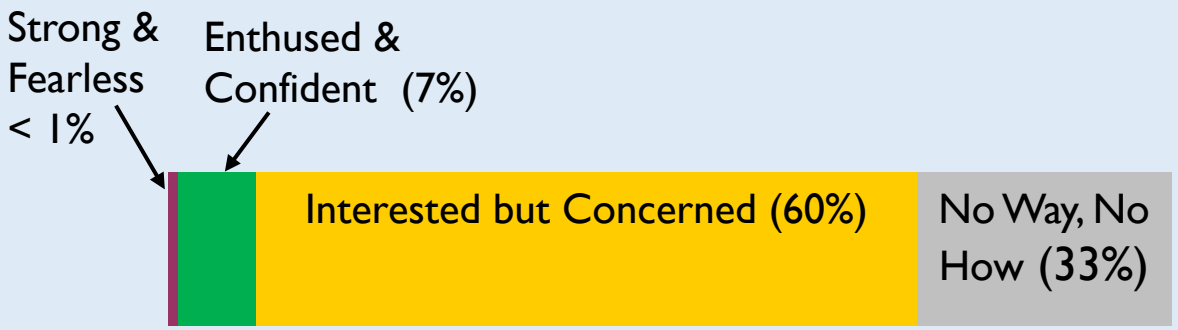
Defining the Network

- All facilities where it is legal to ride a bicycle
- All bicycle-specific infrastructure (bike lanes, shared-use paths, etc.)

Or…

- <u>The routes on which most riders feel comfortable</u>

Four Levels of Traffic Stress (LTS)



Source: Roger Geller, City of Portland

LTS 1 & 2 are considered Low-Stress

LTS 1: Children, Traffic Intolerant

LTS 2: "Interested but Concerned"

LTS 3: "Enthused and Confident"

LTS 4: "Strong & Fearless"

Benefits of Defining and Mapping the Low-Stress Network

- Help riders identify comfortable routes
- Inform bicycle wayfinding program implementation
- Identify gaps in the low stress bikeway network to inform facility plans and project prioritization
- Inform street project design decisions

Benefits of Defining and Mapping the Low-Stress Network (Cont.)

- Develop understanding of how LTS impacts bicycle traffic volume
- Evaluate and score projects for MPO funding
- Utilize in performance management / performance based planning
  - Percentage of defined regional bikeway network that is low stress
  - Measure accessibility to jobs, destinations
  - Measure connectivity of the low stress network

Calculating Bicycle Level of Traffic Stress (LTS)

The methodology used is based on that developed by Mekuria, Furth, and Nixon in their 2012 Mineta Transportation Institute report, Low-Stress Bicycling and Network Connectivity and updated criteria issued in 2017.

Advantages of LTS

- Specifically considers user differences
- Relatively easy to use with readily available data
- Can be used to evaluate a wide variety of facilities and crossings
- Has been widely applied
- Can be applied at the route level for accessibility analysis

Weaknesses of LTS

- Stress level classification scheme is not yet strongly supported by preference data
- Methodology has not yet been validated against behavioral/use data
- For accessibility analyses, little research has been done on how many destinations of different types should be accessible by bicycle

Calculating Bicycle Level of Traffic Stress (LTS)

- Path/Street Segments
- Intersections
  - Intersection Approaches (Right Turn Lanes)
  - Unsignalized Street Crossings

LTS on Path and Street Segments

- Off-street paths are LTS 1
- Street LTS determined by:
  - Bike lanes
    - Width (including gutter pan)
    - Parking
  - Number of traffic lanes
  - Presence of raised medians
  - One-way/two-way streets
  - Traffic speed (speed limit)
  - Avg. daily traffic volume (ADT)
    - On roads without bike lanes

Calculating Bicycle Level of Traffic Stress: Segments

Segment Type	Level of Traffic Stress
Stand-alone paths	LTS = 1
Segregated lanes (protected bike lanes)	LTS = 1 or 2
Bike lanes	LTS can vary from 1 to 4
Mixed traffic	LTS can vary from 1 to 4

Calculating Bicycle Level of Traffic Stress: Mixed Traffic

Number of Travel Lanes	Effective ADT*	20 mph	25 mph	30 mph	35 mph	40 mph
1 thru lane per direction	0-1,500	1	1	2	3	3
	1,501-3,000	2	2	2	3	4
	3,000+	2	3	3	3	4
2+ thru lanes per direction	0-8,000	3	3	3	3	4
	8,001+	3	3	4	4	4

* Effective ADT = 1.5*ADT for 1-way streets

Calculating Bicycle Level of Traffic Stress: Mixed Traffic

Example 1

- 25 mph speed limit
- 1 lane per direction
- 4,400 ADT

LTS 3

400 block of South Mills Street, Madison, Wisconsin

Calculating Bicycle Level of Traffic Stress: Bike Lanes with 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 (incl. gutter pan)	≥15 ft	13 - 14.5 ft	≤ 12.5 ft	(no effect)
Speed limit or prevailing speed	≤25 mph	30 mph	35 mph	≥40 mph
Bike lane blockage	rare	(no effect)	frequent	(no effect)

Note: Dimensions aggregate using Weakest Link logic

Calculating Bicycle Level of Traffic Stress: Bike Lanes with Parking

<u>Example 2</u>

- 35 mph speed limit
- 3 lanes per direction
- bike lane + parking width - 13.5 ft.

LTS 3

800 block of East Washington Avenue, Madison, Wisconsin

Calculating Bicycle Level of Traffic Stress: Bike Lanes with Parking

<u>Example 3</u>

- 30 mph speed limit
- 1 lane per direction
- buffered bike lane + parking width - 20 ft.

LTS 2

200 block of South Segoe Road, Madison, Wisconsin

Calculating Bicycle Level of Traffic Stress: Bike Lanes without 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 (incl. gutter pan)	≥ 6 ft.	≤ 5.5 ft. or less	(no effect)	(no effect)
Speed limit or prevailing speed	≤ 25 mph	30 mph	35 mph	≥ 40 mph
Bike lane blockage	rare	(no effect)	frequent	(no effect)

Note: Dimensions aggregate using Weakest Link logic

Calculating Bicycle Level of Traffic Stress: Bike Lanes without Parking – Example

<u>Example 4</u>

- 25 mph speed limit
- 1 lane per direction
- bike lane - 6 ft.

LTS 1

1000 block of West Dayton Street, Madison, Wisconsin

Adjustments Made to Some Street Segments to Account for Factors Not Addressed

- Streets with limited peak period parking restrictions
  - Treated as 2-lane streets with sub-standard (≤ 13 ft) bike/parking lane = LTS 3
- Streets with striped bike lanes alongside parking lane (<13 ft. width) where parking occupancy was very low
  - Treated as 6 ft. bike lanes without adjacent parking = LTS 2
- Roundabouts
  - 1 lane – LTS 2
  - More than 1 lane – LTS 3

LTS at Intersections

- Unsignalized intersection LTS determined by cross street characteristics:
  - Presence of median refuge
  - Speed limit
  - Number of traffic lanes
- Signalized intersection LTS equals LTS of approaching segment. However…
  - Right turn lanes may increase intersection LTS depending on:
    - Length and number of right turn lane(s)
    - Speed of turning traffic
    - Presence and design of approaching bike lane

Factors Important to Bicyclists Not Incorporated into Methodology

- Effect of left turn lanes (for left turning movements)
- Difference crossing 1-way vs. 2-way streets with same number of lanes
  - Volumes higher on 1-way streets, but typically better traffic gaps
- Topography (steep hills)
- Pavement condition
- High driveway density
- Heavy vehicle use
- Neighborhood crime/safety concerns

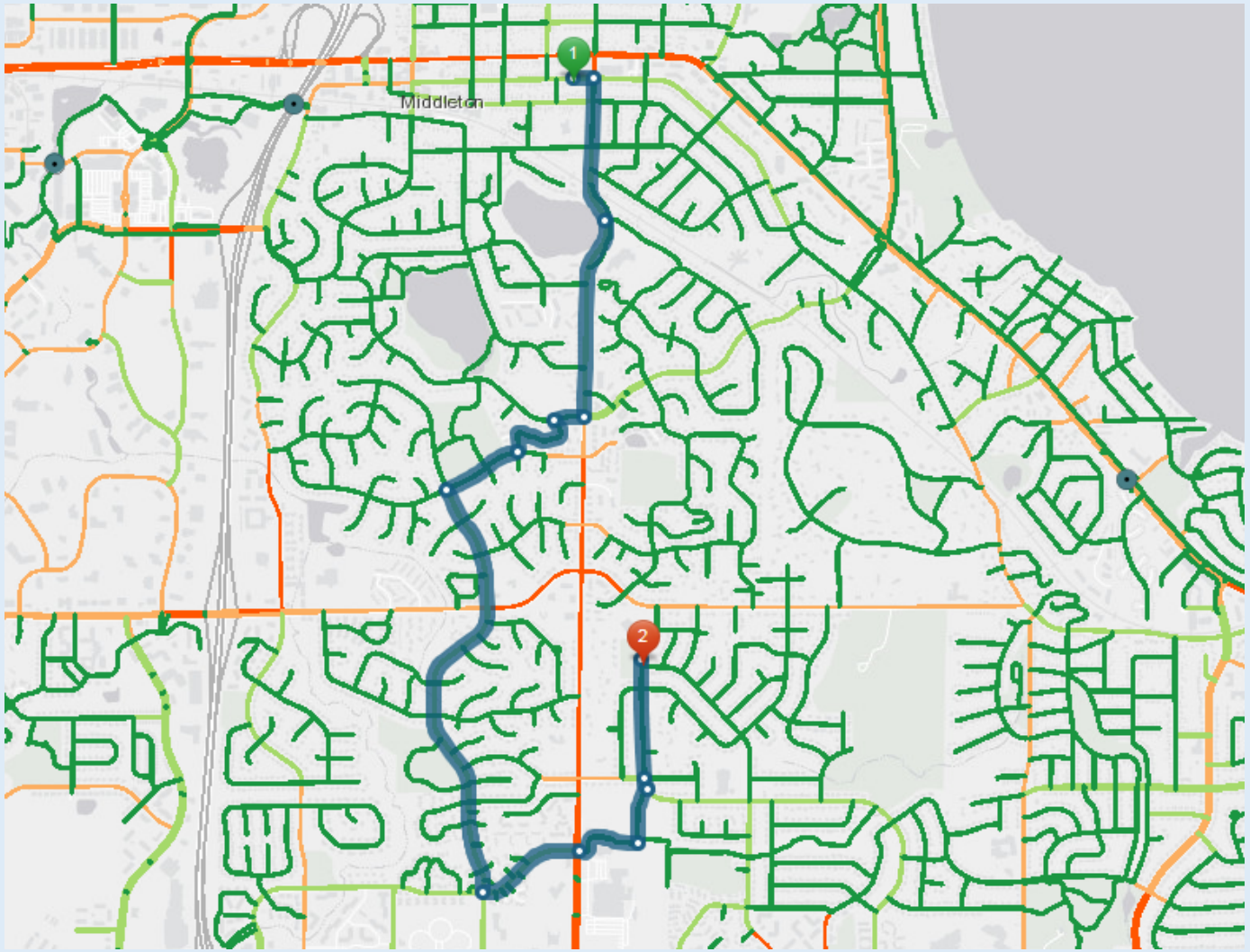
Uses for Bicycle Level of Traffic Stress

- Low-Stress Bike Route Finder
- Low-Stress Bicycle Accessibility
  - Destinations
  - Jobs
- Project prioritization
- Performance Measurement

The Low-Stress Bike Route Finder

Users can find directions between any two points in the Madison area using low-stress routes.

- Start/end addresses can be entered manually or users can click on the map
- Choice of routing options:
  - Low-stress only
  - Moderate-stress (low-stress preferred)
  - Unrestricted (low- and moderate-stress preferred



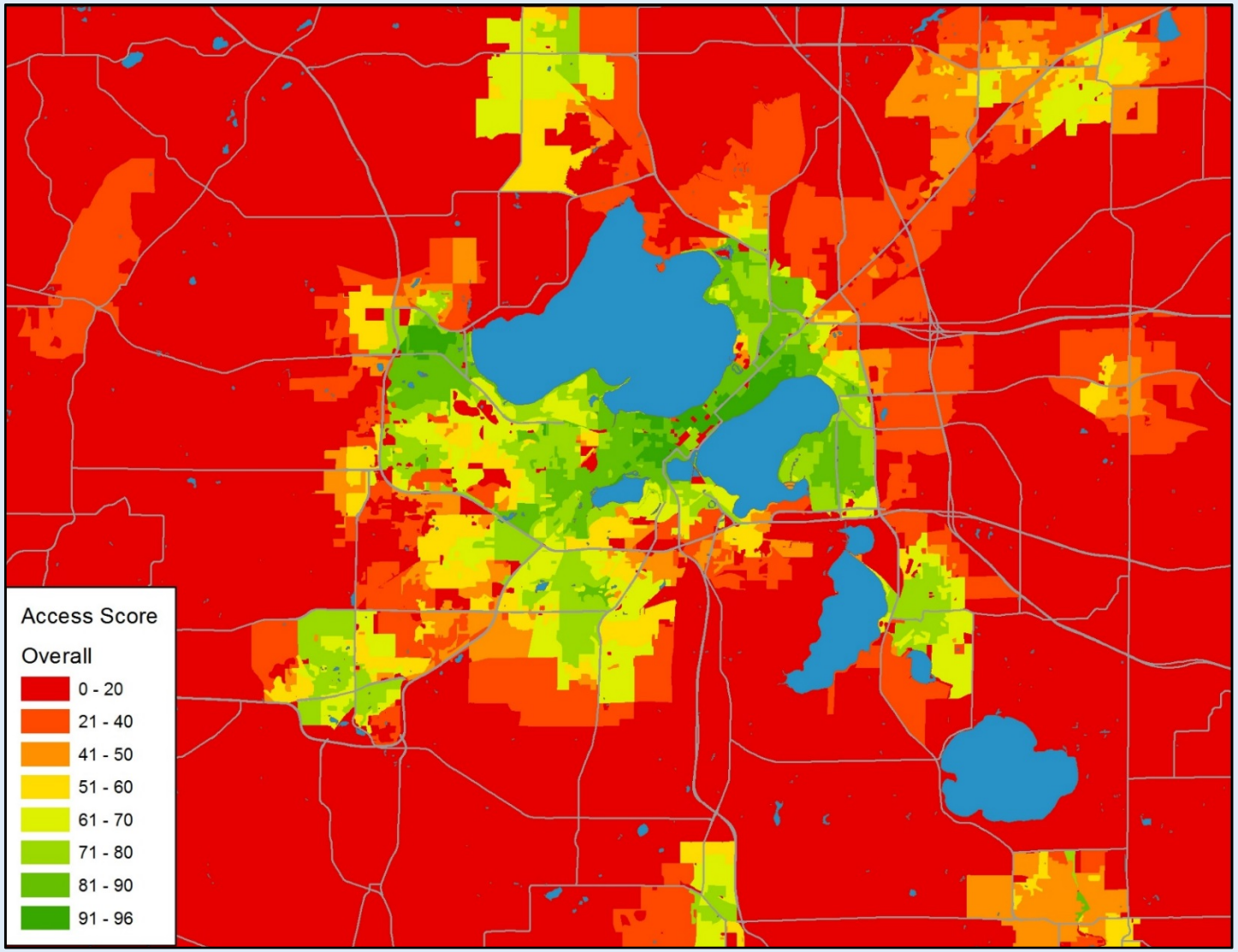
https://cityofmadison.maps.arcgis.com/apps/webappviewer/index.html?id=cb7a2e78477044c19bf6a5eaa1820e38

Low-Stress Accessibility: Destinations

- Scoring system mirrors that used by Toole Design Group for People for Bikes' Bike Network Analysis (BNA) Score. https://bna.peopleforbikes.org/#/
- 25 different types of destinations
  - Parks, grocery stores, convenience stores, schools, medical care, etc.
- Calculated access within 10 minute bike ride of each census block (distance of about $1\frac{2}{3}$ miles)
- Targets and weights vary by destination type.
  - Parks and grocery stores each account for 10% of score
- Scores based on:
  - Absolute accessibility (70%)
  - Relative accessibility – ratio of low-stress destinations/all destinations (30%)

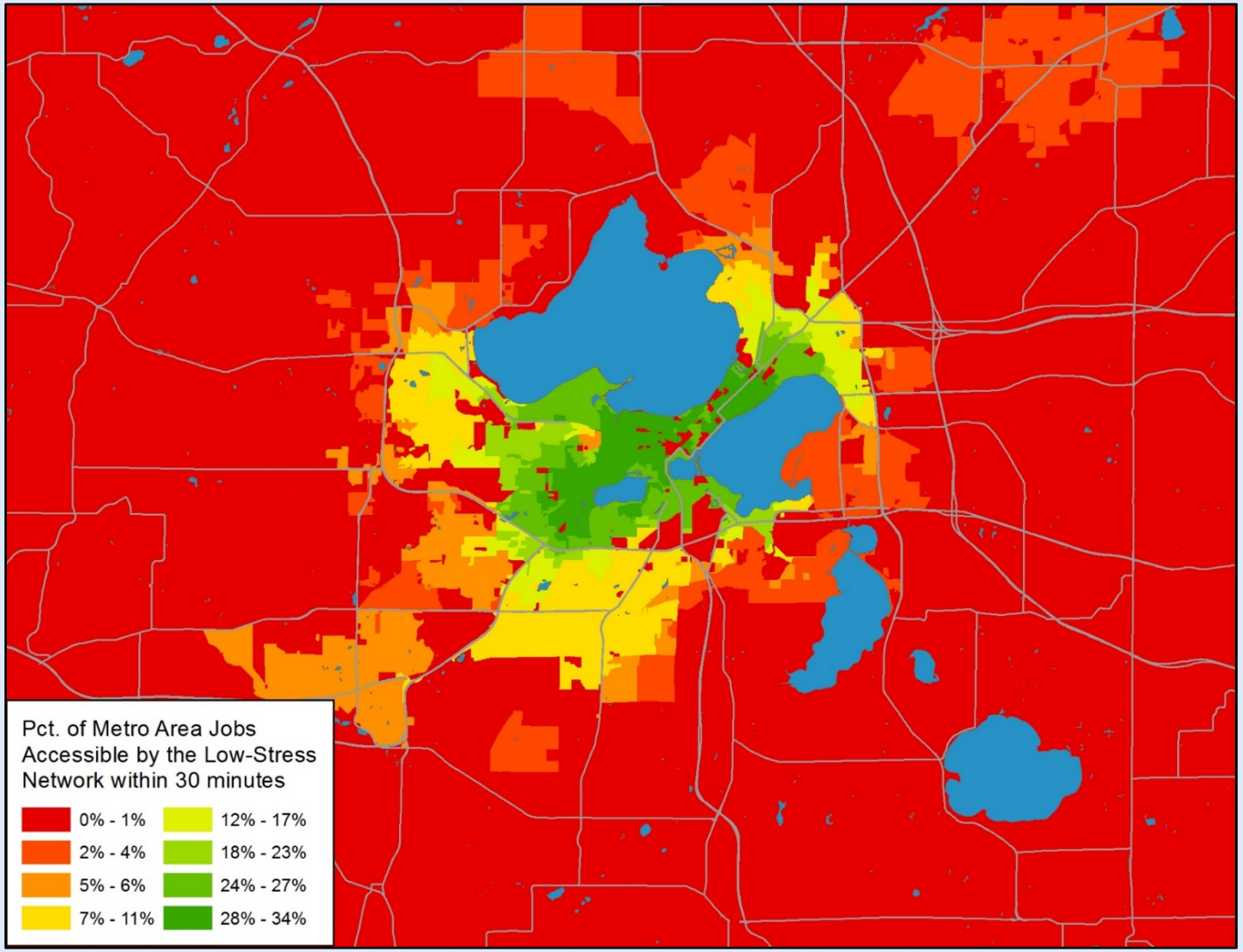
Low-Stress Destination Accessibility

- Low-stress bike accessibility is high in central Madison, Middleton, Monona.
- Rural and most suburban areas receive lower scores because they have fewer, less concentrated destinations and roads over 35 mph are classified as LTS 3 or LTS 4.



Low-Stress Job Accessibility: Absolute

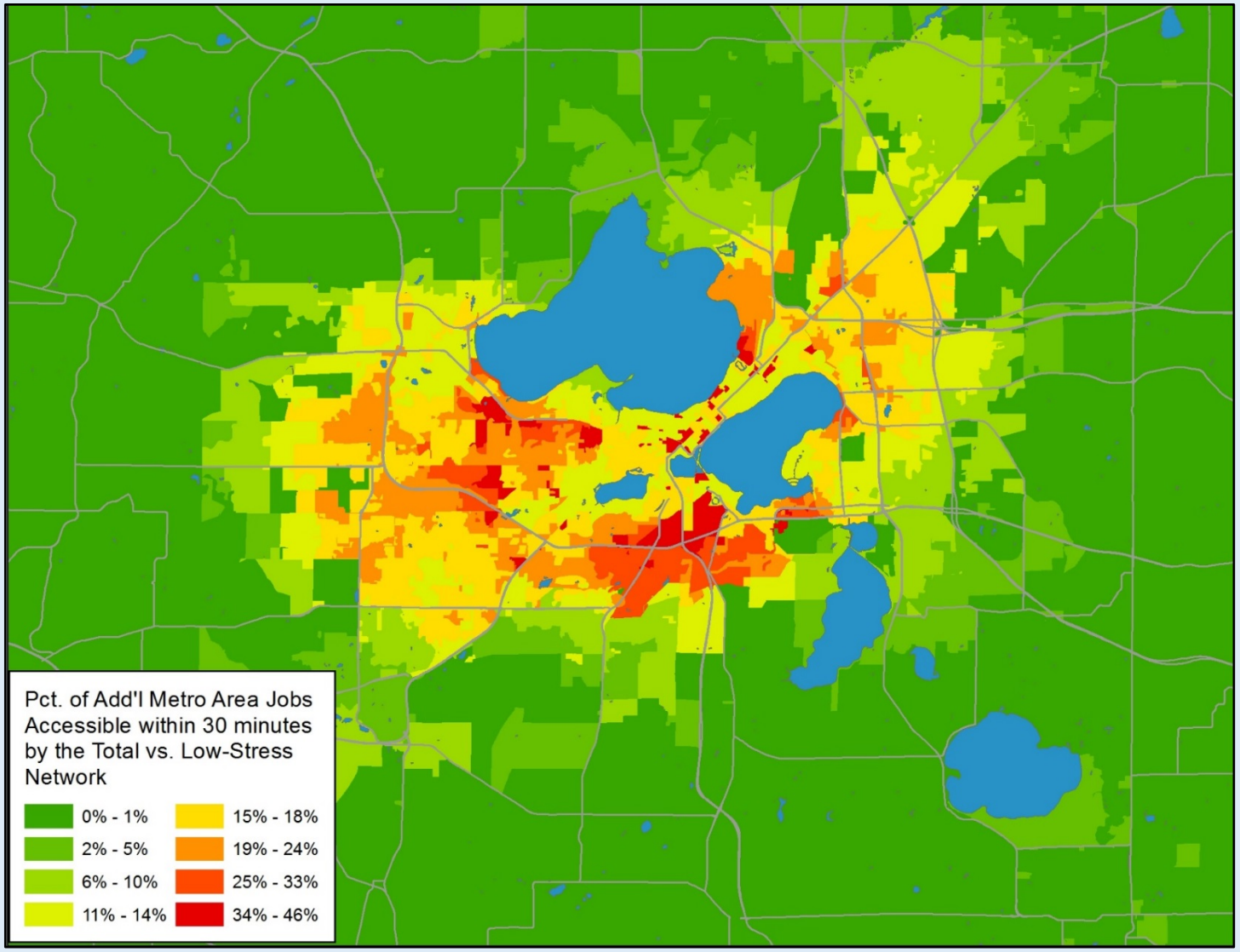
The percentage of jobs (2016) in the Madison Metropolitan Planning Area accessible within 30 minutes via the low-stress network



Low-Stress Job Accessibility: Relative

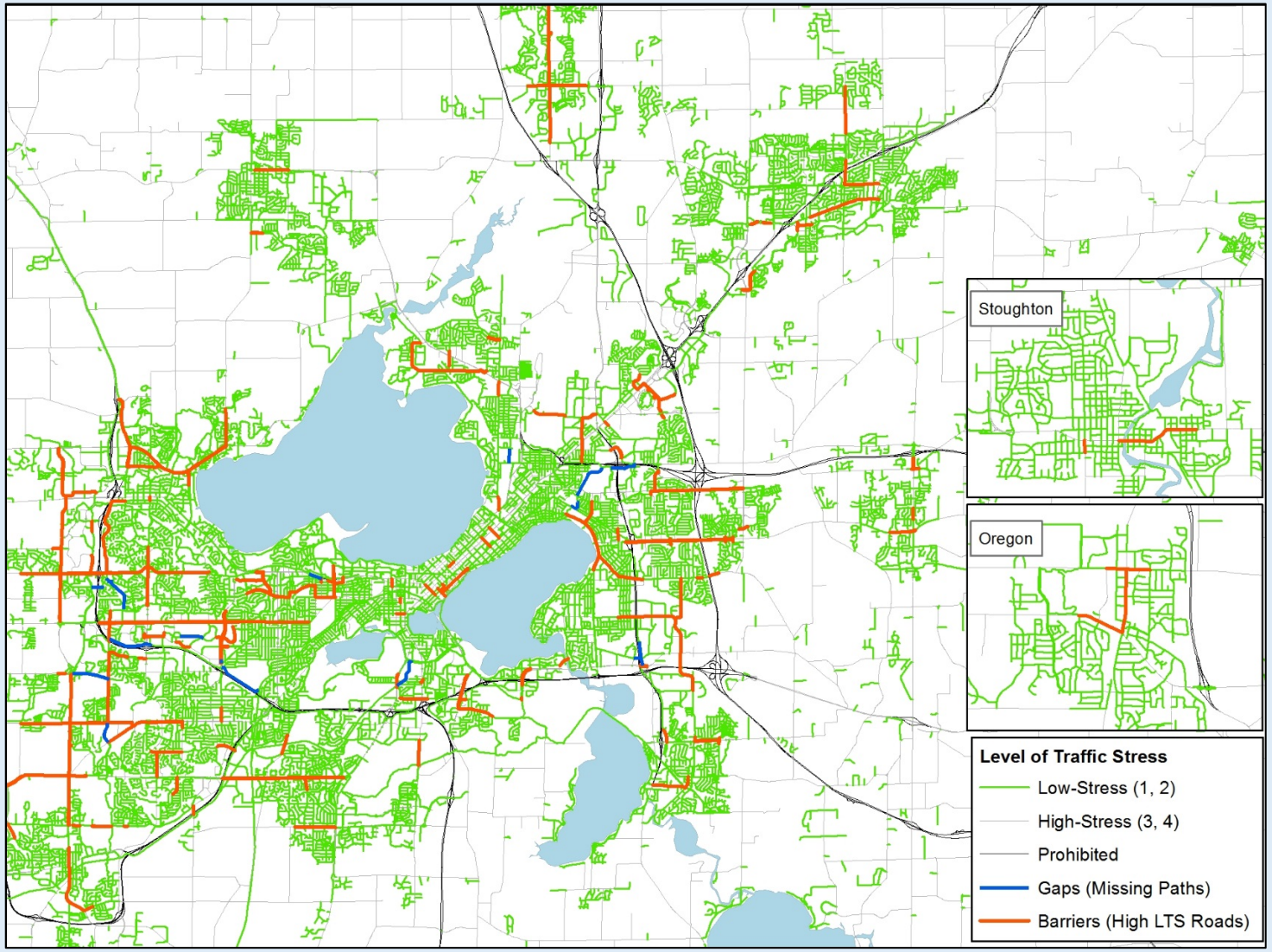
The percentage of additional jobs (2016) in the Madison Metropolitan Planning Area accessible within 30 minutes via all routes versus the low-stress network

- Red areas have a high potential for improvement.



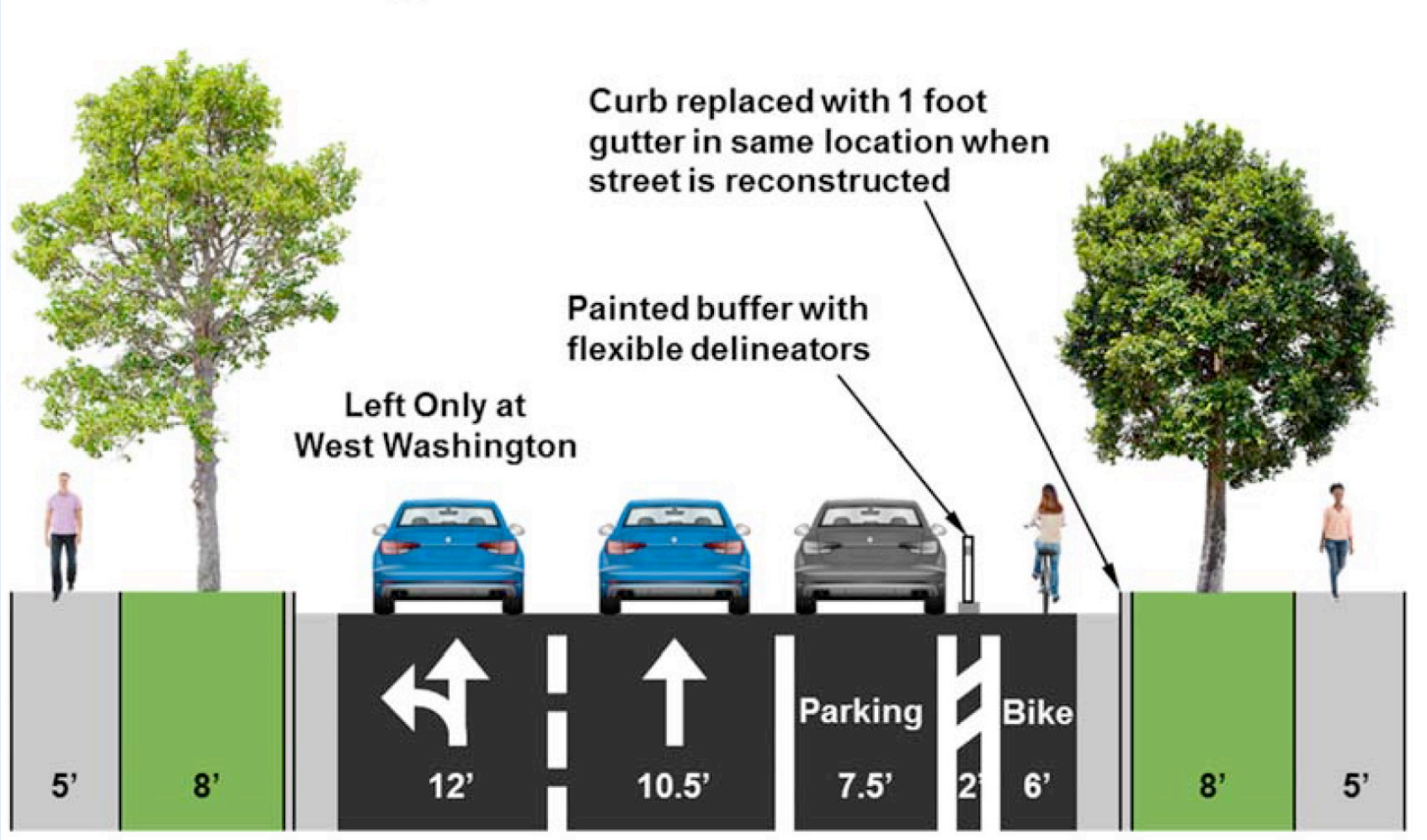
Project Prioritization: Low-Stress Gaps & Barriers (DRAFT)

- Low-stress gaps are areas where new paths could provide significant low-stress access improvements.
- Low-stress barriers are high LTS roads that limit low-stress accessibility.



Project Design: Protected Bike Lanes Lower LTS

- North Bassett Street is a minor arterial with two travel lanes and over 10k vehicles per weekday.
- Only a protected lane can create a low-stress bike route.

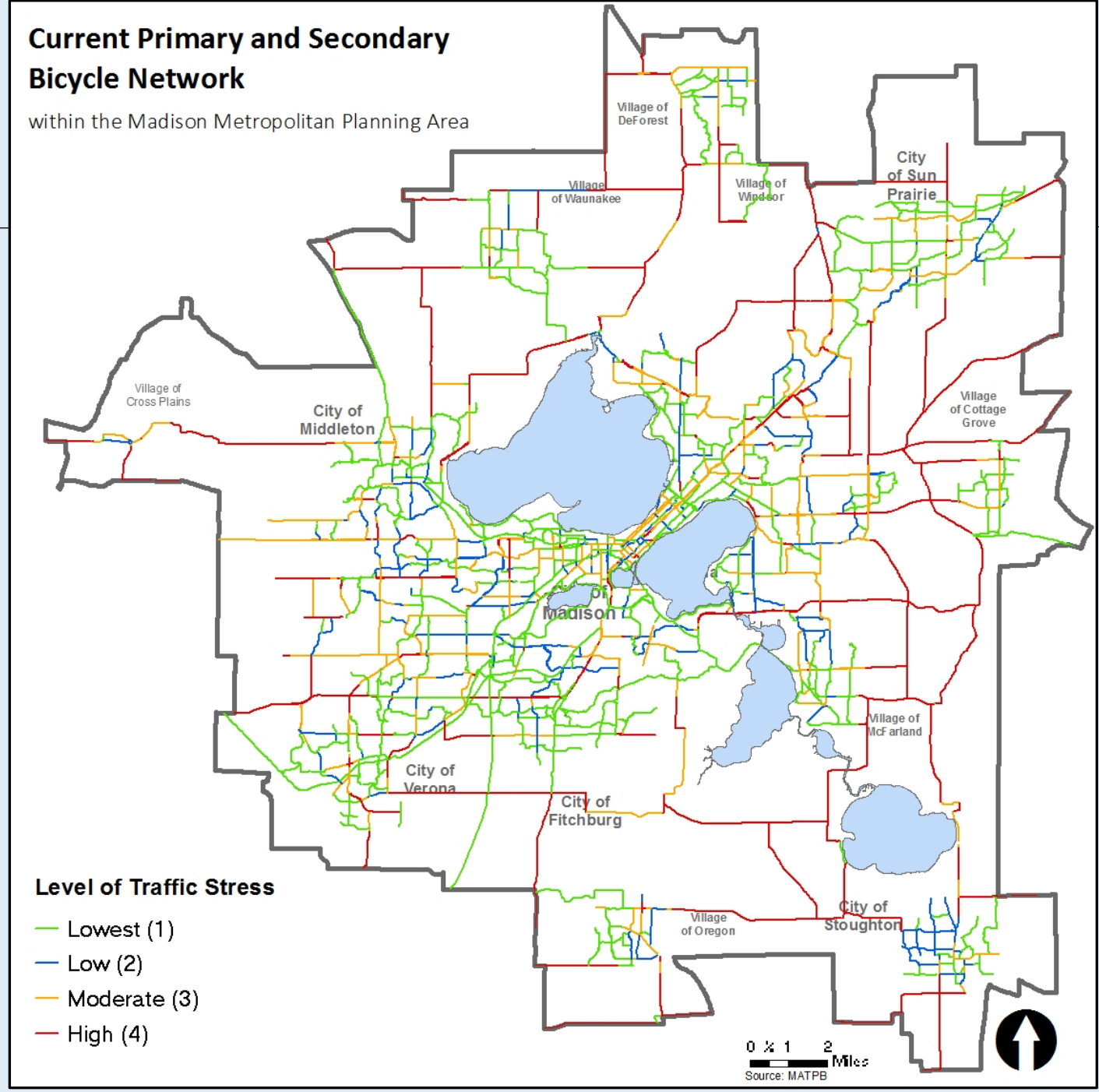


North Basset Street, Madison, Wisconsin

Performance Measurement

The percentage of the primary and secondary networks that are low, moderate, and high stress is a more meaningful gauge of regional bike network quality than measuring miles of designated bicycle facilities (paths, lanes, etc.).

Level of Traffic Stress 2017	Primary Network		Secondary Network	
	Miles	%	Miles	%
Low Stress (1 & 2)	169	64%	264	45%
Moderate Stress (3)	46	17%	142	24%
High Stress (4)	49	19%	180	31%



Implementation Considerations

- Data Collection
  - Staff time required for collection of bike facilities data.
  - Orthographic (aerial) photography can provide most of required data inputs (bike lane width, # of travel lanes, right turn lanes, medians, parking).
- Data Management & Maintenance
  - Maintenance efforts are increased if street centerlines and off-street bike facilities are maintained as separate GIS files. This can be avoided by maintaining connectivity between street centerlines and off-street facilitates in the same line feature file.

Implementation Considerations (cont.)

- Technical Skills
  - Expertise using the ArcGIS Network Analyst extension is needed to conduct accessibility
  - Development and application of scoring methodology for destination accessibility analysis is complicated.
  - Developing routing tool that accounts for out-of-direction travel is complicated.

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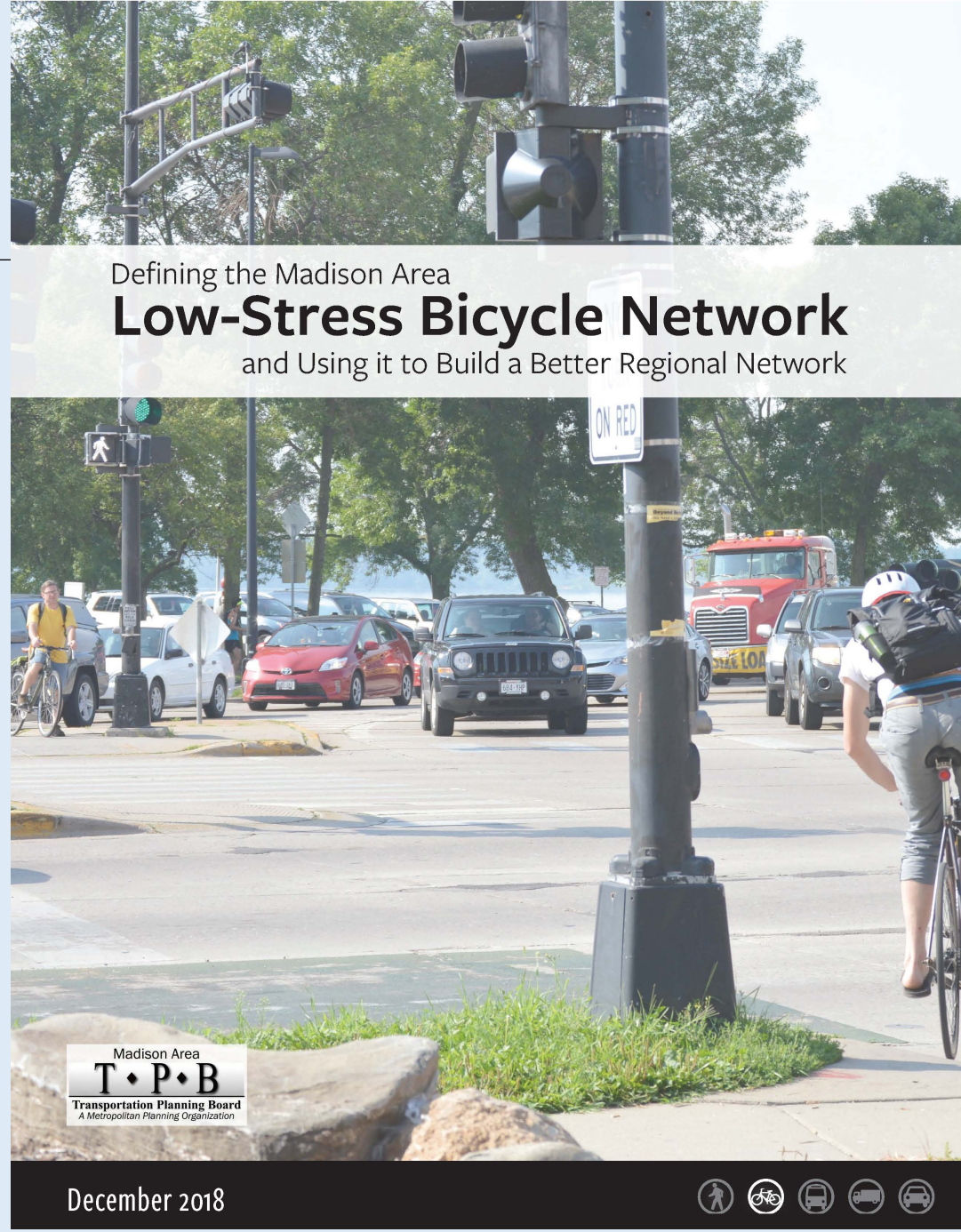

http://www.madisonareampo.org/planning/documents/LTSRReportFinal.pdf