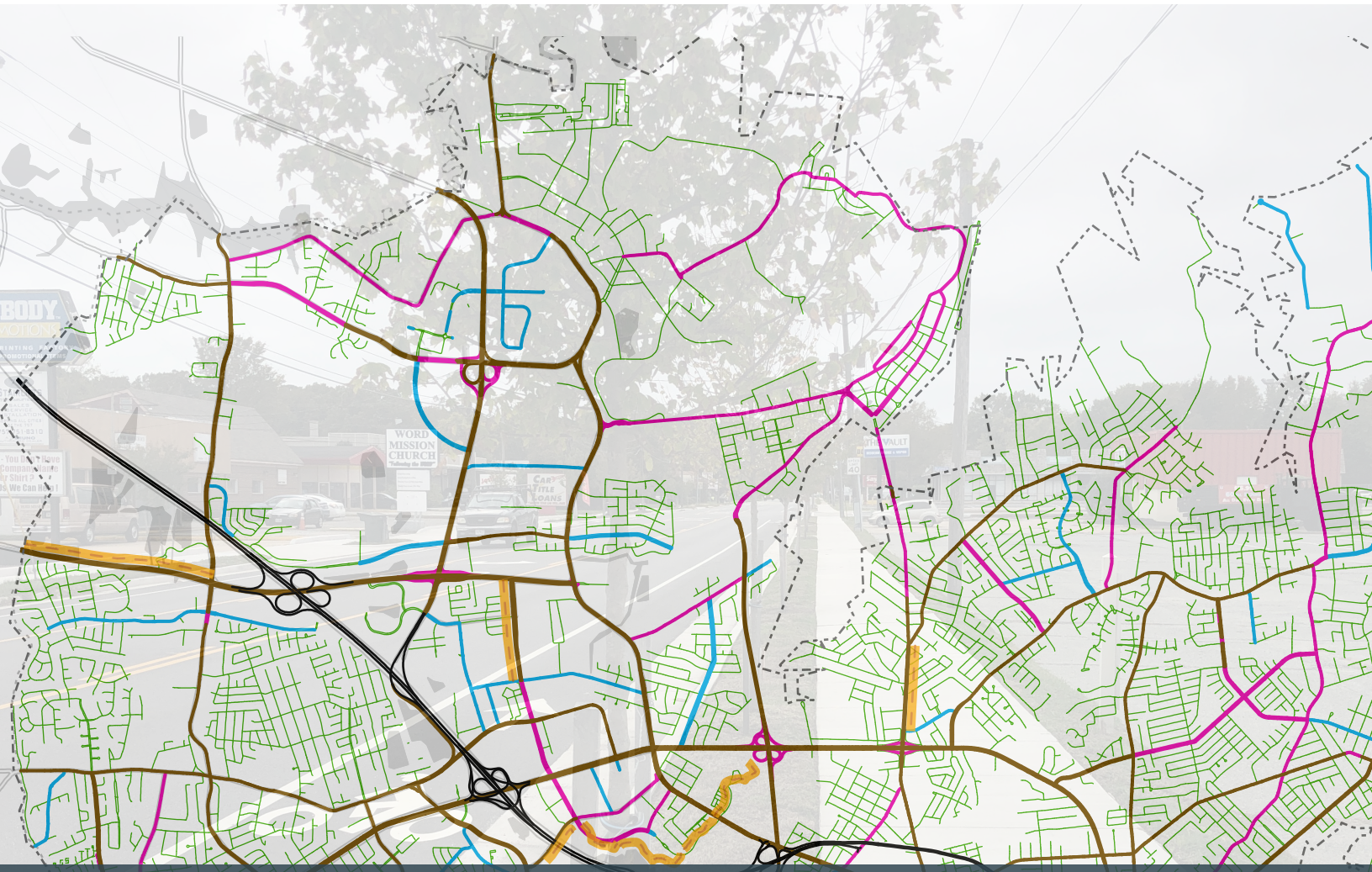
the heartbeat of HAMPTON ROADS TPO
TRANSPORTATION PLANNING ORGANIZATION



LEVEL OF TRAFFIC STRESS ANALYSIS

for The City of Hampton

T22-02

HAMPTON ROADS TRANSPORTATION PLANNING ORGANIZATION VOTING MEMBERS

ROBERT A. CRUM, JR. – EXECUTIVE DIRECTOR

CHESAPEAKE
Richard R. "Rick" West
Ella P. Ward – Alternate

FRANKLIN
Frank M. Rabil
Vacant – Alternate

GLOUCESTER COUNTY
Phillip N. Bazzani
Christopher A. Hutson – Alternate

HAMPTON
Donnie R. Tuck – Chair
Steven L. Brown – Alternate

ISLE OF WIGHT COUNTY
William M. McCarty - Vice-Chair
Rudolph Jefferson - Alternate

JAMES CITY COUNTY
John J. McGlennon
Michael J. Hipple - Alternate

NEWPORT NEWS
McKinley L. Price
David H. Jenkins - Alternate

NORFOLK
Kenneth C. Alexander
Martin A. Thomas, Jr. – Alternate

POQUOSON
Gordon C. Helsel, Jr.
Herbert R. Green – Alternate

PORTSMOUTH
Shannon E. Glover
Lisa L. Lucas-Burke – Alternate

SOUTHAMPTON COUNTY
William Hart Gillette
Vacant - Alternate

SUFFOLK
Michael D. Duman
Leroy Bennett - Alternate

VIRGINIA BEACH
Robert M. "Bobby" Dyer
Norman Dewey "Rocky" Holcomb - Alternative

WILLIAMSBURG
Douglas Pons
Pat Dent – Alternate

YORK COUNTY
Thomas G. Shepperd, Jr.
G. Stephen Roane, Jr. - Alternate

MEMBERS OF THE VIRGINIA SENATE
The Honorable Mamie E. Locke
The Honorable Lionell Spruill, Sr.

MEMBERS OF THE VIRGINIA HOUSE OF DELEGATES
The Honorable Jeion A. Ward
Vacant

TRANSPORTATION DISTRICT COMMISSION OF HAMPTON ROADS
William E. Harrell, President/Chief Executive Officer
Ray Amoruso – Alternate

VIRGINIA DEPARTMENT OF TRANSPORTATION
Christopher Hall, Hampton Roads District Engineer
Todd Halacy – Alternate

VIRGINIA DEPARTMENT OF RAIL AND PUBLIC TRANSPORTATION
Jennifer Mitchell, Director
Jennifer DeBruhl – Alternate

VIRGINIA PORT AUTHORITY
Stephen A. Edwards, CEO/Executive Director
Cathie Vick – Alternate

WILLIAMSBURG AREA TRANSIT AUTHORITY
Zach Trogdon, Executive Director
Vacant - Alternative

HAMPTON ROADS TRANSPORTATION PLANNING ORGANIZATION NON-VOTING MEMBERS

CHESAPEAKE
Christopher M. Price

FRANKLIN
Amanda C. Jarratt

GLOUCESTER COUNTY
Carol Steele

HAMPTON
Mary Bunting

ISLE OF WIGHT COUNTY
Randy R. Keaton

JAMES CITY COUNTY
Scott Stevens

NEWPORT NEWS
Cynthia D. Rohlf

NORFOLK
Larry "Chip" Filer

POQUOSON
J. Randall Wheeler

PORTSMOUTH
Angel Jones

SOUTHAMPTON COUNTY
Michael W. Johnson

SUFFOLK
Albert Moor

VIRGINIA BEACH
Patrick A. Duhaney

WILLIAMSBURG
Andrew O. Trivette

YORK COUNTY
Neil Morgan

FEDERAL HIGHWAY ADMINISTRATION
Thomas Nelson, Jr., Acting Division Administrator, Virginia Division

FEDERAL TRANSIT ADMINISTRATION
Terry Garcia-Crews, Region 3 Administrator

FEDERAL AVIATION ADMINISTRATION
Jeffrey W. Breeden, Airport Planner, Washington Airports District Office

VIRGINIA DEPARTMENT OF AVIATION
Mark Flynn, Director

PENINSULA AIRPORT COMMISSION
Michael A. Giardino, Executive Director

NORFOLK AIRPORT AUTHORITY
Robert S. Bowen, Executive Director

COMMUNITY ADVISORY COMMITTEE
Mark Geduldig-Yatrofsky, Chair

FREIGHT TRANSPORTATION ADVISORY COMMITTEE
Robert Eveleigh, Chair

MILITARY LIAISONS
Harry Hung, Colonel, U.S. Air Force
Sam Stevens, Captain, U.S. Coast Guard
John Hewitt, Captain, U.S. Navy
Gordon Meek, Captain, U.S. Navy - Alternate

INVITED PARTICIPANT
Frederick T. Stant, III, CTB
Stephen A. Johnsen, CTB

REPORT DOCUMENTATION

Title
Level of Traffic Stress Analysis for the City of Hampton

Organization
Hampton Roads Transportation Planning Organization
723 Woodlake Drive, Chesapeake, Virginia 23320
https://www.hrtpo.org/

AUTHORS
Steve Lambert, Transportation Planner II
Sara J. Kidd, GISP, Senior Regional Planner

Project Manager
Dale M. Stith, AICP, GISP, Principal Transportation Planner

PROJECT STAFF
Pavithra Parthasarathi, Deputy Executive Director
Dale M. Stith, Principal Transportation Planner
Steve Lambert, Transportation Planner II
Sara J. Kidd, GISP, Senior Regional Planner
Andrew Margason, General Services Manager
Christopher W. Vaigneur, Assistant General Services Manager

ABSTRACT
This report and the analysis on the Level of Traffic Stress Analysis for the City of Hampton is a local case study to be used for future analysis to assist the Hampton Roads region in long-range planning.

ACKNOWLEDGMENT & DISCLAIMERS
Prepared in cooperation with the U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA), and Virginia Department of Transportation (VDOT). The contents of this report reflect the views of the Hampton Roads Transportation Planning Organization (HRTPO). The HRTPO is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the FHWA, VDOT, or Hampton Roads Planning District Commission. This report does not constitute a standard, specification, or regulation. FHWA or VDOT acceptance of this report as evidence of the fulfillment of the objectives of this planning study does not constitute endorsement/approval of the need for any recommended improvements, nor does it constitute approval of their location and design or a commitment to fund any such improvements. Additional project-level environmental impact assessments and/or studies of alternatives may be necessary.

NON-DISCRIMINATION
The HRTPO assures that no person shall, on the ground of race, color, national origin, handicap, sex, age, or income status as provided by Title VI of the Civil Rights Act of 1964 and subsequent authorities, be excluded from participation in, be denied the benefits of, or be otherwise subject to discrimination under any program or activity. The HRTPO Title VI Plan provides this assurance, information about HRTPO responsibilities, and a Discrimination Complaint Form.

CONTENT


Hampton Waterfront

INTRODUCTION

As localities build out their bike and pedestrian networks across the country, planners have developed new methods to analyze their street network to find out how to connect neighborhoods to destinations. Sometimes localities' priorities for bike and pedestrian facilities are concentrated on bigger projects like regional trails and converting street lanes to bike lanes. But connecting these bigger facilities to and from neighborhoods, businesses, and schools can be done in a fairly inexpensive manner.

One method to identify how to connect these areas is to perform a Level of Traffic Stress Analysis and to find out where localities' low-stress bicycle network is located. This report provides a brief background on what a low-stress bicycle network is, the type of users it would be designed for, and the methodology on how the bicycle level of traffic stress (LTS) was produced and used for the City of Hampton as our test network.

Defining the city's existing and proposed bicycle and pedestrian facilities was completed as part of the City of Hampton's *Bike Walk Hampton* plan in 2016 and Hampton Roads Transportation Planning Organization's *Linking Hampton Roads, a Regional Active Transportation Plan* in 2020. The next step for bicycle and pedestrian planning is to identify gaps within the network that can connect these proposed facilities. Level of Traffic Stress (LTS) analysis is a new tool to study the existing street and bicycle/pedestrian networks' comfort for the average user.

Potential uses of the LTS analysis include:

- Helping users identify safe and comfortable routes
- Identifying safe routes to schools for improvements
- Identifying safe and comfortable routes to local businesses
- Assessing and identifying quick fix gaps in the city's bicycle network (i.e., road diets, signage, bicycle boulevards)

WHAT IS A LOW-STRESS BIKE NETWORK?

A low-stress bicycle network is a network of routes, including streets and off-road separated paths, in which an average user would feel comfortable riding a bicycle. But what is comfortable for an average user? What is comfortable for all users? These are the questions that this analysis will dive into and provide an objective, data-driven approach to evaluate traffic-related stress on bicycle routes in the City of Hampton and recommend critical routes that provide safe, comfortable facilities.

BICYCLE USER TYPES

Localities must first realize who they are creating this safe low-stress bike network for. Following the completed *Linking Hampton Roads* regional active transportation plan, bicycle user types are as follows:

STRONG AND FEARLESS

- Approximately 1% of population
- Willing to ride anywhere regardless of roadway conditions
- Prefer direct routes

ENTHUSED & CONFIDENT

- 5-10% of population
- Comfortable riding on all types of facilities but prefer using dedicated bike facilities
- May stray from a more direct route in favor of a dedicated bike facility

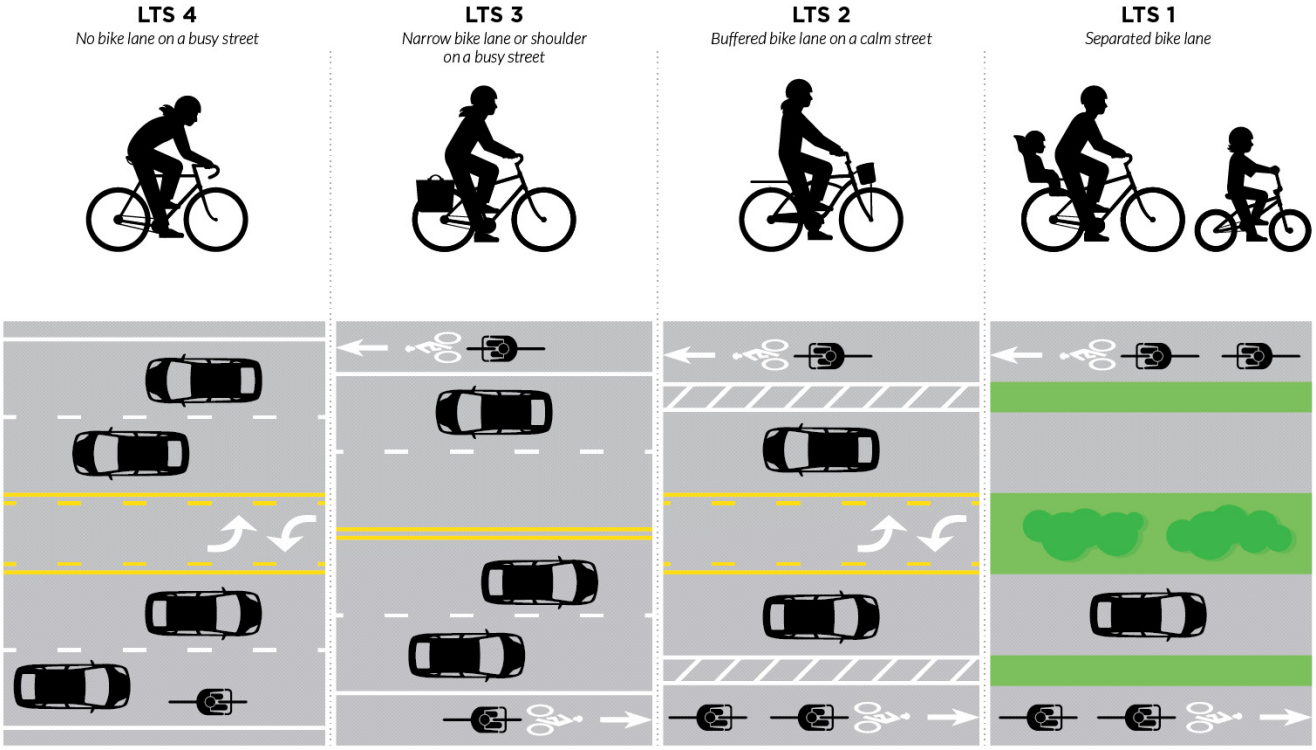
INTERESTED BUT CONCERNED

- Approximately 60% of population
- Prefers biking on trails or other facilities separated from roadway

NO WAY, NO HOW

- Approximately 30% of population
- Not interested or not comfortable biking in most conditions

LEVELS OF TRAFFIC STRESS



Source: blog.altaplanning.com

Level of Traffic Stress (LTS) scoring is designed to correspond with the Types of Bicycle Users (Page 2), with a range from LTS 1 to LTS 4. These scores represent a range from the lowest stress to the highest stress facilities. These facilities are classified into the diagram above using scores, LTS 1, LTS2, LTS 3, and LTS 4.

The Level of Traffic Stress scores are defined below:

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 multi-lane traffic. Crossings that are easy for an adult to negotiate. Limits traffic stress to what the mainstream adult population can tolerate.

LTS 3 Involves interaction with moderate speed or multi-lane 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.

METHODOLOGY

Background

The Bicycle Level of Traffic Stress (LTS) methodology was first published by researchers at the Mineta Transportation Institute in 2012 and has since been used by many transportation planning agencies for a variety of studies. The LTS methodology provides transportation planners with a way to evaluate the rideability and connectivity of roadways for bicyclists. LTS analysis requires commonly available geospatial data to classify road segments into four categories that range from LTS 1 (lowest stress) to LTS 4 (highest stress) for bicyclists. LTS criteria were also developed by the researchers for intersection approaches and crossings. In combination with LTS segment analysis, the results can assist planners with visualizing and measuring connectivity through the entire network. However, due to the limited scope of the project and data availability, intersection approaches and crossings were not evaluated for this case study, but could be examined in the future. The LTS criteria, which was refined later in 2017, was used for this pilot project in the City of Hampton.

Segment LTS Methodology

The LTS criteria differ based on the presence and location of a bike facility. While the existence of separate bike lanes is less stressful for riders overall, bike lanes next to parking lanes create potential hazards —therefore streets with bike lanes have different criteria than a mixed traffic scenario. Separated shared use paths are assumed to have an LTS score of 1 because they are inherently low-stress facilities.

The LTS scores for street segments are based on the following:

- Number of lanes
- Effective ADT (Average Daily Traffic)
- Prevailing speed or speed limit
- Presence of bicycle facilities
- Presence of parking lanes
- Lane Width

METHODOLOGY

The following three tables from Furth (2017) summarize the LTS segment criteria for the various scenarios:

TABLE 1: MIXED TRAFFIC CRITERIA

Number of Lanes	Effective ADT*	Prevailing Speed ≤20 mph	25 mph	30 mph	35 mph	40 mph	45 mph
Unlaned 2-way street (no centerline)	0-750	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3
	751-1500	LTS 1	LTS 1	LTS 2	LTS 3	LTS 3	LTS 3
	1501-3000	LTS 2	LTS 2	LTS 2	LTS 3	LTS 4	LTS 4
	3000+	LTS 2	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4
1 thru lane per direction (1-way, 1-lane street or 2-way street with centerline)	0-750	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3
	751-1500	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	1501-3000	LTS 2	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4
	3000+	LTS 3	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4
2 thru lanes per direction	0-8000	LTS 3	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4
	8001+	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4
3+ thru lanes per direction	any ADT	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4

*Effective ADT (Average Daily Trips in vehicles)= ADT for two-way roads; Effective ADT = 1.5 * ADT for one-way roads

TABLE 2: BIKE LANES AND SHOULDERS NOT ADJACENT TO PARKING LANES

Number of Lanes	Bike lane width	Prevailing Speed 25 mph	30 mph	35 mph	40 mph	45 mph	50+ mph
1 thru lane per direction, or unlaned	6+ ft	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	4 or 5 ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
2 thru lanes per direction	6+ ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	4 or 5 ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
3+ lanes per direction	any width	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4

TABLE 3: BIKE LANES ALONGSIDE PARKING LANES

Number of Lanes	Bike lane reach = bike + parking lane width	Prevailing Speed 25 mph	30 mph	35 mph
1 lane per direction, or unlaned	15+ ft	LTS 1	LTS 2	LTS 3
	12-14 ft	LTS 2	LTS 2	LTS 3
2 lanes per direction (2-way)	15+ ft	LTS 2	LTS 3	LTS 3
2-3 lanes per direction (1-way)		LTS 2	LTS 3	LTS 3
other multilane		LTS 3	LTS 3	LTS 3

DATA INPUT & ANALYSIS

The data used in the analysis was obtained from the City of Hampton and the Virginia Geographic Information Network (VGIN). Hampton staff provided their street centerline file as well as the location of existing bicycle facilities and parking lanes. VGIN maintains a statewide street centerline file based on locality data, but it also includes additional data tables from the Virginia Department of Transportation (VDOT). Widths of bike lanes and parking lanes were measured in the field by HRTPO staff.

Significant data manipulation was needed because neither the Hampton nor VGIN centerline file had complete information for all street segments and the geography of the two files did not match in all areas. The data tables from the Hampton and VGIN street centerline files were combined and joined to the Hampton centerlines in the geospatial database. The VDOT data took precedence where available, while the Hampton data were used to fill in gaps as needed.

Once the street centerline file was updated with the relevant information, a python script was written to assign the correct LTS score to each segment in the geospatial database based on the criteria outlined by Furth (2017).

DATA ASSUMPTIONS

Some assumptions were made in order for each segment to have complete information for the analysis, as described below:

Number of Lanes

The data on the number of lanes was only available in the VGIN dataset. Hence functional attributes was used as a proxy to assign the number of lanes for the remaining segments. However, the functional class names were not consistent between the Hampton and VGIN data so a crosswalk was developed to assign each segment with a lane count.

Traffic Volume

The LTS methodology calls for traffic volume in Average Daily Traffic (ADT) format. However, the only available traffic volume data is Annual Average Daily Traffic (AADT) from VDOT. The AADT number was used to substitute for ADT for the VDOT segments. Most of the smaller local roads do not have measured traffic volumes so functional class was again used as a proxy. A value of 300 vehicles per day was used to approximate the average traffic on local roads. The numbers for collectors and arterials represent median values by road class, devised for an LTS analysis in Fort Worth, Texas by the North Central Texas Council of Governments in 2019.

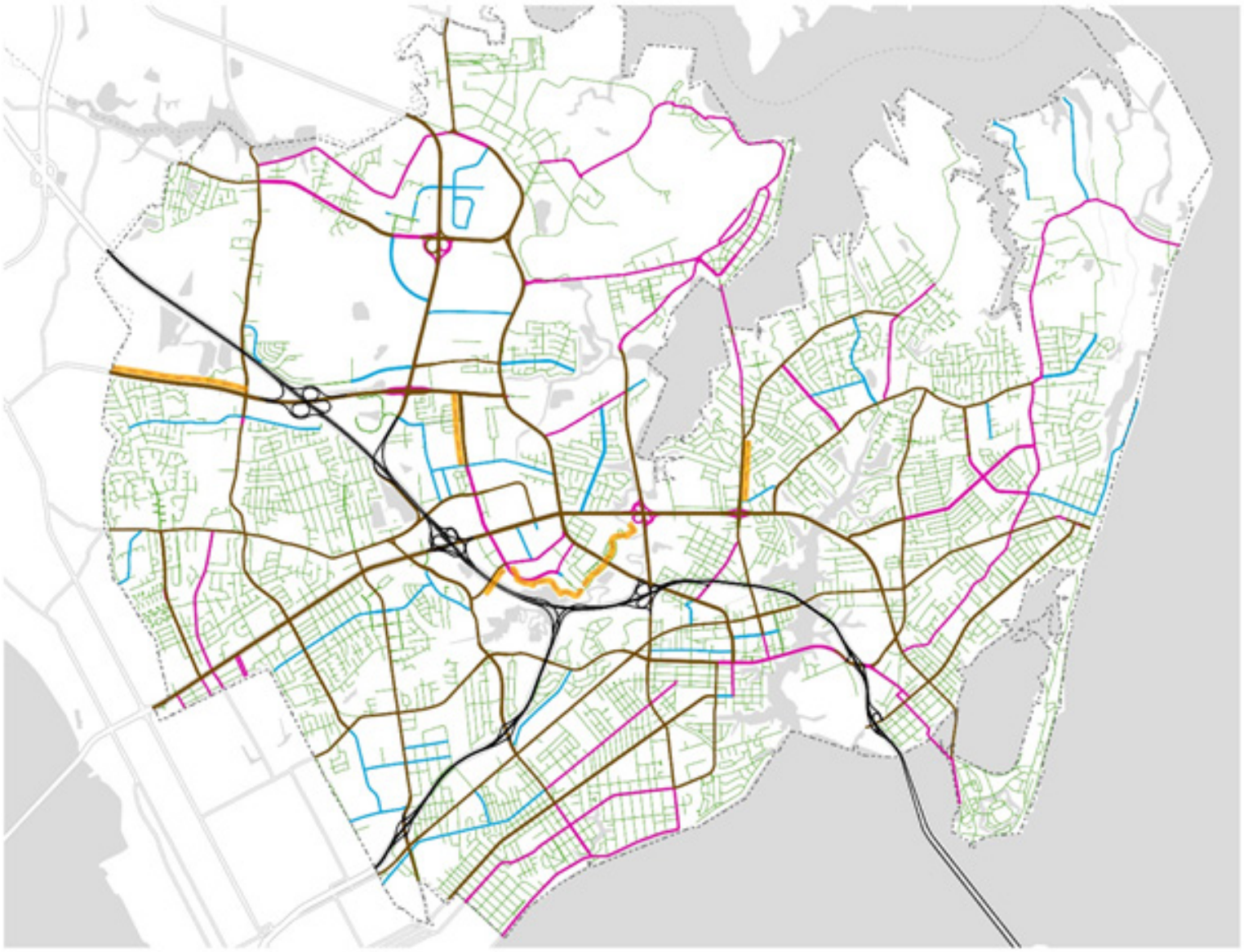
TABLE 4: AADT ASSUMPTIONS

Road Classification	Traffic Volume Assumption
Local	300
Collector	4,000
Arterial	13,000

A map of the Level of Traffic Stress for bicyclists in Hampton is shown in Figure 1 on the following page. The green and blue lines represent largely residential streets which have LTS scores of 1 or 2. These neighborhoods can be thought of as "islands" because they are separated from each other by higher stress collectors and arterials with LTS scores of 3 or 4, which a majority of people would not feel comfortable riding on or crossing. This prevents riders from traveling to all desired locations throughout the city on their bikes. The orange lines represent existing separated shared-use paths. The black lines represent prohibited roadways which includes interstate highways.

LEVEL OF TRAFFIC STRESS MAPPING

FIGURE 1: LEVEL OF TRAFFIC STRESS IN HAMPTON

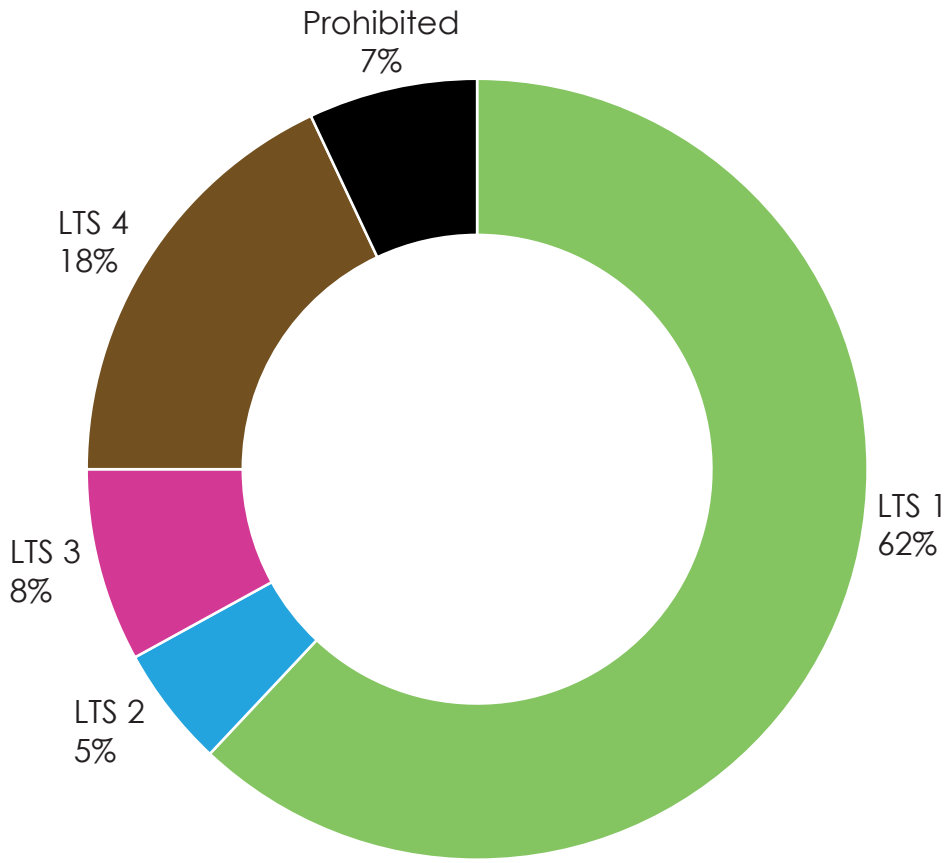


- LTS 1
- LTS 2
- LTS 3
- LTS 4
- Existing Shared-use Paths
- Prohibited Roadways

LEVEL OF TRAFFIC STRESS MAPPING

Figure 2 below summarizes the LTS on road segments by total length. A majority of segments are LTS 1 however the smaller number of LTS 3 and 4 create potential barriers.

FIGURE 2: LTS CATEGORIES BY TOTAL LENGTH (IN MILES)



CONCLUSION

The Level of Traffic Stress Analysis for the City of Hampton has taught HRTPO staff several key takeaways, including:

- City lends itself well to having a high percentage of low-stress roadways
- Possible improvements via signage and wayfinding
- Potential to direct bicyclists to less-congested roadways (LTS 1 and 2)
- Potential for converting on-street parking on LTS 1 roadways to bike lanes
- A need to identify major gaps and barriers in the network

This case study has shown the feasibility of applying this process to any Hampton Roads jurisdiction. The reliability of the analysis depends largely on the level of detail and accuracy of the input data. To refine and improve this analysis, HRTPO staff recommends:

- Improving the quality and accuracy of street data
- Conducting network connectivity analysis using intersection approaches and crossings
- Identifying gaps and barriers in the network

Also, HRTPO staff can provide this analysis for localities and specific regional trail segments. With the analysis, HRTPO can assist the locality with facility decision-making and planning efforts. HRTPO staff welcomes localities to inquiry about this analysis for future research.

REFERENCES

Furth, Peter G. "Level of Traffic Stress Criteria for Road Segments, Version 2.0." Peter G. Furth Northeastern University Faculty Page. June 2017. https://peterfurth.sites.northeastern.edu/2014/05/21/criteria-for-level-of-traffic-stress/

Furth, Peter G.; and Maaza Mekuria. "Network Connectivity for Low-Stress Bicycling." Transportation Research Board Annual Meeting, Compendium of Papers. 2013. https://bit.ly/3n7VEc0

Hillsborough (Florida) Metropolitan Planning Organization. "Evaluating Bicycle and Pedestrian Quality of Service." November 2018. http://planhillsborough.org/wp-content/uploads/2018/03/Bicylce-Pedestrian-Evaluation-Final-Report_Nov-2018-Draft.pdf

Madison Area (Wisconsin) Transportation Planning Board. "Defining the Madison Area Low-Stress Bicycle Network and Using it to Build a Better Regional Network." December 2018. https://www.greatermadisonmpo.org/planning/documents/LTSRReportFinal.pdf

Mekuria, Maaza C.; Peter G. Furth; and Hilary Nixon. "Low-Stress Bicycling and Network Connectivity." Report 11-19. Mineta Transportation Institute. May 2012. https://transweb.sjsu.edu/research/Low-Stress-Bicycling-and-Network-Connectivity

North Central Texas Council of Governments. "Fort Worth Active Transportation Plan." April 2019. https://www.fortworthtexas.gov/departments/tpw/atp

Virginia Department of Transportation. "Functional Classification Comprehensive Guide." June 2014. https://www.virginiadot.org/Functional_Classification_Comprehensive_Guide.pdf