CHARLOTTESVILLE NON-MOTORIZED INFRASTRUCTURE NEEDS PRIORITIZATION PROCESS

Prepared for City of Charlottesville

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ABOUT GAP-TA

Visit vtrans.org/about/GAP-TA for information about the Growth and Accessibility Planning Technical Assistance program.
OIPI will provide a blurb describing the GAP-TA program.

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CHARLOTTESVILLE NON-MOTORIZED INFRASTRUCTURE NEEDS PRIORITIZATION PROCESS

INTRODUCTION

In 2022, the City of Charlottesville (the City) was awarded a grant through the Virginia Office of Intermodal Planning and Investment's (OIPI) Growth and Accessibility Planning (GAP) Technical Assistance program. In its application, the City expressed a desire for technical assistance in the development of a quantitative prioritization process to help determine active transportation projects to select for implementation.

The purpose of this effort is the development of a process to prioritize the City of Charlottesville's non-motorized transportation projects (bike and pedestrian) to support the City's Capital Improvement Program (CIP) and grant-eligible transportation project selection on an annual basis.

Through coordination with City staff, technical guidance was provided for accessing and operationalizing the performance measures, and associated thresholds, that are most likely to facilitate an effective process intended to achieve the stated goal. The process relied on outputs from existing tools and resources, such as Interact VTrans, while allowing city staff to input data related to specific projects.

The result of this study is a process, not a plan, for the City that can be used on an ongoing basis. This guidance document specifies the step-by-step process for evaluating non-motorized projects and includes a description of data sources, outputs, and any data analysis or calculations required to develop project prioritization scores.

STAKEHOLDER ROLES

As the City of Charlottesville applied for the GAP Technical Assistance grant, the City will control the final project deliverables and serve as the main administrator for operating and maintaining items listed in this Process Guide. The following summary describes the overall process and the roles of the stakeholders involved.

City Staff: The City of Charlottesville staffs the planning process and should maintain the procedures described in this Guide. City staff should facilitate the steps and coordinate with the VDOT District, City officials, and local staff. Responsibilities include:

- Maintaining this Process Guide,
- Updating the data and technical elements described herein
- Using the Prioritization and any weighting that the community identifies
- Using the prioritization process in coordination with repaving, equity, neighborhood and other public collaboration efforts to ensure an inclusive planning and infrastructure process.

OIPI: The Office of Intermodal Planning and Investment will be responsible for providing resources on updates to the statewide transportation plan, VTrans, and SMART SCALE. OIPI will also be the state's warehouse for transportation-related data that will populate the tool.

A full matrix of responsibilities for inputting, maintaining, and executing this process in included in the recommendations at the end of this report.

PROCESS

In order to identify best practices applicable for prioritizing non-motorized transportation projects, a review and summary of recent comparable studies from the US was produced as part of this GAP-TA effort. This effort produced a universe of factors and metrics to be considered for prioritization. Following an Internal Capacity Assessment of Charlottesville staffing, software and data (included as Appendix C), the project team focused the list of factors for the prioritization down to 10, in the four topics of Suitability, Demand, Safety, and Connectivity. The sources and process for gathering the data for those 10 factors are described in this report. The main body of the report describes using GIS to determine the raw scores for each factor, and the method for converting raw scores into normalized scores with comparable scoring or valuation. The report concludes with a discussion of merging of the normalized scores across factors, and the methods for weighting the data per Charlottesville's needs to result in a prioritized valuation of sidewalks and bikeways.

ASSESSMENT OF BICYCLE AND PEDESTRIAN PRIORITIZATION METHODS

The City of Charlottesville is in the process of updating the prioritization methods used for the disbursement of funding to non-motorized transportation needs and projects. The process from the City's 2015 Bicycle and Pedestrian Master Plan used methods from the National Cooperative Highway Research Program (NCHRP) 803 report: Pedestrian and Bicycle Transportation Along Existing Roads – ActiveTrans Priority Tool and scores bicycle and pedestrian projects separately. Both proposed sidewalk and bicycle recommendations are ranked based on six scoring criteria with each criteria using different measures. Proposed sidewalk projects are evaluated based on sidewalk context connectivity, proximity to attractors/facilities, street traffic, land use designation, related projects, and a staff-conducted field analysis that determines feasibility and community support. Bikeway projects undergo evaluation based on equity, existing roadway conditions, implementation effort, network connectivity, public support, safety and demonstrated need.[1]

The City adopted the Charlottesville Streets That Work Design Guidelines report in 2016 which updated the bicycle and pedestrian project prioritization process. This process provides a score for each corridor within Charlottesville instead of scoring each individual project based on 11 scoring criteria which include:

- Public Comments (perceived safety)
- Crash Data
- Top 20 Planned Bicycle/Pedestrian Projects
- ADA Accessibility (curb ramps and accessible push buttons)
- Schools
- Parks
- Posted Speed Limit
- Roadway Classification (proximity for traffic volume)
- Bicyclist/Pedestrian Demand
- Transit Stops
- CIP (Capital Improvement Program)

Public Comment is the highest weighted criteria.[2]

REVIEW OF INDUSTRY PRACTICES

In addition to the methods used by the city, the consultant team has assessed existing prioritization methods used in other project selection processes. The assessment allows for direct comparison of methods to produce and refine a new step-by-step process that fits the needs of the city and can be used on an ongoing basis.

NCHRP 803: ActiveTrans Priority Tool

The 2015 National Cooperative Highway Research Program (NCHRP) 803 report: Pedestrian and Bicycle Transportation Along Existing Roads – ActiveTrans Priority Tool Guidebook was produced by the Transportation Research Board. The tool assists in the prioritization of improvements to pedestrian and bicycle facilities along existing roadways using a two phase, ten-step prioritization process.

1. Phase 1: Scoping
   1. Define Purpose
   2. Select Factors
   3. Establish Factor Weights
   4. Select Variables
   5. Assess Data

2. Phase 2: Prioritization
   1. Assess Technical Resources
   2. Set Up Prioritization Tool
   3. Measure and Input Data
   4. Scale Variables
   5. Create Ranked List

State and regional agencies may use the tool to prioritize funding disbursement to local agencies who are seeking to develop and implement bicycle and pedestrian improvements. Local agencies may utilize the tool to establish an implementation process of identified improvements.

Of the many tools developed under the NCHRP, the ActiveTrans Priority tool has the most thorough process incorporating a step by step Excel spreadsheet. The spreadsheet encompasses all the required measures, weighting, and scaling spelled out in the ten-step process. The prioritization process separates the proposed improvements by category, either bicycle or pedestrian. The proposed improvements are further categorized by location type, those being intersections/crossings, roadway segments, roadway corridor, or neighborhood/area. The scoring measures are also grouped into categories including:

- Stakeholder Input
- Constraints
- Opportunities
- Safety
- Existing Conditions
- Demand
- Connectivity
- Equity
- Compliance[3]

Following the assessment of the data and review of technical resources, the inputs placed into the spreadsheet are scaled for prioritization by applying values to non-numeric inputs, identifying a common numerical scale, and adjusting raw values to fit the identified scale. The different potential scaling methods include:

1. Toole Design Group (Silver Spring, Maryland). Master Plan: Report to City of Charlottesville, Virginia.: Toole Design Group, 2015.
2. ibid.

3. "ActiveTrans Priority Tool." Pedestrian & Bicycle Information Center. transportation Research Board of the National Academies. Accessed June 19, 2022. https://www.pedbikeinfo.org/topics/tools_apt.cfm.

- Proportionate Scaling
- Inverse Proportionate Scaling
- Quantile Scaling (4 quantiles)
- Inverse Quantile Scaling (4 quantiles)
- Quantile Scaling (10 quantiles)
- Inverse Quantile Scaling (10 quantiles)
- Rank Order Scaling
- Inverse Rank Order Scaling[4]

FDOT District Six BPTool

The Florida Department of Transportation (FDOT) District Six Data-Driven Bicycle & Pedestrian Facility Needs Prioritization Tool (BPTool) was developed by the FDOT Planning and Environmental Management Office. The interactive GIS-based web platform identifies bicycle and pedestrian priorities through a data-driven process using Connectivity, Demand, Equity, and Safety performance measures. Connectivity measures the access to parallel routes, connection opportunities to paved paths/trails, and connections to bike lanes. Demand measures proximity to schools and universities, premium transit stations and local bus stops, and parks. The equity measure calculates surrounding zero-car households and poverty levels. Safety measures the magnitude of crashes in comparison to the national average and fatalities.

The scoring process consists of several yes/no questions which give each proposed improvement an overall score based around the four key measures. The proposed improvement can receive a maximum potential score of 14 points. The data sets used in the tool can be found in Table 1 below.

4. ActiveTrans Priority Tool." Pedestrian & Bicycle Information Center. transportation Research Board of the National Academies. Accessed June 19, 2022. https://www.pedbikeinfo.org/topics/tools_apt.cfm.

University of Illinois – Chicago Urban Transportation

The University of Illinois' Chicago Urban Transportation Center conducted a study for the development of an analytical framework which provides a prioritization methodology to rank potential bicycle and pedestrian recommendations with the goal of improving deficient facilities. The seven key measures within the framework are:

- Safety - Measuring the frequency and severity of crashes involving pedestrian and cyclists.
- Safety Effectiveness - Measuring the reduction in the frequency and severity of crashes.
- Mobility - Measures the contribution the improvement makes to overall bicycle and pedestrian access.
- Demand - Measuring the likelihood of bicyclists and pedestrians using the facility.
- Equity - Measuring the degree to which a project improves mobility for less privileged areas.
- Cost - Measuring the capital, operating, and maintenance costs over the lifespan of the improvement.
- Qualitative factors - Includes items derived from the opinions of local experts.[5]

The scoring process consists of calculating a value for each of the seven factors. The values are weighted and summed to produce the overall score for each proposed improvement. The Safety and Safety Effectiveness values are given the greatest weight with the Safety Effectiveness value being scaled to ensure that crash reduction rates are measured proportionally to improvement costs.

5. Moini, Nadereh. Publication. Development of an Analytical Framework to Rank Pedestrian and Cyclist Projects. Chicago, IL: Urban Transportation Center, 2015. https://www.cutr.usf.edu/.

Table 1: BPTool Data Sets

Data	Source/Date
Crash Data	FDOT CARS Database (2011-2015)
Communities of Concern	Communities of Concern by census block, Miami-Dare TPO's Federal Planning Emphasis Area (PEAs) for Miami-Dade County report (November 2017)
Existing SHS Bicycle Facilities	FDOT's Roadway Characteristics Inventory (RCJ) database (2018)
Existing SHS Sidewalk Facilities	FDOT's Roadway Characteristics Inventory (RCJ) database (2018)
Existing Parallel Nike Network	Miami-Dade Transportation Planning Organization existing and funded on-road bike facilities and paved paths shapefiles (2019)
Traffic Signals	Miami-Dade County GIS Online Portal (2018)
Schools/University locations	Miami-Dade County GIS Online Portal (2018)
Bus Stop Locations	Miami-Dade County GIS Online Portal (2018)
Premium Transit Locations	Miami-Dade County GIS Online Portal (2018)
Park Locations	Miami-Dade County GIS Online Portal (2018)

Lawrence, Kansas – Bicycle and Pedestrian Prioritization Tool

The City of Lawrence, Kansas developed a Bicycle and Pedestrian Prioritization Tool with the goal of improving infrastructure that provides access to priority and high crash destinations in addition to priority projects in approved plans. The data-driven process acts as the first step in identifying bicycle and pedestrian improvements along roadway corridors with evaluation criteria that are clearly measurable and use easily obtainable data. The tool separates these measures to either evaluate bicycle or pedestrian improvements.

The three pedestrian infrastructure prioritization criteria within the tool are Priority Networks, Pedestrian Access to Priority Destinations, and Safety. Each proposed improvement can receive a maximum of 30 points with Safety being weighted the highest at 20 potential points. The safety measure evaluates the pedestrian-related crash history in the last five years, the AADT roadway volume, and pedestrian crossing improvements on a road with and AADT of 15,000 or higher. The breakdown of each measure and their point distribution criteria can be seen in Table 2 below.[6]

The bicycle infrastructure prioritization criterion has safety as the highest weighted measure with 20 potential points as well. The two remaining measures accounting for the last ten potential points are Adopted Plan Priorities and the Bicycle Demand Model. The Bicycle Demand Model evaluates five proximity factors that place buffers, varying in size, around areas of density, education centers, and the bicycle facilities within the existing infrastructure. The outputs of each factor are added to produce the final improvements range score that feeds into the overall score ranging from one to five. The breakdown of each measure and their point distribution criteria can be seen in Table 3 below.[7]

6. Rep. Non-Motorized Projects Prioritization Policy 2. Vol. 2. Lawrence, Kansas: Multi-modal Transportation Commission, 2019. https://lawrenceks.org/budget/cip/.
7. Rep. Non-Motorized Projects Prioritization Policy 2. Vol. 2. Lawrence, Kansas: Multi-modal Transportation Commission, 2019. https://lawrenceks.org/budget/cip/.

Table 2: Lawrence, KS Prioritization Tool Pedestrian Measures

	Pedestrian Infrastructure Prioritization Criteria	Points
1	**Priority Network (select one, max 5 pts)**	
	Safe Routes to School Route	5
	Arterial/Collection Street Classification of Roadway and/or Parallel Roadway for Off-Road Facilities with no sidewalks on either side	4
	Arterial Street Classification of Roadway and/or Parallel Roadway for Off-Road Facilities	3
	Collector Street Classification of Roadway and/or Parallel Roadway for Off-Road Facilities	2
	Local Street Classification of Roadway and/or Parallel Roadway for Off-Road Facilities	1
2	**Pedestrian Access to Priority Destinations (select one, max 5 pts)**	
	Within ¼ mi of school or 1/8 mi of transit stop	5
	Within ½ mi of school, ¼ mi of transit stop, ¼ mi of neighborhood or community retail (includes grocery store, farmers market and retail food outlets), 1/8 mi of park, 1/8 of library, or 1/8 of post office	3
	Farther than ½ mi of school, ¼ mi of transit stop, ¼ mi of neighborhood or community retail, 1/8 mi of park, 1/8 of library, or 1/8 of post office	1
3	**Safety – Crash History (select all that apply, max 12pts)**	
	Project addresses reported pedestrian-related crash in the last five years (3pts per crash- max 12)	12
	Safety – Roadway Volume (select one, max 5 pts)	
	Project on a road that has over 25,000 AADT on roadway	5
	Project on a road that has over 20,000 AADT on roadway	3
	Project on a road that has over 15,000 AADT on roadway	1
	Safety – Crossing (max 3 pts)	
	Project adds crossing improvements on a road over 15,000 ADT	3
	Max Points - 30	

Rosemount, Minnesota – The League of American Bicyclists

The City of Rosemount, Minnesota's Parks and Recreation Department developed the city's Pedestrian and Bicycle Master Plan. The plan includes an in-depth scoring process from the League of American Bicyclists. The non-profit organization's scoring process awards funding to bicycle friendly communities. The survey style scoring process uses simple yes/no questions to rank all priority projects within five different question categories.

- Education – Educating people on the benefits of walking and biking, walk-bike safety and creating maps to understand the existing system.
- Encouragement – Developing programs and events that get people excited about walking and biking.
- Evaluation – Measuring success of walk-bike efforts.
- Engineering – Physical projects such as sidewalks or bike lanes that create a supportive walk-bike community.
- Enforcement – Enforcing existing traffic laws and ordinances that support walking and biking.[8]

8. Rep. Rosemount Pedestrian & Bicycle Master Plan. Rosemount, Mn: Hoisington Koegler Group, 2010. https://ci.rosemount.mn.us/452/Pedestrian-and-Bicycle-Master-Plan.

To ensure progress towards the goals of the plan is being made, the city uses some of the following potential qualifiable measures:

- Annual or biannual pedestrian counts.
- Vehicle- bike-pedestrian crash rates.
- Number of participants at walk-bike events.
- Number of participants in walk-bike classes.
- Miles/numbers of pedestrian-bicycle facilities: on-road bicycle facilities, trails, sidewalks, bike rack, benches, etc.[9]

Palo Alto – Bicycle and Pedestrian Transportation Plan

Palo Alto, California's Bicycle and Pedestrian Transportation plan provides guidance for investments in non-motorized transportation facilities. The transportation plan incorporates three key measures to evaluate, prioritize and disburse state, regional, and local funds to potential bicycle and pedestrian improvements. The qualitative assessment within the plan uses a high, medium, and low scoring criteria based on Safety, Connectivity, and 'Special' to construct a list of priority projects.

9. ibid.

Table 3: Lawrence, KS Prioritization Tool Bicycle Measures

	Bicycle Infrastructure Prioritization Criteria	Points
1	**Adopted Plan Prioritization (select one, max 5 pts)**	
	Along the Ped/Bike Issues Taskforce Report Long Term Bikeway Priority Network	5
	Along network identified in approved Countywide Bikeway Plan	4
	Arterial/Collector with no Shared Use Path	3
2	**Bicycle Demand (select one, max 5pts)**	
	Bicycle demand is calculated on the bicycle demand heat map which in a prioritization score based on proximity to housing density, K-12 private/public schools, college/university, and existing bikeway infrastructure.	
	Score greater than 66 up to 81	5
	Score greater than 49 up to 65	4
	Score greater than 33 up to 49	3
	Score greater than 17 up to 33	2
	Score greater than 0 up to 17	1
3	**Safety - Crash History (select all that apply, max 12 pts)**	
	Project addresses reported bicycle-related crash in the last five years (3pts per crash- max 12)	12
	Safety – Roadway Volume (select on, max 5 pts)	
	Project on a road that has over 25,000 AADT on roadway	5
	Project on a road that has over 20,000 AADT on roadway	3
	Project on a road that has over 15,000 AADT on roadway	1
	Safety – Crossing (max 3 pts)	
	Project adds crossing improvements on a road over 15,000 AADT	3
	Max Points - 30	

Safety evaluates the crash history of the potential improvement location in addition to verifying the route is a designated School Commute Corridor. Potential improvements satisfying both criteria receive a high rating. A medium rating is given if the project location only satisfies one of the mentioned criteria or addresses an identified safety concern. Project locations that only address an identified low risk safety concern receive a low rating.

Connectivity rewards closing the gap between existing or developing new connections of bicycle and pedestrian facilities within the city's network. Any improvement that connects two Class I trail segments, creates a significant connection to an activity center, or traverses a major circulation barrier receives a high rating. Any enhancement of an existing arterial crossings, access to activity centers, extends a Class I trail segment, or closes a gap between two on-street bikeways receives a medium rating. A low rating is rewarded to any project that improves circulation within the built network or extends an on-street bikeway without traversing barriers or connecting to activity centers.

The measure of Special refers to cases "such as current/past planning and funding commitments and/or public support identified" in the transportation plan. The rating of high, medium, or low is based on the "qualitative assessment" of the factors previously mentioned.[10]

Following the qualitative assessment, the project list undergoes further refinement by an evaluation framework that also provides a high, medium, or low rating. The Five I's framework evaluates each project and measures its potential for Integration, Inclusion, Innovation, Investment, and the incorporation of Institutional Partnerships. Integration rates the potential for a project to be woven into an identified priority or project and incorporates design features to achieve multiple benefits. Inclusion evaluates how a project addressed the needs of potential users with vulnerabilities and/or disabilities. The level of Innovation in a project's planned design is rated based on its readiness to be implemented. Being that projects in this stage of evaluation are limited on the ability to identify the level of innovative, projects are given a 'Yes' if any level of innovation is included or 'No' for the lack there of. Investment evaluates a project's potential to be "competitive for outstanding grants" in addition to its expected benefit to cost ratio.[11] Finally, projects are evaluated based on its ability to provide opportunities or has a need for Institutional Partnerships. The feasibility potential for cost sharing and mutual coordination "between agencies, jurisdictions, and private/public partnerships" determines the rating it receives.[12] It should be noted that a higher rating is ideal but can increase a project's risk level due to the potential need for garnering widespread support or approvals which can prolong the planning implementation process.

10. Rep. City of Palo Alto Bicycle + Pedestrian Transportation Plan. Palo Alto, California: Alta Planning + Design, 2012. https://www.cityofpaloalto.org/Departments/Transportation/Bicycling-Walking.
11. ibid.
12. ibid.

Lincoln, Nebraska – Bicycle and Pedestrian Capital Plan

The City of Lincoln, Nebraska developed their Bicycle and Pedestrian Capital Plan with the intentions of producing a "well-balanced transportation system that includes choice travel, including walking and bicycling".[13] The plan uses an evaluation check list of eight factors by which bicycle and pedestrian projects are prioritized and selected for short term implementation. An additional two measures are added to the check list for pedestrian projects regarding ADA accommodations.

- Connectivity - Measures if a project provides access to activity centers and locations such as those of major employment, business, shopping, civic uses, schools, senior facilities, and public housing.
- Continuity - Determines if a project provides a connection or eliminates a barrier in the current bicycle and pedestrian network.
- Safety - Identifies the elimination of a known safety hazard.
- Joint Construction/Developer Contribution - Verifies if a project can be included in the implementation of other projects such as a road widening or land development project.
- High Use - Looks at the potential usage and/or satisfaction of an identified demand in a project location.
- Neighborhood Support - Verifies the level of support the project has from the impacted constituents surrounding the project location.
- Feasibility – Measures a project's readiness and ability to be implemented.
- Cost Effectiveness - Whether a project represents a good value for the price of its implementation.
- Persons with Disabilities – Evaluates a project's ability to provide improvements that meet the needs of a person with disabilities. (Pedestrian Improvement Projects Only)
- ADA Eligibility – Is the project required to comply with the Americans with Disabilities Act? (Pedestrian Improvement Projects Only)[14]

Los Gatos, California – Bicycle and Pedestrian Transportation Plan

Los Gatos, California developed their Bicycle and Pedestrian Master Plan to deliver a safe bicycle and pedestrian network providing accessibility to priority destinations. The Master Plan uses a developed list of criteria to determine the prioritization of projects based on input gathered during the plan's creation. Based on feedback, the project criteria have been developed for bicycle, pedestrian, and town-wide Improvement projects.

13. Rep. Lincoln MPO 2040 Long Range Transportation Plan -Bicycle and Pedestrian Capital Plan. Lincoln, Nebraska: Lincoln Metropolitan Planning Organization, 2013. https://www.lincoln.ne.gov/City/Departments/Planning-Department/MPO/Projects-Reports.
14. ibid.

- Enhancement Safety – Measures a project's ability to improve the safety of bicycle, pedestrian, or other roadway users versus existing conditions.
- Direct Access to Key Destinations/Trails – Measures a project's ability to connect bicycle and pedestrians to civic, retail, recreational, educational, and employment destinations.
- Closes Existing Network Gaps – Evaluates improvement projects that propose dedicated and separated bicycle infrastructure designed to make significant progress in closing gaps in the current network. (Bicycle Project Improvements Only)
- Improves Access for the Mobility Impaired – Evaluates improvements that enhance access to roadways for mobility impaired pedestrians. (Pedestrian and Town-wide Projects Only)
- Improves Existing Safe Routes to School Access – Evaluates projects identified in the Los Gatos Safe Routes to School Phase one report with the intent of improving connections directly to designated School Walking Routes.
- Improves Existing Infrastructure – Evaluates projects designed to enhance existing sidewalks, crosswalks, and bikeways.
- Existing High-Activity Area – Gives priority to implementation of projects with areas of high bicycle and pedestrian volumes, high amounts of bicycle-vehicle and pedestrian-vehicle collisions.
- Increases Bicycle/Pedestrian Activity – Evaluates improvements designated to encourage bicycle and pedestrian activity by increasing comfort for all users.
- Identified as a Cross County Connector - Bicycle improvements identified as a recommendation in the Santa Clara Valley Transportation Authority's Countywide Bicycle Plan.[15]

Following the initial project evaluation, an additional assessment to determine funding prioritization is conducted. The assessment evaluates the readiness level for implementation of each project. The highest priority projects, Phase one (Short Term), have been established as easily implementable based on the estimated budget, amount of regional collaboration requirements, and complexity of construction. The goal of this phase is to construct the recommendations within one to five years. Phase two (Medium Term) projects are considered high priority and satisfy at least most of the project criteria but may not be as easily implemented or as high of a priority as a Phase one project. The goal of Phase two is to construct the recommendations of the project within five to ten years. Though they are still important, Phase three (Long Term) projects are less urgent and satisfy less criteria than Phase one and two projects.[16]

15. Rep. Los Gatos Bicycle and Pedestrian Plan. Los Gatos, California: PlaceWorks, 2017. https://www.losgatosca.gov/documentcenter/view/17416.

Albany, New York - Capital District Transportation Committee – Bicycle and Pedestrian Prioritization Tool

The Bicycle and Pedestrian Action Plan within the New Visions 2050 Regional Transportation Plan uses the Capital District Transportation Committee (CDTC) Bicycle and Pedestrian Prioritization Tool as a guide to evaluate projects and disburse funding to "projects that will benefit pedestrian and bicyclists most."[17] The ArcGIS-based tool evaluates bicycle and pedestrian projects separately. Districts within the committee's jurisdiction are designated as either Tier one or Tier two. Tier determinations are based on the CDTC staff identifying locations where the most need for safe pedestrian infrastructure exists. Districts with the most need are designated Tier one while Tier two are the remaining districts.[18] Projects are then evaluated by the criteria presented in Table 4.

The CDTC tool produces scores to prioritize funding for bicycle recommendations based on a linear network of priority bicycle routes in addition to the pedestrian district Tier designations. To be eligible for funding, a project must fall within three different categories as indicated in Table 5.

Washington County, Oregon – Bicycle and Pedestrian Improvement Prioritization Project

Washington County, Oregon developed a Bicycle and Pedestrian Improvement Prioritization Project which identifies needs and evaluates recommendations based on a three-step process. Step one is a suitability analysis that evaluates the overall support for bicycle and pedestrian improvements within an area in addition to identifying areas where pedestrian and bicycle improvements would have the highest impact. Step two conducts an overlay analysis to develop a list of scored needs by applying weighted scores to gaps identified in the current bicycle and pedestrian network. Step three narrows the list of "top 30 bicycle and

16. ibid.
17. Rep. New Visions 2050 Regional Transportation Plan - Bicycle & Pedestrian Action Plan. Albany, New York: Capital District Transportation Committee, 2020. https://www.cdtcmpo.org/transportation-plans/nv2050.
18. ibid.

Table 4: CDTC Evaluation Criteria

Pedestrian Districts	Tier 1	Population Density & Employment Density	PLUS Proximity to at least 2 of the following	Schools	Shopping centers	Hospitals	Parks/Trails	Environmental Justice Populations
	Tier 2	The remaining incorporated areas of all cities and villages, not meeting the Tier 1 Ped District Criteria notes above						

Table 5: CDTC Funding Eligibility Categories

<table>
<tr><td rowspan="5">Linear Network</td><td>Federal aid eligible roadway

AADT>= 10,000*</td><td>AND road is located within:</td><td>Tier 1 Ped District

Tier 2 Ped District</td><td>Population Density & Employment Density</td><td>OR road is part of:</td><td>Connects at least 2 pedestrian generators**</td></tr>
<tr><td colspan="6">OR is a...</td></tr>
<tr><td colspan="6">Designated bike route</td></tr>
<tr><td colspan="6">Mohawk Towpath Scenic Byway</td></tr>
<tr><td colspan="6">Multi-use paths (existing & proposed)</td></tr>
</table>

*Only roads that do not currently prohibit bicycles are included
**Pedestrian generators = schools, parks, trails, hospitals, and shopping areas

pedestrian needs by considering public support, geographic equity, right-of-way constraints, and planning-level cost estimates of potential future improvements."[19] A high, medium, or low score is provided to all future improvements based on the following criteria:

- Land use
- Safety
- Street density
- Social equity[20]

Jefferson Area Bicycle and Pedestrian Plan

The Thomas Jefferson Planning District Commission coordinated with the Piedmont Environmental Council to develop the Jefferson Area Bicycle and Pedestrian Plan with the focus of regional bicycle and pedestrian infrastructure improvement. The plan uses the ActiveTrans Priority Tool to rank the potential improvement projects. The four-measure analysis uses Destinations, Equity, Demand, and Connectivity to provide a score for each potential project.

Using a half mile buffer, the Destination measure counts the number of schools, libraries, parks, polling places, and grocery stores in addition to calculating the projected 2045 population and employment densities. The Equity measure calculates the proportion of households with zero vehicles, residents in poverty and minorities within a half mile buffer of a proposed project. Any trip of any mode shorter than five miles in length along the corridor of a proposed project contributes to the score of the Demand measure which uses the StreetLight Data Platform. Connectivity rewards projects on a ten-point or two-point scoring system. For projects traversing city/county boundaries, major barriers, or connecting other existing or proposed bicycle/pedestrian infrastructures at an identified junction/hub, the project receives ten points towards its overall score. If none of the criteria are met, the proposed improvement only receives two points. The final measure entitled "Improvement over Existing Conditions" rewards points for a variety of new potential improvements:

- Ten points – New shared use path, where there is no existing bike/ped infrastructure
- Seven points – New shared use path, where there is any existing bike/ped infrastructure
- Four points – For each new sidewalk or bike lane
- One point – New shared road corridor designation[21]

Conclusion

Following this in-depth review, the City of Charlottesville and the consultant team have a variety of different bicycle and pedestrian prioritization methods to choose from in the development of a new process. The new non-motorized transportation project prioritization process can be tailored to fit the specific needs of the city and be used on an ongoing basis. The step-by-step process will assist in the selection of grant-eligible transportation projects and determine what can be implemented with the City's Operating & Capital Improvement Budget.

19. Rep. Bicycle and Pedestrian Improvement Prioritization Project. Hillsboro, Oregon: Washington County Planning Department. Accessed June 19, 2022. https://www.co.washington.or.us/LUT/Divisions/LongRangePlanning/PlanningPrograms/TransportationPlanning/bikeandped/evaluation-criteria.cfm.
20. ibid.
21. Rep. Jefferson Area Bicycle and Pedestrian Plan. Charlottesville, Virginia: Thomas Jefferson Planning District Commission & Piedmont Environmental Council, 2019. https://tjpdc.org/our-work/bike-and-pedestrian/.

CHOICE OF DATA FOR PRIORITIZATION

CONCEPT

Based on the numerous examples from Chapter 2 and the available data for the City of Charlottesville, it was decided to adopt a hybrid prioritization between local, quantitative and community factors.

This report describes a prioritization process to develope a sidewalk or bikeway for a set of proposed segments. It uses a modified set of the proposed sidewalk and bikeway segments as developed in the Charlottesville 2015 Bicycle and Pedestrian Master Plan as the basic segments to be scored in order to test the validity of the process. The result of this prioritization is presented, however the process is intended to be duplicable by the City for the prioritization of future project lists. The object of this report is to describe the process for producing a sidewalk or bikeway prioritization including factor selection, data gathering, raw scoring, standardized scoring/valuing, and merging of scores to obtain a simple prioritization. It should be noted that the intent of this study was to develop a quantitative prioritization process. The City recognized that there are additional non-quantitative factors that may influence project prioritization such as their repaving schedule or community equity, however these factors are to be considered outside of the process described herein.

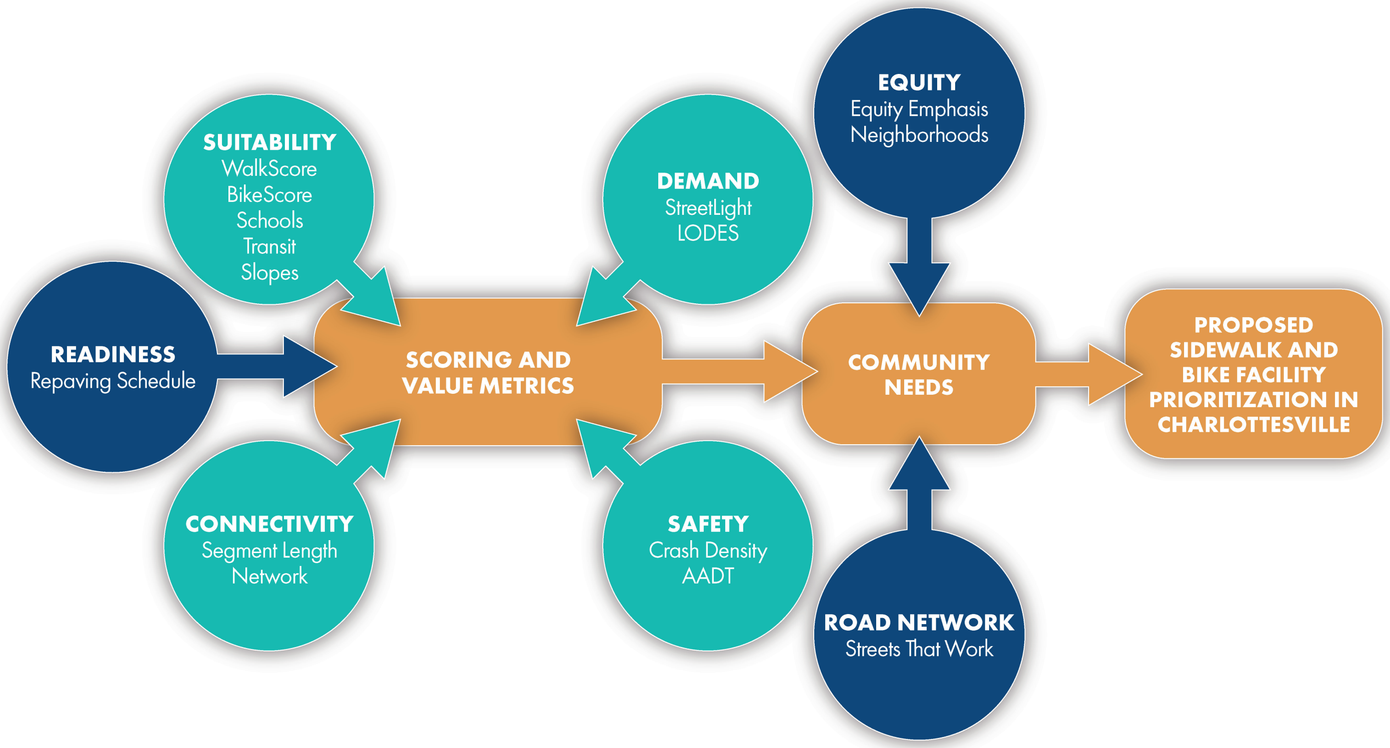
The local repaving schedule for the City of Charlottesville can have a large impact on readiness and scheduling of projects independent of prioritization. If the proposed sidewalk and bikeway program can inform and influence the repaving and reconstruction program within the city, the sidewalk and bikeway network can be expanded as a routine part of road and right of way maintenance.

The qualitative component of the prioritization is the main topic of this report, consisting of four components: Suitability, Demand, Safety, and Connectivity. Suitability includes WalkScore/BikeScore, slope, proximity to schools and proximity to transit stops. Demand includes 2019 StreetLight measures of walking and biking along the proposed sidewalk and bikeway segments, as well as Longitudinal Employer-Household Dynamics Origin. Destination Employment Statistics (LEHD/LODES) from 2019 measure the short distance commutes between adjacent census tracts. Safety includes street density of crashes involving pedestrians or cyclists and Annual Average Daily Traffic (AADT). Connectivity includes a connectivity score and segment length.

The community factors, informing the output of the repaving and quantitative prioritization processes, hands the process back to the City and its communities to balance the output of the prioritization with equity needs and neighborhood apportionments

This hybrid approach was developed in conversation with the City and the OIPI.

Figure 1: Prioritization Process Chart



Repaving Schedule

The annual repaving schedule plays a signifcant role in determining which sidewalk or bikeway segments get rebuilt. This depends on the integration of the non-motorized transportation planning process with repaving design, bidding, and scheduling.

Quantitative Prioritization

For the quantitative prioritization of proposed sidewalk and bikeway segments, it was important to choose diverse topics and measures. Choosing too few metrics would bias the prioritization towards managing only for those few metric. Choosing too many metrics has the risk of prioritizing every segment close to the average, without a clear case for the highest priority segments. Choosing too many metrics also takes more time and effort in data collection, analysis, and scoring.

For these reasons, the prioritization was developed using 10 metrics across four topics. The topics were suitability, demand, safety, and connectivity. These are described in detail below.

Suitability

The suitability of a proposed sidewalk or bikeway segment is a measure of its usefulness as a connection to places that people would want to bike or walk, as well as a route that people would want to walk or bike on. The metrics that comprise Suitability include WalkScore/BikeScore, School Proximity, Transit Proximity and Slope.

- **WalkScore/BikeScore**

WalkScore and BikeScore are proprietary metrics grading the suitability of places for walking or biking, based partially on the block density of places that people would want to walk or bike to, such as shopping or schools. OIPI provides the WalkScore and BikeScore for all blocks in Virginia through the Interact VTrans Map Explorer.

- **School Proximity**

One of the advantages to expanding the sidewalk or bikeway network within Charlottesville is the improvement of opportunities for students to safely travel between home and school. The proposed segments will be graded on how close they are to an elementary school, as elementary students are the most vulnerable and in need of safe routes to school.

- **Transit Stop Proximity**

The sidewalk and bikeway network should connect people's origins and destinations to the existing bus transit network, provided by CAT (Charlottesville Area Transit). This allows multimodal trip making within the City of Charlottesville and can be improved by proposed sidewalk or bikeways that are near stop locations.

- **Slope**

The maximum slope along a proposed segment is a noticeable factor for the usability of proposed sidewalk or bikeway segments in the hilly terrain of Charlottesville.

Demand

The demand topic of proposed sidewalk or bikeway segments is a measure of the existing use of the segments, either on the segments themselves or linking commute origins and destinations. StreetLight and LODES are two data analytics softwares used for producing useful data sets pertaining to the many forms of transportation. An advantage of StreetLight over LODES is that it is more precise and can be used to show pedestrian and cyclist numbers before and after the installation of any proposed facilities. The origins and destinations of pedestrians and cyclists detected by StreetLight are unknown, though they are presumed to be closer to the segment than automotive traffic trips. An advantage of LODES over StreetLight is that it is more accurate, showing short commute trip numbers between home origins and work destinations. Surveyed at the tract geography for all commutes, LODES is not precise by geography or by mode. LODES only suggests the core constituency for short trips within and between adjacent census tracts.

- **StreetLight**

StreetLight data surveys cell phone location and movement to distinguish transportation by mode. By observing movement at average walking speed (three mph) and average biking speed (10 mph), StreetLight develops an index of the non-motorized fraction of movement along each block.

- **LODES**

LODES is available at the tract geography tabulating the number of commutes within and between adjacent tracts. LODES does not indicate the commute mode, but proposes sidewalk or bikeway improvements that connect commutes between residences and workplaces that could divert trips that would otherwise be taken in automobiles.

Safety

The safety of proposed sidewalks and bikeways is primarily measured by their interaction with traffic, which posed the greatest threat to pedestrians and cyclists during their trips.

- **Crash Density**

Proposed sidewalk and bikeway segments will be scored on need based on the incidence of pedestrian- or cyclist-involved collisions with traffic, for the years 2015-2021.

- **AADT**

As pedestrians and cyclists are averse to interacting with vehicular traffic, proposed walkways and bikeways on streets with lower AADT will be prioritized higher than those with higher AADT.

Connectivity

The connectivity topic describes the improvements to non-motorized network connection and extent, and includes variables on network quality and segment length.

- **Network Quality**

It was noted during inspection of the proposed sidewalk and bikeway segments that many segments were not purely new additions to the network, but were partial or full replacements of existing sidewalks and bikeways. It was therefore necessary to develop an index which scored new segments higher than replacement segments. Replacement bikeway segments could be scored higher than new segments, as thier replacement could indicate need for an upgrade with heavy use by cyclists. The data on replacement versus new segments is inculded in the "Charlottesville_Bikeway_Prioritization" Excel spreadsheets provided to the city with the deliverables from this study. As there were many types of bikeways, these also needed to be scored differently based on bikeway type and exposure to traffic.

This network quality metric was carrying several variables, which could have more impact if disaggregated. These factors were initially aggregated into the network quality to account for the differences in data quality between proposed sidewalks and bikeways. Sidewalks did not have different types or qualities, while bikeways did not report planning status of each segment.

- **Segment Length**

Segment length represents the amount that the sidewalk or bikeway can expand the non-motorized network. It is included as a standalone metric of network expansion.

Community Involvement

Neighborhoods

Charlottesville's 19 neighborhoods are diverse in character and needs, and must be balanced with the outcomes of the quantitative prioritization.

Equity Access

The available data on equity access needs for the City of Charlottesville is at the block group scale, which the community has indicated is too coarse a scale to understand the landscape of poverty, linguistic isolation, and need in the City of Charlottesville. The block group data on equity access was therefore not included in the quantitative prioritization. The City agreed that equity access as it relates to non-motorized transportation should be addressed by Charlottesville separately from the GAP-TA effort.

METHOD AND MEASURE DEVELOPMENT

INTRODUCTION

Prioritization of new sidewalk or bikeway infrastructure is based on where it would provide the most benefit. The benefit is not just measured on one attribute, like suitability, demand, safety, connectivity, readiness, or equity. The prioritization needs to balance all those attributes in a quantifiable and repeatable way. Prioritization of the proposed expansions to the sidewalk and bikeway network had to be related to the existing conditions within the City of Charlottesville.

STEP 1: GATHER DATA

Existing Sidewalks

Existing Sidewalk polygons were downloaded from the Charlottesville City GIS at https://gisweb.charlottesville.org/GisViewer/, found under Transportation.

Existing Bikeways

Existing Bike Lanes were downloaded from the Charlottesville City GIS at https://gisweb.charlottesville.org/GisViewer/, found under Transportation.

Proposed Sidewalks

Proposed Sidewalks for consideration in this prioritization were the result of the 2015 "Bicycle and Pedestrian Master Plan" and were provided by City staff.

Proposed Bikeways

Proposed Bikeways for consideration in this prioritization were the result of the 2015 "Bicycle and Pedestrian Master Plan" and were provided by City staff.

WalkScore/BikeScore

OIPI provides WalkScore, BikeScore, and Transit Score at the block resolution available via the Interact VTrans Map Explorer at https://vtrans.org/interactvtrans/map-explorer. This data is listed under Performance Measures and Indices at the VTrans Map Explorer Site. This data is updated quarterly based on changes in land use and trip destination density.

This feature layer displays analysis provided by www.walkscore.com at the census block level. WalkScore measures the walkability of any address using a patented system. Each block is scored based on its availability of amenities, such as errand and amenity destinations and block lengths. WalkScore and BikeScore are calculated differently based on the differing speeds and needs of pedestrians and cyclists. Each block in the City of Charlottesville is assigned a different WalkScore or BikeScore between 0 and 99, based on the destination density within and around that block and its network geometry, with 99 being the most walkable or bikeable blocks. More details of the WalkScore methodology can be found at https://www.walkscore.com/methodology.shtml. More details of the BikeScore methodology can be found at https://www.walkscore.com/bike-score-methodology.shtml .

School Locations

Public elementary school locations were considered instead of all school locations as elementary school students are the most likely to benefit from a safer network of sidewalks and bikeways, not only for their personal use, but also from the potential reduction in traffic volumes by car owners who are able to use walk or bike instead of using a personal vehicle. Elementary school locations were chosen instead of all public school locations to limit the points for proximity consideration for model clarity.

The locations of schools, including elementary schools, was not provided by the city. Elementary school locations in Charlottesville are available from Google Earth (https://www.google.com/earth/) by searching for "elementary schools in Charlottesville, VA". The first results were the public elementary schools in Charlottesville, though deeper searches of more results would have provided locations for private, charter and parochial schools. Nine elementary school locations were identified for the analysis of proposed sidewalk or bikeway suitability. The locations of the schools were current as of 2022. These locations and the data change rarely, only when a elementary school location is moved by the city.

Transit Stop Locations

Transit Stop locations along local CAT bus routes as of 2022 were downloaded from the Charlottesville City GIS at https://gisweb.charlottesville.org/GisViewer/, found under Transportation. The dataset is updated rarely, only when the bus service provider changes their routes or stop locations.

On request, the Charlottesville Area Transit (CAT) agency also provided proprietary data on transit stop daily passenger boarding and alighting at each CAT bus stop, and the city transmitted that data to the project team to weight the prioritization near different bus stops based on the number of passengers boarding or alighting at each stop.

Segment Slope

A two-foot contour layer, surveyed in 2018, was available from Charlottesville City GIS at https://gisweb.charlottesville.org/GisViewer/under Topography. The dataset is updated rarely, as elevation is not likely to change significantly within the developed City of Charlottesville.

StreetLight Movement Data

StreetLight data was available from the commercial provider under license to VDOT and OIPI. StreetLight data on average daily cyclist and pedestrian movements in 2019 was used for this study. The dataset is updated monthly.

LODES Commute Data

LODES data on commute volumes between tracts current as of 2019 was available from the LEHD/LODES OnTheMap site at https://onthemap.ces.census.gov/. The dataset is updated annually.

Crashes

Pedestrian- and cyclist-involved crash location data for the 2016-2021 period was available at the Interact VTrans Map Explorer at https://vtrans.org/interactvtrans/map-explorer, under Roadway Characteristics. Crash data that involves motor vehicles striking or injuring either cyclists or pedestrians was available as a point file and was downloaded for the 2015-2021 period. The dataset is updated annually.

AADT

Roadway Characteristics from 2020, including Annual Average Daily Traffic (AADT) numbers for all arterials, most collectors and a few local roads, was available from Interact VTrans Map Explorer at https://vtrans.org/interactvtrans/map-explorer, under Roadway Characteristics. The AADT data does not include numbers for most local roads. The dataset is updated annually.

Network Quality

Network quality includes the connectivity of proposed non-motorized segments with their existing networks, as well as indications of proposed segment quality and block completion.

STEP 2: ALIGN SEGMENTATION TO LINEAR REFERENCING SYSTEM (LRS)

To relate the proposed sidewalk and bikeway data to polygon data, like WalkScore/BikeScore or LODES, or to centerline data, like network or AADT, it is necessary that the proposed data be aligned with the same street centerlines and block boundaries used in those datasets. In the case of proposed sidewalk data, and the existing sidewalk and bikeway data, the shapefiles provided by the City of Charlottesville were geographically aligned with the edges of roadways, not the centerlines. The proposed bikeway data was provided as centerline data, so only the proposed sidewalk data had to be aligned to roadway centerlines.

This was necessary for the existing and proposed sidewalks. The existing sidewalk data from Charlottesville was provided only as detailed polygons locating them specifically in the streetscape. There were no line features showing the extent of existing sidewalks. The proposed sidewalk line features for the prioritization were provided as a line feature. That line feature, like the existing sidewalk geography, was geographically specific and not aligned to the street centerlines. If a sidewalk improvement was proposed for both sides of the street, it was represented as a single line with a crossing at one end of the block.

PROCESS:

To associate the existing and proposed sidewalk features with street centerlines, use the following procedures:

Step 1: Inspect the attributes of the existing sidewalks/bikeways or proposed sidewalks features to ensure that their street names are identical to the nearest LRS Street centerline feature. Either create a new field in the sidewalk features to match to the LRS or edit the Street names field in the sidewalk features to match the LRS street names. Do not edit the LRS street names.

Step 2: Buffer the existing sidewalks/bikeways or proposed sidewalk by enough distance to overlap the LRS centerlines. In the case of Charlottesville streets, a buffer distance of 80 feet was sufficient to intersect sidewalk features with LRS centerlines. It is important to avoid the buffers from adjacent blocks overlapping. Charlottesville's minimum block length was 180 feet, so an 80' buffer was the maximum usable buffer distance.

Step 3: Intersect the buffered sidewalk or bikeway features with the LRS features for the City. The resulting feature will be a line feature including all the LRS line features that fall within the buffer from Step two.

Step 4: In the new intersected coverage created in Step three, select "Select By Attributes" for all items where the street names match for the sidewalk feature and the LRS feature. This will exclude all street centerlines that do not have the same name as the LRS street centerline. If the name matching from Step one was complete, then the selected features from this set should be aligned to the LRS.

Step 5: Export the selected line features from Step four to a new line feature that will contain the attributes for the sidewalk or bikeway and the LRS, associated with line features on the LRS centerlines.

Step 6 Use the GIS "dissolve" function to reunify each center lined sidewalk or bikeway coverage into distinct records. Select the same fields as the original sidewalk or bikeway attribute table for the dissolve. Because some proposed segments in the Charlottesville Sidewalk plan have multiple parts along multiple blocks, leave "Create Multipart Features" checked. The resulting dissolved coverage should have as many records as the original coverages. There are 120 proposed sidewalk segments and 96 proposed bikeway segments being considered in the study.

STEP 3: GENERATE RAW SCORES FOR SIDEWALK AND BIKEWAY SEGMENTS

Note that the maps shown in this section are showing the scored/ranked data on Charlottesville Streets, not the raw data. This section describes the application of raw data to the proposed sidewalks or bikeways, but the conversion of this data into standardized scores/values is described in the next section.

Suitability

WalkScore/BikeScore

To calculate the average WalkScore for a proposed sidewalk segment, or the average BikeScore for a bikeway segment, it is necessary to use the centerline-projected sidewalks line feature or proposed bikeway layer. To intersect the proposed sidewalk and bikeway line features with the WalkScore or BikeScore polygonal features.

Process:

To associate the proposed sidewalk and bikeway features with WalkScore/BikeScore feature, use the following procedure:

Step 1: Ensure that each proposed sidewalk or bikeway feature has a unique index in its attributes and note which field in the attributes carries this index. This will be needed in Step eight.

Step 2: Buffer the centerline versions of the proposed sidewalk by a nominal distance, such as 10 feet. Use flat, not rounded buffer ends and do not dissolve features.

Step 3: Add a field for segment area and calculate the area to that field in square feet. This will provide the total area of the buffered proposed segment.

Step 4: Intersect the buffered proposed segments with the WalkScore or BikeScore polygon feature. This will produce a polygon feature with the same polygons as produced in Step two, but with the WalkScore or BikeScore attributes associated with it.

Step 5: Add a field for shape area to the intersected polygon feature from Step four and calculate the area to that field in square feet. This will provide several areas with different WalkScores or BikeScores on either side of the centerline along the length of the proposed sidewalk or bikeway segment.

Step 6: Add a field for segment weight as a ratio of the WalkScore-BikeScore areas from Step five and the overall segment area from Step three. This should produce a value between 0 and one.

Step 7: Add a field for weighted score and calculate it as the product of the WalkScore or BikeScore and the weight field from Step six above.

Step 8: Dissolve the buffered intersected polygon coverage from Step three with attributes modified in Steps five, six, and seven. Use the index field and the street name as the dissolve fields. In the dissolve statistics, sum the weighted score from Step seven. Allow multipart features, as some proposed bikeway or sidewalk features are not continuous.

Step 9: Join the attribute table from the dissolved layer in Step eight to the proposed sidewalk or bikeway centerline features, using the index field for the join.

Step 10: Export the line feature with joined attributes to include the weighted average WalkScore or BikeScore in the attributes of the proposed sidewalk or bikeway centerlines. This will produce the raw WalkScore/BikeScore results for proposed sidewalk or bikeway segments.

Figure 2: Proposed Sidewalks: WalkScore

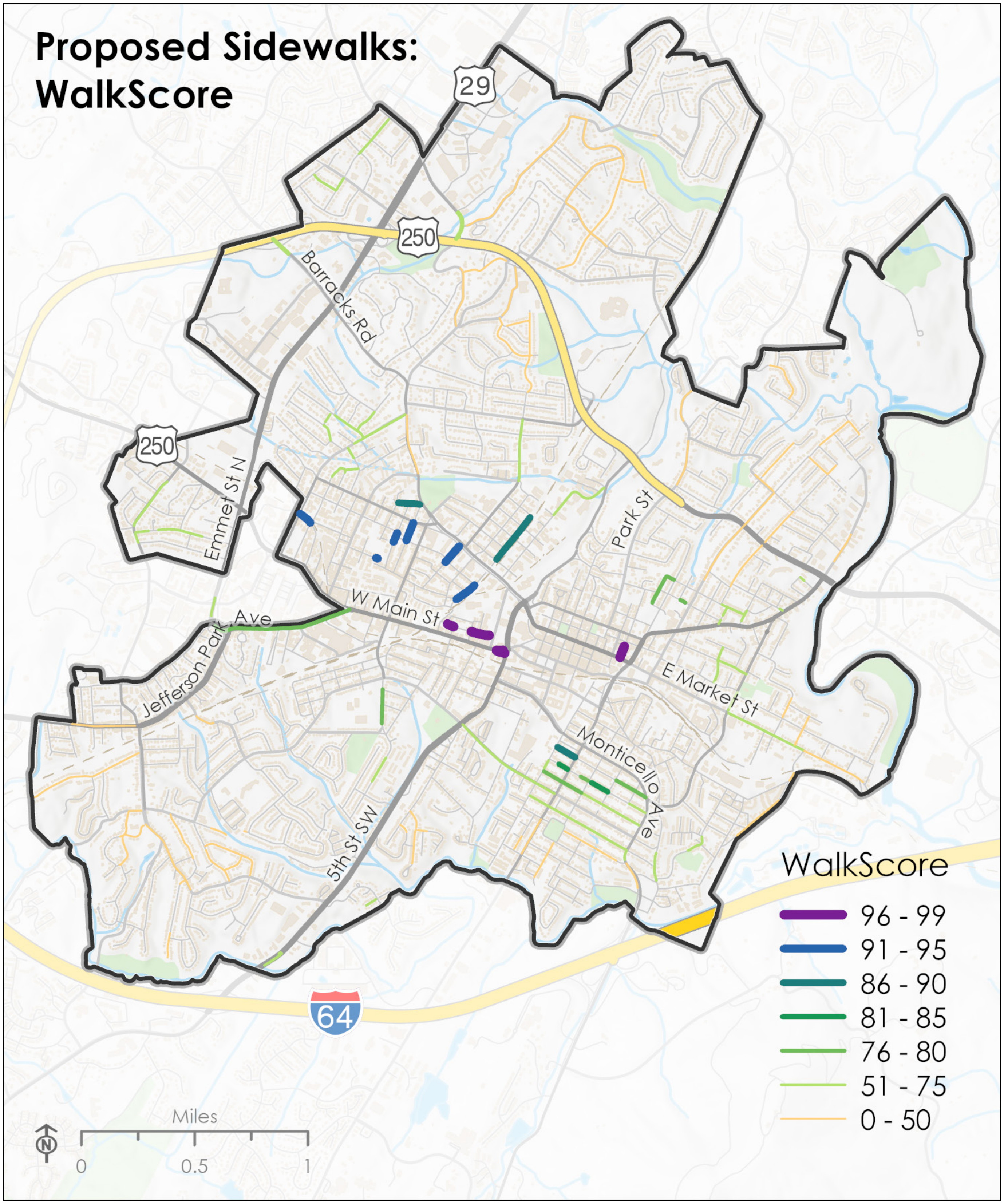
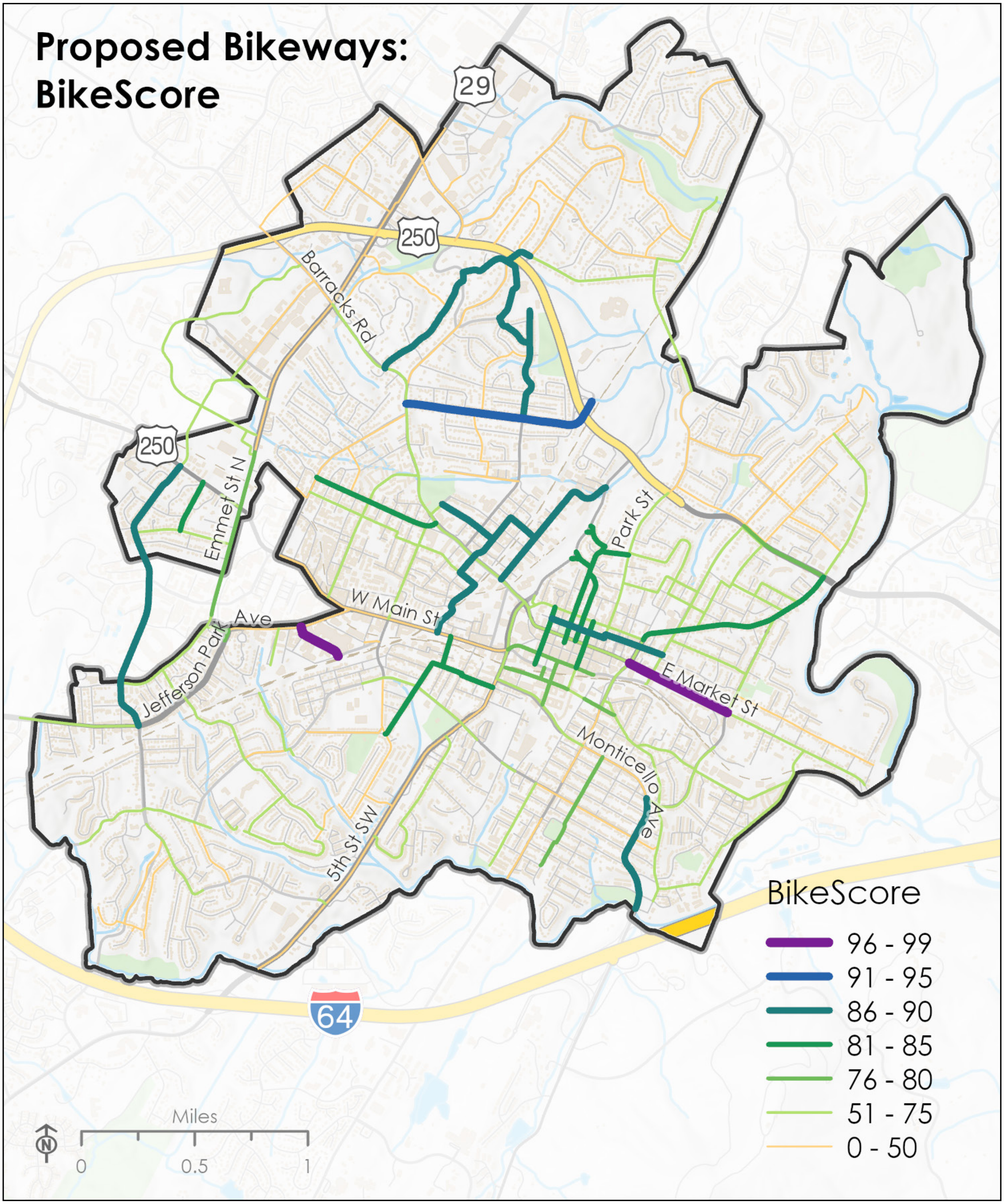


Figure 3: Proposed Bikeways: BikeScore



School Proximity

Process:
To associate the proposed sidewalk and bikeway features with proximity to schools, use the following procedure:

Step 1: Use the GIS "Near" function to populate the attribute table with the minimum distance between the elementary school center-points and each proposed sidewalk or bikeway feature.

Figure 4: Proposed Sidewalks: Distance to Elementary Schools

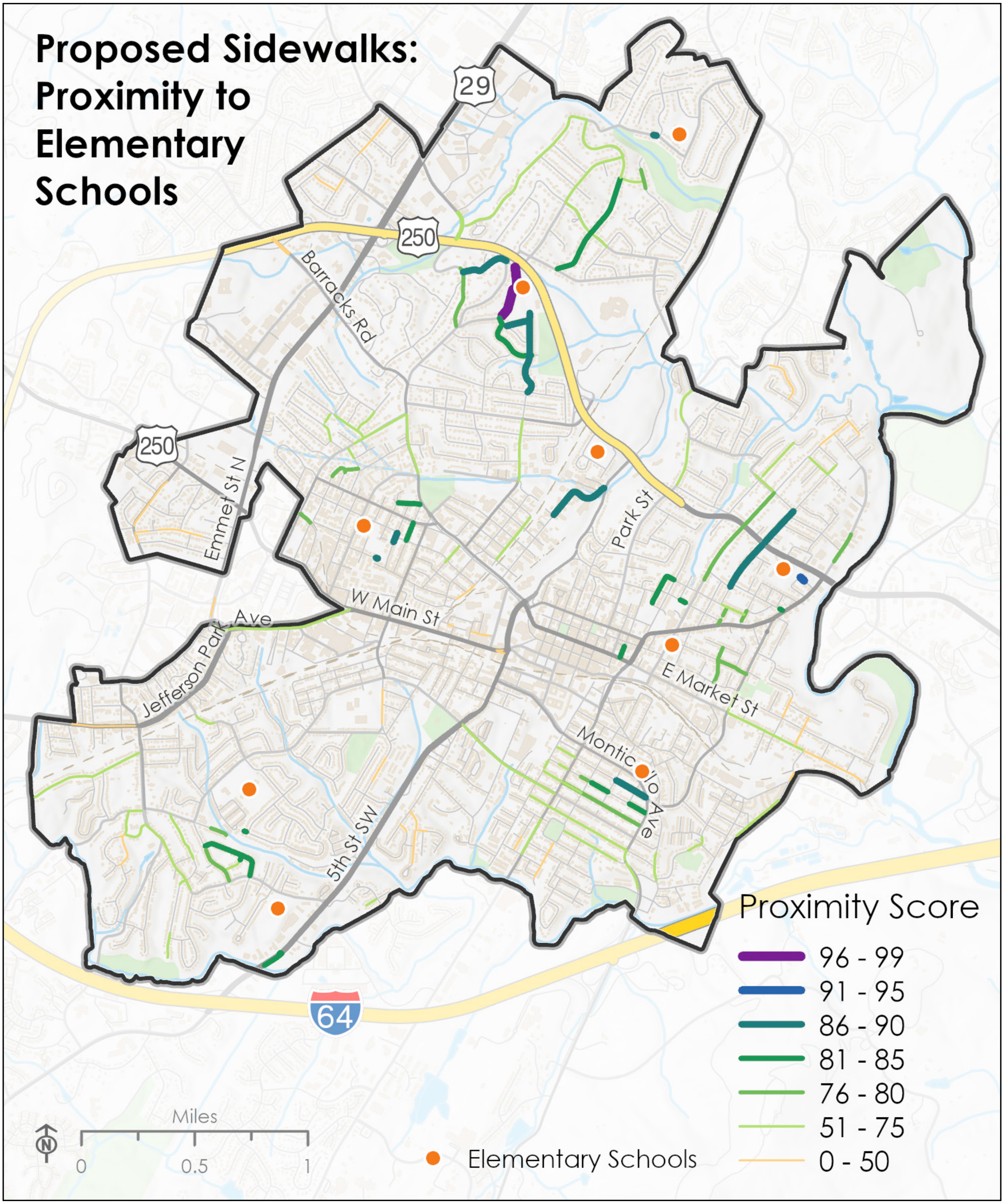
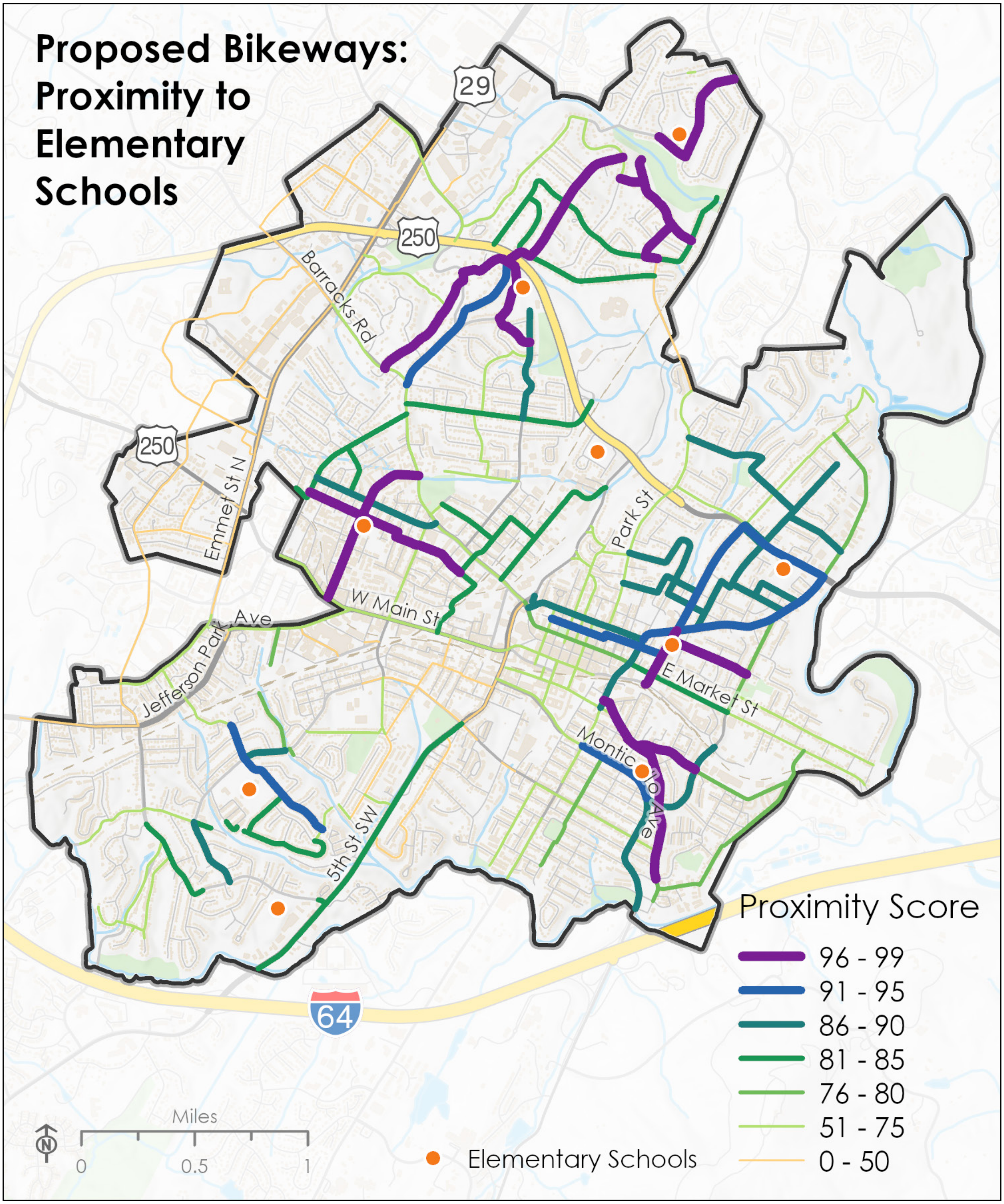


Figure 5: Proposed Bikeways: Distance to Elementary Schools



Transit Proximity

CAT bus stop locations, like elementary schools, are a point feature of specific locations. The GIS "Near" function provides the best measure of proposed sidewalk or bikeway segment proximity and service to bus stop locations. Smaller "near" scores are preferable to larger, as they indicate shorter distances between proposed sidewalks or bikeways and existing transit stops and service. There are many more transit stop locations than school locations, so most proposed sidewalk or bikeway segments are near a bus stop. A valuation, rather than a numeric score, was used for transit stop proximity to account for the uneven distribution of GIS "near" results.

Process:
To associate the proposed sidewalk and bikeway features with proximity to transit stops, use the following procedure:

Step 1: Use the "near" function to populate the attribute table with the minimum distance between the transit stop locations and each proposed sidewalk or bikeway feature.

Weighting by Transit Stop Activity

The City of Charlottesville provided daily average passenger boarding and alighting numbers for each stop in 2019. The GIS "buffer" function is used to define a circular area of influence around each transit stop based on its relative overall passenger service (boardings + alighting). This weighted circular buffer is used instead of the transit stop point locations in the near function for proposed sidewalks and bikeways. Where the circular "buffer" polygons intersect proposed sidewalks or bikeways, the "near" function will return zero. It was necessary to choose the scale of the circular buffers based on the data, as one stop in the CAT transit network serves many more passengers than all others.

Process:
If transit stop activity numbers are available, use the following modified procedure to weight transit stop activity and proximity to proposed sidewalk and bikeway features instead:

Step 1: Join the transit stop activity data to the transit stop locations

Step 2: Use the GIS "buffer" function to generate a circular polygon around each transit stop point, based on the joined activity data. It may be necessary to divide the transit activity numbers from Step one by a constant, such as two, five, or eight, to produce a buffer that is appropriately scaled for the study area.

Step 3: Use the GIS "near" function to populate the attribute table with the minimum distance between the activity-weighted transit stop buffers and each proposed sidewalk or bikeway feature. Where the proposed sidewalk or bikeway features intersect the weighted circles, the near function will return a value of 0.

Figure 6: Proposed Sidewalks: Distance to Transit Stops

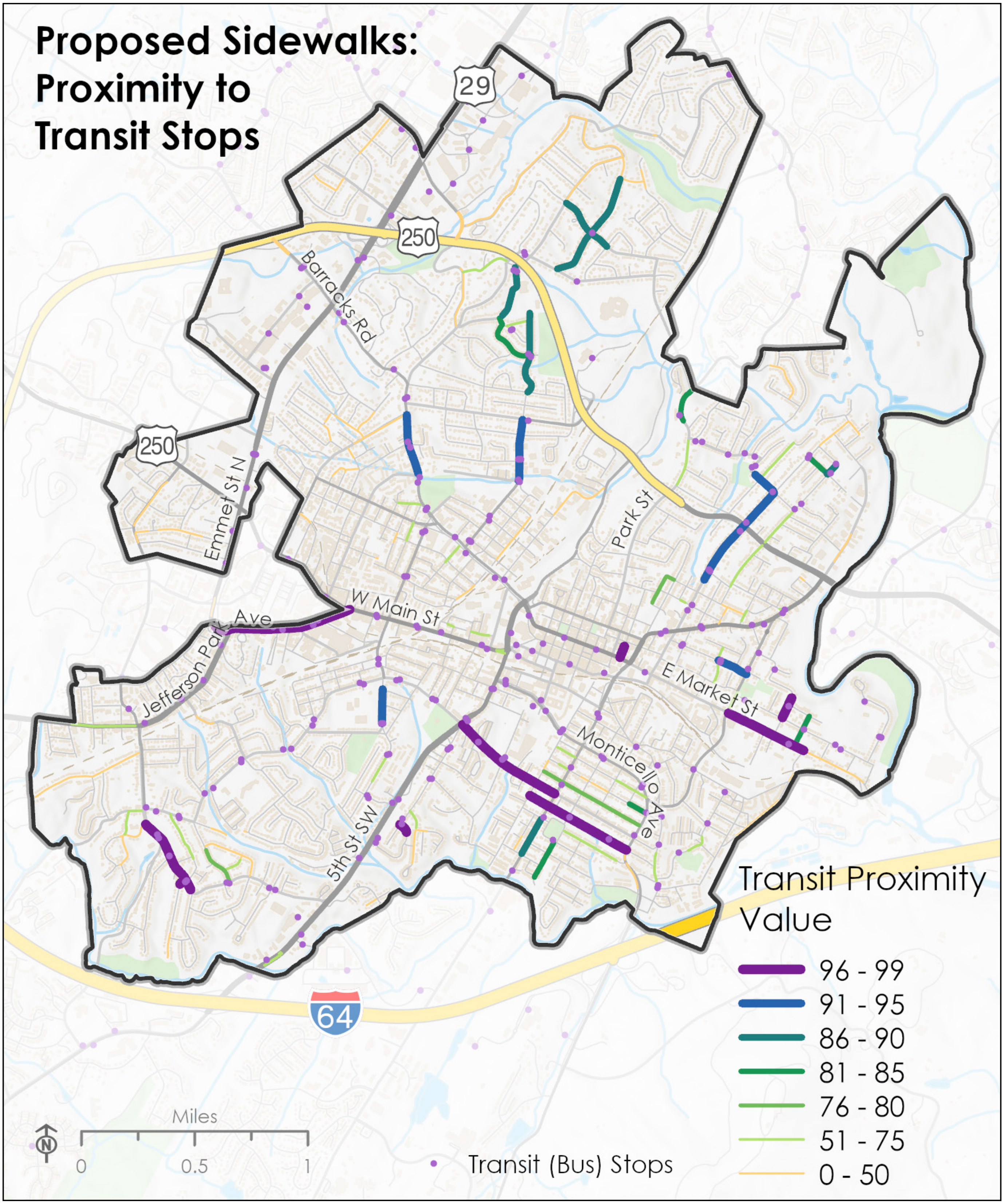
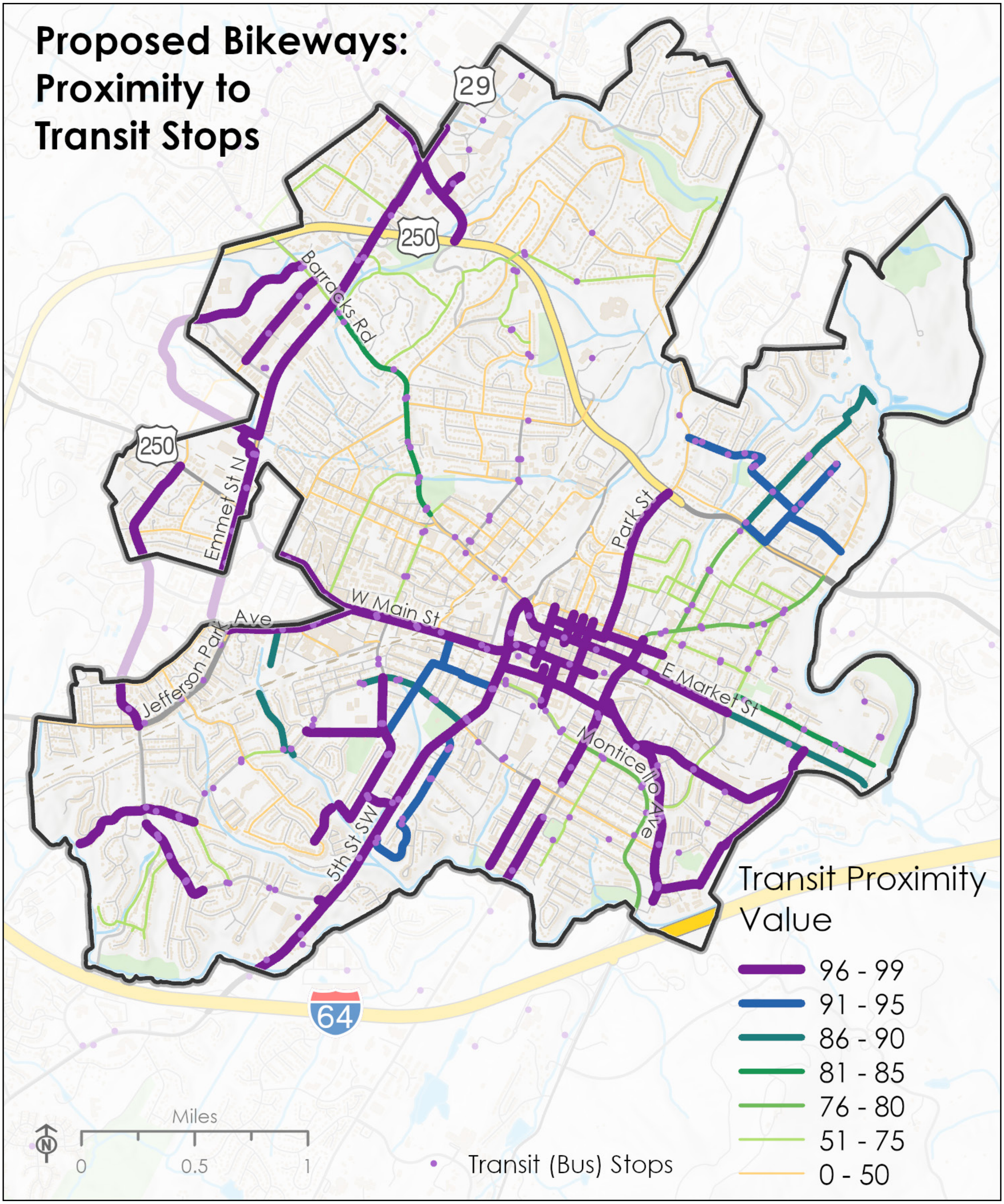


Figure 7: Proposed Bikeways: Proximity to Transit Stops



Segment Slope

Process:
To associate the proposed sidewalk and bikeway features with maximum slope experienced over 150 feet, use the following procedure:

Step 1: Use the GIS "topo to raster" function to convert the contour shapefile to a raster with elevation data for each cell value. For the contour layer, set the field to the elevation field of the slope data and the data type to contour. Topo to raster accepts several other types of elevation inputs, in case a contour shapefile is not available for your study area. Set the cell size of your desired resolution. For Charlottesville, a cell size of 50 feet worked best.

Step 2: Use the GIS "buffer" function to create a clip polygon for the raster around all the road centerlines in the study area. In the case of the Charlottesville study area, a clip radius of 100 feet was necessary to capture enough elevation information from the elevation raster. A 100-foot buffer polygon completely covered the area of the small blocks of downtown, but most of the streets in Charlottesville were surrounded by 200-foot wide polygons.

Step 3: Use the GIS "extract by mask" function to clip the elevation raster from Step one to the buffered polygon extent from Step two. This will generate a new raster with only cells along the road centerlines for the study area. This is to enforce measurement of slopes along the street centerline and minimize the measurement of cross slopes that a pedestrian or cyclist would not experience on existing or proposed sidewalks or bikeways.

Step 4: Use the GIS "Slope" function in GIS to generate a slope raster from the clipped elevation raster.

Step 5: Use the GIS "Add Surface Information" function in GIS to assign the maximum and average slopes to each proposed sidewalk and bikeway segment. This will alter the attribute table of the proposed segment features to indicate the maximum slope endured by pedestrians or cyclists on the proposed infrastructure.

Figure 8: Proposed Sidewalks: Slope

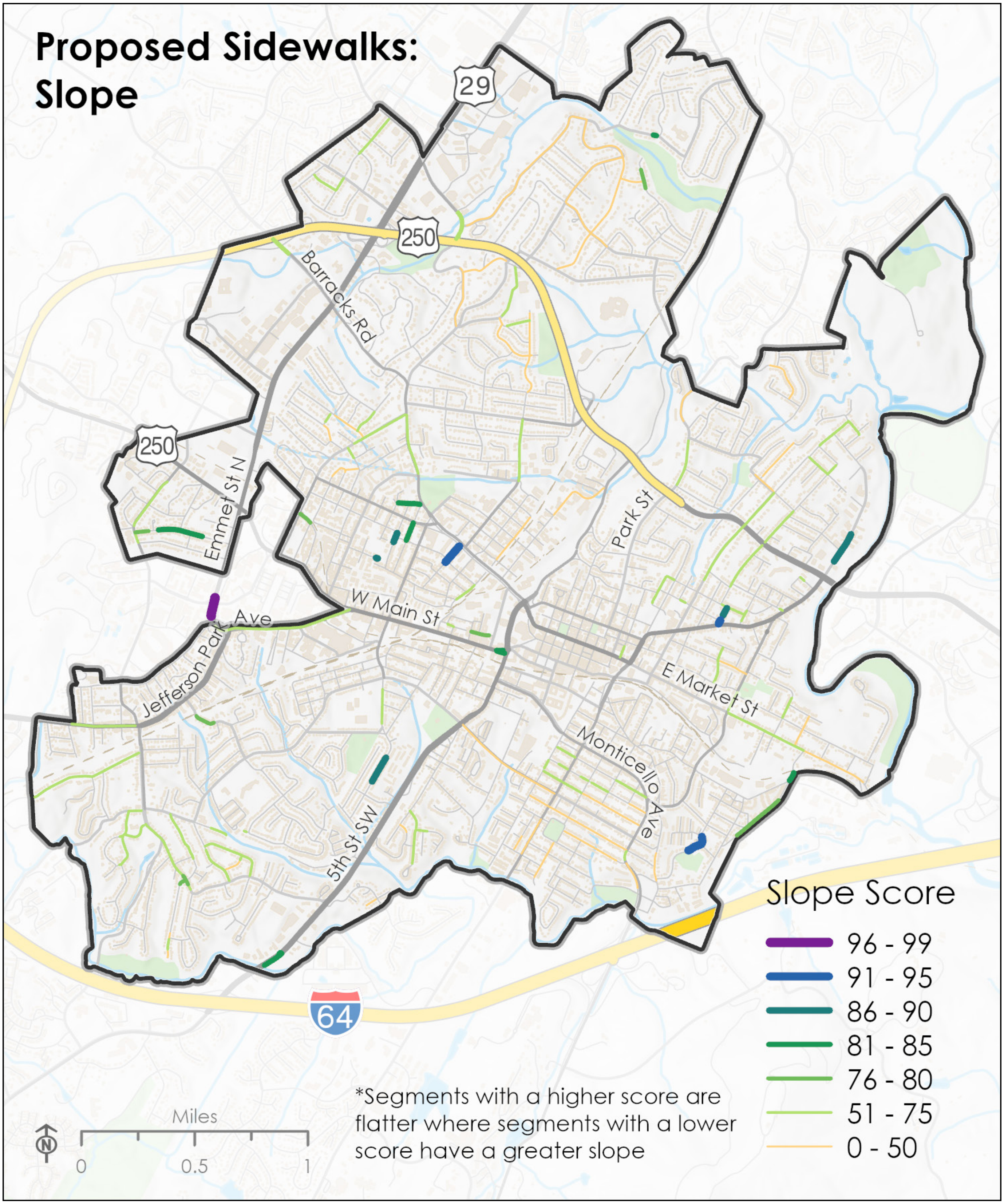
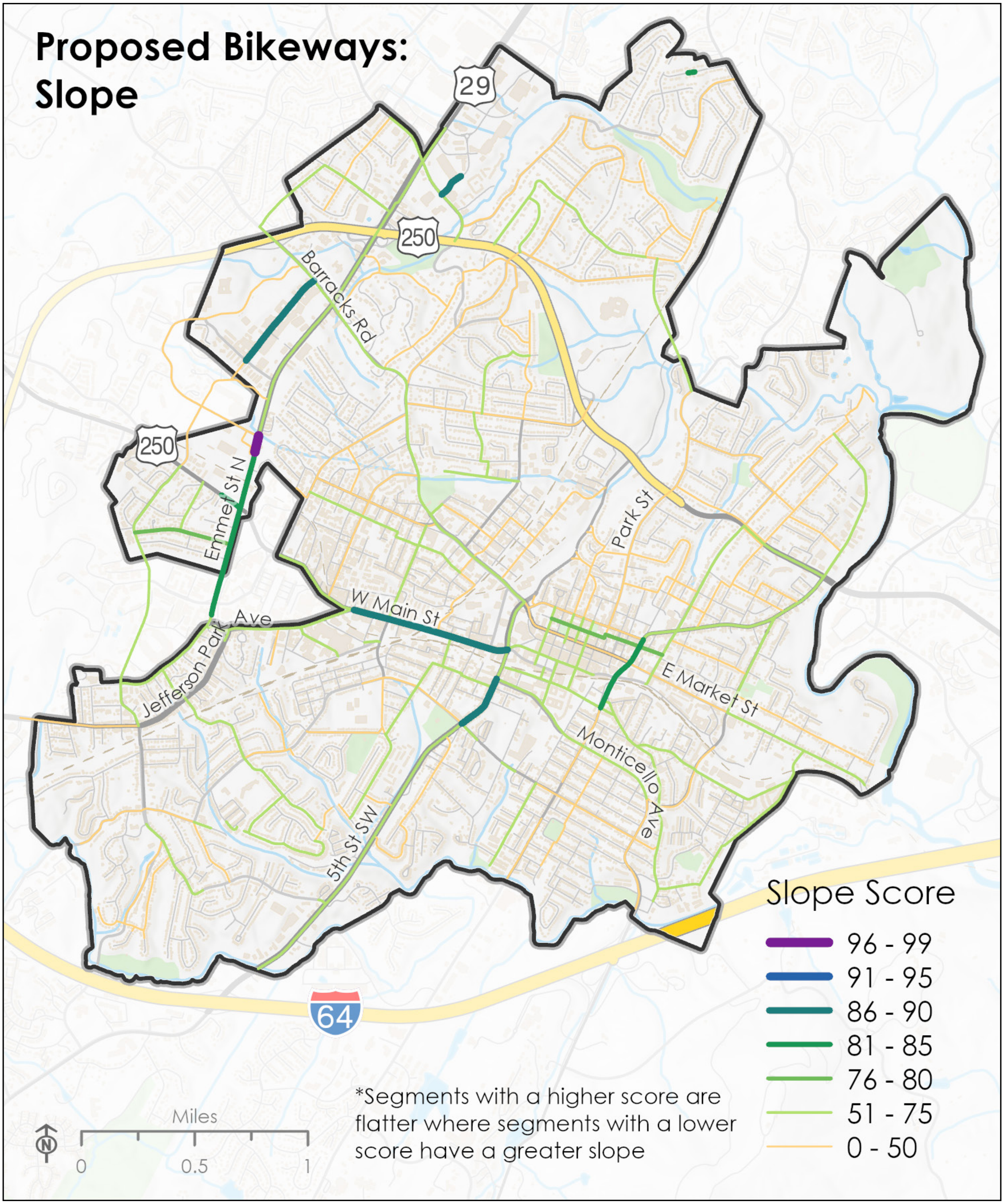


Figure 9: Proposed Bikeways: Slope



Demand

StreetLight Movement Data

StreetLight data is used in this prioritization to define the existing (c. 2019) walking and biking volumes on the proposed sidewalk and bikeway segments. The pedestrians and cyclists who already use the routes potentially served by the proposed segments are the most likely to benefit from infrastructure investments on their routes. To measure the volumes along proposed segments, define midpoints along each segment and measure the daily walking and biking numbers passing through that midpoint gate.

Process:

To measure walking and biking traffic volumes along proposed sidewalk and bikeway segments using StreetLight, use the following procedures:

Step 1: In GIS, use the "Buffer" function to define a polygon offset from the proposed sidewalk or bikeway segments. For segments with several separate parts, this buffer function will define several separate polygons.Be sure to choose a buffer distance that is large enough to capture existing sidewalks and bikeways, but not so large that it overlaps. For this study of Charlottesville the buffer distance is 50 feet. Select the "Square End" option, not "rounded".

Step 2: Use the GIS "Polygon to Line" function on the buffer from Step one. "Preserve features" at all steps, to ensure that the line features remain associated with their proposed sidewalk and bikeway segment centerlines.

Step 3: Use the GIS "Split Line at Vertices" function to further decompose the buffer elements from Step one.

Step 4: In the line feature generated in Step three, select all features with a length twice the buffer length. In the case of Charlottesville this length would by 2 x 50 = 100 feet.

Step 5: Carefully inspect the selection to ensure that no lines parallel to proposed sidewalk or bikeway segments were selected. This is particularly important for shorter sidewalk segments.

Step 6: Delete the selection made in Step four and checked in Step five, leaving only offset lines for every proposed sidewalk or bikeway centerline.

Step 7: Use the GIS "Feature Vertices to Points" function with the "MID" option to create a point feature with the midpoints for the offset lines. These points should still have the attributes for the proposed centerline files associate with the offsets.

Step 8: Use the GIS "Points to Line" function on the offset midpoint feature from Step seven to connect the offset midpoints with a line perpendicular to the proposed centerlines. Use the attribute of the points in the "Line Field" to ensure that separate lines are created across every proposed centerline.

Step 9: Use the GIS "buffer" function on the perpendicular line feature from Step eight to produce a polygon with width along each segment to survey walking and biking volumes. For Charlottesville, a buffer radius of five feet is used.

Step 10: Import the resulting midpoint "fence" polygon feature from Step 9 into StreetLight.

Step 11: Use the midpoint fence feature from Step 9 to measure pedestrian or cyclist numbers using each segment or segment part on an average day.

Step 12: To calculate the raw StreetLight score for segments use the midpoint volumes of the StreetLight surveys as described in Step seven. For proposed segments with several parts, calculate the average volume of the component segments weighted by the length of each segment part.

Figure 10: Proposed Non-Motorized Segments Example

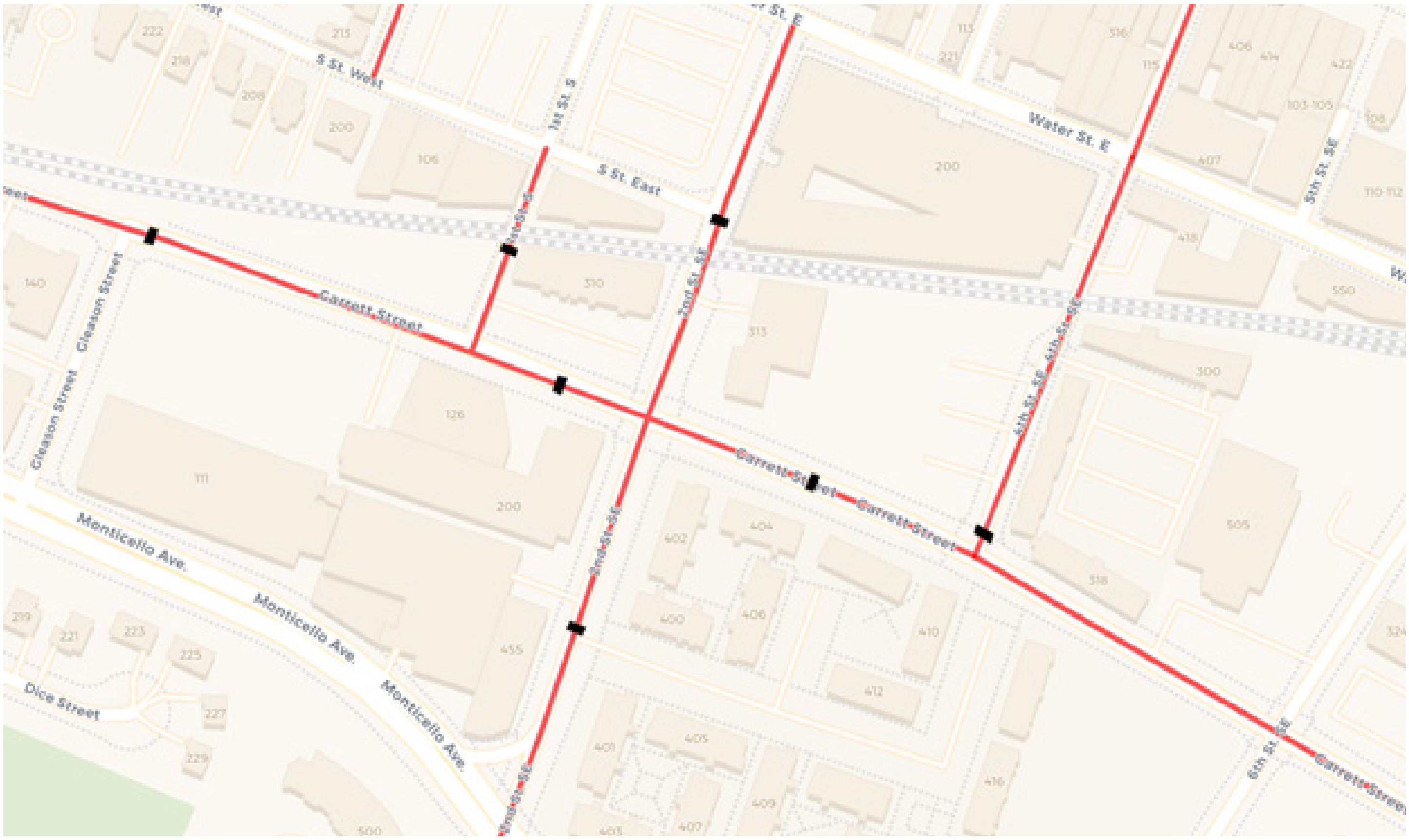


Figure 11: Proposed Sidewalks: Daily Walking Trips (StreetLight)

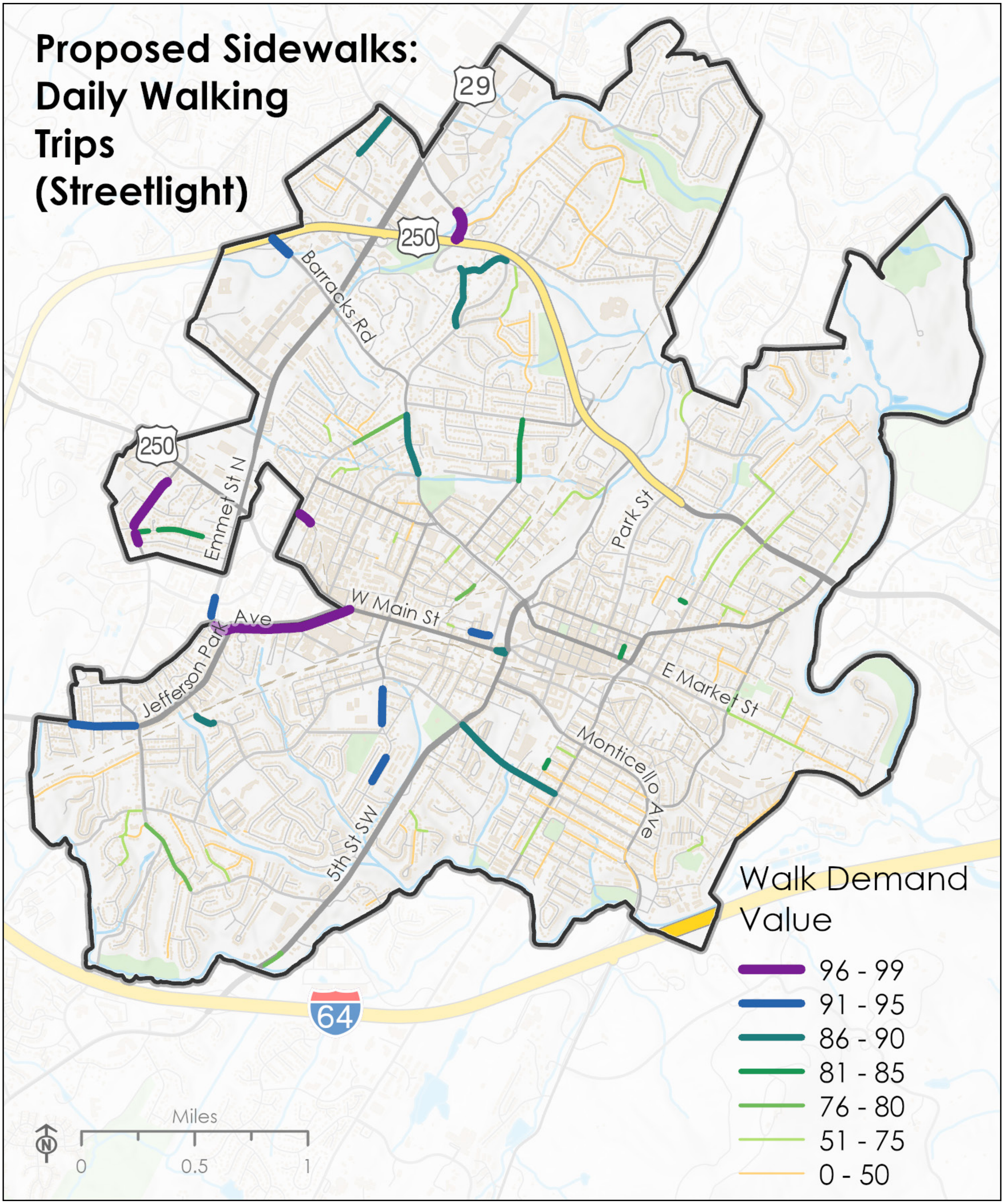
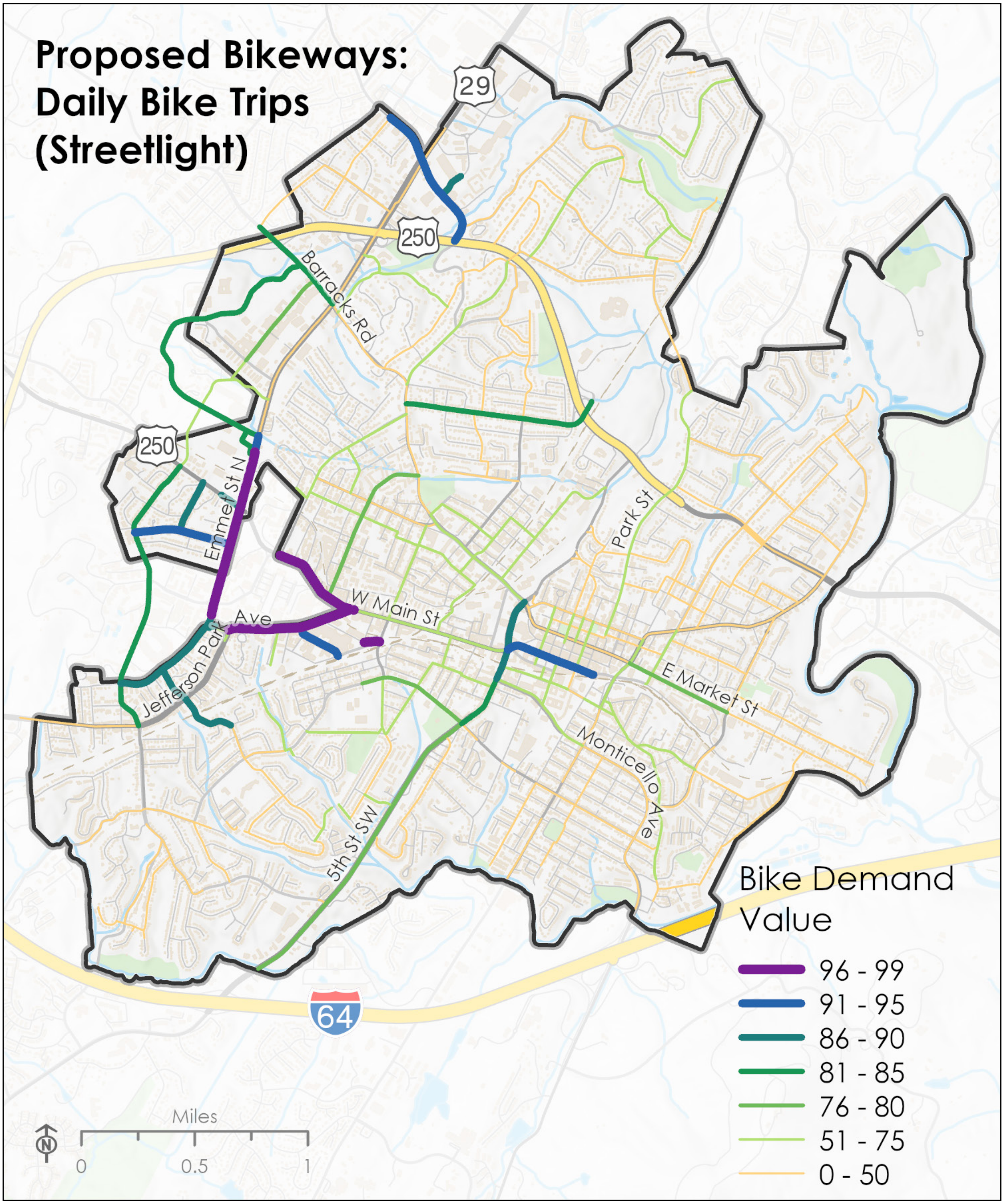


Figure 12: Proposed Bikeways: Daily Bike Trips (StreetLight)



LODES Commute Data

LODES provides information about home to work commute origins and destinations. It does not provide information on the mode of the commute and does not provide finer destination geography than tract geography. LEHD does provide commute numbers at the tract geography but requires judgment to be made about which blocks to include in the proposed sphere of influence for each walkway or bikeway.

The goal is to understand the number of commute trips to adjacent census tracts. The average radius of the tracts (0.75 miles) in the Charlottesville are similar to 20-minute average trip distances of walk (one mile) or bike trips (three miles). The commute is a foundational trip type because residents need to make the trip from their homes to their workplaces to earn a living. Even with the recent increase of working from home, specific land uses such as businesses, offices, and manufacturing centers are still significant work destinations. The workplace is still a place for work and is not yet replaced by working from home.

Process:
To associate the proposed sidewalk and bikeway features with commute potential for short trips using LODES, use the following procedure:

Step 1: Use the Commute Destination in the OnTheMap tool (https://onthemap.ces.census.gov/) to get a list of origins and destinations for all tracts within the study area. In Charlottesville there were 12 census tracts reporting their commute numbers for the 2019 reporting year, using geography updated in 2010. Download this list of origins and destinations from both home (Work Destination) and work (Home Destination), at the tract geography, to other tracts in the study area. Under "Number of Results", select "all" to avoid missing rare commutes within the study area. Export a detailed report to XLS format for each destination analysis for import into Excel.

For each Destination query, the Destination type should be set to "Census Tracts" as those are the smallest geography available for LODES OnTheMap queries, and they are also universally available for the United States.

For every census tract in the study area, use LODES OntheMap at https://onthemap.ces.census.gov/ to perform a destination query for all workers for home- and work-based commutes. As there are 12 census tracts in the City of Charlottesville LODES OntheMap will need to be queried 24 times, once each for home-based trips and work-based trips.

Select "All Jobs" as Job Type, 2019 (or the latest year available).

After performing each query, LODES OntheMap should display a color-coded map showing darker blues for higher commute numbers. Better numbers are needed, however. Under Display settings, to the left of the screen, for Number of Results, select "All". Under Report/Map Outputs, select Detailed Report. On the resulting popup, select "Export to XLS" at the top of the Popup window. The full listing of destinations will download to your computer, with a "otm_" prefix and several randomly assigned digits. For each download, rename the file to indicate which tract it is for, and whether it is home-based or work-based.

It is important to rename the downloaded LODES Excel files to indicate what tract they show and whether they show work-destination commutes or home-destination commutes, because the Detailed Reports from LODES do not indicate the tract number anywhere in the body of the XLSX.

Step 2: After saving and renaming all the destination reports for the tracts in your study area, open each one in Excel.

Step 3: Within each home-based or work-based commute report, select only the commutes to or from the tracts in the study area.

Step 4: Build a table of home-based and work-based commutes of all the tracts in the study area. For proposed sidewalks and bikeways, both commute origins are of interest to measure the potential demand for a new sidewalk or bikeway. This table needs to link the commute numbers for each tract in the study area to a Federal Information Processing Standard (FIPS) code, not the descriptions provided by LODES in Step one.

Step 5: Using the FIPS code as a common field, join the commute volume table from Step four to a tract GIS coverage. The 2019 data for Charlottesville is joined to a 2010 tract geography.

Step 6: Inspect the joined geography from Step four to identify the commute volumes from, to, and within each tract in the study area. Select and calculate these in the attribute table in new fields. The object is to produce a smaller set only of all the short commutes between neighboring tracts.

Step 7: The short commute score for each tract is the sum of commutes to, form, and within each tract, only for its neighbors.

Step 8: The raw commute score for each proposed sidewalk or bikeway is the sum of to- and from- commutes between tracts, as well as the commutes within tracts, for all tracts intersected by the proposed sidewalks or bikeways.

Use the GIS "Polygon to Line" function to develop a tract boundary coverage with the commutes between neighboring tracts in the attribute tables.

Step 9: To get the raw LODES commute numbers for each proposed sidewalk or bikeway segment, use the GIS "Intersect" function with the proposed sidewalk and bikeway segments and the GIS polygon feature of commutes within each tract and the GIS line feature of commutes between each neighboring tract to assign commute volumes to the proposed non-motorized segments.

Figure 13: Proposed Sidewalks: Daily Walking Commutes (LODES)

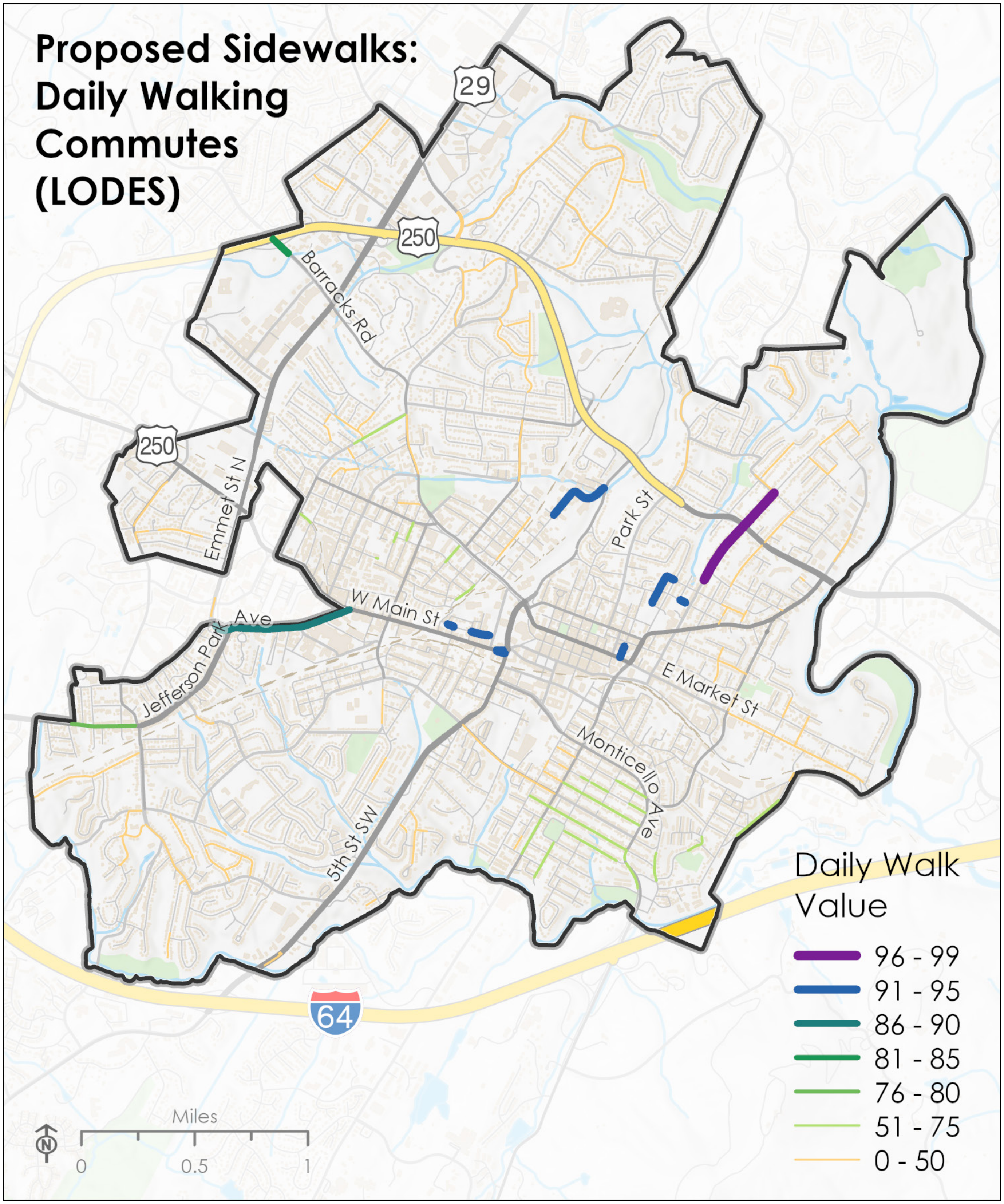
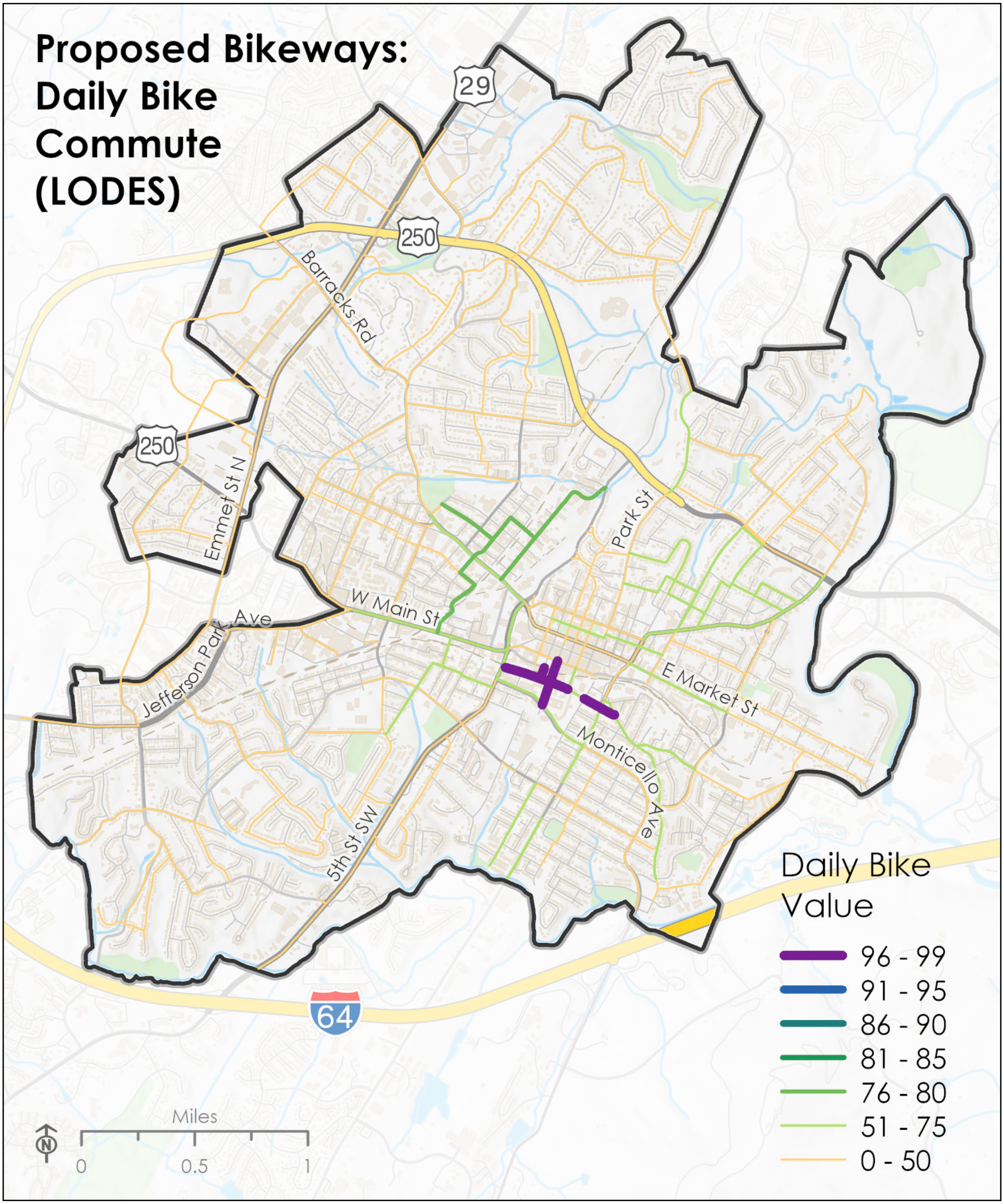


Figure 14: Proposed Bikeways: Daily Bike Commutes (LODES)



Safety

Crash Density

Fortunately, crashes involving pedestrians or cyclists are not frequent enough to intersect most proposed sidewalk or bicycle segments in the City of Charlottesville. The locations of crashes do suggest places where there is more need for protection of pedestrians and cyclists from interactions with traffic. This raw metric will be scored to prioritize the need for sidewalk or bikeway infrastructure at locations where there have been crashes. Crashes between automotive traffic and pedestrians and cyclists may indicate that there is a need for better clarity of separation between sidewalks/bikeways and the trafficway.

Step 1: In GIS, right-click on the center-lined proposed sidewalk or bikeway coverage, select "Join..." from the dropdown menu, and select "Join data from another layer based on spatial location" in the first dropdown box.

Step 2: Select the walk or bike crash coverage in the second dropdown box as the layer to join to the line layer

Step 3: Select "each line will be given a summary of the numeric attributes of the points that are" then select:

a. "closest to it", if the crash data locations are not along the centerline, but geographically accurate to the location within the right of way, or
b. "intersected by it" if the crash locations are aligned along the LRS centerline.

Step 4: Specify the location for the new shapefile that will contain the point intersection data. In the resulting coverage, the "Join Count" Attribute will indicate the number of walk or bike crashes along each segment.

Step 5: To calculate crash density for each segment, add a segment length field and calculate the geometry of walk or bike segments in the proposed sidewalk or bikeway centerline coverages.

Step 6: Add a crash density field to divide the number of crashes intersecting the segment by the length off the segment.

Figure 15: Proposed Sidewalks: Crash Density

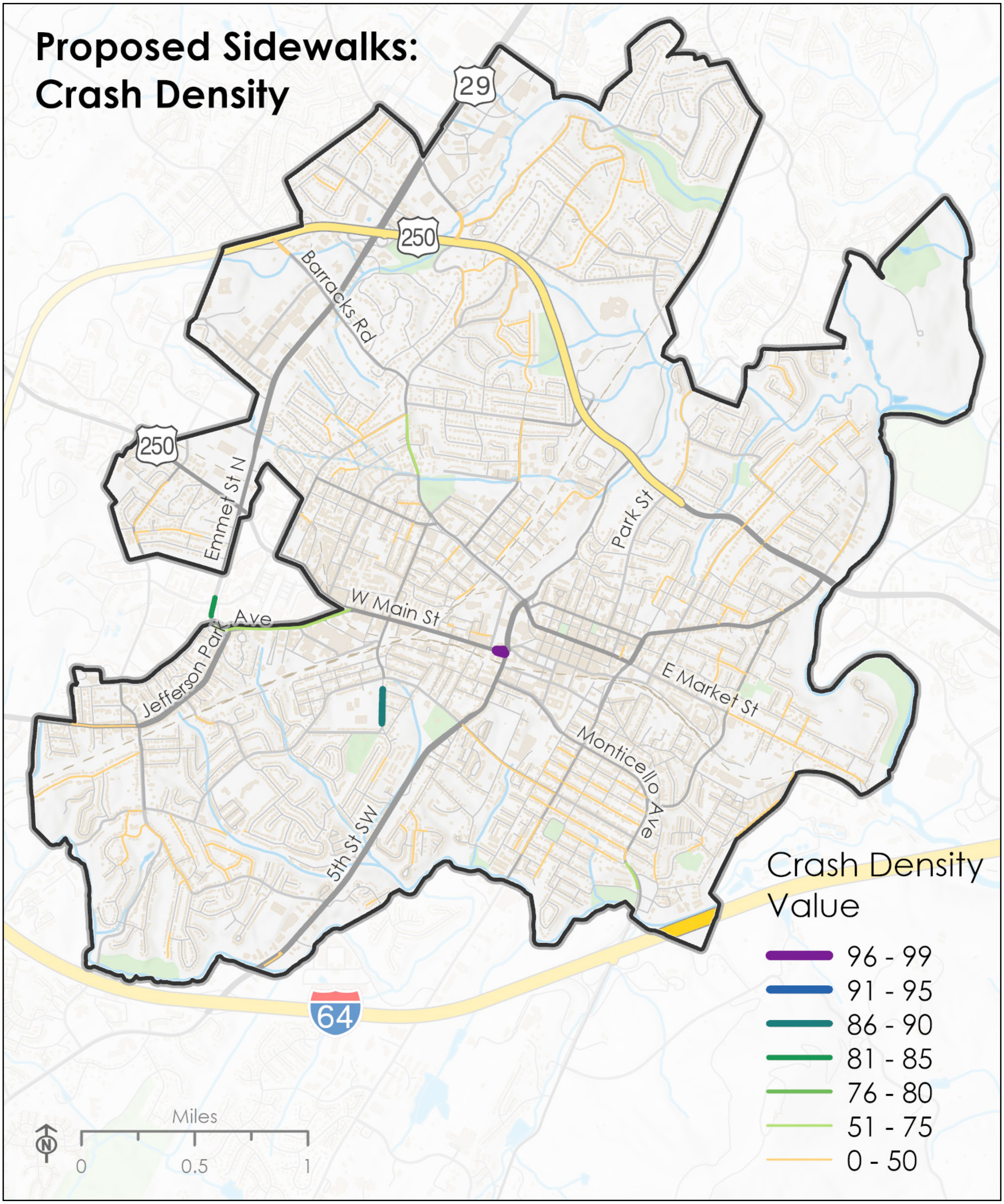
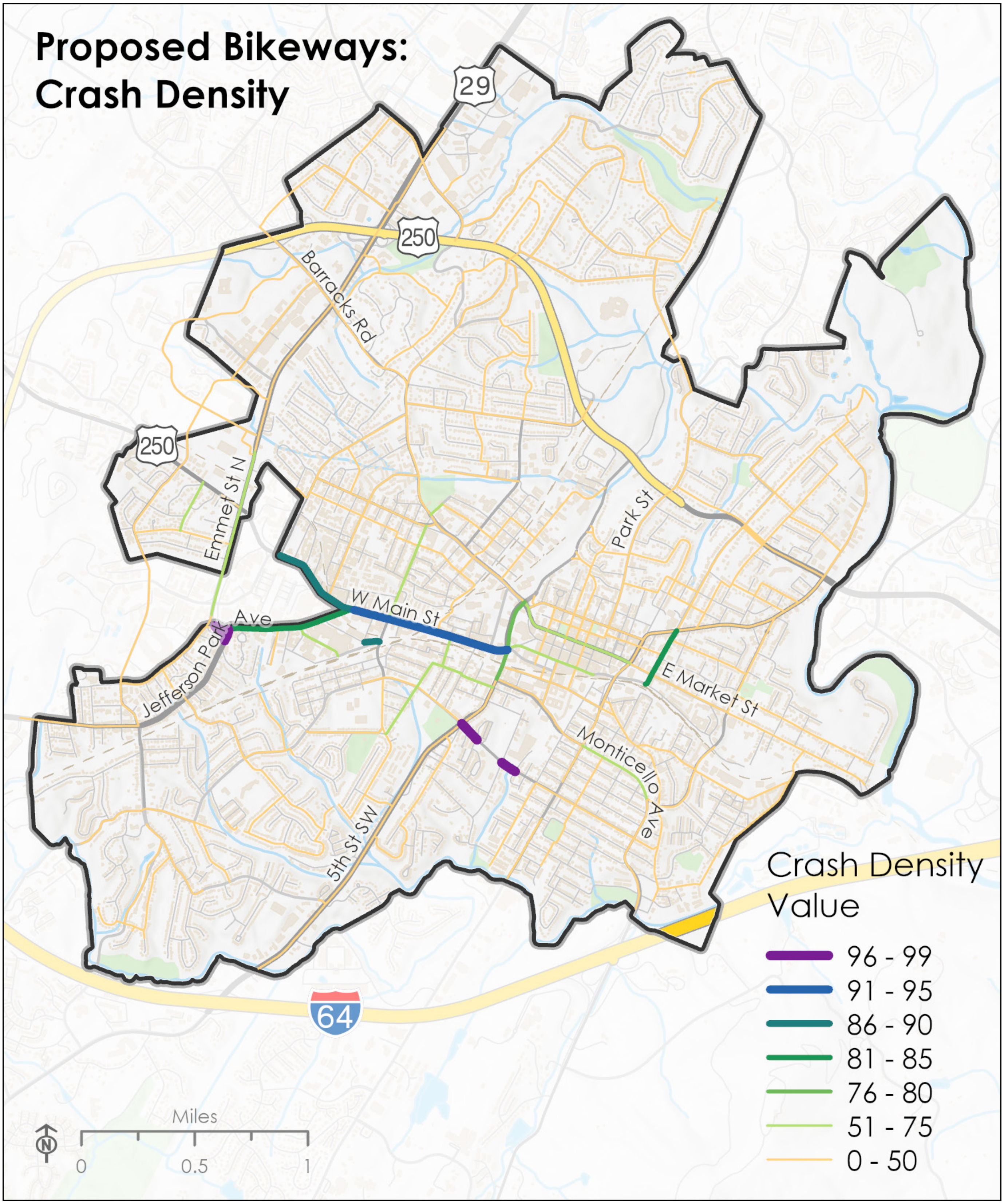


Figure 16: Proposed Bikeways: Crash Density



AADT

Many bike/walk facility prioritizations throughout the United States use roadway Annual Average Daily Traffic (AADT) as a metric of how attractive different blocks will be to pedestrians or cyclists. Pedestrians and cyclists prefer lower traffic streets to higher traffic highways, as they are less dangerous, polluted and noisy. Walking and biking are both more hazardous than driving in traffic, primarily because of the danger of being struck by vehicles in traffic. Streets with higher traffic volumes have a greater chance of striking a pedestrian or a cyclist, injuring or killing them.

If the bikeways and sidewalks are mapped to the same centerlines as the AADT, mapping the Traffic AADT along proposed bikeways and sidewalks is straightforward. The procedure does require a couple of steps to deal with the fact that the street centerlines are available from VTrans in blocks, while proposed bikeway and sidewalks from Charlottesville are defined as single multi- or sub-block segments.

Process:
To associate the proposed sidewalk and bikeway features with average AADT along each proposed segment, use the following procedure:

<u>Step 1:</u> For all local and other streets with no value given for field "VDOT_AADT", calculate the AADT based on the following local approximation of AADT:

> Length in feet of block with null AADT / 30 feet per average commercial or residential lot * 2 sides of the streets * 6 trips per day

<u>Step 2:</u> Use the GIS "intersect" function to intersect the bikeway or sidewalk centerlines with the VTrans coverage containing the AADT information, including the values filled in for the blank local blocks in Step 1. The resulting output of the intersect will be a linear feature along the centerline with the attributes of the centerline and the attributes of the bikeway or walkway.

<u>Step 3:</u> Find a raw overall AADT for each proposed sidewalk or bikeway segment by adding a field to the attribute table and calculate the product of the AADT for each street block in the segment by the length of the block in the intersected sidewalk or bikeway segment.

<u>Step 4:</u> Finding a raw overall AADT for each proposed sidewalk or bikeway segment by dissolving the intersected sidewalk or bikeway segment layer. Use the dissolve fields that are unique to each segment, such as FID or street name. Most importantly, in the statistics field, select the AADTxLength field from Step three and calculate the sum of that field for the dissolve. Create multipart features if some of the proposed segments involve multiple separate blocks.

<u>Step 5:</u> In the coverage of dissolved segments from Step four, create a new weighted average field and calculate the Summed AADTxLength from Step four by the total segment length. This will result in the mean AADT for each sidewalk or bikeway segment.

Figure 17: Proposed Sidewalks: Annual Average Daily Traffic

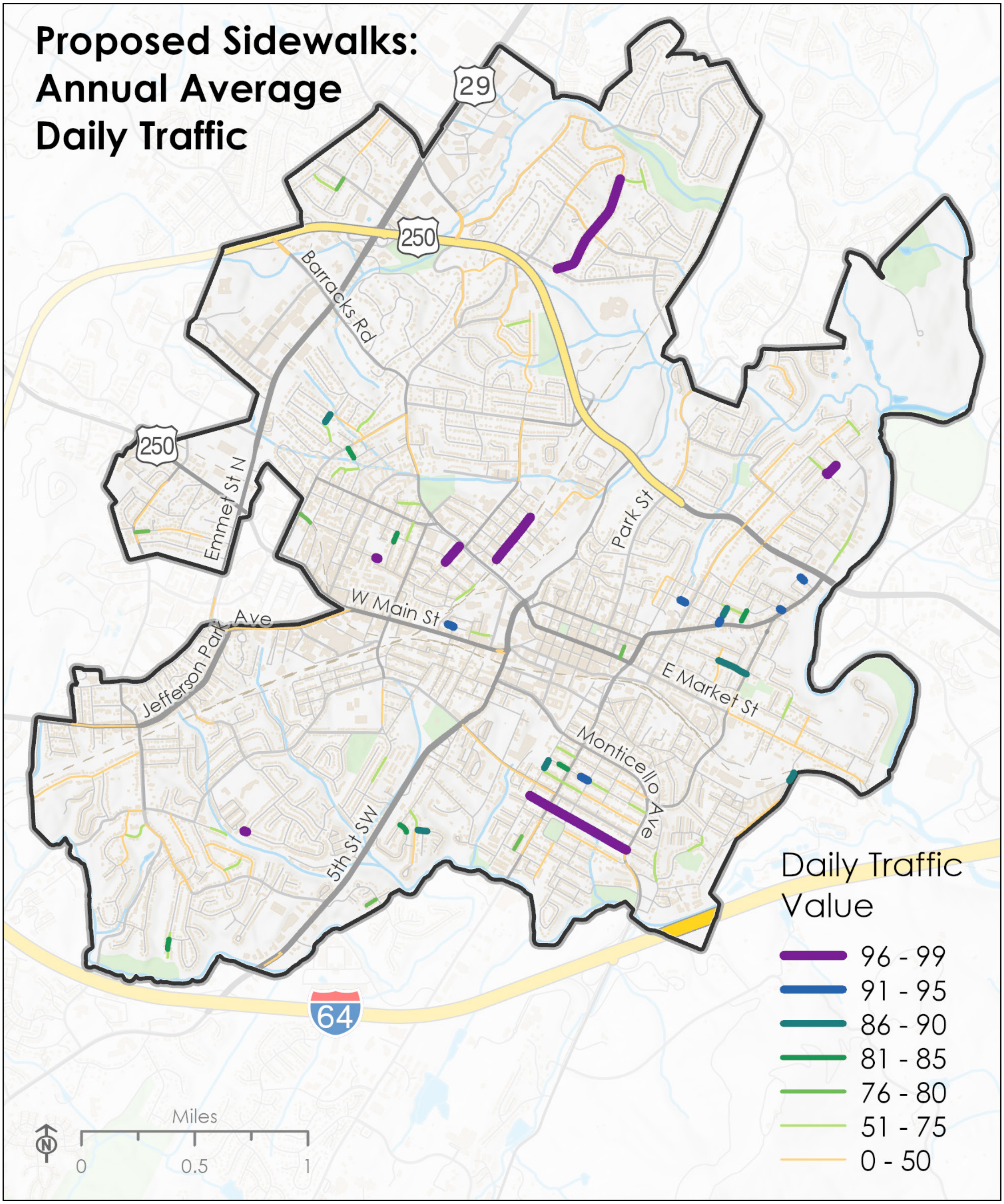
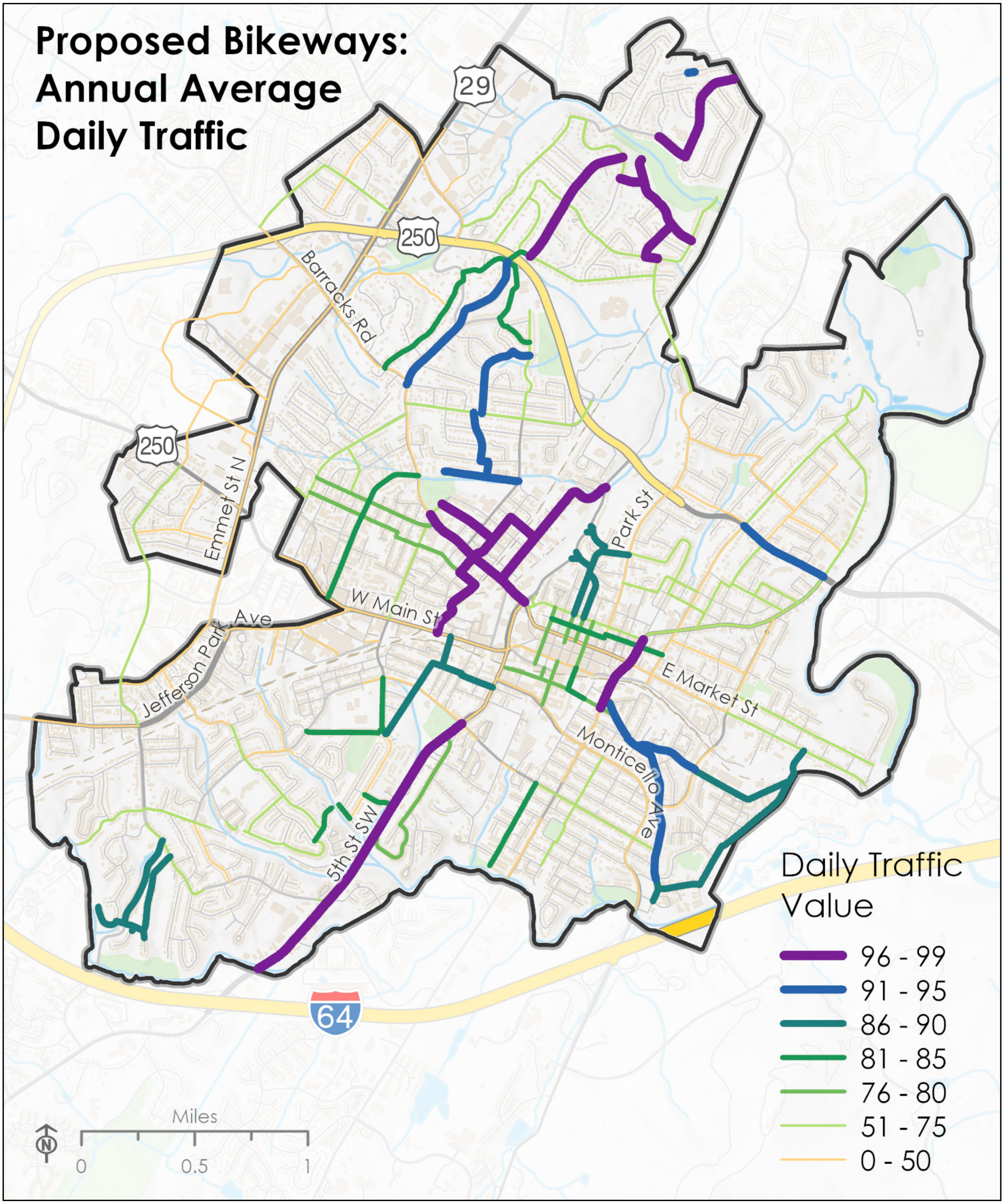


Figure 18: Proposed Bikeways: Annual Average Daily Traffic



Connectivity

Network

This variable incorporates several connectivity aspects, so several sub-processes are described.

Network connectivity is the metric of how many connections the proposed segment has with the existing non-motorized network. Segment completion relates the proposed segments to existing non-motorized network extent. The side number indicates whether the proposed sidewalk is to be built on one or both sides of the streets that it serves. Bikeway type ranks each bikeway based on its protection from traffic.

Network Intersection Process:

To associate the proposed sidewalk and bikeway features with connection to the existing sidewalk and bikeway network, use the following procedure:

Step 1: Using the GIS "intersect" tool, compare the existing and proposed sidewalk centerline networks, or the existing and proposed bikeway centerline networks. The intersection of two line networks will produce a point feature with the attributes of both line features. The attribute table of this point feature can be compared with the attribute table of the proposed sidewalk or bikeway network line feature to count the number of intersections.

Step 2: For each proposed sidewalk or bikeway segment with more than two connections to the existing network, assign 100% of the connection grade. For each proposed segment with one or two connections, assign 50% of the grade. For proposed segments with no connections to the existing network, assign 0% of the grade.

Connections	Connection Grade
>2	100
1-2	50
0	0

Blockwise Completion Process:

To score the proposed non-motorized features based on their relationship to existing sidewalk or bikeway networks, use the following procedure:

Step 1: In GIS, inspect each proposed non-motorized segment to identify the nature of the proposed improvement.

Step 2: For each proposed non-motorized segment that serves new streets with no existing sidewalk or bikeway, assign 100% of the completion grade. For each proposed segment that extends or completes existing sidewalk or bikeway blocks, assign 67% of the grade. For proposed segments that add to the other side of streets in the existing network, assign 33% of the grade. For proposed segments that replace or upgrade existing facilities completely, but do not add any new network length, assign 0% of the grade.

Completion Type	Completion Grade
New Segment	100%
Fill in or Extend Existing	67%
Other-side completion	33%
Replacement of existing	0%

Facility Location Process:

To score the proposed facility features based on whether the proposed facility is on one or both sides of the segment, use the following procedure:

Step 1: Inspect the attribute table of the proposed non-motorized segments to verify the installation on one or both sides of the street.

Step 2: For each proposed non-motorized segment, assign 100 % of the side grade to the segment if it is planned for both sides of the street. Assign 0% of the side grade if it is planned for only one side of the street.

Side Number	Side Grade
Both Sides	100%
One Side	0%

Proposed Sidewalks did not differentiate between sidewalk widths or qualities, nor do they include shared use paths. Proposed bikeways for the City of Charlottesville included a field in the attribute table for several different types of bikeways. These are graded for this score based on their separation from traffic.

Bikeways Type Process:

To score proposed bikeway features based on bikeway type, use the following procedure:

Step 1: Identify the attribute field that distinguishes the type of bikeway in the proposed bikeway coverage. If sidewalk types are available, they can be graded on similar criteria.

Step 2: Grade the bikeway segments using the following table.

Bikeway Segment Type	Bikeway Grade
Shared Use Path	100%
Cycle Track	80%
Bike Lanes	60%
Climbing Lane (1 side)	40%
2-way bikes in 1-way traffic	20%
Shared Roadway	0%

Merging Network Score Process:

Step 1: To merge the three proposed sidewalk criteria and four bikeway criteria, assign each grade 99/3 for sidewalks and 99/4 for bikeways. Multiply each segment's grades by each of the three or four grades, and sum those three or four grades to get a connection score of 0-99.

Figure 19: Proposed Sidewalks: Network Connectivity

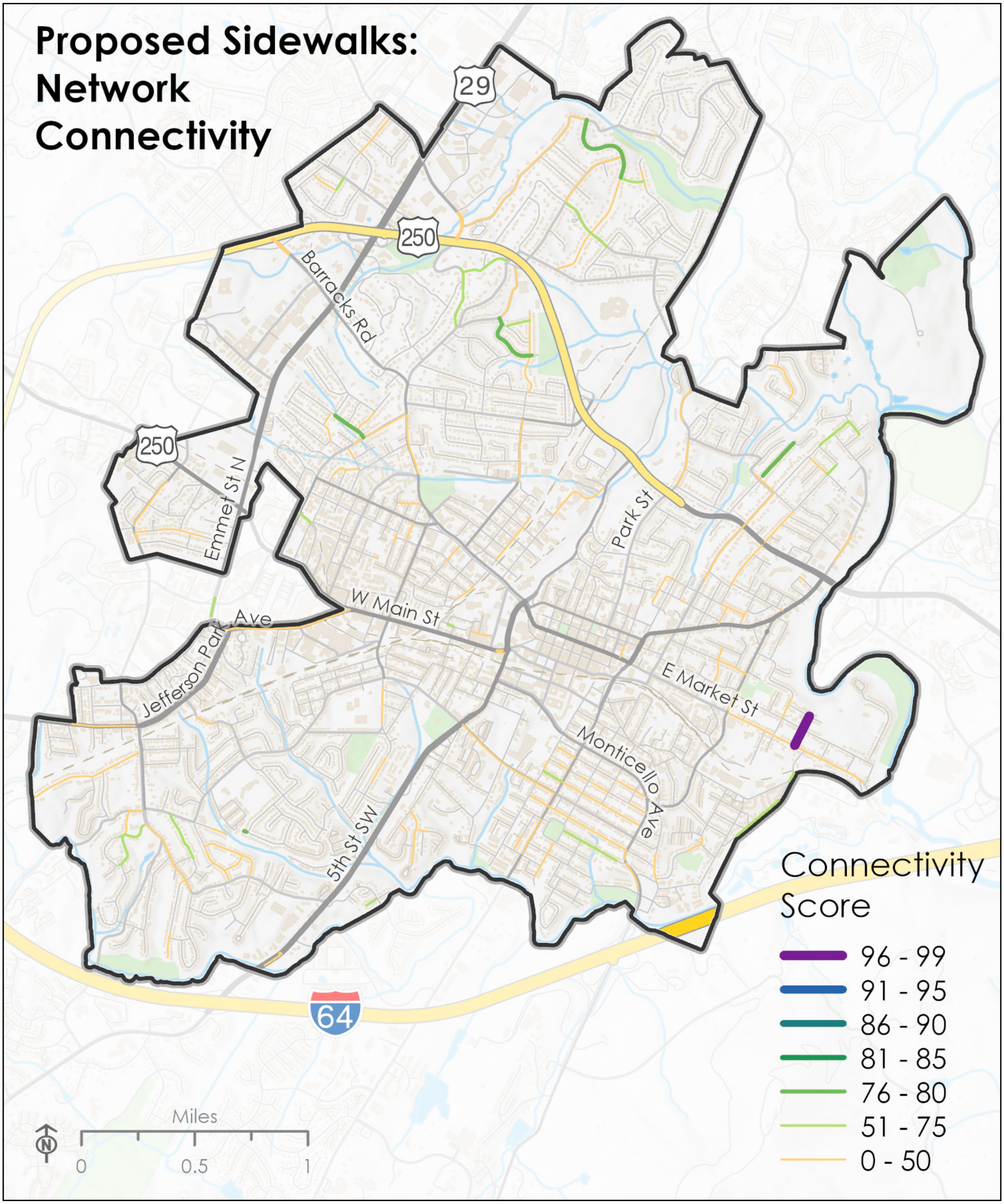
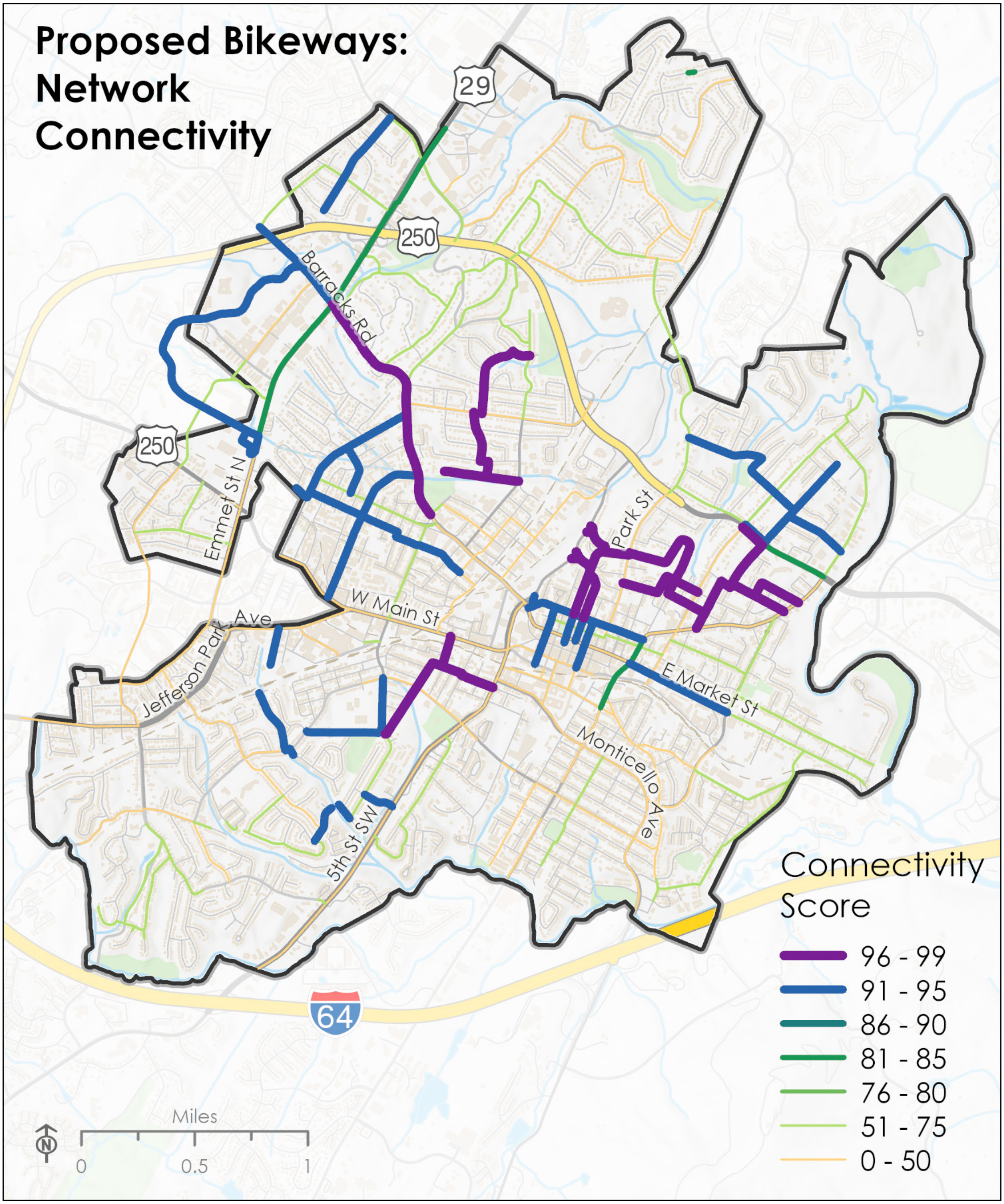


Figure 20: Proposed Bikeways: Network Connectivity



Segment Length

Proposed bikeway and sidewalk lengths mapped along the street centerline are network assets. A long bikeway or sidewalk project expands the non-motorized network more than a short segment. Long proposed segments were not specifically scored by any of the other data categories that went into the scoring. Therefore, segment length was considered independently as part of the scoring.

Process:
To associate the proposed sidewalk and bikeway features with segment length by proposed segment, use the following procedure:

Step 1: Create a field in the attribute table of the proposed centerline sidewalk or bikeway.

Step 2: Calculate the length of the segment into that field. Multipart segments should calculate the total length of the segments in the field.

Figure 21: Proposed Sidewalks: Segment Length

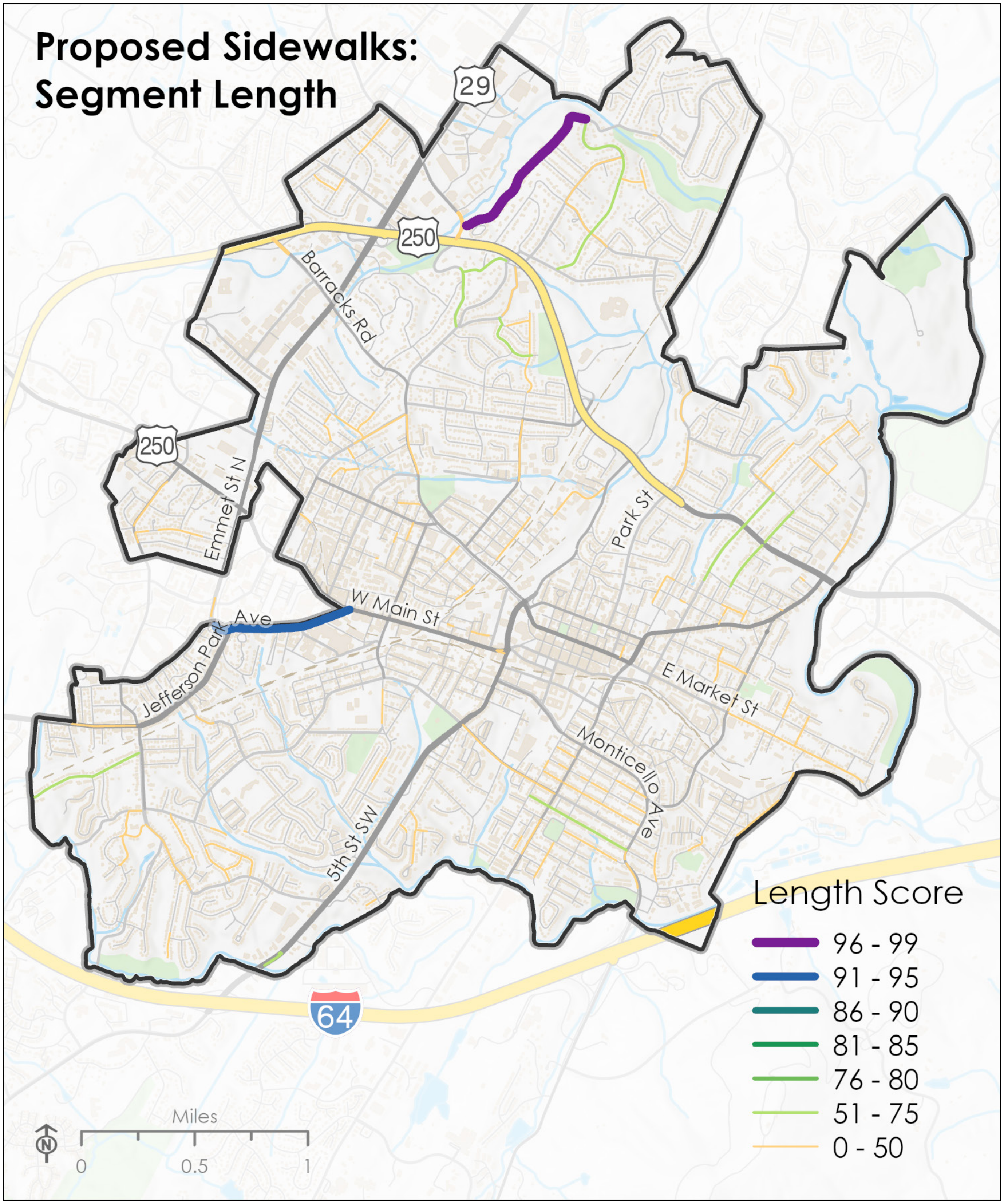
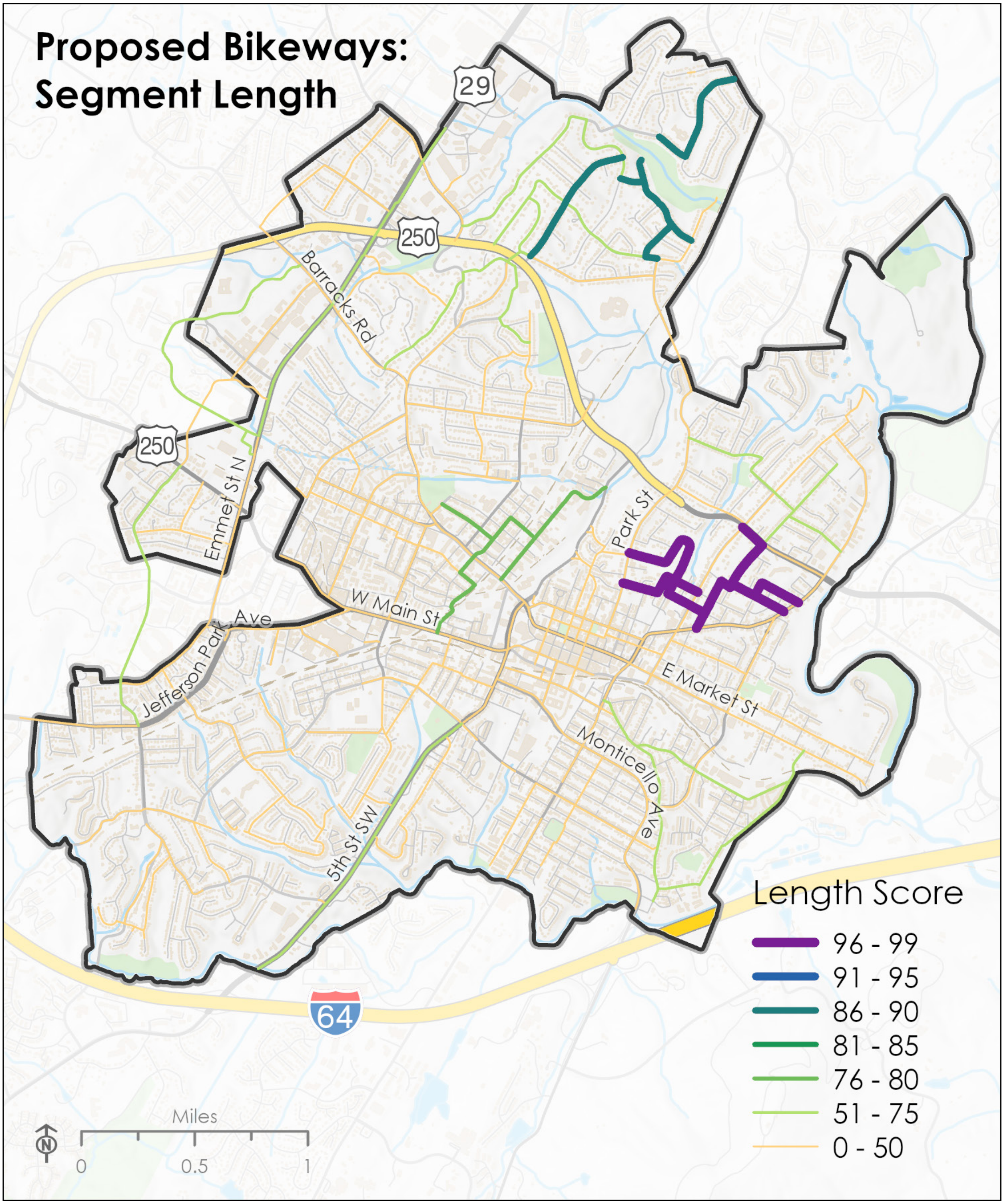


Figure 22: Proposed Bikeways: Segment Length



STEP 4: CONVERTING RAW DATA TO NORMALIZED SCORES OR VALUES

To convert raw metric scores to normalized scores, they must all be recoded to a comparable 0-99 score and the direction of the data must be the same for each metric. Every metric score must have the highest value condition set to value 99.

For some metrics, like proximity, the normalized score needs to be inverted so that the shortest distances are scored with the highest values. When inverting a score subtract the raw data values from their maximum value before dividing that by the range of raw values and dividing by 99 to invert the Score:

(Maximum Raw Value-Item Value)/Raw value Range * 99

For direct, not inverted, scoring of raw data use the following formula:

(Item Value-Minimum Raw Value)/Raw value Range * 99

For metrics where the raw data is not evenly distributed, have very large numbers, or are majority, valuation is better than scoring for evenly transforming raw data into valued data that can be compared with other scores and values in a merged prioritization. To merge factors, high quality segments have high scores or values across all factors in the prioritization.

There is no straightforward way to value data in GIS, so it is necessary to export the raw values, open them in Excel, sort them, value them evenly in a new column and join that valuation back to the GIS data or use it in merged data outputs.

The metrics used in the prioritization and their justification for scoring or valuing are shown in table six below.

STEP 5: COMBINE SCORES AND VALUES INTO A MERGED PRIORITIZATION SCORE

To merge the scores and ranks for proposed sidewalks and bikeways for each proposed segment, average the scores and ranks for each of the four subjects: Suitability, Demand, Safety, and Connectivity. Average those four averages to generate the merged prioritization score for each sidewalk or bikeway segment.

Process:
To merge the scored/valued factors across prioritization topics to obtain a single prioritization score for each proposed sidewalk or bikeway segment, use the following procedure:

<u>Step 1:</u> In Excel, export the FID, index or other unique identifying field from the GIS proposed centerline sidewalk or bikeway coverages into the leftmost column.

<u>Step 2:</u> For each of the 10 factors described above, export the raw and scored/valued data from the GIS proposed centerline sidewalk or bikeway coverages into the columns to the right of the column from Step one. With each data import to excel, ensure that the order of the index column is consistent, as a mis-sorting of factor data with index data would result in an incorrect merged score.

<u>Step 3:</u> To the right of the raw and scored/valued data, calculate the average of the topical averages as the merged score. In the case of this prioritization, there are four factors for Suitability, two factors for Demand, two factors for Safety, and two factors for Connectivity. The merged score would average within the four for Suitability, two for Demand, two for Safety, and two for Connectivity, and then average those four topic averages.

Excel spreadsheets for proposed sidewalks and bikeways showing raw, scored/valued, merged, and weighted factors have been updated per the above process and are available on the OIPI Teams site under the Task 4.2 directory.

Merging the Sidewalk Score

For the proposed sidewalks, the Jefferson Park Avenue sidewalk segment between McCormick Avenue and W. Main Street was the highest prioritized sidewalk segment for the overall merge. Note that the highest merged score is below 65, not 99. No segment had a perfect score for all metrics in the prioritization. Table 7 shows the top-10 (of 120) proposed sidewalk segments from the overall merge. The FID shown at the left of the table is to link to the proposed FID of the 2015 Bicycle and Pedestrian Master Plan. The status given is construction status as reported in 2015. See Appendix A for the complete lists of the prioritized proposed sidewalk segments.

Merging the Bikeway Score

For the proposed bikeways, the segment with the highest score was the 7 ½ Street two-way bikeway on a one-way street as seen on table 8. This proposed bikeway facility was the only two-way bikeway on a one-way street among the 96 proposed bikeways considered in the 2015 Bicycle and Pedestrian Master Plan. Its merged score was higher than the rest on school proximity value, AADT value, and connectivity score. Note that a third (32) of the 96 proposed bikeways were “shared roadway” projects, involving sharrows road markings and signage, but no lane allocation for cyclists in the roadway. Also, note the highest merged score was just above 65, not 99. No segment had a perfect score for all metrics in the prioritization. See Appendix B for the complete lists of the proposed bikeway segments.

Unlike Sidewalks, no information was given for the planning status of proposed segments. Also unlike sidewalk, there were diverse types of bikeways recommended in the 2015 bikeways dataset. This diversity informed the connection score in the analysis above.

Table 6: Methods for Standardizing Raw Factor Scores

Metric	Highest Rank or Value	Score or Rank type
WalkScore/BikeScore	Higher	Scored
School Proximity	Closer	Scored Inverse
Transit Proximity (Weighted)	Closer	Ranked Inverse
Maximum Segment Slope	Flatter	Scored
StreetLight Movement	More Segment Use	Ranked
LODES	More Commutes Between & within	Ranked
Crash density	More crashes indicate greater need	Ranked
AADT	Lower AADT	Ranked Inverse
Network	More, Additional Connections	Scored
Segment Length	Longer	Scored

Table 7: Top 10 Proposed Sidewalk Segments

FID	Street	Planning Status	Sides	WalkMerge	Rank
68	Jefferson Park Avenue	Not initiated	1	64.02307	1
24	8th Street NE	Not initiated	1	57.3741	2
112	W Main Street	Not initiated	1	57.25282	3
10	Elsom Street	Not initiated	1	56.98162	4
111	Sycamore Street	Not initiated	1	54.38521	5
50	Chancellor Road	Not initiated	1	54.23946	6
8	9th Street NW	Preliminary Engineering	2	53.90443	7
9	Commerce Street	Not initiated	1	52.21866	8
119	Rugby Road Extended	Not initiated	1	50.68287	9
15	9th Street SW	Preliminary Engineering	1	50.17522	10

Table 8: Top 10 Proposed Bikeway Segments

FID	Street	Major Action	Facility Type	BikeMerge	Rank
20	7 1/2 Street SW	Signage	One way except bikes	66.3969	1
61	E Market Street	Consolidate Parking	Climbing lane	63.18133	2
59	2nd Street NW	Reverse vehicle traffic direction	Contraflow bike lane	61.61592	3
13	Farish Street	Pavement Marking	Shared roadway	59.87457	4
62	9th Street NE	Road Diet	Bike lanes, cycle track	58.43139	5
41	W Jefferson Street	Pavement Marking	Shared roadway	57.39486	6
11	8th Street NW	Pavement Marking	Shared roadway	56.01956	7
12	Garrett Street	Pavement Marking	Shared roadway	55.74234	8
45	Preston Avenue	Alter Curb Location, Lane Diet	Cycle track	55.18404	9
22	14th Street NW	Pavement Marking	Shared roadway, bike & climbing lane	54.9404	10

Figure 23: Sidewalk Prioritization Score Frequency

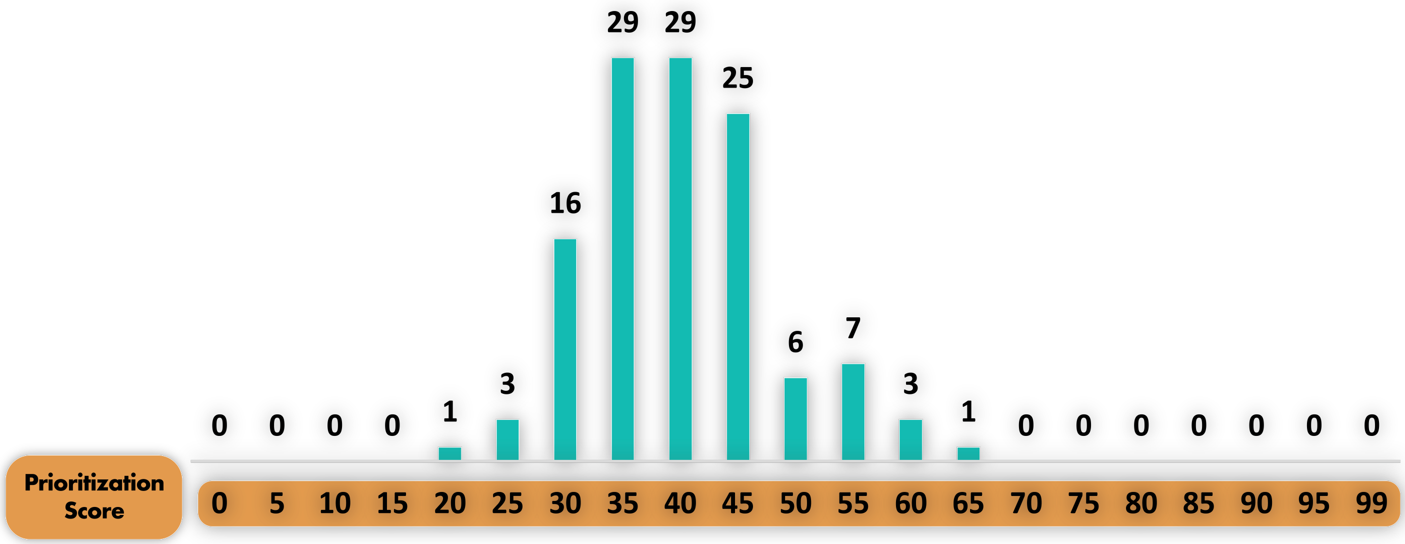


Figure 24: Bikeway Prioritization Score Frequency

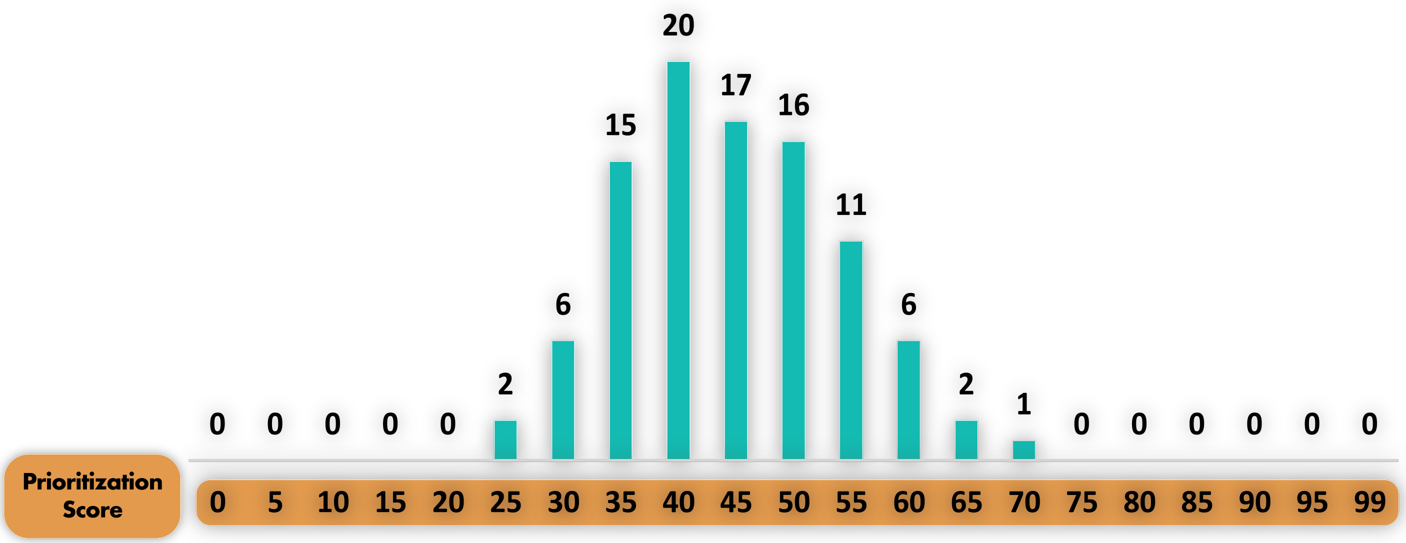


Figure 25: Proposed Sidewalks: Prioritization

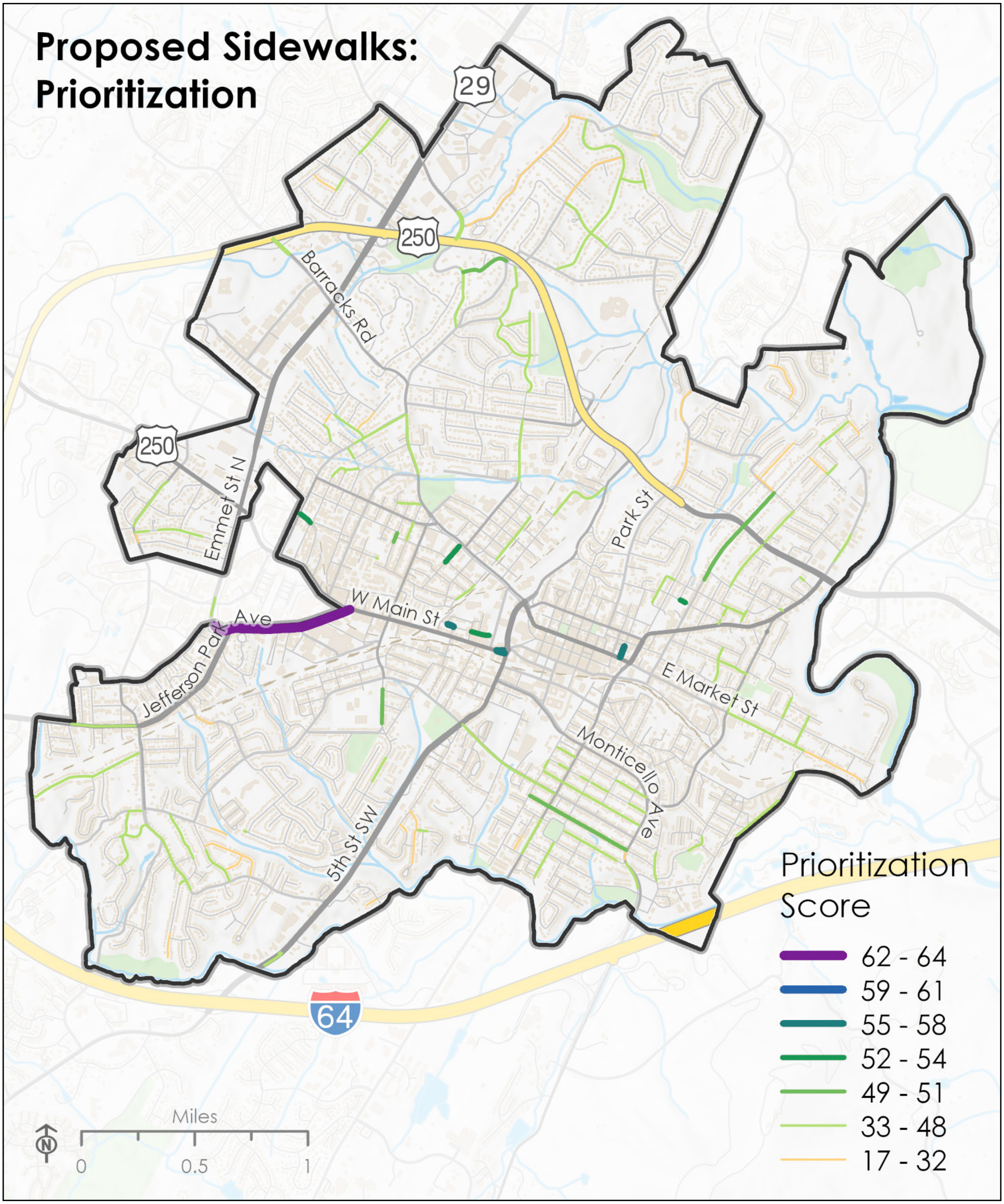
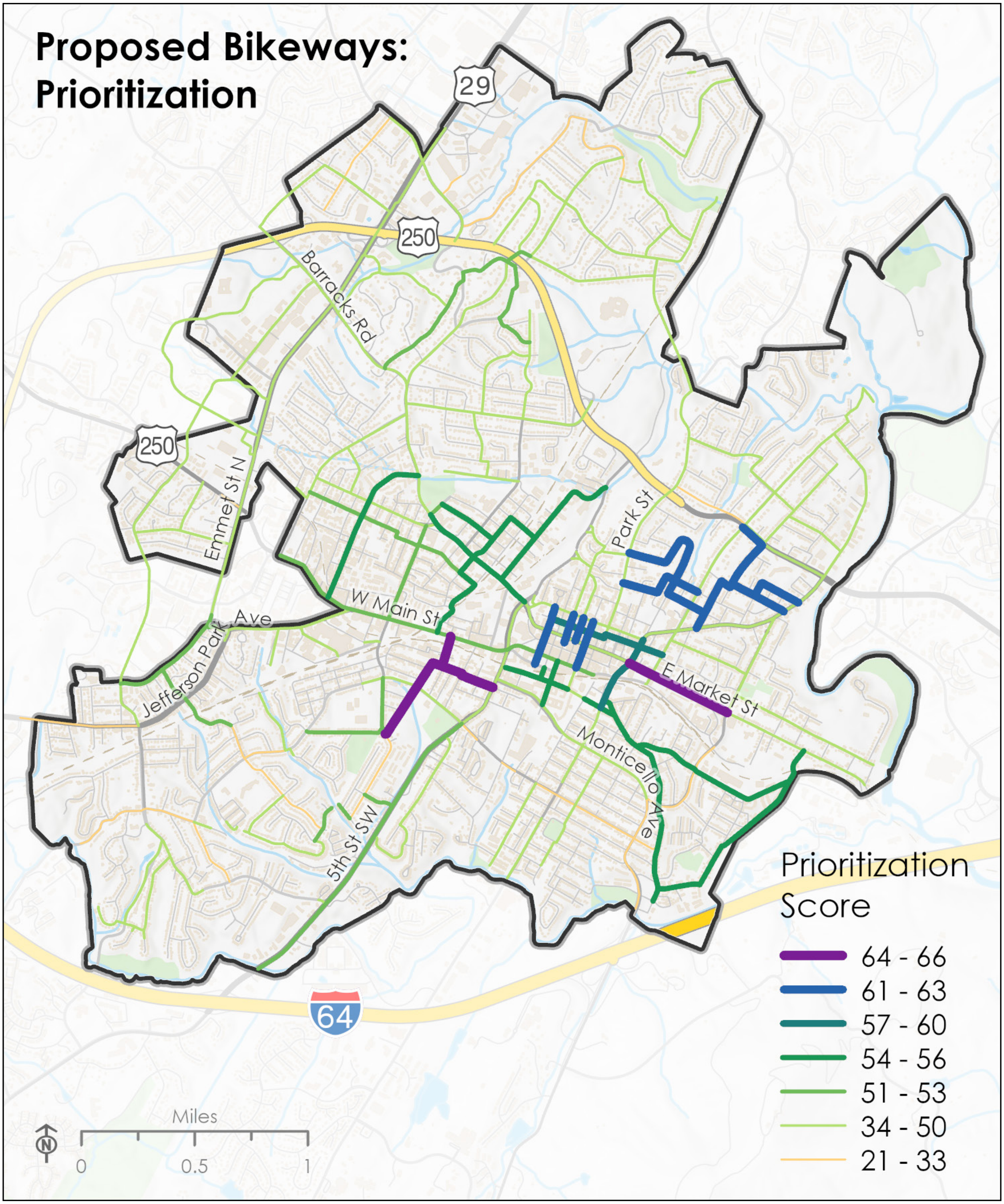


Figure 26: Proposed Bikeways: Prioritization



STEP 6: SENSITIVITY ANALYSIS

To investigate the stability of the prioritizations, it was important to test the response of the prioritization to changes in the component data. For Suitability, the WalkScore/BikeScore Score was either removed or left as the only suitability variable. For Demand, either 2019 StreetLight measured walking and biking use or 2019 LODES short commute numbers were used as the only demand variable, instead of both being included in the merge. For Safety and Connectivity, scores were increased within the merge relative to other scores in the merge, instead of using an either/or test.

Process:

To weight the merge of the scored/valued factors across prioritization topics to obtain a weighted prioritization score for each proposed sidewalk or bikeway segment, use the following procedure:

Step 1: In Excel, add columns for weighted merges to the right of the columns for the data and the overall merge from above.

Step 2: To the right of the merged score in Excel, further columns can calculate alternatives to the topical average merge in Step three. By modifying the formula for merge to exclude certain scores, it is possible to see the effect of weighting or excluding different factors in the merged calculation.

The following are the merge alternative weights tried in the proposed sidewalk and bikeway data.

- Suitability: calculate the merged score with WalkScore/BikeScore only or with the other suitability factors and without WalkScore/BikeScore.
- Demand: calculate the merged score with WalkScore/BikeScore only or with the other suitability factors and without WalkScore/BikeScore.
- Safety: calculate the topic average multiplied by 112% and 124%, with the other three topic averages multiplied by less than one to compensate.
- Connectivity: calculate the topic average multiplied by 112% and 124%, with the other three topic averages multiplied by less than one to compensate.

The Excel spreadsheets for proposed sidewalks and bikeways showing raw, scored/valued, merged factors also show weighted merges per the above process and are available on the OIPI Teams site under the Task 4.2 directory. These Excel spreadsheets show the formulas to produce the overall topical and weighted merges.

For proposed sidewalks, the Jefferson Park Avenue sidewalk segment is consistently the highest priority segment. Consistency between merges degrades with value. Merged prioritization scores will produce a rank, but the choice of factors in that prioritization is important in determining which segments will be higher priority. In Charlottesville's public planning and equity process, it could consider polling citizens to see which factors they find most important.

Table 9: Comparison between merged ranking using all topics (left) versus merges with certain factors eliminated or weighted.

For proposed bikeways, the two-way bikeway on the one-way segment of 7 ½ Street SW was consistently the highest priority segment in all merged weightings. As with proposed sidewalks, consistency was reduced in segments with lower prioritizations. The City of Charlottesville can control the merged prioritization per their staff judgment and community preferences.

Table 9: Comparison Between Merged Ranking: Sidewalks

FID	Street	WalkScore	No Score	Street Light	LODES	12% Safety	24% Safety	12% Connect	24% Connect	Rank
68	Jefferson Park Avenue	68	68	68	68	68	68	68	68	1
24	8th Street NE	112	24	15	10	112	112	10	10	2
112	W Main Street	10	112	50	24	24	10	24	24	3
10	Elsom Street	24	10	55	112	10	24	112	112	4
111	Sycamore Street	50	111	112	111	111	111	50	50	5
50	Chancellor Road	9	119	24	8	8	8	8	8	6
8	9th Street NW	8	8	119	31	50	50	111	119	7
9	Commerce Street	111	74	10	74	9	15	119	111	8
119	Rugby Road Extended	26	50	8	70	15	9	9	74	9
15	9th Street SW	12	9	111	9	119	26	74	9	10

Table 10: Comparison Between Merged Ranking: Bike Segments

FID	Street	BikeScore	No Score	Street Light	LODES	12% Safety	24% Safety	12% Connect	24% Connect	Rank
20	7 1/2 Street SW	20	20	20	20	20	20	20	20	1
61	E Market Street	61	61	59	13	61	61	61	13	2
59	2nd Street NW	59	59	61	61	59	59	59	61	3
13	Farish Street	11	13	62	41	13	62	13	59	4
62	9th Street NE	13	62	22	12	62	13	62	62	5
41	W Jefferson Street	15	41	53	11	41	45	41	41	6
11	8th Street NW	41	92	50	4	11	41	11	22	7
12	Garrett Street	12	12	94	59	45	11	22	11	8
45	Preston Avenue	22	4	57	45	12	12	45	72	9
22	14th Street SW	87	45	71	62	22	4	12	45	10

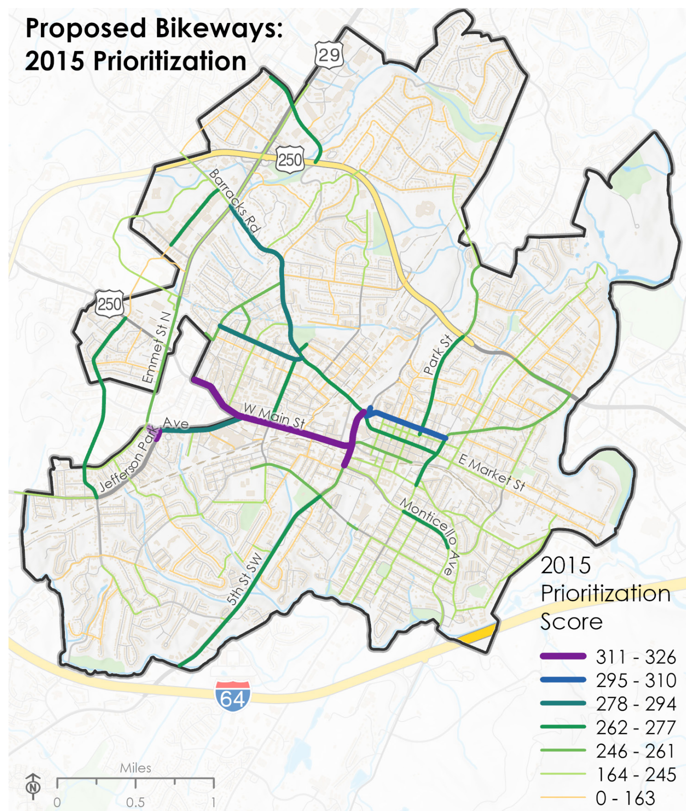
STEP 7: MERGED SCORE AND 2015 BIKEWAY PRIORITIZATION

The Charlottesville 2015 Bicycle and Pedestrian Master Plan only presented prioritization scores for proposed bikeways, not sidewalks. At the time, the 2015 list of proposed sidewalks was still in progress, including several projects that were not considered in this report. Therefore, the following section pertains to the comparison between the 2015 and current prioritization of proposed bikeways, using the same set of proposed bikeways.

The results of the 2015 Prioritization are dissimilar to the prioritization in this report. The only area with similar ranking in both prioritizations is the multiblock proposed segment between North Downtown and Martha Jefferson neighborhoods. The highest priority segments are towards the edges of Charlottesville in the 2015 prioritization, and between downtown and the University of Virginia campus in this current report.

This difference between the 2015 prioritization and the prioritization in the report are due to the choice of different factors in 2015 than in the current report, underscoring the sensitivity of the prioritization to the data chosen for the analysis. Every prioritization of proposed pedestrian or cyclist infrastructure must balance effort, availability, and redundancy. Most importantly, a prioritization of non-motorized infrastructure should seek to include factors that are relevant to pedestrian or cyclist needs.

Figure 27: Proposed Bikeways: 2015 Prioritization



22. Charlottesville 2015 Bicycle and Pedestrian Master Plan https://www.charlottesville.gov/DocumentCenter/View/480/2015-Bicycle-and-Pedestrian-Master-Plan-PDF

ROLES AND RESPONSIBILITIES MATRIX

The matrix below outlines the roles and responsibilities to execute the prioritization in this report. The three levels of participation are input as to the prioritization selection, maintenance, collection and update of the data sources, and execution of the factors that go into the prioritization per the steps in this report.

Table 11: Roles and Responsibilities Matrix

Measure	Category	Updates	Source	Public	City Staff	Transit Agency	MPO	Public Works	OIPI	VDOT	Census
Paving & Work Schedule	Readiness	Annual	Charlottesville		**I&E**			**M**		**M**	
Walk/ BikeScore	Suitability	Quarterly	Interact VTrans		**E**			**M**			
School Proximity	Suitability	Rarely	Google Earth		**E**						
Transit Proximity	Suitability	Rarely	Charlottesville		**M&E**	**I**					
Segment Slope	Suitability	Never	Charlottesville		**M&E**		**M**				
StreetLight	Demand	Monthly	StreetLight		**E**				**M**		
LODES	Demand	Annual	LEHD/LODES		**E**						**M**
Crashes/Mile	Safety	Annual	Interact VTrans		**E**				**M**		
AADT	Safety	Annual	Interact VTrans		**E**				**M**		
Network Connectivity	Connectivity	Rarely	Charlottesville		**M&E**						
Segment Length	Connectivity	Rarely	Charlottesville		**M&E**						
Equity Emphasis	Equity	Rarely	InteractVTrans/ Charlottesville	**I**	**M&E**				**M**		
Neighborhoods	Equity	Rarely	Charlottesville	**I**	**M&E**						
Streets That Work Typology	Road Network		Charlottesville		**M&E**			**I**			

Legend : **I** - Input to Process
E - Execute Process
M - Maintains Data Source

CONCLUSIONS AND FUTURE CONSIDERATIONS

As described in this report, the City of Charlottesville has the raw and scored data for each factor in spreadsheets for proposed sidewalks and bikeways and can change the weighting or inclusion of factors in the excel equations for new columns that contain their desired mix of factors. For example, because WalkScore/BikeScore is the aggregation of several factors relevant to walking or biking, there may be a desire to only include specific factors in Suitability. Additionally, StreetLight measures the walking and cycling activity along proposed segments in existing conditions, while LODES measures the existing distribution of commutes within and between tracts. Each of these factors are showing something unique about demand for sidewalks and bikeways. The network score can be disaggregated into several scores, using columns of data describing each network factor in the "Charlottesville_Sidewalk_Prioritization" and "Charlottesville_Bikeway_Prioritization" Excel spreadsheets provided to the city with the deliverables from this study.

With the specific crash location data available from OIPI, it is possible to rank crash density by block rather than segment. However, the current valuation of crash density by segment downplays the crash density of long segments. One option the City may wish to consider if this is a concern in the future is to calculate crash density by block as an intermediate step, then identify which proposed sidewalk or bikeway segments include those blocks with nonzero crash density. This is similar to the method used for the slope factor, where the maximum slope in the segment determines the score for the entire segment.

Per City of Charlottesville direction, this prioritization is not meant to determine the final ranking of sidewalk and bikeway segments. The repaving schedule has changed several times since the 2015 "Bicycle and Pedestrian Master Plan". For this prioritization to make use of the repaving schedule, the planners of the sidewalk and bikeway improvements will need to be included to inform the design, bid, and execution of the repaving projects. It is important for the City of Charlottesville to involve the public and its communities of need in this process as well, not algorithmically, but through outreach, collaboration, and empowerment. Public inclusion and equity should not be an invitation to slow the process of improving Charlottesville's sidewalk and bikeway network, but to build it in a way that best serves the needs and connection of all residents, workers, and students in Charlottesville.

The factors and topics used for this prioritization were chosen for their diversity and relevance to the motivations and needs of pedestrians and cyclists that would make proposed segments appealing. This report is focused on the description of the process for developing the prioritization, including the process for deciding on factors, sorting into topics, gathering data, analyzing raw scores from that data, scoring or valuing those raw scores to enable comparison between factors, and merging those standardized factors into overall prioritizations for proposed sidewalks or bikeways. The process was tested on the project lists presented in the Charlottesville 2015 Bicycle and Pedestrian Master Plan and resulted in the rankings shown in Appendix A and B .

APPENDIX A: LIST OF PRIORITIZED SIDEWALKS

Rank	Street	Begin	End	Sides	SegmentID	Prioritization
1	Jefferson Park Avenue	McCormick	W Main Street	1	68	64.02
2	8th Street NE	E Market Street	700 E Jefferson	1	24	57.37
3	W Main Street	Ridge Street	Existing	1	112	57.25
4	Elsom Street	Cream Street	7th Street NW	1	10	56.98
5	Sycamore Street	St. Charles Avenue	601 Locust Avenue	1	111	54.39
6	CHancellor Road	Rugby Road	Madison Lane	1	50	54.24
7	9th Street NW	Preston Avenue	West Street	2	8	53.90
8	Commerce Street	6th Street NW	Existing	1	9	52.22
9	Rugby Road Extended	Dairy Road	250 Ramp	1	119	50.68
10	9th Street SW	Elm Street	Existing	1	15	50.18
11	Locust Avenue	Poplar Street	Calhoun Street	1	74	50.02
12	11th Street NW	West Street	Existing	1	26	49.33
13	Alta Vista Avenue	Monticello Avenue	6th Street SE	1	31	48.34
14	Little High Street	12th Street NE	Meade Avenue	2	73	46.56
15	Hazel Street	E High Street	1424 Hazel	1	63	45.87
16	Rugby Road Extended	Dairy Road	250 Ramp	1	104	45.84
17	Greenleaf Lane	Gentry Lane	Rose Hill Drive	2	61	45.53
18	Albemarle Street	Dale Avenue	Rivanna Avenue	1	7	44.88
19	Emmet Street N	Stadium Road	McCormick	1	55	44.82
20	7th Street NW	Page Street	West Street	1	23	44.64
21	10 1/2 Street NW	Grady Avenue	West Street	1	25	44.44
22	Harris Street	Rivanna Avenue	McIntire	1	11	44.41
23	Yorktown Drive	Grove Road	Bunkerhill Drive	1	117	43.97
24	Oakleaf Lane	Greenleaf Lane	RoseHIll Drive	2	85	43.94
25	Blenheim Avenue	Existing	Rialto Street	1	37	43.93
26	Kelley Avenue	Taylor Street	Lexington Avenue	1	70	43.93
27	Fontaine Avenue	Summit Street	Jefferson Park Ave	1	18	43.53
28	Orange Street	Poplar Street	Existing	1	86	43.42
29	Druid Avenue	Monticello Avenue	Rialto Street	1	52	43.40
30	Orange Street	E High Street	Existing	1	87	43.40
31	St. Clair Avenue	Calhoun Street	Hazel Street	1	109	42.65
32	Rose Hill Drive	Rugby Avenue	Madison Avenue	1	4	42.47
33	Rives Street	Ridgecrest Drive	Existing	1	99	42.34
34	Poplar Street	St. Claire Avenue	Gillespie Avenue	1	91	41.53
35	Gentry Lane	250 Ramp	Greenleaf Lane	1	60	41.04
36	Rugby Road	Rugby Place	Preston Avenue	1	103	40.79
37	Preston Road	Rugby Road	Madison	1	1	40.56
38	Montrose Avenue	Avon Street	Rialto Street	1	83	40.50
39	Riverdale Drive	1319 Riverdale Drive	Willow Drive	1	98	40.45
40	John Street	11th Street NW	Existing	1	69	40.40
41	Montrose Avenue	Monticello Avenue	Avon Street	1	81	40.39
42	St. Claire Avenue	Pear Tree Avenue	Smith Street	1	6	40.30
43	Montrose Avenue	Avon Street	6th Street SE	1	82	39.83
44	Blenheim Avenue	Castalia Street	Monticello Avenue	1	39	39.69
45	18th Street NE	Little 18th Street	E Market Street	2	27	39.67
46	Gillepsie Avenue	Moore Street	1301 Gillepsie	1	62	39.52
47	Franklin Street	1500 Franklin	800 Franklin	1	59	38.82
48	Fairview Avenue	Chesapeake Street	317 Fairview	2	56	38.77
49	5th Street SW	Existing	City Limits	2	21	38.67
50	E Market Street	Franklin Street	Meade Avenue	1	12	38.46
51	Blenheim Avenue	Rialto Street	Meridian Street	1	38	38.36
52	Lewis Mountain Road	Existing	Existing	1	72	38.31
53	Prospect Avenue	Existing	Existing	1	93	38.21
54	Elliot Avenue	Ridge Street	Avon Street	1	14	38.03
55	Blenheim Avenue	Existing	Avon Street	1	36	38.02
56	Winston Road	Rugby Road	Old Farm Road	1	113	37.89
57	6th Street SE	Montrose Avenue	Blenheim Avenue	1	22	37.88

Rank	Street	Begin	End	Sides	SegmentID	Prioritization
58	Bolling Avenue	Avon Street	6th Street SE	2	41	37.53
59	Barracks Road	Existing	250 Bypass	1	0	37.44
60	Jefferson Park Avenue	Park Road	Cammelia Drive	1	66	36.70
61	Lewis Mountain Road	Alderman Road	Existing	1	71	36.69
62	Bolling Avenue	Meridian Avenue	Monticello Avenue	1	40	36.54
63	Jamestown Drive	1608 Jamestown	1511 Jamestown	1	65	36.52
64	Rosser Avenue	12th Street NW	Preston Avenue	1	101	36.12
65	Avon Street	Druid Avenue	Palantine Avenue	1	32	36.01
66	Fendall Avenue	Winston Terrace	Edgewood Lane	1	57	35.86
67	Kenwood Lane	Meadowbrook Heights	Concord Drive	1	5	35.61
68	Cedar Hill Road	Hydraulic Road	N Berkshire Road	2	48	35.58
69	Willard Drive	Harris Road	Existing	1	115	35.29
70	Preston Place	Existing	Burnley Avenue	1	92	35.25
71	Rialto Street	Belmont Park	Bincoe Lane	2	96	35.08
72	Meade Avenue	E Market Street	Jefferson Street	1	77	34.92
73	Highland Avenue	Rainier Road	Existing	2	64	34.87
74	Woodland Drive	Park Lane	Cleveland Avenue	1	116	34.71
75	Rose Hill Drive	Walker Elementary	Oxford Road	1	100	34.68
76	Park Road	Jefferson Park Avenue	Brunswick Road	1	88	34.63
77	Franklin Street	Carlton Avenue	RR	1	58	34.34
78	12 Street NE	E Jefferson Street	Meriwether Street	1	19	34.33
79	Alderman Road	Kent Road	Morris Road	1	2	34.22
80	River Road	Existing	Existing	1	97	34.01
81	Hydraulic Road	250 Bypass	Dominion Energy	1	3	33.90
82	Bunker Hill Drive	Yorktown Drive	Jamestown Drive	1	45	33.71
83	Brunswick Road	Park Road	Jefferson Park Avenue	1	44	33.65
84	Yorktown Drive	Brandwine Drive	Bunkhill Drive	2	118	33.33
85	Azalea Drive	Existing	Jefferson Park Avenue	2	34	33.02
86	Locust Avenue	Locust Lane	Peartree Lane	1	75	32.97
87	Stribling Avenue	Jefferson Park Avenue	City Limits	2	110	32.87
88	Baylor Lane	Existing	Raymond Road	1	35	32.67
89	Jefferson Park Circle	Park Road	McElroy Drive	1	67	32.58
90	Monticello Avenue	Quarry Road	Druid Avenue	1	13	32.53
91	Cedar Hill Road	Angus Road	Dellmead Lane	1	49	32.49
92	Monticello Road	Elliott Avenue	Druid Avenue	1	79	32.40
93	Burnley Avenue	Rugby Road	Tunlaw Place	1	46	32.15
94	Raymond Road	Ridge Street	Baylor Lane	1	94	31.96
95	Winstonter	Winston Road	Existing	1	114	31.93
96	Shamrock Road	Railroad	220 Shamrock	1	106	31.87
97	St. Charles Avenue	Calhoun Street	St. Charles Court	2	108	31.55
98	Brookwood Drive	Ridge Street	Existing	2	43	31.12
99	Rosser Lane	Winston Road	Westview Road	1	102	31.04
100	Shale Place	Harris Road	Cul de Sac	2	105	30.91
101	Brandywine Drive	Greenbrier Drive	Hydraulic Road	1	42	29.53
102	Calhoun Street	Locust Avenue	Existing	1	47	29.50
103	Azalea Drive	Existing	City Limits	2	17	29.04
104	Alderman Road	Thomson Road	Lewis Mountain Road	1	29	28.97
105	E Market Street	Franklin Street	Riverside Avenue	1	53	27.75
106	Locust Lane	Locust Avenue	St. Claire Avenue	1	76	27.07
107	Azalea Drive	Trailhead	223 Azalea Drive	1	33	26.68
108	Moseley Drive	Harris Road	Willard Drive	1	84	26.55
109	Allen Drive	Moseley Drive	Williard Drive	1	30	26.43
110	Meadowbrook Heights Road	Yorktown Drive	Kenwood Lane	1	78	26.10
111	Monticello Avenue	Alta Vista Avenue	Druid Avenue	1	80	26.05
112	Cleveland Avenue	Rainier Road	Existing	1	16	25.63
113	Raymond Road	Baylor Lane	Existing	1	95	25.62
114	Early Street	Palantine Street	Existing	1	54	25.57
115	Smith street	Locust Avenue	St. Clair Avenue	1	107	25.17

Rank	Street	Begin	End	Sides	SegmentID	Prioritization
116	Greenbrier Drive	Greenbrier Park entrance	1922 Greenrbier	1	20	25.05
117	Dellmead Lane	RIcky Road	Cedar Hill Road	1	51	23.40
118	Park Street	North Avenue	250 Bypass	1	90	23.28
119	Park Street	Melbourne Road	Existing	1	89	23.03
120	Agnese Street	Elizabeth Avenue	1231 Agnese Street	1	28	17.14

APPENDIX B: LIST OF PRIORITIZED BICYCLE SEGMENTS

Rank	Street	Major Actions	Recommended Facility	SegmentID	Prioritization
1	7 1/2 Street SW	SIgnage	One way except bikes	20	66.40
2	E Market Street	Consolidate Parking	Climbing lane	61	63.18
3	2nd Street NW	Reverse vehicle traffic direction	Contraflow bike lane	59	61.62
4	Farish Street	Pavement Marking	Shared roadway	13	59.87
5	9th Street NE	Road Diet	Bike lanes, cycle track	62	58.43
6	W Jefferson Street	Pavement Marking	Shared roadway	41	57.39
7	8th Street NW	Pavement Marking	Shared roadway	11	56.02
8	Garrett Street	Pavement Marking	Shared roadway	12	55.74
9	Preston Avenue	Alter Curb Location, Lane Diet	Cycle track	45	55.18
10	14th Street NW	Pavement Marking	Shared roadway, bike & climbing lane	22	54.94
11	Monticello Road	Pavement Marking	Shared roadway	4	54.88
12	Monticello Road	Pavement Marking	Shared roadway	72	53.21
13	10th Street NW	Pavement Marking	Shared roadway	71	53.02
14	5th Street SW	Road Diet, Road Widening	Cycle track	50	52.80
15	E Water Street	Consolidate Parking	Shared roadway	57	52.59
16	W Main Street	Alter Curb Location	Cycle track	92	52.53
17	University Avenue	Pavement Marking	Priority shared lanes, climbing lanes	53	51.36
18	Del Mar Drive	Consolidate Parking	Climbing lane	87	51.19
19	Stadium Road	Pavement Marking	Shared roadway, climbing lane	18	50.97
20	Gordon Avenue	Pavement Marking, Consolidate Park	Shared roadway, climbing lane	1	50.80
21	Antoinette Avenue	Consolidated Parking	Climbing lane	19	49.84
22	Alderman Road	Pavement Marking, Lane Diet	Shared roadway, bike lane	51	49.72
23	Emmet Street S	Lane Diet	Bike lanes	94	48.95
24	10th Street NW	Consolidate Parking	Climbing lane	10	47.83
25	Ridge McIntire Road	Lane Diet	Bike lane, extend 5th St SE lane	58	47.70
26	3rd Street NE	Pavement Marking	Shared roadway	15	47.60
27	Rugby Road	Lane Diet, Pavement Marking	Contraflow_climbing bike lane, shared r	90	47.45
28	Massie Road	Pavement Marking	Shared roadway, bike lane	21	47.19
29	Rugby Avenue	Construct New	Shared use path	67	46.03
30	Lee Street	Pavement Marking	Shared roadway	31	46.03
31	Madison Avenue	Pavement Marking	Shared roadway	9	45.97
32	Jefferson Park Avenue	Lane Diet	Cycle track,widen road,remove turn lanes	85	45.67
33	Preston Ave_Barracks Rd	Lane Diet, Remove Parking	Possible cycle track, climbing lane	64	45.64
34	10th Street NE	Consolidate Parking	Climbing lane	73	45.57
35	Cherry Avenue	Consolidate Parking	Climbing lane	56	45.48
36	Locust Avenue	Remove Parking	Bike lanes	74	45.23
37	6th Street SE	Pavement Marking	Shared roadway	47	44.64
38	Lane Road	Pavement Marking	Shared roadway	34	44.38
39	W Market Street	Remove Turn Lane, Lane Diet	Climbing lane	60	44.34
40	Grady Avenue	Pavement Parking	Priority shared lanes, remove parking	75	44.23
41	Belleview Avenue	Consolidate Park, Pave Mark, Lane Diet	Shared roadway, climbing lane	2	44.10
42	W High Street	Remove Left Turn Lane	Climbing lane	65	43.99
43	Dairy Road	Pavement Marking	Shared roadway	5	43.39
44	Greenbrier Drive	Consolidate Parking	Bike lane, shared road	23	43.34
45	Monticello Avenue	Remove Parking	Bike lanes	80	42.76
46	Monte Vista Avenue	Pavement Marking	Shared roadway	30	42.52
47	E High Street	Lane Diet	Bike lane	63	42.39
48	Monticello Avenue	Remove Parking	Climbing lane, cycle track	81	42.15
49	Jefferson Park Avenue	Lane Diet	Climbing lane	52	42.05
50	Rialto Street	Pavement Marking	Shared roadway	3	42.01
51	Cameron Lane	Pavement Marking	Shared roadway	28	41.85
52	Long Street	Construct New	Shared use path	79	41.75
53	Chesapeake Street	Pavement Marking	Shared roadway	38	40.19
54	Kenwood Lane	Pavement Marking	Shared roadway	40	39.72
55	Hydraulic Road	Alter Curb Location, Lane Diet	Cycle track	91	39.55
56	JPA and Emmett	Lane Diet	Extend existing bike lanes	55	39.29
57	Emmet Street N	Construct New	Shared use path	46	39.13
58	Park Street	Lane Diet	Climbing lane	7	39.08
59	E Market Street	Pavement Marking	Shared roadway	16	38.98
60	Lewis Mountain Road	Consolidate Parking	Climbing lane	32	38.69
61	Rose Hill Drive	Pavement Marking	Shared roadway	83	38.60
62	Avon Street	Remove Parking	Climbing lane	66	38.56
63	Park Street	Pavement Marking	Shared roadway	42	38.24
64	Meadowbrook Road	Pavement Marking	Shared roadway	29	37.27
65	Ridge Street	Lane Diet	Bike lanes	49	36.90
66	Little High Street	Pavement Marking	Shared roadway	39	36.61
67	Emmet Street S	Lane Diet	Bike lanes	95	36.51

Rank	Street	Major Actions	Recommended Facility	SegmentID	Prioritization
68	Locust Avenue	Pavement Marking	Shared roadway	44	36.28
69	Millmont Street	Lane Diet	Bike lanes	86	36.26
70	Meade Avenue	Consolidate Parking	Climbing lane	76	36.20
71	Ridge Street	Pavement Marking	Wayfinding sharrows	37	36.04
72	Melbourne Road	Lane Diet	Cycle track	48	35.71
73	Barracks Road	Alter Curb Locations	Bike lanes	89	35.44
74	River Road	Remove Parking	Climbing lane	68	34.74
75	Angus Road	Consolidate Parking	Bike lane	24	34.72
76	Locust Avenue	Pavement Marking	Shared roadway	6	34.55
77	Cherry Avenue	Lane Diet	Climbing lane	69	34.17
78	Kerry Lane	Construct New	Shared use path	43	33.93
79	Village Road	Pavement Marking	Shared roadway	36	33.82
80	Park Street	Pavement Marking	Shared roadway	8	33.78
81	Copeley Road	Lane Diet	Bike lane	25	33.61
82	Grove Road	Consolidate Parking	Bike lane	88	33.31
83	Carlton Road	Lane Diet, Pavement Marking	Bike lanes, climbing lane	0	33.14
84	Hillsdale Drive	Lane Diet	Bike lanes	33	31.70
85	Prospect Avenue	Pavement Marking	Shared roadway	35	31.60
86	Sunset Avenue	Pavement Marking	Shared roadway	26	31.58
87	Elliot Avenue	Consolidate Parking	Climbing lane	78	31.16
88	Monticello Avenue	Road Diet	Bike lanes	82	30.36
89	Ivy Road	Lane Diet	Bike lanes	54	28.72
90	Elliot Avenue	Consolidate Parking	Climbing lane	77	28.52
91	Shamrock Road	Consolidated Parking	Climbing Lane	17	27.88
92	Willard Drive	Consolidate Parking	Climbing lane	70	27.22
93	Watson Avenue	Pavement Marking	Shared roadway	14	26.48
94	Cedar Hill Road	Lane Diet	Bike lanes	93	25.68
95	Brandywine Drive	Pavement Marking	Shared roadway	27	24.61
96	Fontaine Avenue	Alter Curb Locations	Bike lane	84	20.93

APPENDIX C: INTERNAL CAPACITY ASSESSMENT

This methodology documentation outlines the City of Charlottesville's multimodal process for prioritizing and ranking non-motorized transportation projects in its Capital Improvement Program (CIP). The prioritization process is supported by a custom geoprocessing workflow that consists of project inputs (i.e., segments, intersections, corridors, etc.), raw data sources (e.g., annual average daily traffic, functional classification, WalkScore, Equity Emphasis Areas, etc.), configuration files, interim measures, and factor weights.

The City of Charlottesville ("City") indicated that the project inputs to test the multimodal process are identified in the City's 2015 Bicycle and Pedestrian Master Plan and the 2016 Streets that Work Plan. Since these earlier rankings are based on different factors and weights, the intent of this process and tool is to compare projects in these lists and to address identified problems.

The prioritization process workflow and its associated toolset were developed with a set of criteria that consider the City's project development process, its long range planning objectives, available software licenses and computer hardware, geographic information systems (GIS) software experience, internal and external data sources, and data collection practices. The process's objectives, workflow concept, and the overall approach to rankings were discussed in meetings and through messages on Microsoft Teams. The potential constraints for the process and tool, such as software availability, staff capacity, and staff experience were identified in a survey completed by the City's Public Works and Neighborhood Development Services (NDS) departments. Furthermore, the project team overlaid GIS data layers to determine the extent of statewide datasets and the feasibility of implementing elements of existing project prioritization processes.

Software, Hardware, and Staff Capacity

Internal capacity assessments are fundamental to the development of a process or tool for an organization. From the perspective of a performance-based empirical planning tool, getting information about an organization's internal capacity is an essential part of designing an appropriate process for its users. This includes choosing factors and interim measures that reflect an organization's long range planning objectives and data availability, and developing tools that allow planning staff to implement the process without exceeding their current capacity and their level of experience. This section highlights constraints for the multimodal prioritization process, such as software licenses and computer hardware, GIS software experience, internal and external data sources, and data collection practices.

A Python-based GIS toolset is a likely candidate that can provide the structure that is needed to support a repeatable, semi-automated, and modifiable workflow that can evaluate transportation improvements and rank projects for inclusion in the CIP. Although there are open source software alternatives that are also candidates, ESRI's ArcGIS is a commonly used program that is available to local and regional governments and is understood by technicians who will be running the tool. Furthermore, ArcGIS is analytically powerful and customizable, especially with custom Python geoprocessing scripts and extensions that are capable of running advanced geospatial analysis.

Currently the City has five computers that are available for the prioritization process and are installed with advanced ArcGIS licenses. The computers will be used by up to five focused team members, which are part of a larger 10 member scoring committee. The Network Analyst extension is also available for ArcMap and ArcGIS Pro is available with all five licenses. Network Analyst is an import resource to consider because it can be used to determine congested travel times, estimate access to jobs, and determine changes to interim performance measures after project implementation. Although there are currently no individuals within Public Works or NDS who have a strong background in GIS and Python programming, the proposed tool will only require simple network modifications, user inputs for parameters that refer to the configuration files, and consistent file management for managing inputs and outputs. While adjustments to factor weights and configuration files are rare, changing input parameters does not require advanced GIS experience. However, if help is needed, there are many resources online for troubleshooting errors, including extensive written documentation, active question and answer forums, and video help tutorials for many topics.

According to the survey completed by the City of Charlottesville, Public Works and NDS does not have an overall data management policy for collecting, storing, and distributing data. In terms of data collection, Public Works routinely uses Survey 1-2-3 in ArcGIS for workplace assignments and for erosion and sediment control inspections which are conducted daily. Public Works also maps storm drains and structures and drainage problems on a monthly basis or when there are citizen complaints. On an annual basis, Public Works coordinates with NDS to map ramp compliance with the Americans with Disabilities Act (ADA). While additional data collection is not needed for the proposed process, having the necessary equipment and experience to measure existing conditions is useful.

Multimodal Project Prioritization Process Workflow

Figure 1 provides an overview of them mulimodal prioritization workflow. The elements of the proposed project prioritization process are summarized in the following list.

- Input database – A list of projects compiled by the City that will be ranked and compared against each other.
- Resource data – Data available to the City and its external partners, including data layers on Interact VTrans and locally collected data.
- Configuration files – Background files that are rarely altered including the file location of input data, geoprocessing scripts, user interface, graphics and images, dialog box information that provides tool help, environmental settings, and global parameters. Configuration files are typically not adjusted unless initial assumptions change.
- Interim data (metrics) – Interim data is obtained from existing data sources and local data collection, or derived from the application of configuration files in a geoprocessing script.
- Metric weights and config files – Input files that are applied to raw factor scores to obtain a normalized and weighted average project score. Weights assign the relative importance of different factors to a community and can be adjusted to reflect changes in community goals.
- Project evaluation outputs – The normalized project benefit scores for each factor are grouped into three categories for low, medium, and high project cost estimates. The weighted normalized project benefit score is the final output of this process and can be compared to projects within the same cost estimate range.

Figure 1: Multimodal Project Prioritization Process Workflow

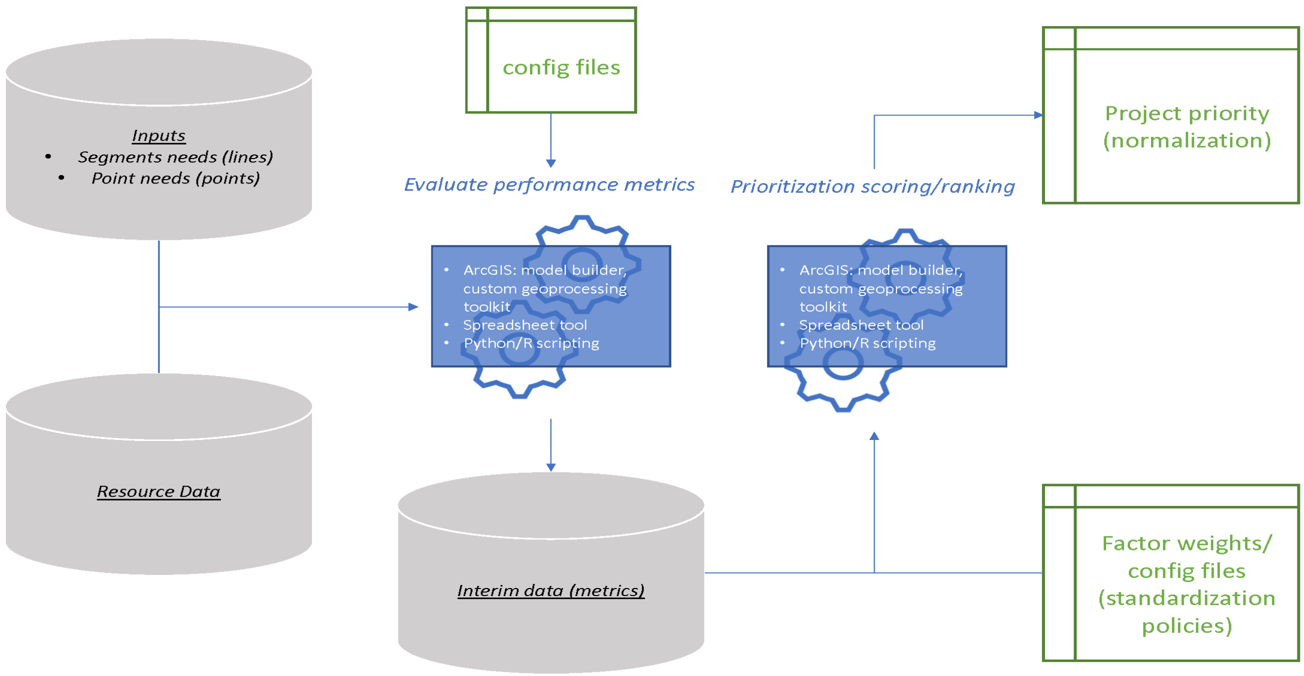


Table 1: Multimodal Project Prioritization Workflow Parameters

Component	Frequency of Change	Ease of Troubleshooting	Expertise Required
Input Database	**Routine**	**Easy**	**Identification of segment to prioritize by updating a file that has route identification and start and end milepoints**
Resource Data	Frequent	Easy to moderate	Creation/export of shapefile/ feature class; assurance of consistent formatting, column naming, feature enumeration
Config Files/ Standardization Policies	Rare (Match changes in methodology, data sources/ formats)	Moderate	Understanding of how config files/ parameters relate to performance measure procedures
Factor Weights	Scenario Testing Applications	Easy	Update a table

Data Requirements

Potential data layers for the prioritization process can be obtained from many sources, including locally generated data, state agencies, and national data, including federal agencies and third-party proprietary data. Although some data is available from multiple sources, one benefit of using statewide resources for the project prioritization process is the consistency of VDOT's linear referencing system (LRS) for referencing points' and segments' locations and distances. Another benefit is the ease of accessing and transferring data internally and with external organizations. Another benefit of using an authoritative statewide dataset is that it allows the City to spend fewer resources on data collection, thus leaving more time and resources to focus on developing projects and evaluation scenario, running and rerunning the tool, developing new metrics or performance measures, and post-processing data outputs for reporting the final rankings for the CIP.

Given these benefits, InteractVTrans is the proposed primary data source for the project prioritization process. Interact VTrans is a web-based mapping application for viewing and downloading data layers, existing studies, VTrans mid-term needs, long-term planning trends, and systemwide performance indicators. However, the prioritization process and tool shall also be allowed to accept alternative data sources using a set of standardized data input table templates. For example, locally generated data may be used if statewide data is not available for a given segment. Since statewide data is typically available for VDOT maintained facilities only, the City of Charlottesville may need to use more local data. Secondly, other datasets are acceptable when new data collection is needed, such as peak hour transit ridership and pedestrian counts, or if an interim measure is derived from other datasets such as connectivity indices, access to jobs, and estimated levels of future pedestrian demand.

In addition to InteractVTrans, other state and federal data sources include VDOT's Roadway Inventory Management System (RIMS) for roadway inventory data (e.g., roadway width, right of way, pavement type), the American Community Survey, Decennial Census, and Longitudinal Employer-Household Dynamics survey for socioeconomic and demographic data, and Open GIS data on Virginia Roads for pavement condition, existing bicycle and pedestrian facilities inventory, and the VDOT LRS. Finally, some network derived data, such as auto and transit travel times can be obtained from the regional travel demand model, Google API, and General Transit Feed Specific repositories.

Based on feedback gathered from the project team about their needs, the preferred prioritization criteria, and assumptions about additional data needs, the following list highlights InteractVTrans data layers that are relevant to Charlottesville's multimodal project prioritization process for non-motorized transportation improvements. All data layers are available on InteractVtrans to view and download in multiple formats.

- Corridors of Statewide Significance (CoSS)
- Regional Networks (RN)
- Urban Developments Areas (UDA)
- Industrial Economic Development Areas (IEDA)
- Six-Year Improvement Program (SYIP)
- Strategically Targeted Affordable Road Solutions (STARS) Studies, Arterial Management Plans, and Growth and Accessibility Program (GAP) Technical Assistance (TA) projects
- Average Annual Daily Traffic (AADT), Functional Classification, Speed (MPH), Number of Lanes
- Travel Time Index (TTI), Planning Time Index (PTI), and Level of Travel Time Reliability (LOTTR)
- Crash Data
- Flooding Risk Assessment
- Bus Stops
- Park and Ride Lots
- Intercity Bus Routes
- Passenger Rail Stations and Rail Lines
- Long Distance Bicycle Routes
- Bicycle Facilities
- Sidewalks
- WalkScore, Transit Score, and BikeScore
- Truck Bottlenecks, Truck Delay, Truck Travel Time Reliability (TTTR), Truck Commodity Flow, Rail Commodity Flow, Urban Freight Corridors, Rural Freight Corridors
- Number of Distribution Centers, Total Distribution Center Rentable Area, Number of Warehouses, Total Warehouses Rentable Area
- Interact VTrans Public Comments
- VTrans Activity Centers
- Equity Emphasis Area (EEA) Index

While statewide data has limited local availability, local data covers the boundaries of the City of Charlottesville and the Charlottesville-Albemarle Metropolitan Planning Organization (e.g., the urbanized portions of Albemarle County and the City of Charlottesville). Furthermore, some local data covers the area of the Thomas Jefferson Planning District Commission (TJPDC) and its constituent jurisdictions, while University of Virginia data covers the extent of the University's Grounds. Lastly, local data layers encompass numerous socioeconomic, demographic, roadway, transit, environmental, municipal, and cadastral categories. While many data layers can be obtained from multiple sources, it is important to get the latest data whenever possible to ensure the process is consistent, defensible, and reliable results.